Indiana's Landscape of Care: A Technical Analysis of Healthcare, Aviation, and Ecological Resources

Story Map: https://storymaps.arcgis.com/stories/5b5176efda8f44ea8be9bd9e6103830e

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Abstract

This report presents a comprehensive spatial analysis of Indiana's healthcare, aviation, and ecological infrastructure using advanced geospatial techniques. By integrating datasets on population density, aviation facilities, healthcare access points, and wetlands, the study evaluates spatial patterns, identifies underserved regions, and prioritizes conservation hotspots. Analytical methodologies include buffer creation, spatial overlays, and hotspot analyses to assess infrastructure coverage and ecological pressures. The findings inform strategic recommendations for enhancing emergency preparedness and ecological preservation across the state.

1. Introduction

Indiana represents a unique interplay of urbanization, rural landscapes, and critical natural resources. Ensuring equitable access to emergency healthcare while preserving ecological zones is a complex challenge. This study adopts a spatially informed approach to evaluate:

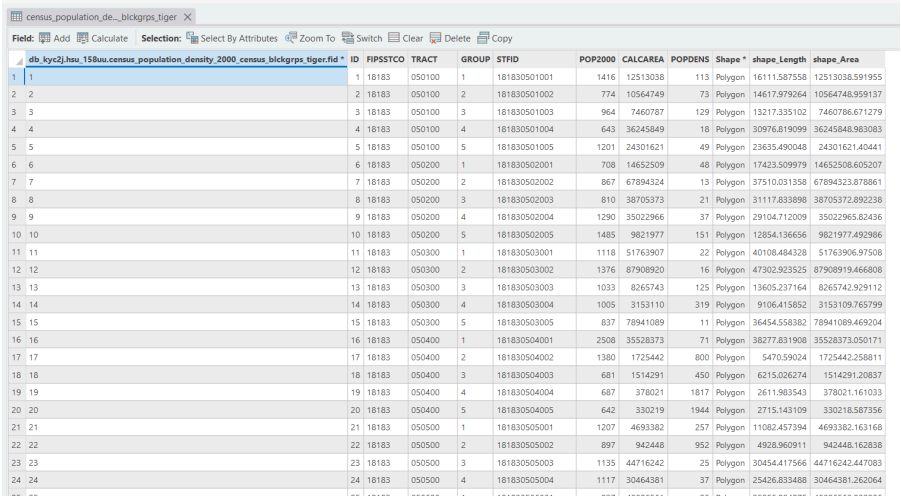
- Accessibility of aviation and healthcare infrastructure.
- Gaps in service coverage across urban and rural regions.
- The intersection of high-priority wetlands with human activity.

By leveraging ArcGIS and advanced spatial analysis, this report bridges technical insights with actionable policy recommendations.

2. Data Sources and Preprocessing

2.1 Data Sources The datasets used in this study are as follows:

1. **Population Data**: Detailed geospatial data sourced from Indiana's GIS resources, representing demographic patterns and density.



census_population_de..._blckgrps_tiger

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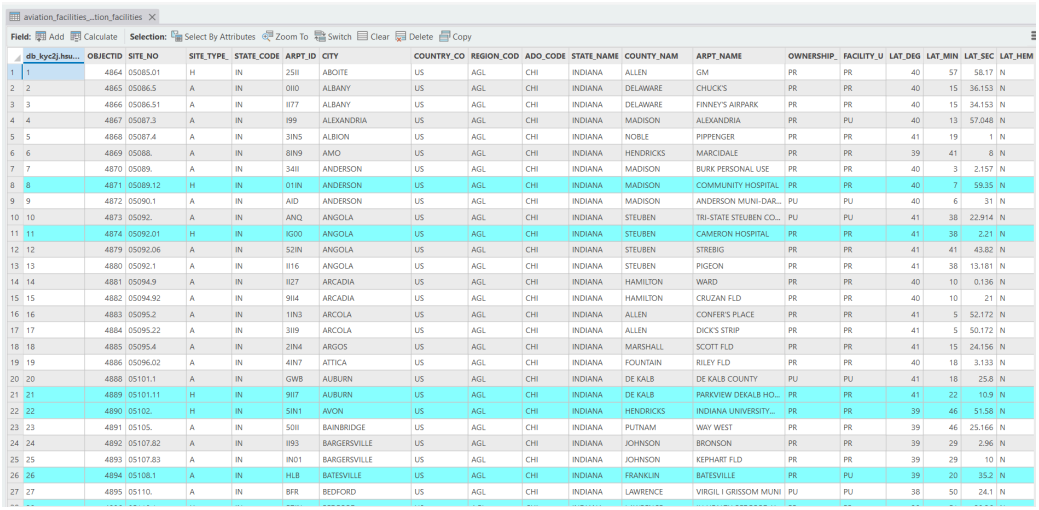
	db_kyc2j.hsu_158uu.census_population_density_2000_census_blckgrps_tiger.fid *	ID	FIPSSTCO	TRACT	GROUP	STFID	POP2000	CALCAREA	POPDENS	Shape *	shape_Length	shape_Area
1	1	1	18183	050100	1	181830501001	1416	1251303	113	Polygon	16111.587558	12513038.591955
2	2	2	18183	050100	2	181830501002	774	10564749	73	Polygon	14617.979264	10564748.959137
3	3	3	18183	050100	3	181830501003	964	7460787	129	Polygon	13217.335102	7460786.671279
4	4	4	18183	050100	4	181830501004	643	36245849	18	Polygon	30976.819099	36245848.983083
5	5	5	18183	050100	5	181830501005	1201	24301621	49	Polygon	23635.490048	24301621.40441
6	6	6	18183	050200	1	181830502001	708	14652509	48	Polygon	17423.509979	14652508.605207
7	7	7	18183	050200	2	181830502002	867	67894324	13	Polygon	37510.031358	67894323.878861
8	8	8	18183	050200	3	181830502003	810	38705373	21	Polygon	31117.833898	38705372.892238
9	9	9	18183	050200	4	181830502004	1290	35022966	37	Polygon	29104.712009	35022965.82436
10	10	10	18183	050200	5	181830502005	1485	9821977	151	Polygon	12854.136656	9821977.492986
11	11	11	18183	050300	1	181830503001	1118	51763907	22	Polygon	40108.484328	51763906.97508
12	12	12	18183	050300	2	181830503002	1376	87908920	16	Polygon	47302.923525	87908919.466808
13	13	13	18183	050300	3	181830503003	1033	8265743	125	Polygon	13605.237164	8265742.929112
14	14	14	18183	050300	4	181830503004	1005	3153110	319	Polygon	9106.415852	3153109.765799
15	15	15	18183	050300	5	181830503005	837	78941089	11	Polygon	36454.558382	78941089.469204
16	16	16	18183	050400	1	181830504001	2508	35528373	71	Polygon	38277.831908	35528373.050171
17	17	17	18183	050400	2	181830504002	1380	1725442	800	Polygon	5470.59024	1725442.258811
18	18	18	18183	050400	3	181830504003	681	1514291	450	Polygon	6215.026274	1514291.20837
19	19	19	18183	050400	4	181830504004	687	378021	1817	Polygon	2611.983543	378021.161033
20	20	20	18183	050400	5	181830504005	642	330219	1944	Polygon	2715.143109	330218.587356
21	21	21	18183	050500	1	181830505001	1207	4693382	257	Polygon	11082.457394	4693382.163168
22	22	22	18183	050500	2	181830505002	897	942448	952	Polygon	4928.960911	942448.162838
23	23	23	18183	050500	3	181830505003	1135	44716242	25	Polygon	30454.417566	44716242.447083
24	24	24	18183	050500	4	181830505004	1117	30464381	37	Polygon	25426.833488	30464381.262064

2. **Aviation Facilities Data**: Includes locations and attributes of helipads, airports, and airstrips, essential for medical and logistical connectivity.



