A Geodatabase Designed to Inform and Support Safe CO_2 Transport-Route Planning

NATIONAL ENERGY TECHNOLOGY LABORATORY

Cat Schooley

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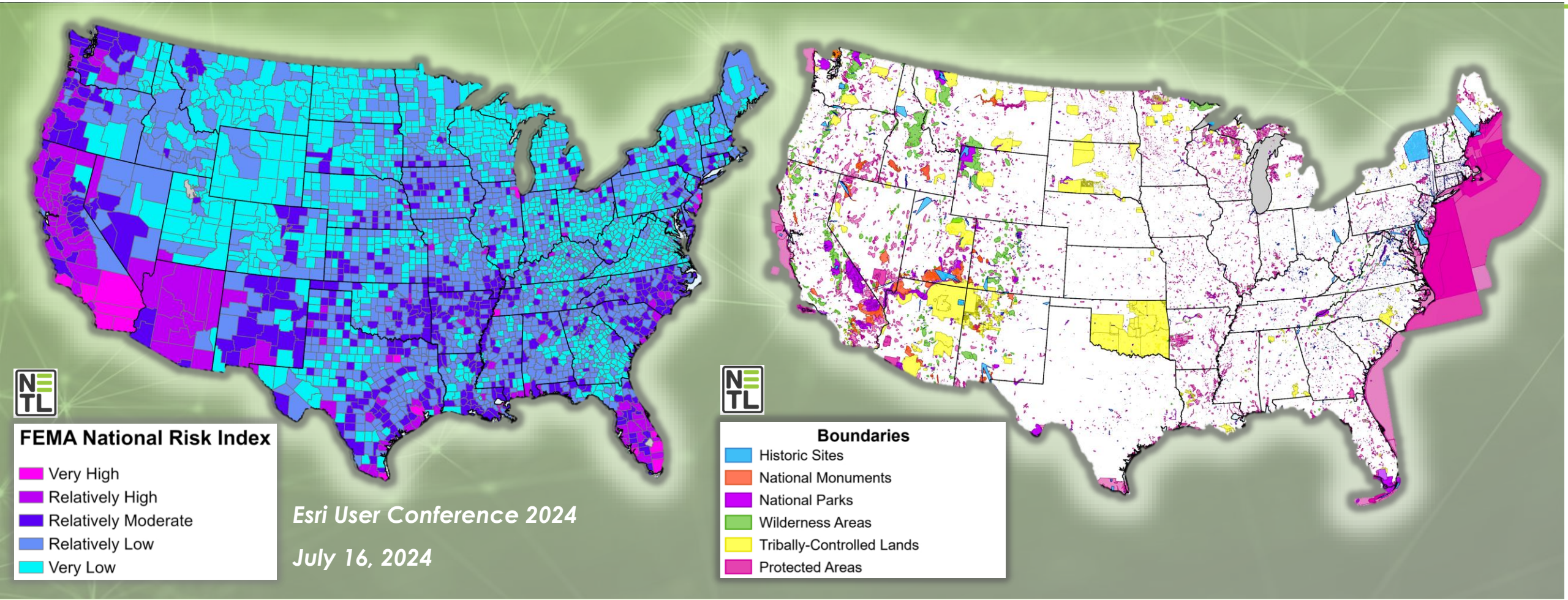

Esri User Conference 2024

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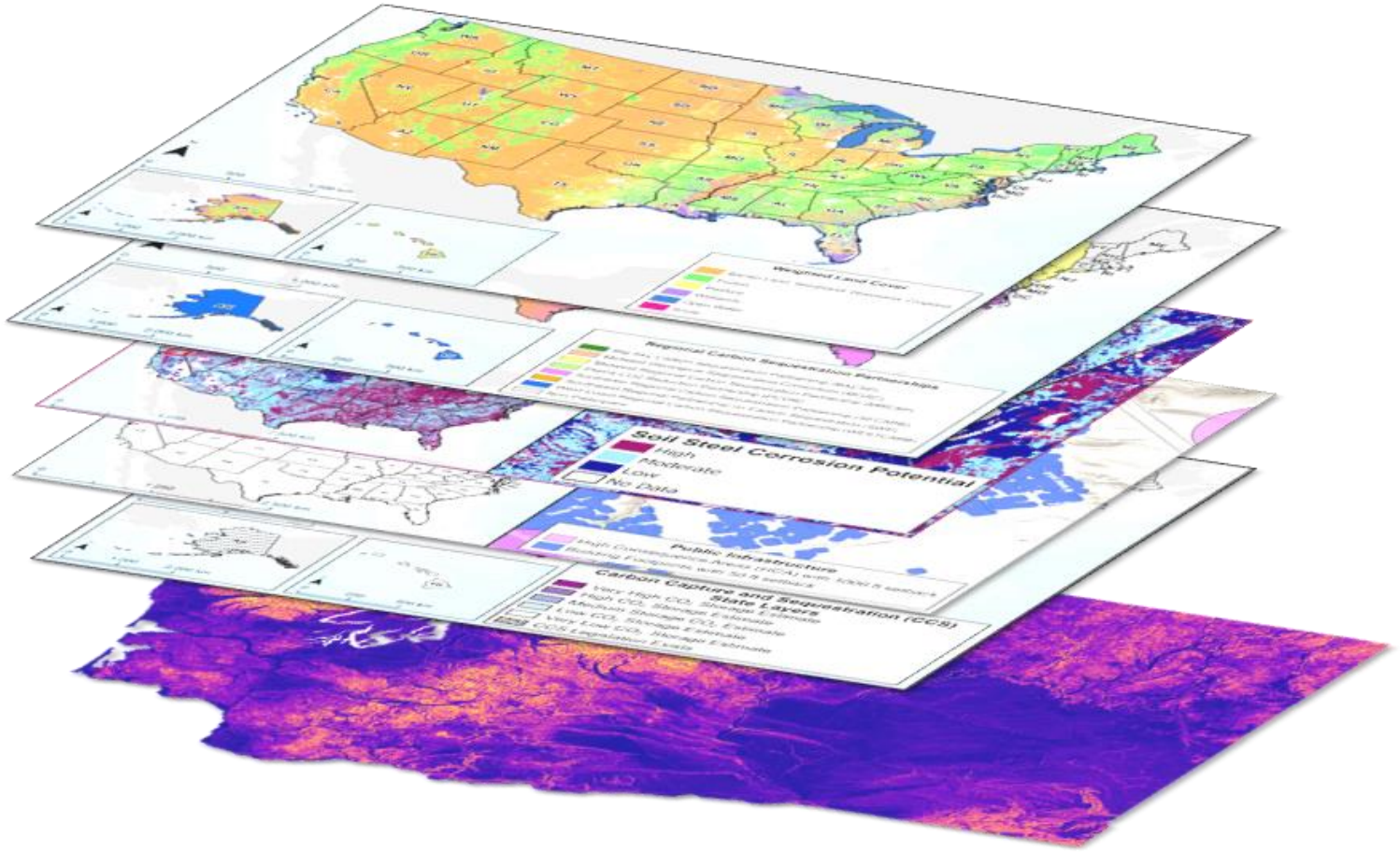
A Geospatial Database To Support Safe & Sustainable CO_2 Transport-Route Planning

Challenge: Current energy transport pipeline models **fail to integrate complex economic, social, and environmental variables** that can greatly affect the success of developing new pipelines and increase project costs.

Outcome: NETL has published an extensive geospatial database integrating **more than 70 layers** representing **key regulatory, legislative, best-practice, published,** and **environmental and social justice factors** to inform CO_2 transport models and planning.



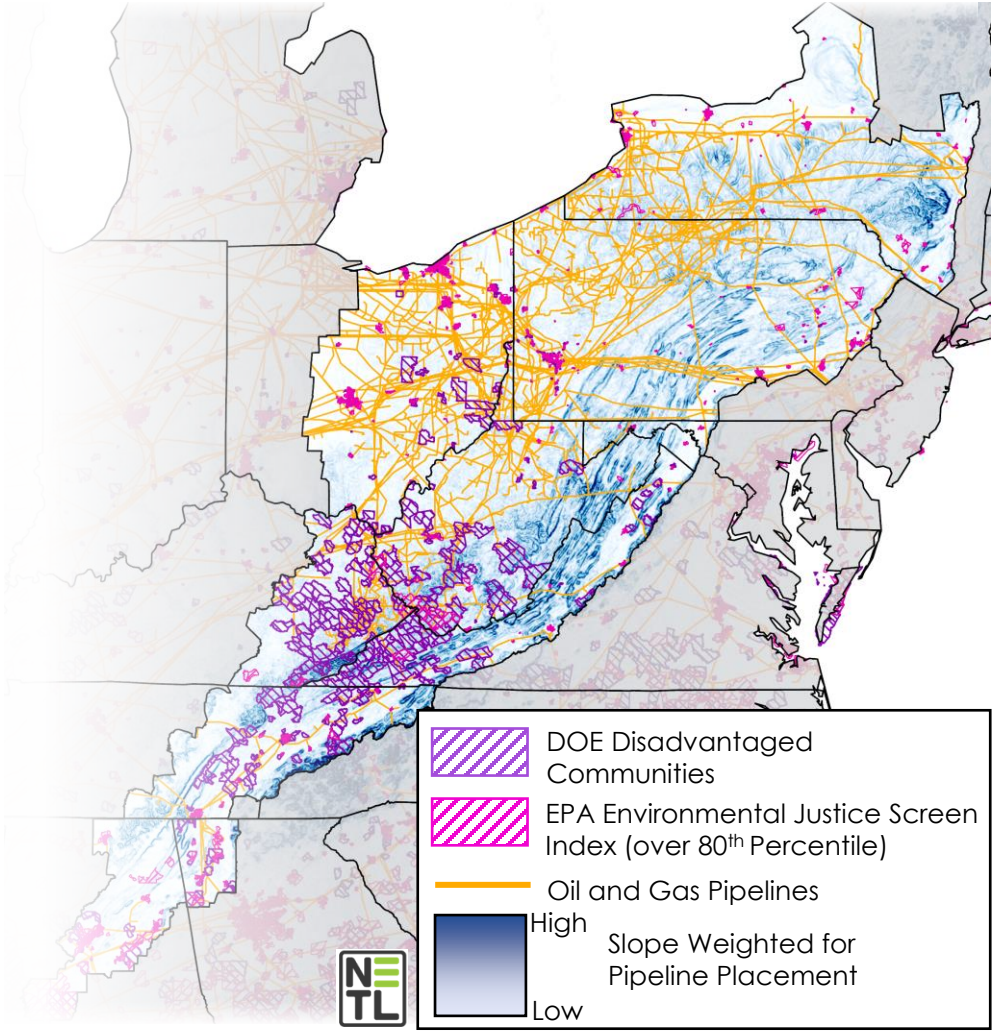
A Geospatial Database To Support National CO_2 Transport-Route Planning

