From Scar To Scaffold

The Afterlife of the Oil Pipeline for a Decarbonizing World

by

Katerina Apostolopoulou

Diploma in Architectural Engineering

University of Patras, School of Engineering - Department of Architecture, 2022

Submitted to the Department of Architecture in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE IN ARCHITECTURE STUDIES

at the

Massachusetts Institute of Technology

May 2025

Authored by: Katerina Apostolopoulou
Department of Architecture
May 9, 2025

Certified by: Roi Salgueiro Barrio
Lecturer in Architecture and Urbanism
Thesis Advisor

Accepted by: Timothy Hyde
Professor of the History of Architecture
Chair, Department Committee on Graduate Students

Thesis Committee

Roi Salgueiro Barrio, PhD
Lecturer in Architecture and Urbanism

and readers

Nicholas de Monchaux, MArch
Professor of Architecture | Professor of Urban Studies and Planning | Head, Department of Architecture

Laura Narvaez Zertuche, PhD
Partner, Urban Design at Foster + Partners

From Scar To Scaffold

The Afterlife of the Oil Pipeline for a Decarbonizing World

by

Katerina Apostolopoulou

Submitted to the Department of Architecture on

May 9, 2025

in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Architecture Studies

ABSTRACT

With over 86,000 kilometers of crude oil pipelines—and more than 2.13 million kilometers of total oil and gas pipelines in the United States as of 2024—many segments are already corroded and aging, deeply embedded within urban and ecological systems that are increasingly endangered. As the global energy transition accelerates, this thesis investigates the future of these infrastructures, reconsidering the vast network of decommissioned and declining legacy pipelines not as obsolete relics, but as latent spatial assets for ecological repair, climate resilience, and socio-environmental justice. Moving beyond narratives of extraction and decay, the project repositions pipelines as linear territories of opportunity—capable of being retrofitted into new civic, ecological, and infrastructural frameworks.

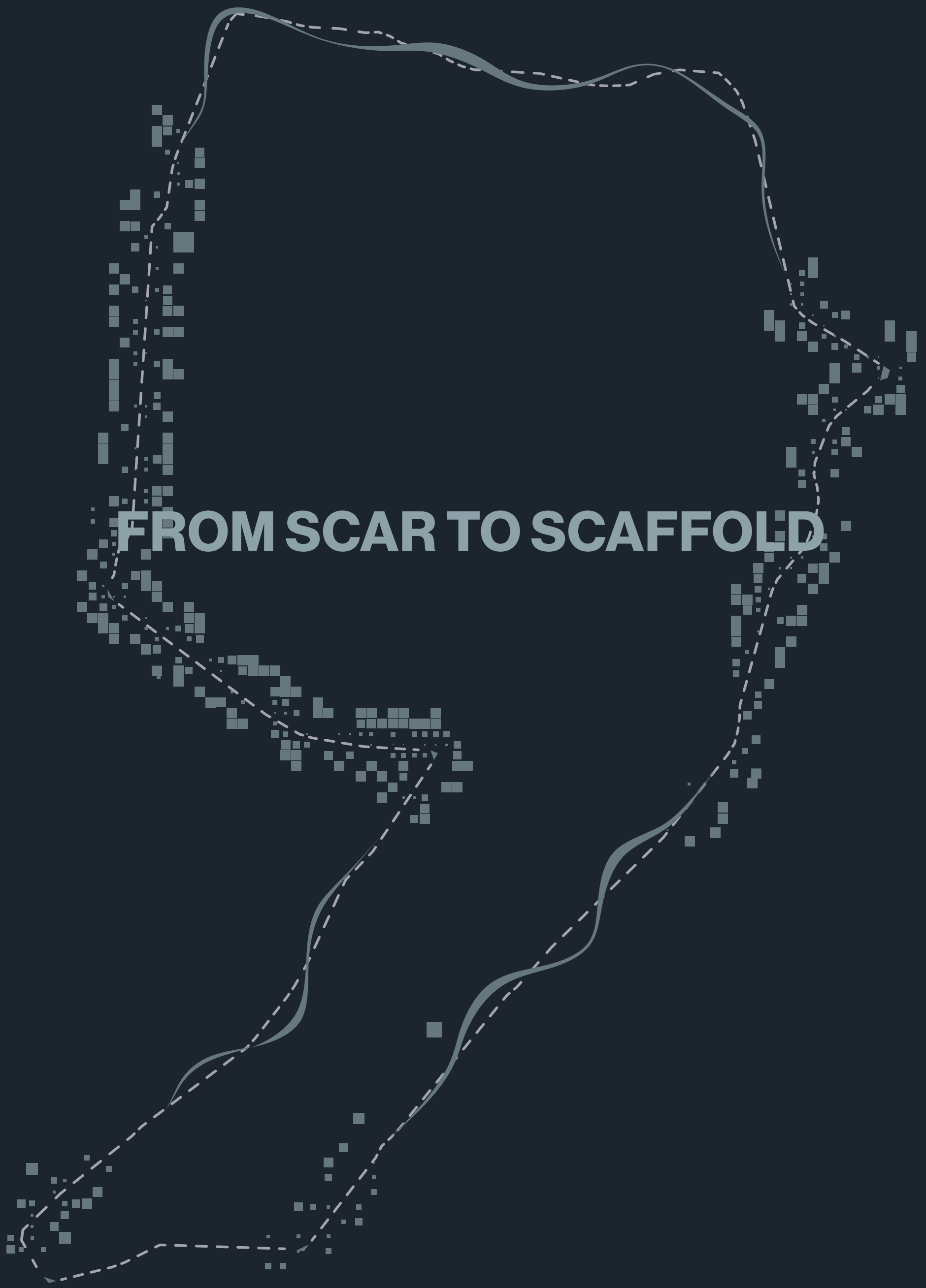
Central to the project is the transformation of the pipeline's linear, extractive logic into a circular and connective one: a loop that is both finite and infinite, territorial and experiential. Focusing on a strategically selected loop of crude oil pipelines spanning 14 states, the thesis constructs a cartographic and architectural framework to reimagine these lines as sites of ecological repair, social infrastructure, and alternative energy distribution—where design, much like a biological scaffold, acts as a catalyst for regeneration along landscapes shaped by extraction.