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	db_kyc2j.hsu...	OBJECTID	SITE_NO	SITE_TYPE_	STATE_CODE	ARPT_ID	CITY	COUNTRY_CO	REGION_COD	ADO_CODE	STATE_NAME	COUNTY_NAM	ARPT_NAME	OWNERSHIP_	FACILITY_U	LAT_DEG	LAT_MIN	LAT_SEC	LAT_HEM
1	1	4864	05085.01	H	IN	25II	ABOITE	US	AGL	CHI	INDIANA	ALLEN	GM	PR	PR	40	57	58.17	N
2	2	4865	05086.5	A	IN	0II0	ALBANY	US	AGL	CHI	INDIANA	DELAWARE	CHUCK'S	PR	PR	40	15	36.153	N
3	3	4866	05086.51	A	IN	II77	ALBANY	US	AGL	CHI	INDIANA	DELAWARE	FINNEY'S AIRPARK	PR	PR	40	15	34.153	N
4	4	4867	05087.3	A	IN	I99	ALEXANDRIA	US	AGL	CHI	INDIANA	MADISON	ALEXANDRIA	PR	PU	40	13	57.048	N
5	5	4868	05087.4	A	IN	3IN5	ALBION	US	AGL	CHI	INDIANA	NOBLE	PIPPENGER	PR	PR	41	19	1	N
6	6	4869	05088.	A	IN	8IN9	AMO	US	AGL	CHI	INDIANA	HENDRICKS	MARCIDALE	PR	PR	39	41	8	N
7	7	4870	05089.	A	IN	34II	ANDERSON	US	AGL	CHI	INDIANA	MADISON	BURK PERSONAL USE	PR	PR	40	3	2.157	N
8	8	4871	05089.12	H	IN	01IN	ANDERSON	US	AGL	CHI	INDIANA	MADISON	COMMUNITY HOSPITAL	PR	PR	40	7	59.35	N
9	9	4872	05090.1	A	IN	AID	ANDERSON	US	AGL	CHI	INDIANA	MADISON	ANDERSON MUNI-DAR...	PU	PU	40	6	31	N
10	10	4873	05092.	A	IN	ANQ	ANGOLA	US	AGL	CHI	INDIANA	STEUBEN	TRI-STATE STEUBEN CO...	PU	PU	41	38	22.914	N
11	11	4874	05092.01	H	IN	IG00	ANGOLA	US	AGL	CHI	INDIANA	STEUBEN	CAMERON HOSPITAL	PR	PR	41	38	2.21	N
12	12	4879	05092.06	A	IN	52IN	ANGOLA	US	AGL	CHI	INDIANA	STEUBEN	STREBIG	PR	PR	41	41	43.82	N
13	13	4880	05092.1	A	IN	II16	ANGOLA	US	AGL	CHI	INDIANA	STEUBEN	PIGEON	PR	PR	41	38	13.181	N
14	14	4881	05094.9	A	IN	II27	ARCADIA	US	AGL	CHI	INDIANA	HAMILTON	WARD	PR	PR	40	10	0.136	N
15	15	4882	05094.92	A	IN	9II4	ARCADIA	US	AGL	CHI	INDIANA	HAMILTON	CRUZAN FLD	PR	PR	40	10	21	N
16	16	4883	05095.2	A	IN	1IN3	ARCOLA	US	AGL	CHI	INDIANA	ALLEN	CONFER'S PLACE	PR	PR	41	5	52.172	N
17	17	4884	05095.22	A	IN	3II9	ARCOLA	US	AGL	CHI	INDIANA	ALLEN	DICK'S STRIP	PR	PR	41	5	50.172	N
18	18	4885	05095.4	A	IN	2IN4	ARGOS	US	AGL	CHI	INDIANA	MARSHALL	SCOTT FLD	PR	PR	41	15	24.156	N
19	19	4886	05096.02	A	IN	4IN7	ATTICA	US	AGL	CHI	INDIANA	FOUNTAIN	RILEY FLD	PR	PR	40	18	3.133	N
20	20	4888	05101.1	A	IN	GWB	AUBURN	US	AGL	CHI	INDIANA	DE KALB	DE KALB COUNTY	PU	PU	41	18	25.8	N
21	21	4889	05101.11	H	IN	9II7	AUBURN	US	AGL	CHI	INDIANA	DE KALB	PARKVIEW DEKALB HO...	PR	PR	41	22	10.9	N
22	22	4890	05102.	H	IN	5IN1	AVON	US	AGL	CHI	INDIANA	HENDRICKS	INDIANA UNIVERSITY...	PR	PR	39	46	51.58	N
23	23	4891	05105.	A	IN	50II	BAINBRIDGE	US	AGL	CHI	INDIANA	PUTNAM	WAY WEST	PR	PR	39	46	25.166	N
24	24	4892	05107.82	A	IN	II93	BARGERSVILLE	US	AGL	CHI	INDIANA	JOHNSON	BRONSON	PR	PR	39	29	2.96	N
25	25	4893	05107.83	A	IN	IN01	BARGERSVILLE	US	AGL	CHI	INDIANA	JOHNSON	KEPHART FLD	PR	PR	39	29	10	N
26	26	4894	05108.1	A	IN	HLB	BATESVILLE	US	AGL	CHI	INDIANA	FRANKLIN	BATESVILLE	PR	PU	39	20	35.2	N
27	27	4895	05110.	A	IN	BFR	BEDFORD	US	AGL	CHI	INDIANA	LAWRENCE	VIRGIL I GRISSOM MUNI	PU	PU	38	50	24.1	N

3. **Hospital Data**: Contains geolocations of hospitals, with an emphasis on those equipped with helipads.

hospitals_2023_in_hospitals

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	OBJECTID_1 *	OBJECTID	ID	NAME	ADDRESS	CITY	STATE	ZIP	ZIP4	TELEPHONE	TYPE	STATUS	POPULATION	COUNTY	COUNTYFIP
1	1	2157	0000146628	A ROSIE PLACE	53131 QUINCE RD	SOUTH BEND	IN	46628	NOT AVAILABLE	(574) 235-8899	CHILDREN	OPEN	10	ST. JOSEPH	18141
2	2	2158	0000246733	ADAMS MEMORIAL H...	1100 MERCER AVE	DECATUR	IN	46733	NOT AVAILABLE	(260) 724-2145	CRITICAL ACCESS	OPEN	35	ADAMS	18001
3	3	2159	0012746016	ASCENSION ST VINCEN...	2015 JACKSON ST	ANDERSON	IN	46016	NOT AVAILABLE	(765) 646-8373	GENERAL ACUTE CARE	OPEN	195	MADISON	18095
4	4	2160	0014146032	ASCENSION ST VINCEN...	13500 N MERIDIAN ST	CARMEL	IN	46032	NOT AVAILABLE	(317) 582-7000	GENERAL ACUTE CARE	OPEN	107	HAMILTON	18057
5	5	2161	0014247834	ASCENSION ST VINCEN...	1206 E NATIONAL AVE	BRAZIL	IN	47834	NOT AVAILABLE	(812) 442-2500	CRITICAL ACCESS	OPEN	25	CLAY	18021
6	6	2162	0014347421	ASCENSION ST VINCEN...	1600 23RD ST	BEDFORD	IN	47421	NOT AVAILABLE	(812) 275-3331	CRITICAL ACCESS	OPEN	25	LAWRENCE	18093
7	7	2163	0013947750	ASCENSION ST VINCEN...	3700 WASHINGTON AVE	EVANSVILLE	IN	47750	NOT AVAILABLE	(812) 485-4000	GENERAL ACUTE CARE	OPEN	426	VANDERBURGH	18163
8	8	2164	0156946037	ASCENSION ST VINCEN...	13861 OLIO ROAD	FISHERS	IN	46037	NOT AVAILABLE	(317) 415-9000	GENERAL ACUTE CARE	OPEN	46	HAMILTON	18057
9	9	2165	0014546290	ASCENSION ST VINCEN...	10580 N MERIDIAN ST	CARMEL	IN	46290	NOT AVAILABLE	(317) 583-5000	GENERAL ACUTE CARE	OPEN	107	HAMILTON	18057
10	10	2166	0014646260	ASCENSION ST VINCEN...	2001 W 86TH ST	INDIANAPOLIS	IN	46260	NOT AVAILABLE	(317) 338-7000	GENERAL ACUTE CARE	OPEN	840	MARION	18097
11	11	2167	0014847265	ASCENSION ST VINCEN...	301 HENRY ST	NORTH VERNON	IN	47265	NOT AVAILABLE	(812) 352-4228	CRITICAL ACCESS	OPEN	17	JENNINGS	18079
12	12	2168	0013746904	ASCENSION ST VINCEN...	1907 W SYCAMORE ST	KOKOMO	IN	46904	NOT AVAILABLE	(765) 452-5611	GENERAL ACUTE CARE	OPEN	117	HOWARD	18067
13	13	2169	0014946036	ASCENSION ST VINCEN...	1331 S A ST	ELWOOD	IN	46036	NOT AVAILABLE	(765) 552-4743	CRITICAL ACCESS	OPEN	18	MADISON	18095
14	14	2170	0015047394	ASCENSION ST VINCEN...	473 E GREENVILLE AVE	WINCHESTER	IN	47394	NOT AVAILABLE	(765) 584-0004	CRITICAL ACCESS	OPEN	25	RANDOLPH	18135
15	15	2171	0015147167	ASCENSION ST VINCEN...	911 N SHELBY ST	SALEM	IN	47167	NOT AVAILABLE	(812) 883-5881	CRITICAL ACCESS	OPEN	25	WASHINGTON	18175
16	16	2172	0015346260	ASCENSION ST VINCEN...	8050 TOWNSHIP LINE...	INDIANAPOLIS	IN	46260	NOT AVAILABLE	(317) 415-8500	LONG TERM CARE	OPEN	74	MARION	18097
17	17	2173	0014047601	ASCENSION ST VINCEN...	1116 MILLIS AVE	BOONVILLE	IN	47601	NOT AVAILABLE	(812) 897-4800	CRITICAL ACCESS	OPEN	35	WARRICK	18173
18	18	2174	0015447993	ASCENSION ST VINCEN...	412 N MONROE ST	WILLIAMSPORT	IN	47993	NOT AVAILABLE	(317) 767-1353	CRITICAL ACCESS	OPEN	16	WARREN	18171
19	19	2175	0172546214	ASSURANCE HEALTH P...	900 NORTH HIGH SCH...	INDIANAPOLIS	IN	46214	NOT AVAILABLE	(317) 982-3715	PSYCHIATRIC	OPEN	23	MARION	18097
20	20	2176	0003447150	BAPTIST HEALTH FLOYD	1850 STATE ST	NEW ALBANY	IN	47150	NOT AVAILABLE	(812) 944-7701	GENERAL ACUTE CARE	OPEN	236	FLOYD	18043
21	21	2177	0000447404	BLOOMINGTON MEAD...	3600 N PROW RD	BLOOMINGTON	IN	47404	NOT AVAILABLE	(812) 331-8000	PSYCHIATRIC	OPEN	78	MONROE	18105
22	22	2178	0000546714	BLUFFTON REGIONAL...	303 S MAIN ST	BLUFFTON	IN	46714	NOT AVAILABLE	(260) 824-3210	GENERAL ACUTE CARE	OPEN	79	WELLS	18179
23	23	2179	0000647630	BRENTWOOD SPRINGS	4488 ROSLIN RD	NEWBURGH	IN	47630	NOT AVAILABLE	(812) 858-7200	PSYCHIATRIC	OPEN	48	WARRICK	18173
24	24	2180	0196784588	BRIGHTWELL BEHAVIO...	1612 BLACKISTON VIE...	CLARKSVILLE	IN	47129	NOT AVAILABLE	(574) 339-3094	PSYCHIATRIC	OPEN	-999	CLARK	18019
25	25	2181	0000746703	CAMERON MEMORIAL...	416 E MAUMEE ST	ANGOLA	IN	46703	NOT AVAILABLE	(260) 665-2141	CRITICAL ACCESS	OPEN	25	STEUBEN	18151
26	26	2182	0000847303	CENTRAL INDIANA AM...	2401 W UNIVERSITY A...	MUNCIE	IN	47303	NOT AVAILABLE	(765) 751-5253	LONG TERM CARE	OPEN	41	DELAWARE	18035
27	27	2183	0000947130	CLARK MEMORIAL HE...	1220 MISSOURI AVE	JEFFERSONVILLE	IN	47130	NOT AVAILABLE	(812) 283-2147	GENERAL ACUTE CARE	OPEN	236	CLARK	18019