CCS Route Planning Database

- **Publicly accessible curated geospatial resource**
- Built to **inform safe** and **sustainable carbon transport** planning as outlined in Bipartisan Infrastructure Law

Values Delivered:

- Accelerates carbon management capabilities to **safely and responsibly** meet **net-zero emissions by 2050**
- Provides **data-driven insights** supporting **CO_2 transport-route research, planning,** and **development**
- Accounts for **energy, social, and environmental justice variables**



CCS – Carbon Capture and Storage

More Than 70 Layers Organized Into Eight Categories for Improved Reusability

Category	Layer
Boundaries	Protected Areas
	Wilderness Areas
	Tribally Controlled Land
	National Monuments
	National Parks
	Historic Sites
	Urban Developed Areas
	Weighted Land Cover
CCS by State	CO_2 Atlas CCS Storage Availability by State
	CO_2 Atlas CCS Emissions Estimate by State
	CO_2 Taskforce Involvement by State
	CO_2 Infrastructure Legislation Availability by State

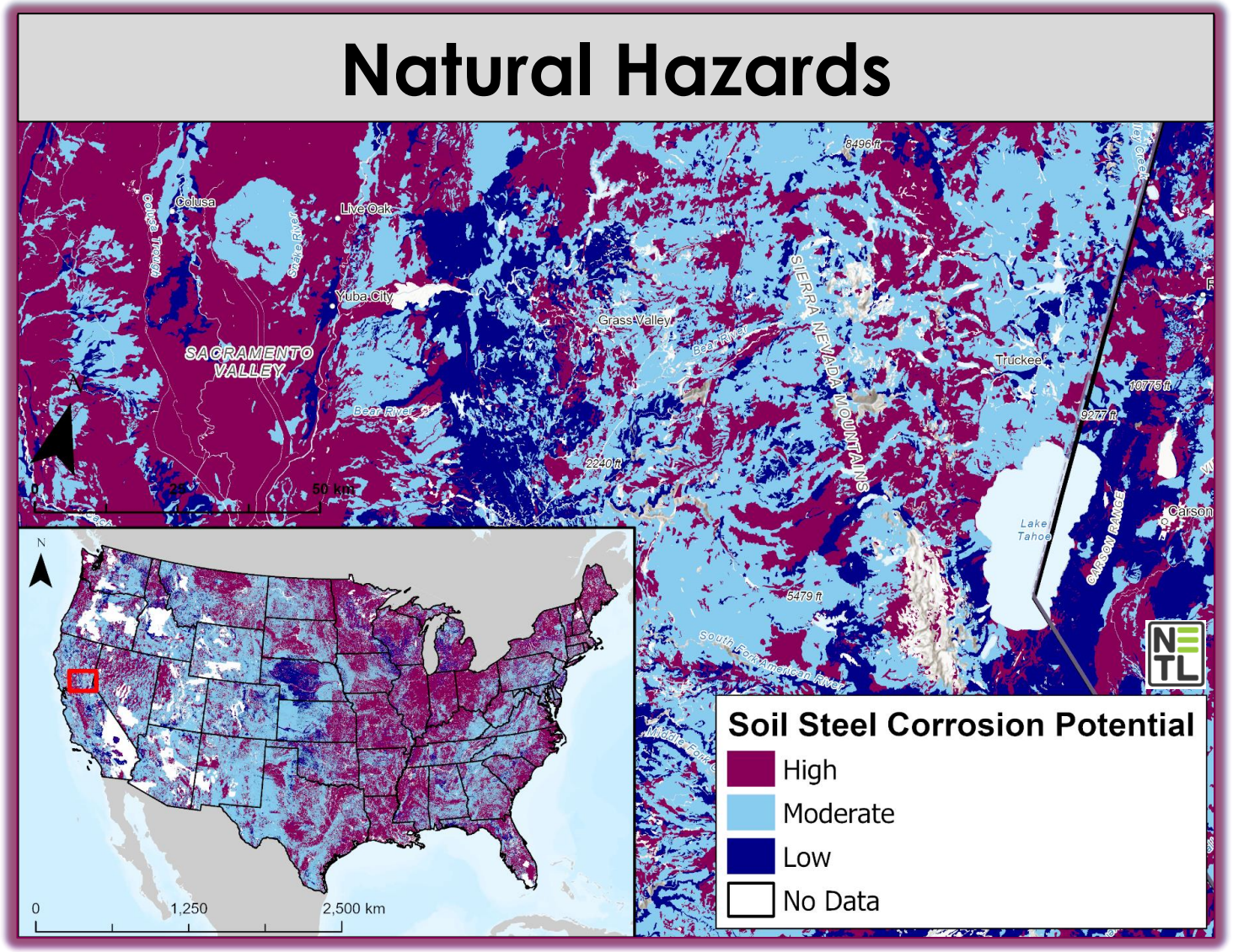
Category	Layer
CO_2 Sinks	Active Sinks
	Storage
CO_2 Sources	Active Sources
	Power Plants
	Processing Plants
	Refineries
Environmental, Energy, and Social Justice	National Risk Index by County
	National Risk Index Social Vulnerability by County
	National Risk Index Community Resilience by County
	Environmental Justice Screen by Tract
	Social Vulnerability Index by Tract
	Environmental Justice Index by Tract
	Disadvantaged Communities

More Than 70 Layers Organized Into Eight Categories for Improved Reusability

Category	Layer
Hydrology	National Hydrology Dataset Wells
	National Hydrology Dataset Waterbodies
	National Hydrology Dataset Areas
	National Hydrology Dataset Flowlines
	Aquifers
	Groundwater Monitoring Locations
Natural Hazards	National Risk Index Earthquake Risk by County
	National Risk Index Riverine Flood Risk by County
	National Risk Index Coastal Flood Risk by County
	National Risk Index Wildfire Risk by County
	National Risk Index Landslide Risk by County
	Soil Frost Action Potential
	Soil Steel Corrosion Potential
	Landslide Susceptibility
	Slope
	Floodplains