Through spatial analysis, typological classification, and mapping, five territorial conditions are defined along the pipeline loop, each offering distinct opportunities for intervention. These are tested through speculative design prototypes that transform the pipeline through operations of repurpose, renewable energy distribution, or ecological remediation. The interventions reframe invasive infrastructures into public and environmental assets—generating new spaces for inhabitation, production, and collective memory.

Ultimately, the thesis proposes a post-carbon design paradigm rooted in ecological reciprocity, collective agency, and infrastructural care—revealing hidden energy landscapes and inscribing them with new values: resilience, equity, and repair.

Thesis Advisor: Roi Salgueiro Barrio

Title: Lecturer in Architecture and Urbanism



FROM SCAR TO SCAFFOLD

Katerina Apostolopoulou

Thesis 2025
MIT SMArchS Urbanism

Figure cover _ The loop in diagram.

Acknowledgements

This thesis is the result of many conversations, long nights, quiet doubts, and shared moments that stretched far beyond the confines of a desk. I would not have arrived here without the people who held me up along the way—with patience, honesty, and care.

To **Roi Salgueiro Barrio**, thank you for being both a provocateur and a supporter, always pushing me to think critically, to question what's taken for granted, and to stand firmly in my position. Your guidance has been both grounding and generative.

To **Nicholas de Monchaux**, thank you for your calm presence, thoughtful questions, and careful attention to the ambitions—and contradictions—of this work. Your mentorship allowed the project to grow with integrity.

To **Laura Narvaez Zertuche**, thank you for your warmth, sharp insight, and continued encouragement from the studio to the thesis. Working with you was a gift, and your belief in this project meant more than I can say.

To **my parents,** thank you for your unwavering support and for teaching me how to navigate the world with curiosity and resolve. Your belief in me—quiet and constant—has been the foundation of it all.

To **my sister**, Niki, for your brilliance, your questions, and your courage. You are the person I turn to when I need to think things through—architecturally, ethically, and otherwise. Thank you for walking beside me, always.

To my **cohort and friends**, thank you for the early-morning coffees, the walks, and the idea exchanges. The joy of learning together, within a space of solidarity, honesty, and care that we created, carried and amplified my work and journey at MIT. I'm grateful for every step we shared.

Table of Contents

All images created by author unless otherwise noted.

List of Figures

00 Introduction

Introduction

Thesis Statement
Oil pipelines were built to connect, transport, and fuel economies, yet their decommissioning exposes the paradox of their existence: they were designed to function indefinitely but are now unwanted relics of a dying era. What if, instead of simply erasing them, we could reimagine them as infrastructures of ecological repair, social reconciliation, and climate adaptation?