4. **Wetlands Data**: Extracted from the National Wetlands Inventory (NWI), classifying wetlands by type, acreage, and ecological importance.

IN_Wetlands

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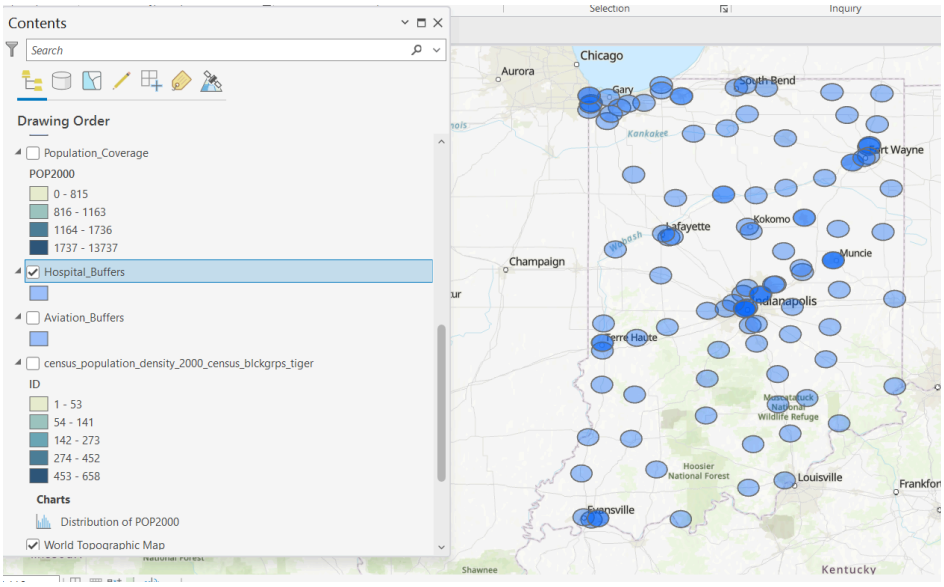
	OBJECTID *	Shape *	ATTRIBUTE	WETLAND_TYPE	ACRES	NWI_ID	Shape_Length	Shape_Area	NEAR_FID	NEAR_DIST
1	1	Polygon	L1UBH	Lake	21.583083	202409CSw{7EC8BD27...	1583.734466	87343.63715	25	21722.981655
2	2	Polygon	PABF	Freshwater Pond	0.70724	202409CSw{D4EEBFA7...	290.465554	2862.0973	25	25727.940889
3	3	Polygon	PABF	Freshwater Pond	0.164523	202409CSw{EFD8B3D9...	122.074079	665.8015	25	25778.751079
4	4	Polygon	PABF	Freshwater Pond	0.11776	202409CSw{7B06E881...	123.439074	476.557	25	25817.962613
5	5	Polygon	PABF	Freshwater Pond	4.338317	202409CSw{069B7520...	1037.727947	17556.5442	25	23505.122731
6	6	Polygon	PABF	Freshwater Pond	0.372787	202409CSw{C760D127...	165.052735	1508.61425	25	23507.169122
7	7	Polygon	PABF	Freshwater Pond	0.328504	202409CSw{DF658718...	145.066551	1329.41035	25	19695.431729
8	8	Polygon	PABF	Freshwater Pond	0.287501	202409CSw{4E0B3473...	124.262566	1163.4746	25	19954.137642
9	9	Polygon	PABF	Freshwater Pond	0.581759	202409CSw{8A6C4C95...	218.975679	2354.2969	25	17539.114881
10	10	Polygon	PABF	Freshwater Pond	0.717261	202409CSw{8E279195...	232.719151	2902.6522	25	19224.895356
11	11	Polygon	PABF	Freshwater Pond	0.168657	202409CSw{3A38869F...	134.914227	682.52865	25	19019.019425
12	12	Polygon	PABF	Freshwater Pond	0.187466	202409CSw{DDFE8BFB...	102.110509	758.646869	25	16317.217121
13	13	Polygon	PABF	Freshwater Pond	8.910128	202409CSw{C51E68FB...	1056.30435	36058.008357	25	18997.920836
14	14	Polygon	PABF	Freshwater Pond	1.760517	202409CSw{0824DC0...	364.743606	7124.557541	25	16304.522467
15	15	Polygon	PABF	Freshwater Pond	0.098247	202409CSw{1A1DE6F8...	70.777532	397.59075	25	18609.985187
16	16	Polygon	PABF	Freshwater Pond	0.09827	202409CSw{AF654DBE...	70.785946	397.68555	25	18563.167947
17	17	Polygon	PABFx	Freshwater Pond	0.267543	202409CSw{8B1043C6...	124.905163	1082.70945	25	18909.382839
18	18	Polygon	PABG	Freshwater Pond	0.475508	202409CSw{7287E4E0-...	164.177498	1924.314396	25	19265.322035
19	19	Polygon	PABG	Freshwater Pond	8.846813	202409CSw{5FDF72C7...	957.184609	35801.781849	25	19386.774541
20	20	Polygon	PABG	Freshwater Pond	3.976368	202409CSw{1E73EB2A...	768.02141	16091.789476	25	19708.345301
21	21	Polygon	PABG	Freshwater Pond	23.173478	202409CSw{6951370B...	1827.35146	93779.738944	25	19861.366295
22	22	Polygon	PABG	Freshwater Pond	7.095506	202409CSw{3E2ACBD8...	1078.554013	28714.492456	25	18467.270783
23	23	Polygon	PABGh	Freshwater Pond	0.000374	202409CSw{DA10CDEE...	9.386717	1.515139	25	19110.470068
24	24	Polygon	PABGh	Freshwater Pond	0.107082	202409CSw{A49D296B...	88.282273	433.344959	25	19112.57931
25	25	Polygon	PABGh	Freshwater Pond	14.545202	202409CSw{B3BF87EB-...	1549.740749	58862.343499	25	15732.451712
26	26	Polygon	PABGh	Freshwater Pond	1.952021	202409CSw{40B3B0B8...	536.964281	7899.547517	25	16263.240371
27	27	Polygon	PABGx	Freshwater Pond	0.710754	202409CSw{17EE9571-...	337.945641	2876.319658	25	19539.183405