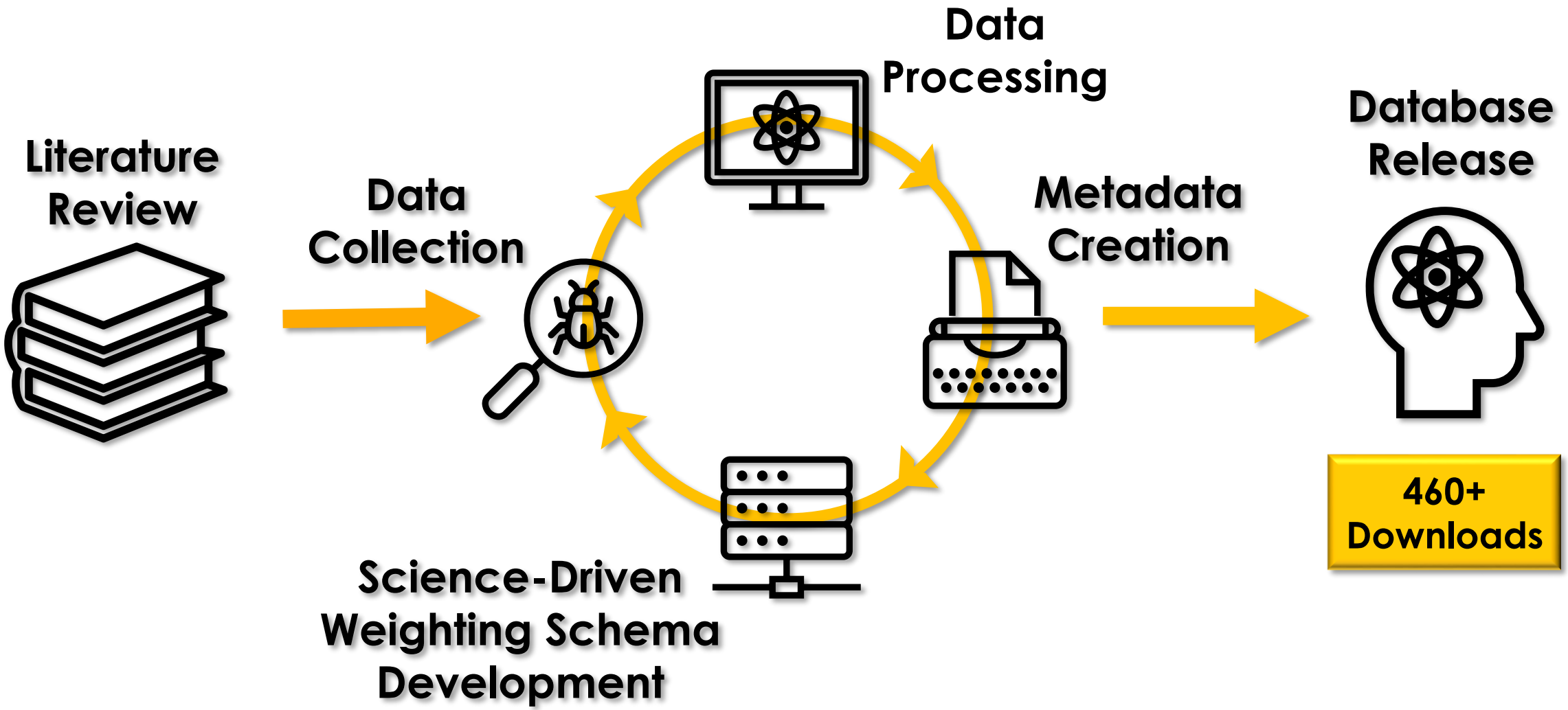
Category	Layer
Infrastructure	Oil and Gas Wells
	Offshore Platforms and Well Pads
	Natural Gas Pipeline Rights-of-Way
	Hydrocarbon Pipeline Rights-of-Way
	Areas Surrounding Natural Gas Pipelines
	Areas Surrounding Hydrocarbon Pipelines
	Primary Roads
	Secondary Roads
	Railroads
	Buildings
	Public Infrastructure
	Underground Structures
	Local Roads
	Ports
	Stations
	Manufacturing Facilities
	Electric Transmission Lines

Database Examples



(Schooley et al., 2024)

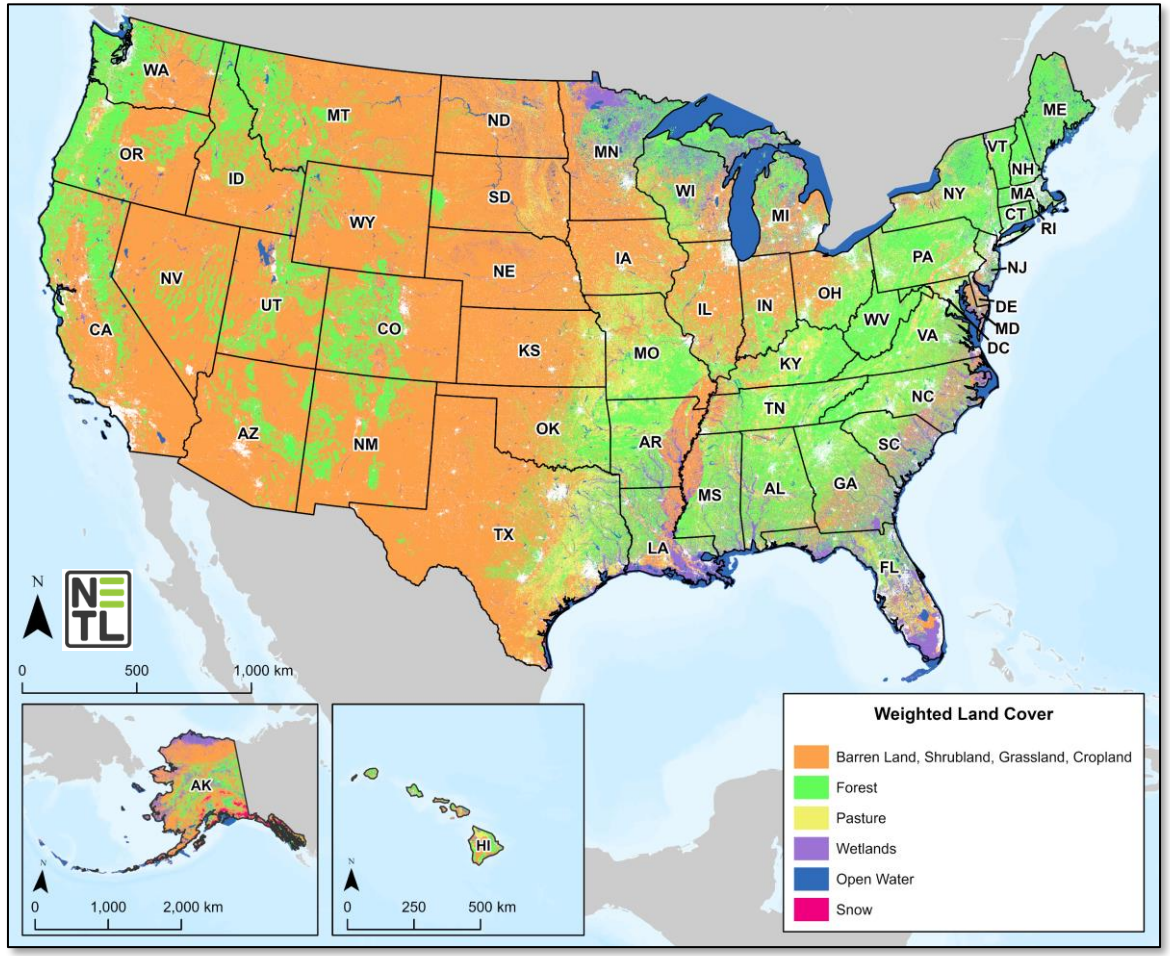
Accessibility and Reproducibility of Research Were Incorporated into the Development Process