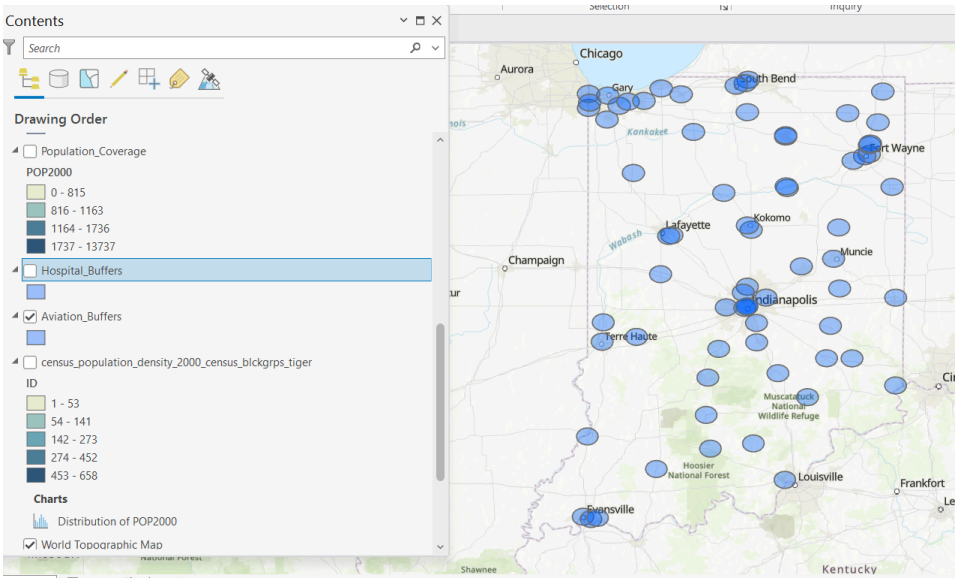
2.2 Data Preprocessing A systematic preprocessing pipeline ensured data compatibility and accuracy:

1. **Standardization**:

- All datasets were projected to a common coordinate system (NAD 1983 Indiana State Plane East).
- Inconsistent records, duplicates, and missing values were addressed through Python scripts and ArcGIS tools.

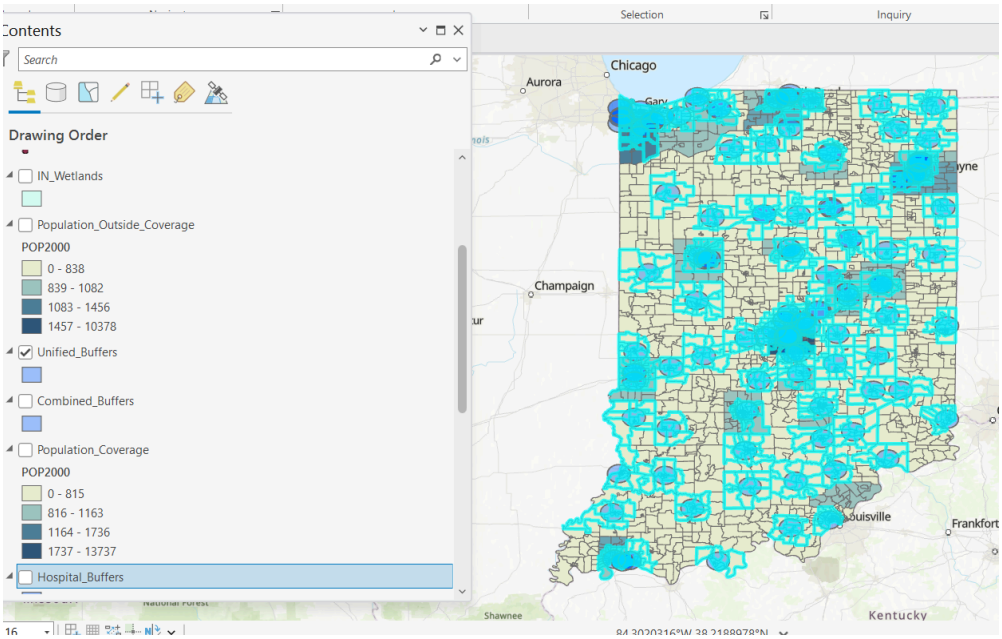
2. **Buffer Creation**:
   - 10-mile buffer zones were generated around aviation facilities and hospitals using the ArcGIS Buffer tool to delineate service coverage areas.





3. **Spatial Joins**:
   - Population density data was spatially joined with buffer zones to quantify accessibility.

- Wetlands were overlaid with aviation and population layers for multi-dimensional analysis.

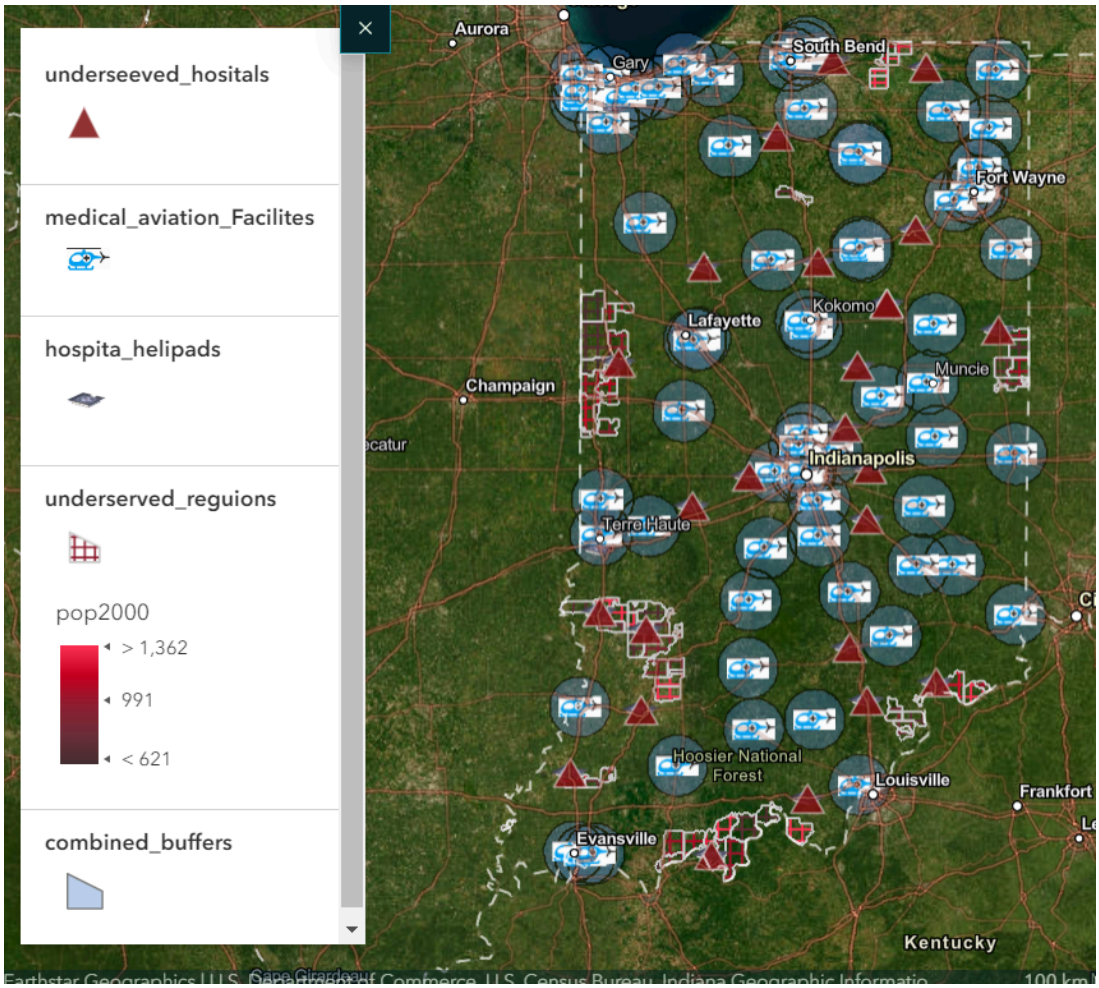


4. **Visualization Prep**:
    - Layers were symbolized with consistent symbology, ensuring clarity in maps and graphical outputs.