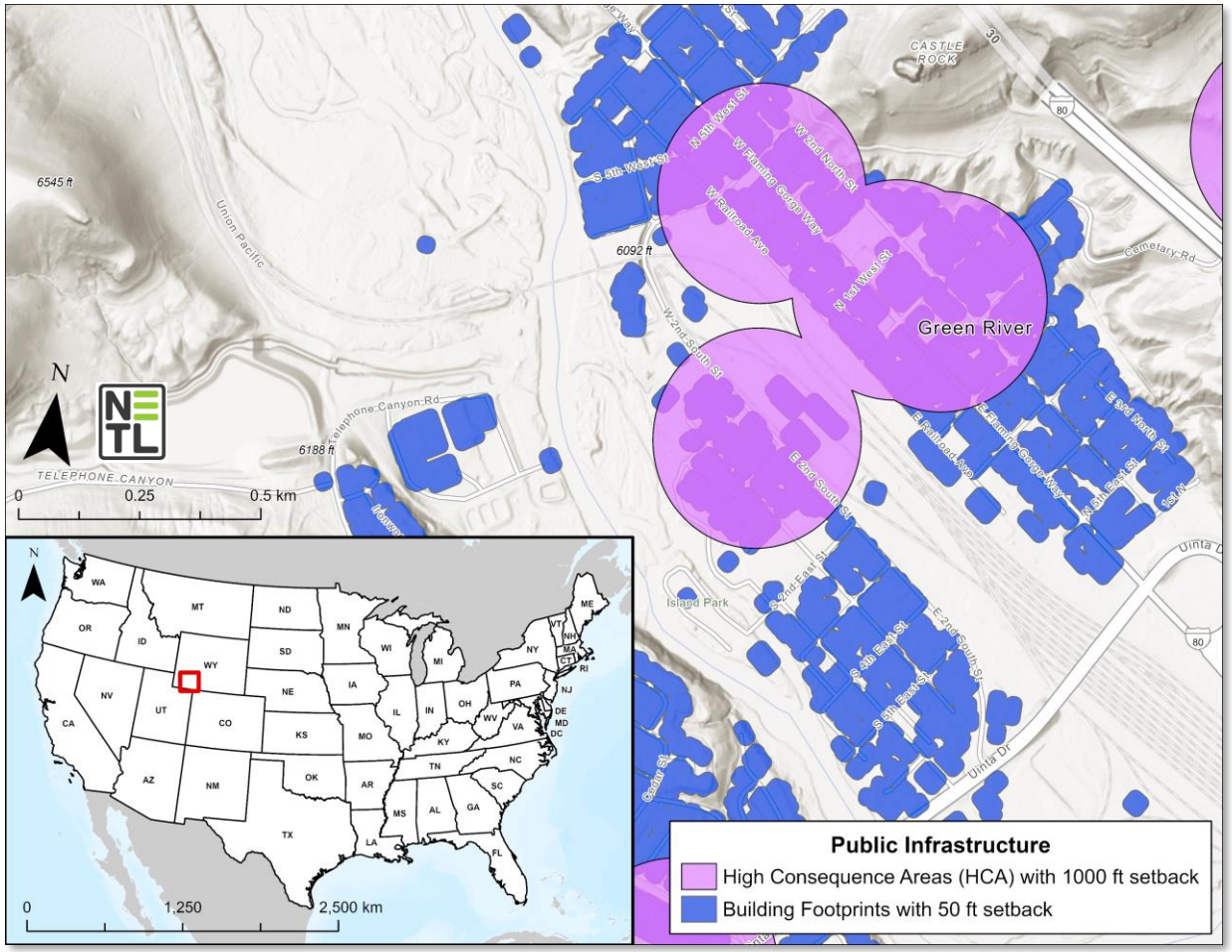


Large, Complex Datasets Required Additional Processing

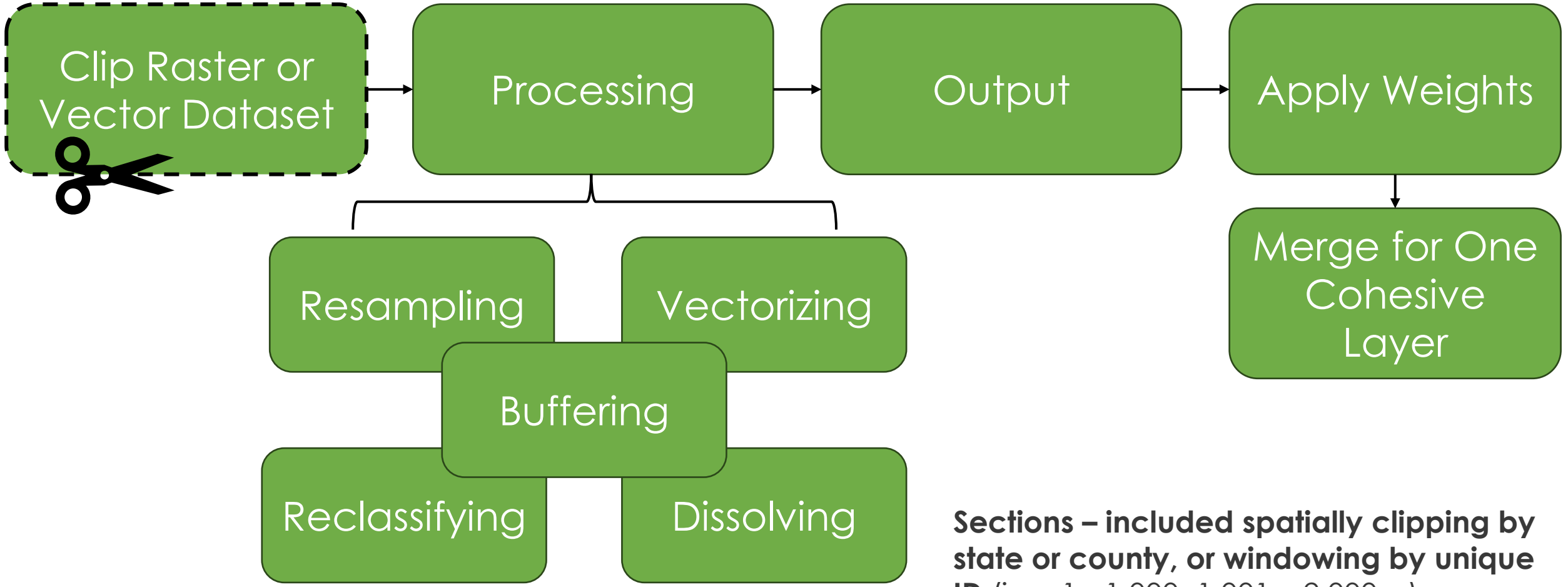
Vectorizing and Simplification through GIS with Python

(Schooley et al., 2024)



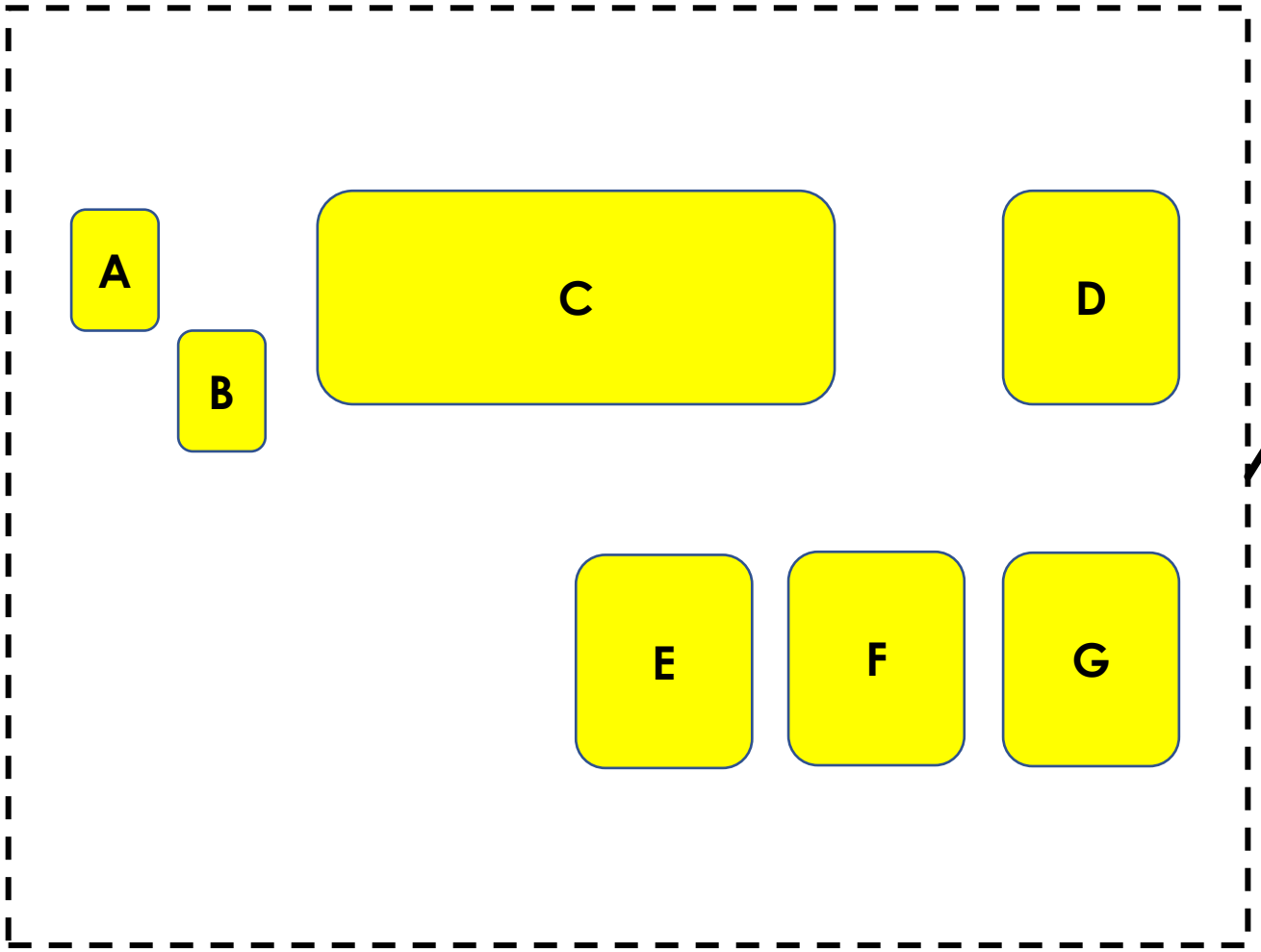


Processing Large Datasets in Sections Improved Computation Time Significantly



Sections – included spatially clipping by state or county, or windowing by unique ID (i.e., 1 - 1,000, 1,001 – 2,000…)

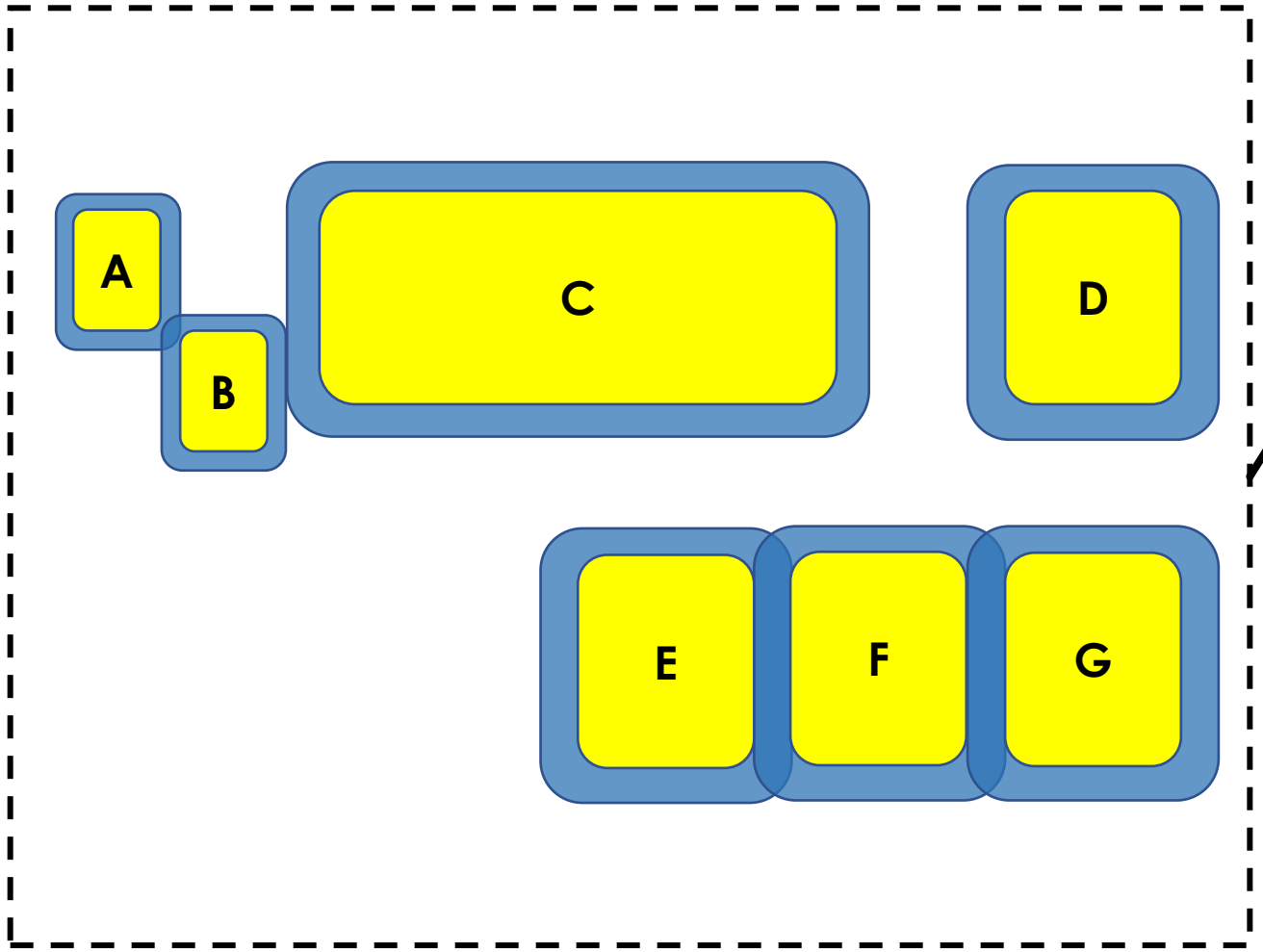
Dissolving Vector Data Improved Performance and Utility of the Database



Original Building Footprints Feature Class

Building Name	Area (ft²)
A	250
B	250
C	1500
D	500
E	500
F	500
G	500

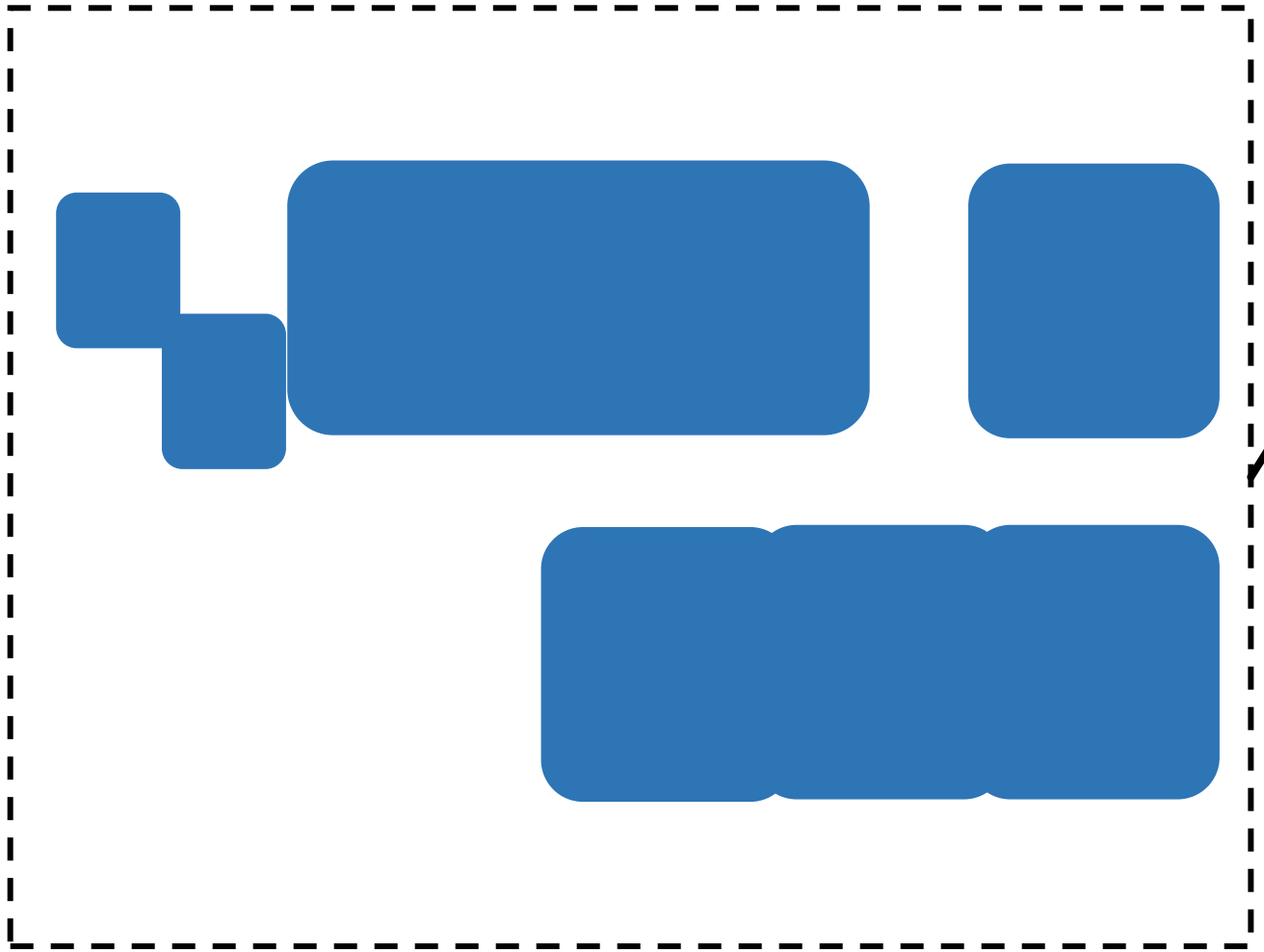
Dissolving Vector Data Improved Performance and Utility of the Database



Building Footprints Buffer Feature Class

Building Buffer	Area (ft²)
A	3,500
B	3,500
C	21,000
D	7,000
E	7,000
F	7,000
G	7,000

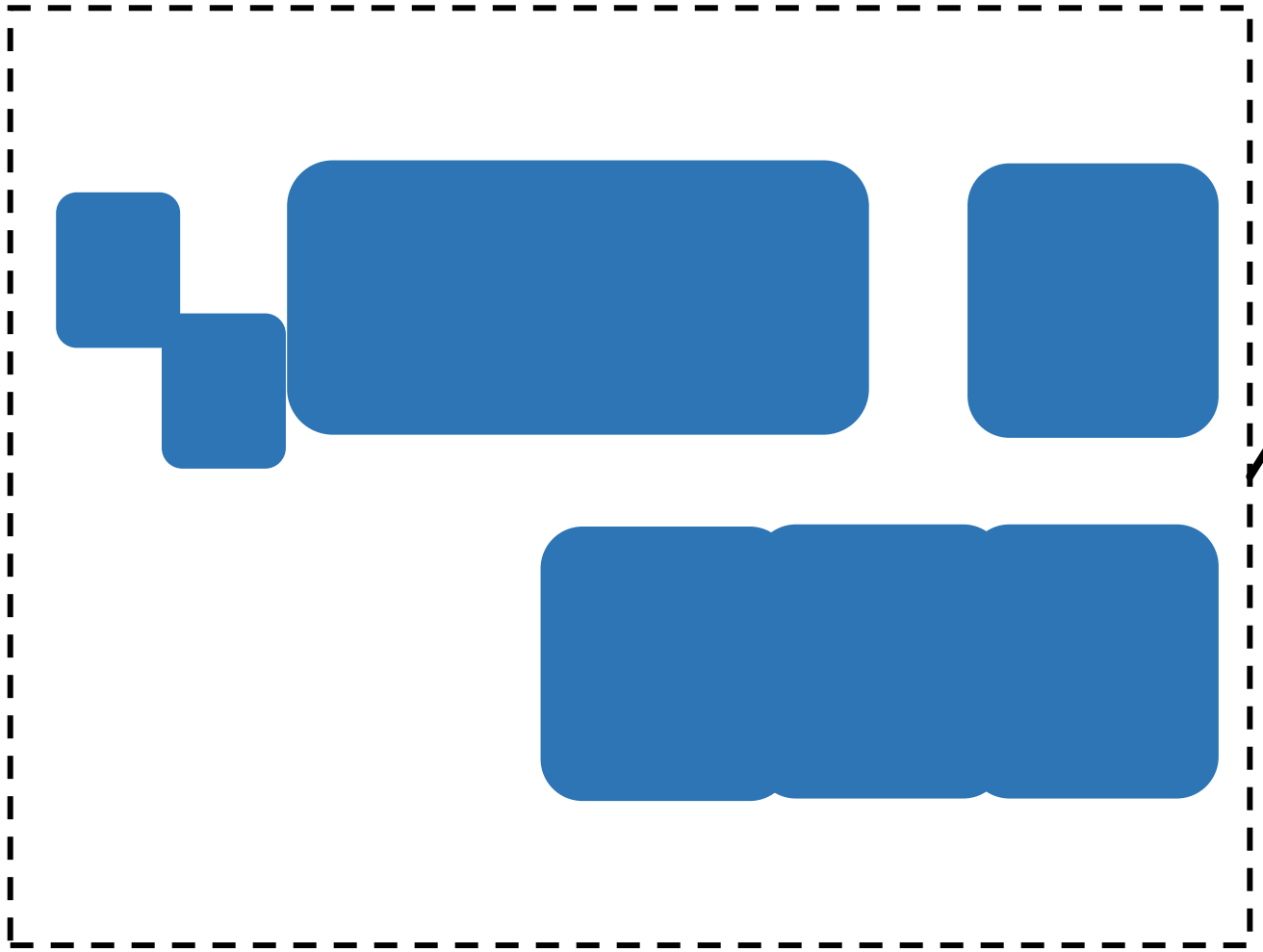
Dissolving Vector Data Improved Performance and Utility of the Database