3. Analytical Methodology:

3.1 Spatial Analysis of Underserved Hospitals and Regions

This analysis aims to evaluate accessibility gaps in Indiana's healthcare and aviation infrastructure by calculating underserved hospitals, underserved regions, and their buffer intersections. It incorporates an inverse spatial relationship between population density and infrastructure coverage to highlight areas requiring urgent intervention.



3.1.1. Underserved Hospitals and Buffer Zones

- **Objective**: Identify hospitals lacking sufficient population coverage within their service areas.
- **Methodology**:
    - Buffer zones of 10 miles were created around each hospital and aviation facility using the **Buffer tool in ArcGIS**.
    - Hospitals located in regions with lower population density were flagged as "underserved hospitals" (represented as red triangles).
- **Insights**:
    - Hospitals in rural areas, particularly in southern and western Indiana (e.g., near the Hoosier National Forest and Evansville), demonstrate limited coverage due to sparse population density.
    - Urban hospitals, despite dense surrounding populations, may face resource strain due to overlapping demand zones.

3.1.2. Underserved Regions

- **Objective**: Identify areas with significant population density that fall outside the service coverage of hospitals and aviation facilities.
- **Methodology**:
    - A spatial overlay of population density data and buffer zones was performed.
    - Regions with higher population densities but no intersection with service buffers were classified as "underserved regions" (represented in red gradients based on population levels).
- **Insights**:
    - Dense population pockets in western and southern Indiana (e.g., near Louisville and southwestern Indiana) emerge as underserved regions.
    - This highlights a significant disparity between infrastructure placement and population needs.

3.1.3. Buffer Intersections

- **Objective**: Assess redundancy and overlap in coverage zones.
- **Methodology**:
    - Buffer intersections were calculated to identify regions with overlapping service coverage from hospitals and aviation facilities.
    - Overlapping zones signify robust infrastructure, while non-overlapping zones indicate accessibility gaps.
- **Insights**:
    - Urban centers like Indianapolis, Lafayette, and Fort Wayne have dense and overlapping buffer zones, ensuring redundancy and resilience.
    - Rural areas, especially near Evansville and southwestern Indiana, lack intersections, indicating isolated or nonexistent coverage.

3.1.4. Inverse Spatial Relationship

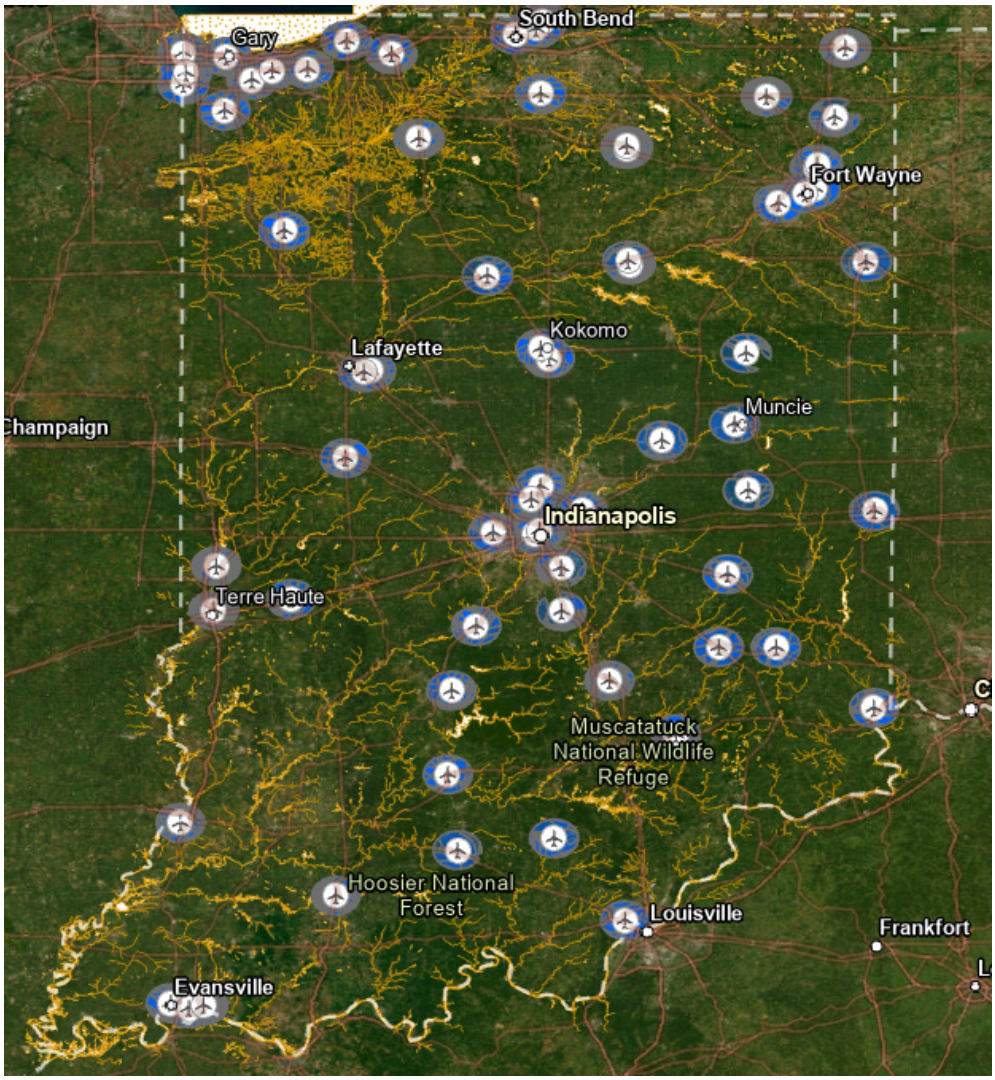
- **Objective**: Examine the spatial relationship between population density and infrastructure accessibility.
- **Methodology**:
    - The inverse relationship was evaluated by comparing high-density population areas with underserved hospital zones.
    - Spatial visualizations revealed gaps where high population areas fall outside buffer zones, as well as sparsely populated areas with available infrastructure.
- **Insights**:
    - High-density regions near Indianapolis and northern Indiana are generally well-served, reflecting planned infrastructure alignment.
    - Low-density rural areas often possess hospitals or aviation facilities but lack the population to justify extensive service coverage.

3.1.5. Visual Summary

1. **Hospitals with Buffers**: Blue circles represent the 10-mile service zones around hospitals and aviation facilities.
2. **Underserved Hospitals**: Red triangles highlight hospitals with insufficient population within their service areas.
3. **Underserved Regions**: Red gradient areas represent densely populated regions falling outside the coverage of both hospitals and aviation facilities.

3.2: Aviation Facilities and Wetland Interactions

This map explores the spatial relationship between Indiana's aviation facilities and its natural wetlands, emphasizing the balance between development and conservation. By overlaying aviation infrastructure with wetland data, the analysis highlights areas where ecological preservation intersects with infrastructure needs, revealing critical insights into sustainable planning.



3.2.1. Purpose of the Analysis

The goal of this analysis is to:

- Assess how aviation facilities overlap or interact with Indiana's wetlands.
- Identify potential ecological challenges arising from aviation operations near sensitive wetland areas.
- Highlight the spatial distribution of aviation infrastructure to inform conservation-friendly planning strategies.

3.2.2. Data Inputs

- **Aviation Facilities**: Includes helipads, airports, and airstrips. Each facility is represented by a blue icon, with a 10-mile buffer zone indicating its area of influence.

- **Wetlands**: Derived from the National Wetlands Inventory (NWI), represented by intricate yellow patterns, emphasizing their widespread yet fragmented nature.

3.2.3. Methodology

1. **Overlay Analysis**:
    - Aviation facilities and their respective 10-mile buffer zones were overlaid on Indiana's wetland data.
    - This spatial intersection identifies aviation facilities in close proximity to ecologically sensitive wetlands.
2. **Buffer Analysis**:
    - The buffer zones were analyzed to estimate the spatial influence of aviation facilities relative to wetland areas.
    - Gaps in aviation facility coverage were also identified to assess service accessibility.
3. **Visual Representation**:
    - Yellow patterns denote wetland distributions across Indiana, illustrating their fragmentation and proximity to aviation infrastructure.