Sublette County, WY Feature Class

County Name	Area (ft^2)	Weight
Sublette County, WY	56,000	1

Dissolving Vector Data Improved Performance and Utility of the Database



Dissolved Counties Feature Class

County Name	Area (ft²)	Weight
Sublette County, WY	56,000	1
Cache County, UT	100,000	1
Delta County, CO	250,000	1
Benton County, OR	500,000	1
San Diego County, CA	8,000,000	1

Resampling and Reclassification Improved Performance and Applied Weighting Schema

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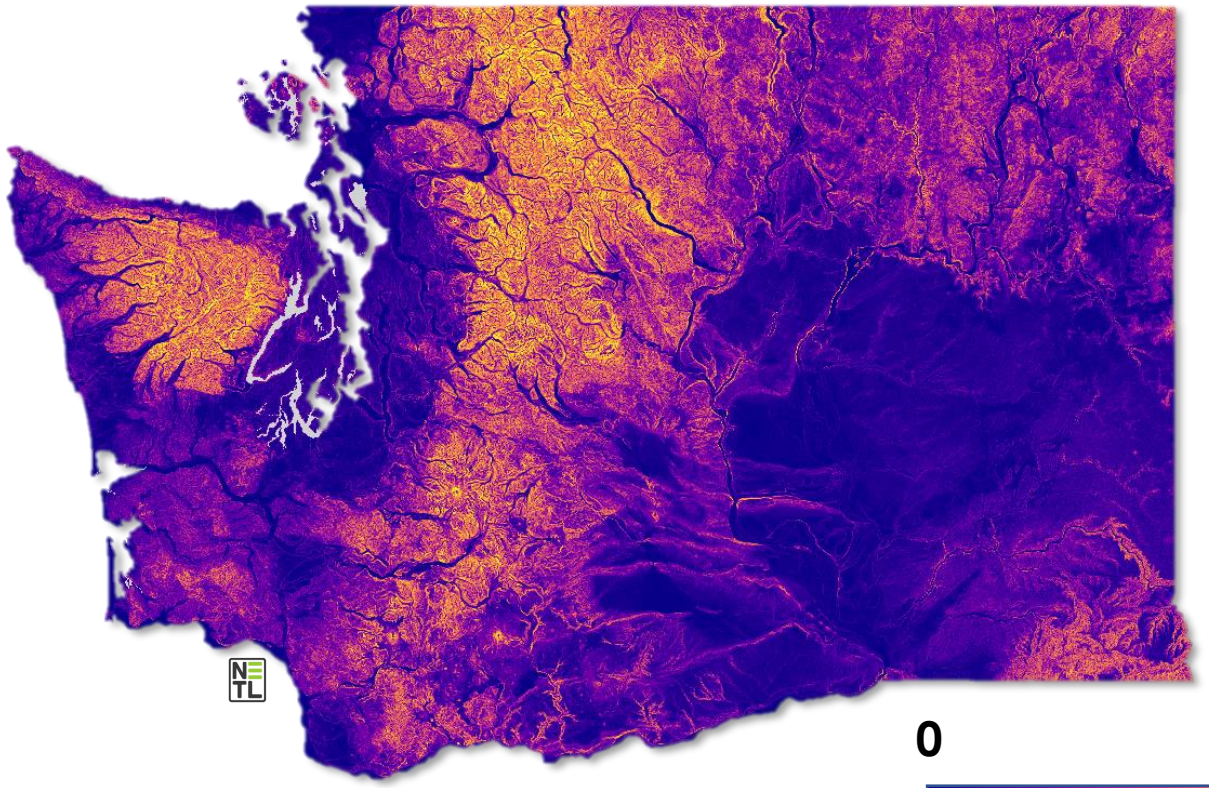
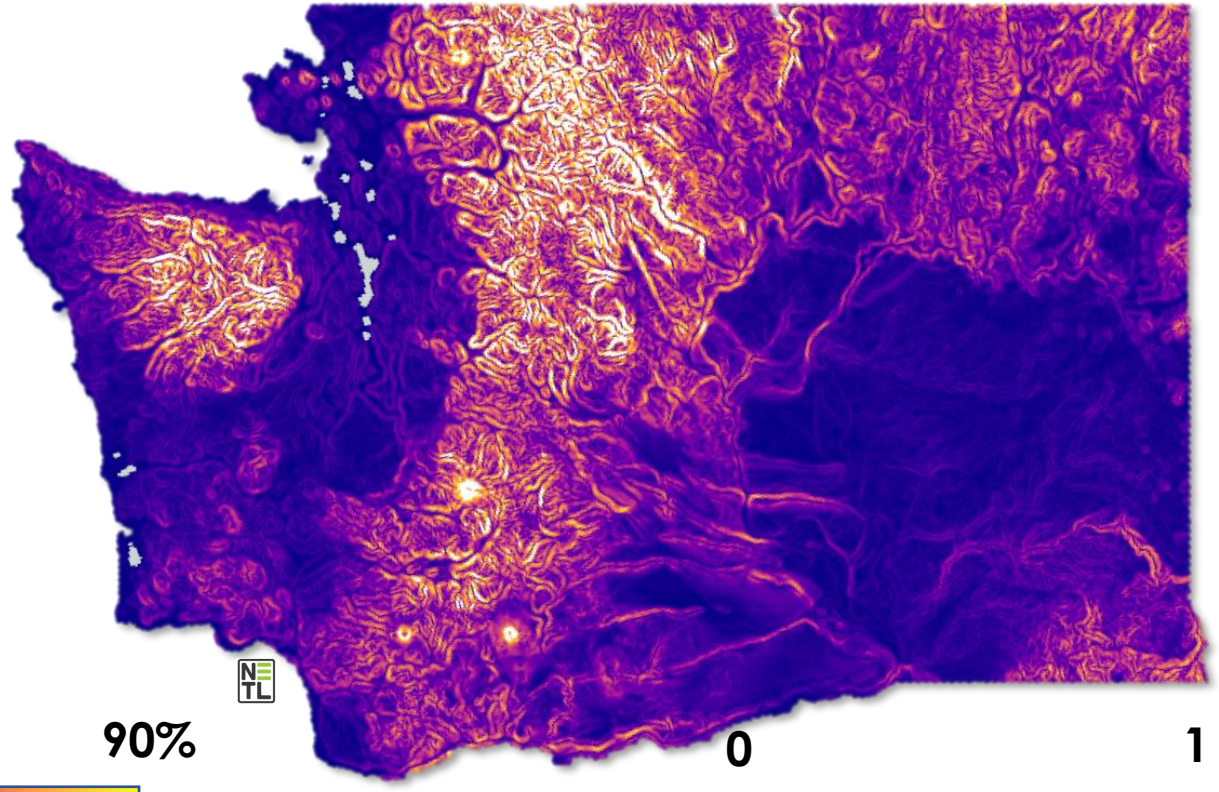
Washington State – 10 m Slope Raster (percent grade)



0

90%

Washington State – 1 km Weighted Raster



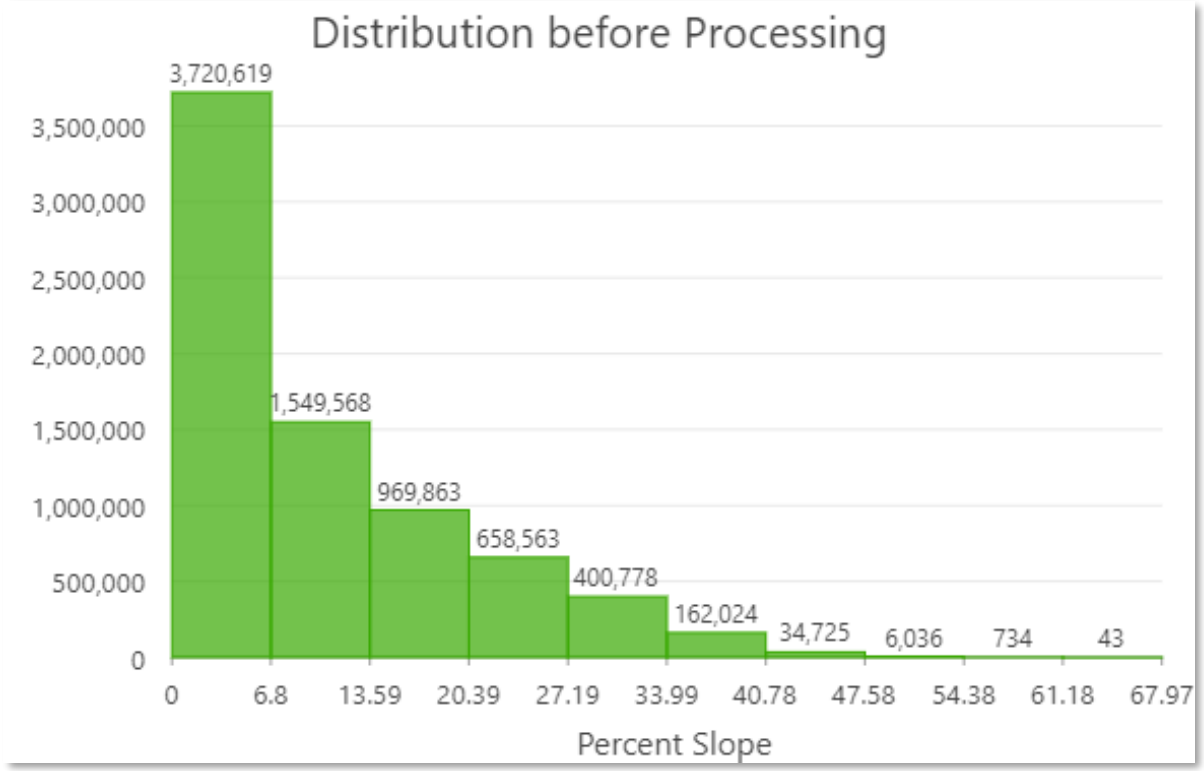
0

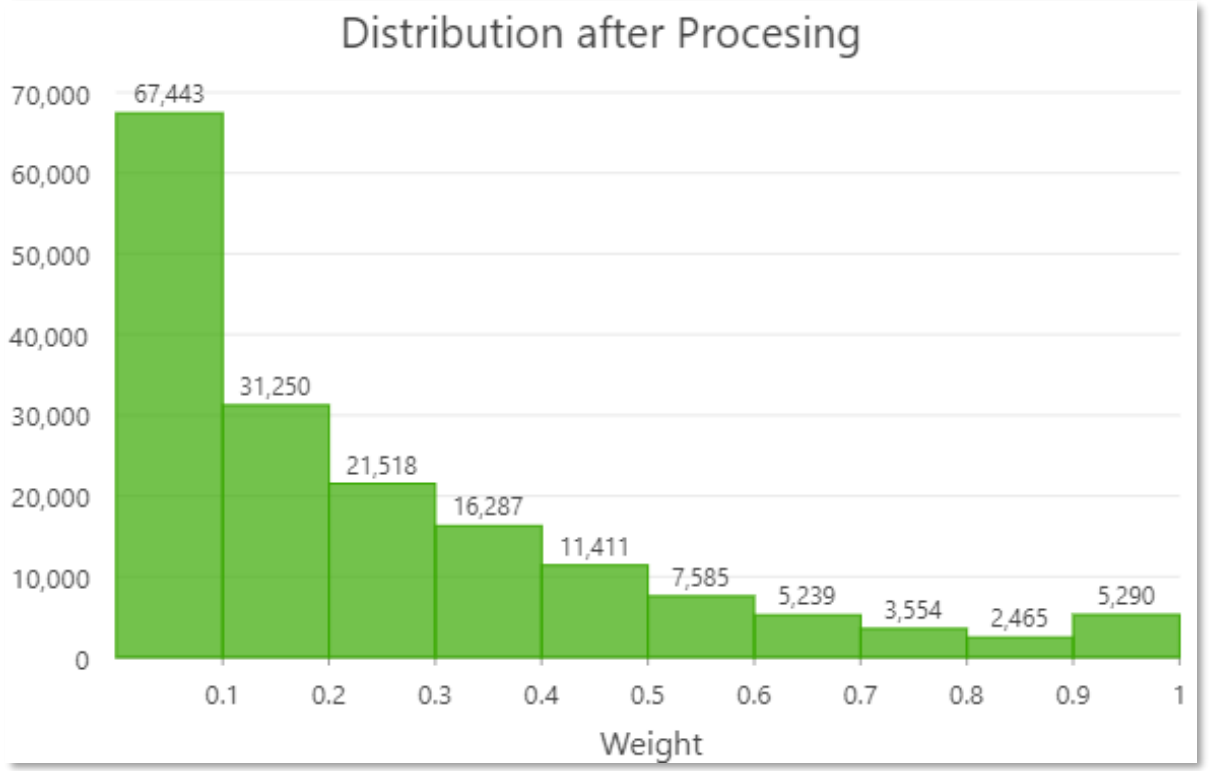
1

Weighting Schemas were based on federal or state legislation or regulations, or best practices, when available.

Processing Improves Utility and Understanding of Datasets

Quality Control and Curation to Support Data Interpretation and Reusability





Robust Metadata Detailing the "What," "Why," and "How"

Geodatabase Layer	Dataset	Primary Data Source	Processing Steps	Weights	Weight Threshold Defense	Weight Threshold	Regulation	Regulation Source
Protected_Areas_300ft	Boundaries	U.S. Geological Survey (USGS) Gap Analysis Project (GAP) (2022). Protected Areas Database of the United States (PAD-US) 3.0: U.S. Geological Survey data release. https://doi.org/10.5066/P9Q9LQ4B.	Selected for GAP Status 1 and 2; Created 300 foot buffer	All areas: 1	GAP Statuses 1 and 2 were selected and exported to shapefile because these are restricted from disturbance. Status 3 can still be used in certain circumstances. Status 4 generally has no known restrictions. Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management. Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or	U.S. Geological Survey GAP Analysis Project (2021). GAP Status Code Assignment. Accessed June 4, 2023. Retrieved from https://www.usgs.gov/media/files/gap-status-code-assignment	49 CFR 195.6(b)	https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-D/part-195#:~:text=%C2%A7%20195.6%20Unusually%20Sensitive%20Areas%20(USAs).
Wilderness_Areas	Boundaries	U.S. Geological Survey (USGS). (2023). National Wilderness Areas Dataset. Retrieved from https://data.fs.usda.gov/geodata/edw/datasets.php?dsetCategory=boundaries#:~:text=National%20Wilderness%20Areas.	No additional processing	All areas: 1	GAP Statuses 1 and 2 were selected and exported to shapefile because these are restricted from disturbance. Status 3 can still be used in certain circumstances. Status 4 generally has no known restrictions. Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management. Status 2: An area having permanent protection from conversion of natural land cover and a mandated	U.S. Geological Survey GAP Analysis Project (2021) GAP Status Code Assignment. Retrieved from https://www.usgs.gov/media/files/gap-status-code-assignment	49 CFR 195.6(b)	https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-D/part-195#:~:text=%C2%A7%20195.6%20Unusually%20Sensitive%20Areas%20(USAs).
Tribally_Controlled_Land	Boundaries	U.S. Census Bureau. (2022). American Indian Area Geography (Ver. 2022). Retrieved from https://www.census.gov/cgi-bin/geo/shapefiles/index.php.	No additional processing	All areas: 1	Tribally-controlled lands are not included in the definiton of "Federal Lands" for pipeline rights-of-way Considered areas of concern in energy, environmental, and social justice work	30 U.S. Code § 185(a)	Title 30 U.S.C. 185 Title 25 USC 321	https://www.govinfo.gov/content/pkg/USCODE-2020-title30/pdf/USCODE-2020-title30-chap3A-subchapI-sec185.pdf

Dataset Information

Processing and Weighting Threshold

Regulatory Information

Metadata Includes Details of Legislation and Weight Reasoning for Improved Transparency and Credibility