3.2.4. Key Findings

- **Aviation-Wetland Overlap**:
    - Several aviation facilities are situated near wetlands, particularly in southern and central Indiana, such as regions near Terre Haute and the Hoosier National Forest.
    - This overlap raises potential ecological concerns, as aviation operations may disturb wetland ecosystems, impacting biodiversity and natural flood control mechanisms.
- **Urban vs. Rural Dynamics**:
    - Urban centers, such as Indianapolis and Fort Wayne, have dense aviation infrastructure but limited wetlands, indicating less ecological conflict.
    - Rural regions, especially southern Indiana near Evansville and Louisville, display significant wetland presence alongside aviation facilities, necessitating careful planning to mitigate ecological impact.
- **Fragmentation of Wetlands**:
    - Wetlands are widely distributed but highly fragmented, particularly in proximity to aviation facilities. This fragmentation underscores the need for conservation efforts to maintain connectivity and ecological balance.

3.2.5. Implications

- **Ecological Challenges**:

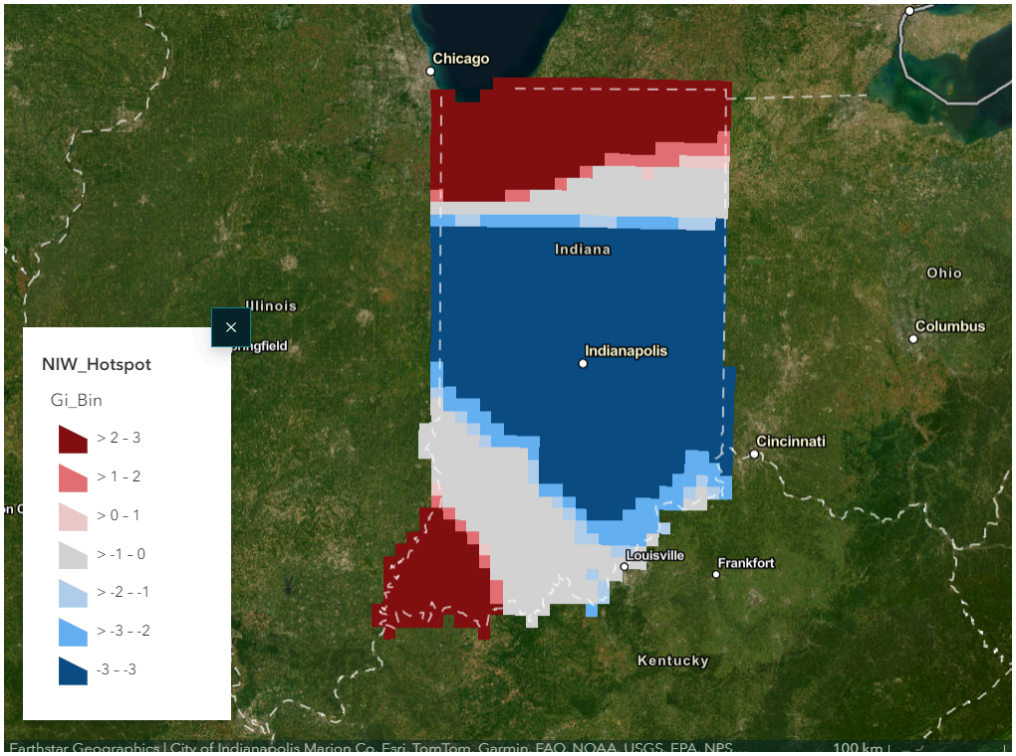
    - Aviation infrastructure near wetlands can disrupt ecosystems through noise, pollution, and physical disturbance. Conservation-friendly planning is essential to minimize these impacts.
- **Opportunities for Sustainable Development**:
    - Proper zoning and wetland-friendly aviation practices, such as raised runways or protective buffers, can allow infrastructure development while preserving wetland integrity.

3.2.6. Recommendations

1. **Conservation-Friendly Aviation Planning**:
    - Adopt wetland-friendly practices, such as eco-friendly construction techniques, around facilities near wetlands.
    - Implement strict environmental regulations to limit ecological disruptions from aviation operations.
2. **Integrated Resource Management**:
    - Develop policies that balance aviation infrastructure development with wetland conservation priorities.
    - Use this spatial analysis as a framework for identifying regions that require collaborative planning between aviation and conservation stakeholders.
3. **Data-Informed Expansion**:
    - Focus future aviation facility expansion in areas with minimal wetland interference to reduce ecological stress.

3.3 Wetland Conservation Hotspots

This map provides a hotspot analysis of Indiana's wetlands using the **Getis-Ord Gi*** statistic to identify regions with high and low ecological significance. By categorizing wetlands into clusters of conservation priority, the analysis highlights areas requiring immediate attention and those with lower ecological pressures.



3.3.1. Purpose of the Analysis

The primary goal is to:

- Prioritize wetland conservation efforts based on spatial patterns of ecological significance.
- Identify high-pressure regions where wetlands are under stress due to environmental or human activity.
- Highlight low-pressure regions where proactive conservation measures can sustain ecological health.

3.3.2. Data Inputs

- **Wetland Data**: Derived from the National Wetlands Inventory (NWI), providing detailed spatial and categorical data on wetland distribution across Indiana.
- **Statistical Hotspot Analysis**: The *Gi_Bin (Getis-Ord Gi) statistic** was applied to generate clusters of wetland health and stress.

3.3.3. Methodology

1. *Getis-Ord Gi Statistic**:
    - This spatial statistic evaluates local clustering of wetland attributes (e.g., size, ecological importance) to classify regions into "hotspots" and "coldspots."

    - Regions with a positive Gi_Bin value (red zones) are hotspots, indicating areas of high ecological stress or importance.
    - Negative Gi_Bin values (blue zones) represent coldspots, where wetlands are under less stress or are ecologically stable.
2. **Visual Representation**:
    - Red zones highlight critical areas requiring immediate conservation efforts.
    - Blue zones indicate regions of ecological stability that may serve as benchmarks for wetland management.
3. **Spatial Overlay**:
    - The hotspot map was overlaid with other datasets (aviation and population) to assess multi-dimensional interactions, identifying regions where conservation intersects with human activity.

3.3.4. Key Findings

Hotspot Clusters (Red Zones):

- Located primarily in southern Indiana, especially near Evansville and Louisville.
- These areas exhibit high ecological stress due to their proximity to human activity or natural vulnerability.
- Wetlands in these regions are crucial for flood mitigation, biodiversity, and water quality but face significant threats.

Coldspot Clusters (Blue Zones):

- Found predominantly in northern Indiana near urban centers like Gary and South Bend.
- These wetlands are under relatively low ecological stress, likely due to better preservation or reduced human interference.
- Serve as examples of effective wetland management practices.

Neutral Zones (Gray Areas):

- Represent regions with balanced ecological conditions, often acting as buffers between hotspots and coldspots.
- May not require immediate intervention but should be monitored for future changes.

3.3.5. Implications

- **Targeted Conservation Efforts**:
    - Southern Indiana emerges as a critical zone for wetland conservation, where immediate action can prevent further ecological degradation.
- **Sustainable Development**:
    - Northern Indiana and coldspot regions present opportunities for proactive conservation that can prevent future stress.
- **Integrated Planning**:

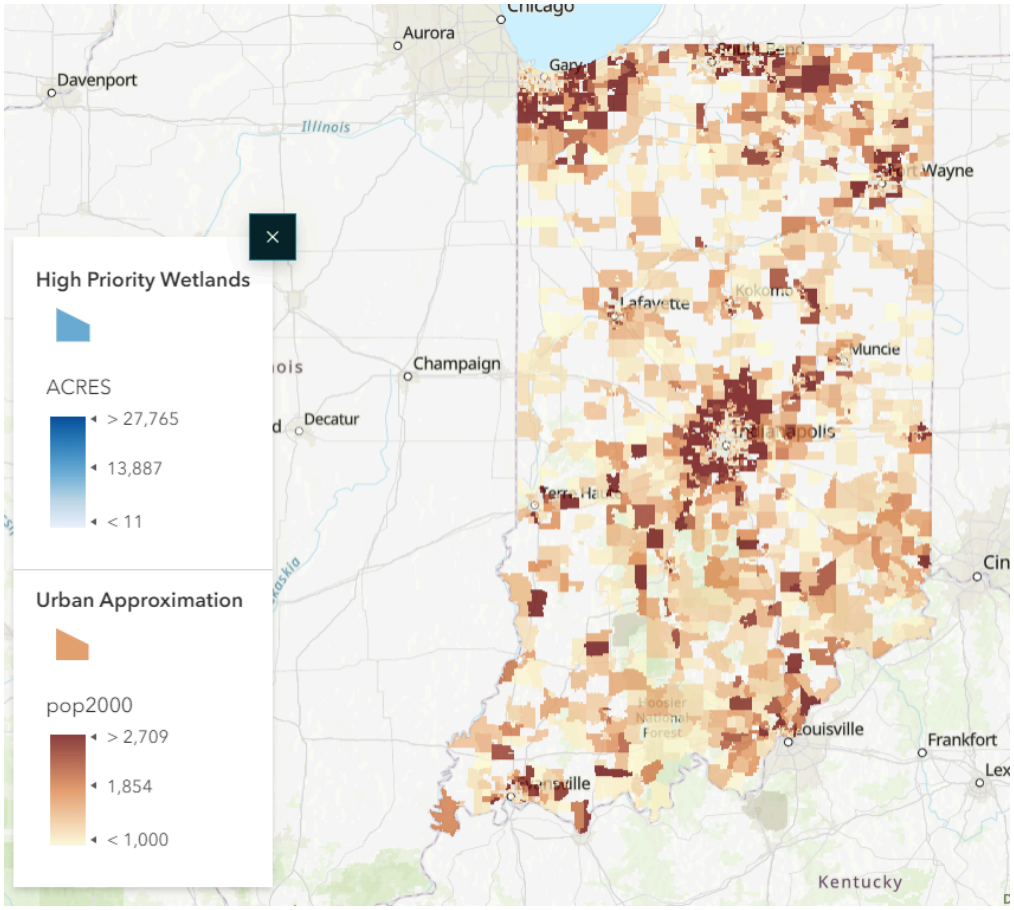
- By linking wetland hotspot data with aviation and population datasets, planners can ensure infrastructure development aligns with conservation goals.

3.3.6. Recommendations

1. **Hotspot Interventions**:
   - Allocate resources to restore and protect wetlands in southern Indiana's hotspot regions.
   - Implement stricter environmental regulations in high-pressure areas to limit human impact.
2. **Coldspot Maintenance**:
   - Use coldspot regions in northern Indiana as benchmarks for successful wetland management practices.
   - Monitor these areas regularly to ensure stability and prevent potential stress.
3. **Policy Integration**:
   - Integrate this analysis into state-level planning frameworks to guide conservation and development decisions.
   - Prioritize funding and initiatives for hotspot regions with significant ecological importance.

3.4 High-Priority Wetlands and Urban Proximity

This map combines spatial datasets on **wetland distribution** and **urban population density**, offering insights into the relationship between Indiana's natural resources and its growing urban footprint. The analysis highlights wetlands of high ecological value and areas of dense human activity to inform conservation and urban planning.



3.4.1. Purpose of the Analysis

The primary objective is to:

- Identify high-priority wetlands based on acreage and ecological significance.
- Examine the spatial relationship between urban areas and wetlands.
- Highlight regions where urban proximity may pose risks to wetland ecosystems.

3.4.2. Data Inputs

- **Wetland Data**: Categorized by acreage to highlight large, ecologically significant wetlands.
    - Larger wetlands are represented by darker shades of blue.
- **Urban Population Density Data**: Represented as brown gradients to show areas of concentrated human activity.
    - Darker brown shades indicate higher population densities.

3.4.3. Methodology

1. **Classification of Wetlands**:

    - Wetlands were categorized by acreage, with darker blue representing larger, high-priority areas. These wetlands are critical for flood control, biodiversity, and water quality.
    - Smaller wetlands were assigned lighter blue shades, reflecting their reduced but still significant ecological role.
2. **Urban Population Overlay**:
    - Population density data was overlaid with wetland locations to identify urban proximity to wetlands.
    - Areas with both high population density and significant wetlands were flagged as zones of potential ecological conflict.
3. **Visual Representation**:
    - Blue gradients represent wetland priority based on size and ecological value.
    - Brown gradients indicate population density, with darker shades highlighting urban centers such as Indianapolis, Lafayette, and Evansville.

3.4.4. Key Findings

High-Priority Wetlands:

- Large wetlands (dark blue zones) are concentrated in southern Indiana, particularly near the Hoosier National Forest and southern rural regions.
- These areas serve as critical ecological buffers but are susceptible to urban encroachment and development pressures.

Urban Proximity:

- Urban centers like Indianapolis and Lafayette exhibit high population densities (dark brown zones) near smaller wetlands, emphasizing the need for urban planning that incorporates ecological considerations.
- Southern Indiana showcases an inverse trend, with large wetlands near low-density population areas, presenting opportunities for proactive conservation.

Potential Ecological Conflicts:

- Wetlands located near high-density urban areas are at risk of degradation from pollution, runoff, and land development.
- Regions near Evansville and Louisville, where urban areas intersect with significant wetlands, require targeted mitigation strategies.

3.4.5. Implications

- **Urban Growth and Wetland Preservation**:
    - The map underscores the importance of balancing urban expansion with wetland conservation to protect ecological health and provide natural flood control in urban areas.

- **Conservation Opportunities**:
    - Rural regions with large wetlands offer opportunities for proactive preservation before urban pressures increase.
- **Data-Driven Urban Planning**:
    - Incorporating this spatial analysis into urban planning ensures that wetland ecosystems remain intact while supporting sustainable urban growth.

3.4.6. Recommendations

1. **Targeted Conservation Efforts**:
    - Focus on protecting large wetlands in southern Indiana, which serve as critical ecological zones.
    - Implement conservation policies for wetlands near high-density urban areas, particularly around Indianapolis and Evansville.
2. **Urban Planning Integration**:
    - Incorporate wetland protection measures into zoning laws for urban areas.
    - Encourage green infrastructure projects that mitigate the impact of urban development on nearby wetlands.
3. **Public Awareness and Collaboration**:
    - Promote community awareness about the importance of wetlands in urban resilience and biodiversity.
    - Collaborate with local governments and environmental organizations to implement conservation strategies.

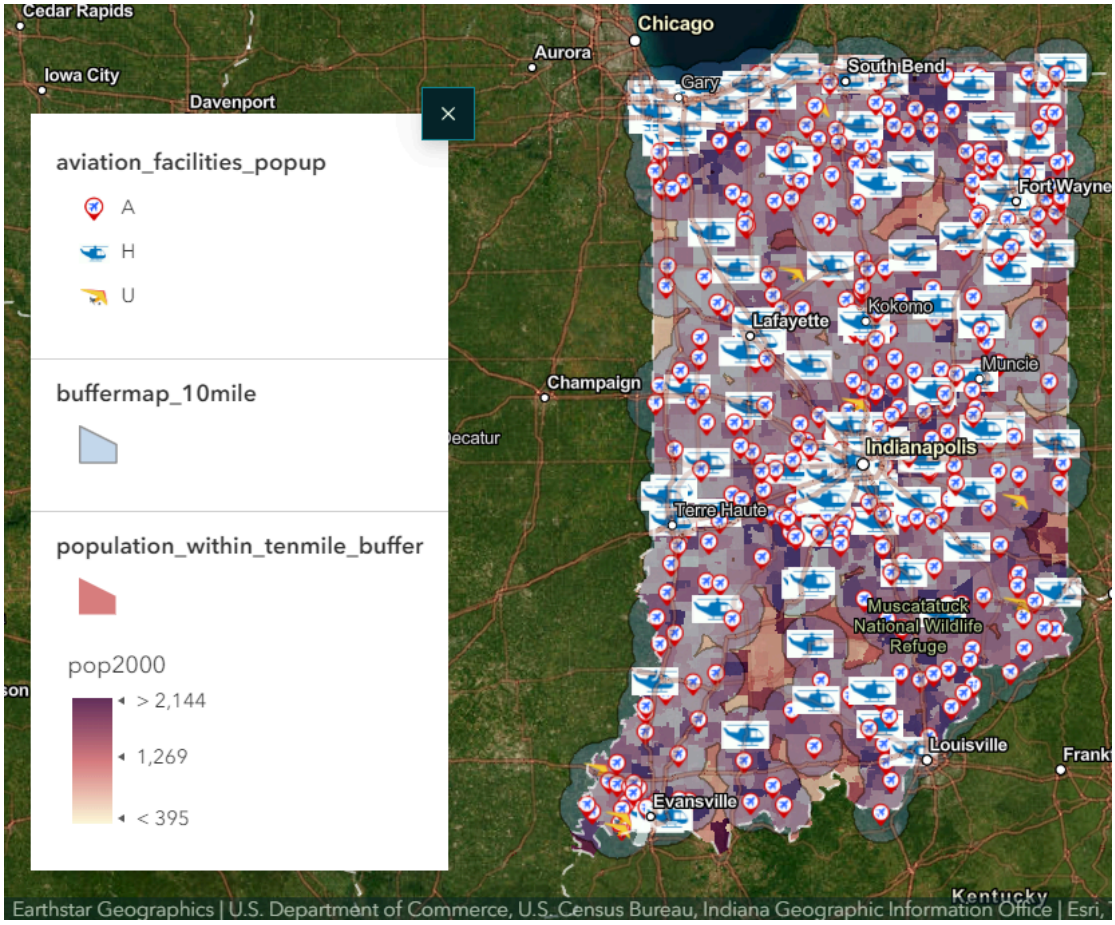
3.5 : Aviation Accessibility and Population Coverage

This map provides an analysis of aviation accessibility across Indiana, focusing on the population within 10-mile buffer zones of aviation facilities. By integrating aviation facility locations with population density data, the study evaluates the extent of coverage and identifies underserved areas.