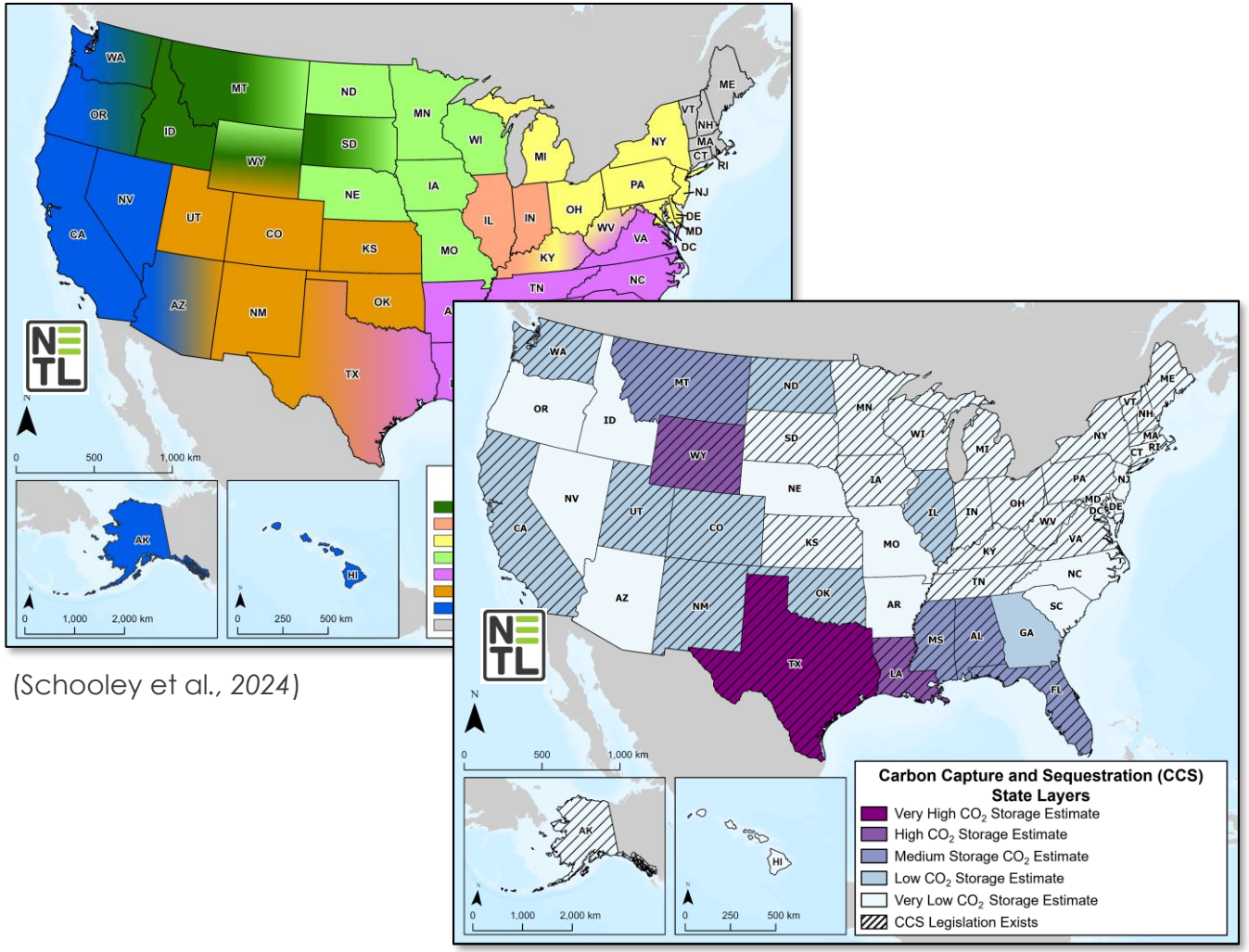
State	Proposed_Legislation	Proposed_Source	CCS_Regulations	Regulation_Legislation	Regulation_Source	Brief_Description
Alabama	AL SB 36	https://legiscan.com/AL/text/SB36/2022	Exists	AL Section 335-6-8-.16 to .27	https://casetext.com/regulation/alabama-administrative-department-of-environmental-management/division-water-quality-program/chapter-335-6-8-underground-injection-control	AL Section 335-6-8-.16 to .27 are regulations for permitting underground injection wells, including permanent CO2 storage. Proposed bill AL SB 36 expands the definition of gas to include carbon oxides for purpose of regulating underground storage facilit
Alaska			Exists	AK HB 196	https://www.akleg.gov/basis/Bill/Text/23?Hsid=HB0196B	AK HB 196 defines "carbon sequestration" as the long-term storage of carbon in forests, soils, the ocean, and other carbon sinks; does not exclude or include geologic sequestration specifically
Arizona			Non-existent			
Arkansas			Non-existent			
California	CA SB1399	https://legiscan.com/CA/text/SB1399/2021	Exists	CA SB905	https://legiscan.com/CA/text/SB905/2021	CA SB905 requires the creation of a carbon capture program to evaluate efficacy and viability; creation of regulations for CCS by 2025; centralized database by 2025. Proposed bill CA SB1399 creates a grant program for CCS development.

Proposed Regulation Information

Adopted Regulation Information

Spatial Research Product Enabling Novel CCS Insights

Leveraging Scientific Research to Produce CCS Layers

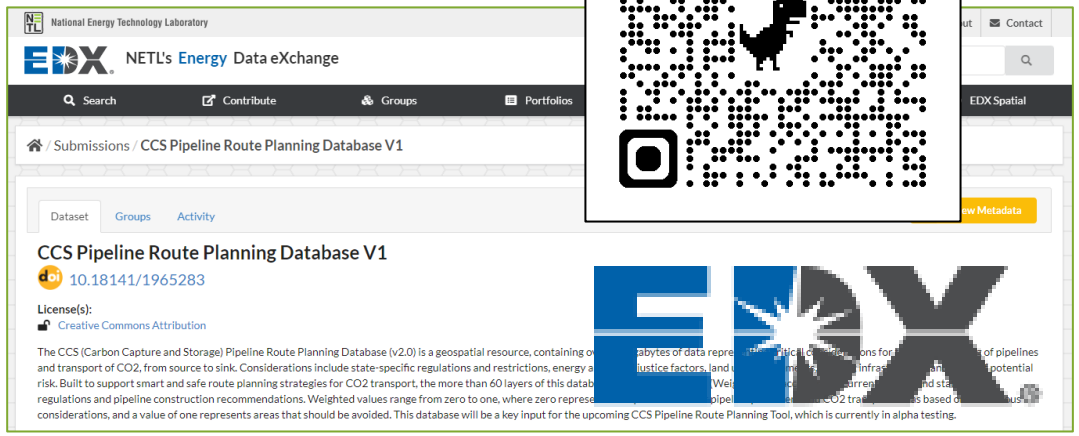


(Schooley et al., *2024*)

The CCS Pipeline Route Planning Database (v2)

Now Available on

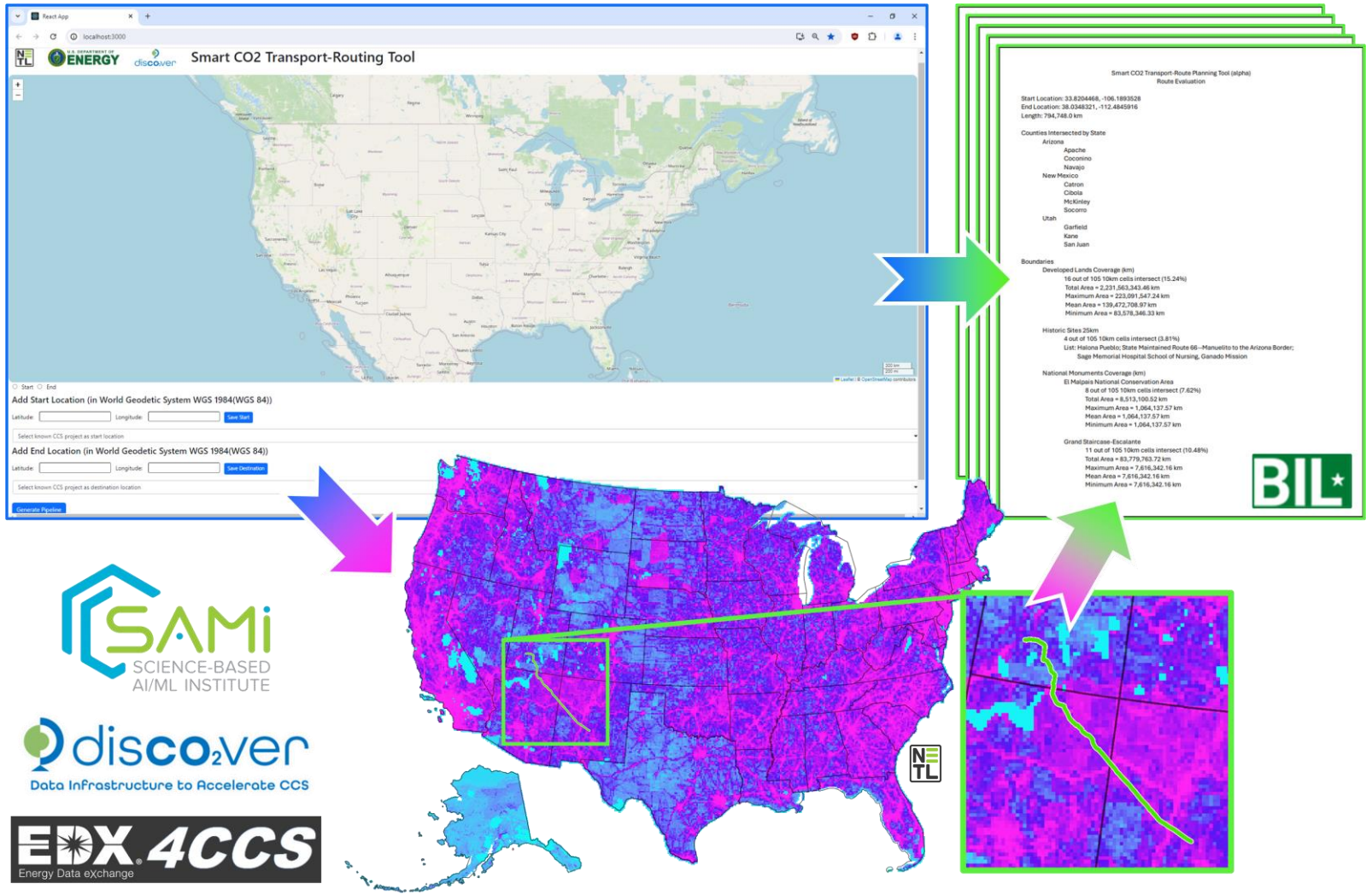
Energy Data eXchange!



What's Next?

How Resources Are Applied to Support Safe Transport Planning

- Apply geospatial resource to inform ML algorithm in the **Smart CO_2 Transport-Route Planning Tool**
- Stay current with federal and state legislation and regulations, and best practices
- Leveraged for other pipeline-related research efforts
- Invited presentations at international pipeline conferences and meetings



Acknowledgments

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