3.5.1. Purpose of the Analysis

The objective of this analysis is to:

- Assess the spatial coverage of aviation facilities across the state.
- Examine population density within the service areas of aviation facilities.
- Highlight underserved regions where aviation infrastructure is lacking\



3.5.2. Data Inputs

- **Aviation Facilities**: Represented by three categories:
  - **A (Airports)**: General aviation facilities (red icons).
  - **H (Helipads)**: Primarily used for medical or emergency purposes (blue icons).
  - **U (Airstrips)**: Smaller, utility-based facilities (yellow icons).
- **Population Data**: Visualized as gradients of red to pink, where darker shades indicate higher population density.
- **Buffer Zones**: 10-mile radius around each aviation facility, represented as transparent blue polygons, indicating their area of influence.

3.5.3. Methodology

1. **Buffer Analysis**:
   - Buffer zones with a 10-mile radius were created around each aviation facility using ArcGIS tools to represent their service coverage.

    - The buffer zones were overlaid on population density data to calculate the number of people within the service areas.
2. **Population Intersection**:
    - Population density within the 10-mile buffers was quantified to measure the level of aviation accessibility.
    - Areas outside the buffers were flagged as underserved regions.
3. **Visualization**:
    - Aviation facilities are symbolized by distinct icons for airports, helipads, and airstrips.
    - Population density is represented in a gradient, with darker reds showing higher densities.
    - Buffer zones are shown as overlapping transparent blue polygons.

3.5.4. Key Findings

Coverage Analysis:

- Urban areas such as Indianapolis, Lafayette, and Fort Wayne exhibit dense coverage, with overlapping buffer zones ensuring redundancy and robust accessibility.
- Rural regions, particularly in southern Indiana near Evansville and along the state borders, have sparse coverage, indicating gaps in aviation infrastructure.

Population Accessibility:

- High-density population areas in central and northern Indiana benefit from significant aviation infrastructure.
- Low-density rural areas, particularly in southern and western Indiana, remain underserved, with many residents outside the 10-mile buffer zones.

Overlap and Redundancy:

- Overlapping buffer zones in urban centers ensure multiple options for aviation services, critical during emergencies.
- Limited or no overlap in rural areas highlights a lack of infrastructure resilience, making these regions vulnerable in emergencies.

3.5.5. Implications

- **Urban Strengths**:
    - Robust aviation infrastructure in urban centers ensures accessibility, redundancy, and resilience.
- **Rural Challenges**:
    - Sparse coverage in rural areas creates significant accessibility challenges, especially during emergencies.
- **Service Gaps**:

- Underserved regions, with high populations outside the buffer zones, require targeted infrastructure development.

3.5.6. Recommendations

1. **Infrastructure Development**:
   - Establish new aviation facilities in underserved regions, particularly in southern and western Indiana.
   - Upgrade existing facilities in rural areas to improve coverage and service quality.
2. **Targeted Investments**:
   - Prioritize investments in high-population areas outside the 10-mile buffer zones.
   - Expand helipad infrastructure to enhance emergency medical services in remote locations.
3. **Community Collaboration**:
   - Engage local governments and communities to identify critical gaps and align infrastructure planning with population needs.
   - Increase awareness of aviation accessibility benefits to support development initiatives.

4. Conclusion

The comprehensive spatial analysis of Indiana's infrastructure, wetlands, and population dynamics provides critical insights into the state's emergency preparedness, ecological conservation priorities, and aviation accessibility. Urban areas like Indianapolis and Fort Wayne exhibit robust infrastructure coverage with overlapping service zones, ensuring accessibility and redundancy. However, rural areas, particularly in southern and western Indiana, face significant challenges, including underserved populations, limited aviation facilities, and ecologically sensitive wetlands under threat.

Through buffer analysis, hotspot identification, and population overlays, the study underscores the disparities between urban and rural areas. It highlights the importance of balancing infrastructure expansion with ecological preservation, offering a roadmap for targeted planning and sustainable development.

5. Results and Discussion

Key Findings

1. **Urban Strengths**:
   - Urban centers benefit from dense aviation and hospital infrastructure, ensuring redundancy and resilience in emergency services.
   - Population within 10-mile buffer zones of aviation facilities is significantly higher in urban areas, reflecting adequate accessibility.

2. **Rural Vulnerabilities**:
    - Rural regions, especially in southern Indiana, have sparse coverage of aviation facilities and hospitals, leaving populations underserved.
    - Wetlands in these areas are ecologically critical but face threats from potential infrastructure development.
3. **Ecological Insights**:
    - Southern Indiana emerges as a hotspot for wetland conservation, requiring immediate attention to prevent further ecological degradation.
    - Coldspot regions in northern Indiana provide benchmarks for effective wetland management and conservation efforts.
4. **Inverse Spatial Relationships**:
    - High-density population regions are generally well-served by infrastructure, while low-density rural areas often lack sufficient services despite their ecological importance.

Insights from Buffer Intersections:

- Overlapping buffer zones in urban areas ensure robust emergency preparedness.
- Non-overlapping buffers in rural areas highlight service gaps, necessitating targeted infrastructure investments.

6. Limitations

1. **Data Limitations**:
    - Some datasets may not reflect recent infrastructure developments, population shifts, or changes in wetland ecology.
    - Wetland classifications may not account for dynamic environmental factors, such as climate change or seasonal variations.
2. **Assumptions in Buffer Analysis**:
    - Uniform 10-mile buffer zones do not consider travel barriers or real-world road networks, leading to overgeneralization of accessibility.
3. **Static Analysis**:
    - The study provides a snapshot of current conditions without incorporating predictive models for future trends in urbanization, population growth, or ecological changes.
4. **Granularity**:
    - Population data resolution might not capture micro-level disparities, especially in highly fragmented rural areas.

7. Recommendations

1. **Infrastructure Development**:

    - Establish new aviation facilities and helipads in underserved rural areas to improve accessibility.
    - Upgrade existing rural hospitals to include trauma centers and emergency medical facilities.
2. **Conservation Measures**:
    - Protect wetlands in southern Indiana through targeted conservation policies and funding.
    - Implement wetland-friendly practices near aviation facilities, such as raised runways or protective buffers.
3. **Integrated Urban Planning**:
    - Incorporate ecological considerations into urban planning to ensure wetlands near urban areas are preserved.
    - Balance infrastructure expansion with conservation priorities to avoid compromising ecological health.
4. **Policy Advocacy**:
    - Advocate for state and federal policies that fund healthcare and aviation infrastructure in rural areas.
    - Develop zoning laws that protect wetlands from encroachment and degradation.
5. **Community Engagement**:
    - Collaborate with local communities to identify critical gaps in services and prioritize investments.
    - Raise awareness about the importance of wetlands and aviation infrastructure for public health and safety.

8. Technical Tools

- **ArcGIS**:
    - Employed for spatial analysis, including buffer creation and hotspot mapping.
    - Used for visualizing multi-layered datasets with consistent symbology.
- **Data Sources**:
    - Population and aviation datasets from Indiana geospatial resources.

9. Future Scope

1. **Dynamic Modeling**:
    - Incorporate predictive models to simulate future scenarios, including urbanization trends, population growth, and climate change impacts on wetlands and infrastructure.
2. **Real-Time Accessibility**:
    - Use advanced GIS tools to analyze real-world travel times and road networks, providing more accurate accessibility assessments.
3. **Ecological Monitoring**:

    - Establish long-term monitoring systems for wetlands using remote sensing and geospatial analysis to track changes over time.
4. **Expanded Study**:
    - Extend the analysis to neighboring states to understand regional dynamics and identify cross-border collaboration opportunities.
5. **Smart Infrastructure Planning**:
    - Integrate smart technologies into infrastructure development, such as AI-based resource allocation for emergency preparedness and IoT-based environmental monitoring systems.
6. **Public-Private Partnerships**:
    - Leverage partnerships between governments, environmental organizations, and private sectors to fund and implement conservation and infrastructure projects.