Decommissioning a pipeline does not remove its impact—ecologically, socially, or politically. Instead of treating abandoned pipelines as obsolete, this thesis recognizes them as latent infrastructures capable of being activated for a post-carbon future.

Rethinking Infrastructure in a Changing World
Pipelines are not merely infrastructures of extraction; they are spatial organizers of planetary flows—shaping economies, settlements, and ecosystems in ways that extend beyond their material presence.[1] They operate as territorial systems, governing not only the movement of oil but also the landscapes they intersect, the regulations they reinforce, and the communities they impact. Large-scale infrastructures are not static objects but agents of urban and environmental transformation, continuously shaping territorial ecologies.[2] Understanding pipelines within this broader system of spatial and economic forces allows us to move beyond a purely technological view of infrastructure and instead interrogate how these networks produce urbanization itself.

The legacy of infrastructure is one of progress and consequence. Pipelines, veins of the fossil fuel era, have not only transported energy but have also carved deep scars into the landscapes they traverse. They have enabled economies to flourish while simultaneously fragmenting ecosystems, displacing communities, and reinforcing environmental inequality.[3]

Today, there are over 2.6 million miles of pipelines crisscrossing the planet—a web of extraction, largely unseen yet inescapably present.[4] These subterranean veins, threading through landscapes from boreal forests to coastal wetlands, connect sites of extraction to centers of consumption, yet remain invisible. They exist in the periphery of public consciousness, yet their presence is absolute. They are both essential to modernity and obstacles to decarbonization—integral to an energy economy emblematic of an era that must come to an end.

Their impact is staggering: for every 1,000 miles of pipeline laid, 20,000 square miles of habitat are fragmented. In addition, in the United States alone, more than half of all pipelines have surpassed their operational lifespan, leading to over 5,500 leaks, 2,500 injuries, and 600 fatalities since 2010 (PHMSA, 2022).[5]

---

[1] Timothy Mitchell, Carbon Democracy: Political Power in the Age of Oil (London: Verso, 2011).

[2] Brian Larkin, “The Politics and Poetics of Infrastructure,” Annual Review of Anthropology 42, no. 1 (2013): 327–343, https://doi.org/10.1146/annurev-anthro-092412-155522.

[3] Rob Nixon, Slow Violence and the Environmentalism of the Poor (Cambridge, MA: Harvard University Press, 2011)

[4] Global Energy Monitor, Global Oil and Gas Infrastructure Tracker, data and reports.

[5] Pipeline and Hazardous Materials Safety Administration (PHMSA), “Pipeline Incident 20-Year Trends,” U.S. Department of Transportation, 2022. https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-incident-20-year-trends

Fig. 0.1 _ Elevated oil pipelines traverse Alaska's Western Arctic tundra, cutting through the Lake Teshekpuk region—ancestral grazing grounds for caribou and a critical habitat for migratory birds. This image captures the uneasy coexistence of industrial infrastructure and fragile ecosystems—an entanglement of mobility, extraction, and survival shaped by competing claims to land and future. (Photo: Kiliii Yuyan for Earthjustice)

Fig. 0.2 _ Bouquet Inlet-Outlet Pipe Line - San Francisquito Canyon, CA 2021

The Bouquet Inlet-Outlet Pipe Line is a welded steel pipeline 80 to 94 inches in diameter which extend 3.5 miles. It connects the Bouquet Reservoir to the Los Angeles Aqueduct just north of Power Plant 1. The Bouquet Reservoir serves as a water storage reservoir as well as power regulation for the City of Los Angeles.(Photo: Brad Temkin)

These ruptures—both material and symbolic—raise a critical question:

What happens to these vast, decaying networks as the world transitions away from fossil fuels?

Globally, pipelines remain silent contributors to environmental collapse. They are responsible for 35% of greenhouse gas emissions linked to fossil fuel transportation (IPCC, 2021),[6] yet their presence extends beyond the carbon they move. They disrupt the delicate balance of ecosystems, cutting through wetlands that store 30% of the world's soil carbon and provide $500 billion in flood protection annually.[7] Policies such as the Coastal Zone Management Act[8] mandate that pipeline corridors be revegetated after use, yet enforcement is inconsistent, leaving behind barren, eroded landscapes.

But what if these linear scars could become corridors of renewal?

The Urgency of Rethinking Pipelines

As the world faces an accelerating climate crisis, the need for decarbonization has created an unprecedented opportunity to redefine the role of pipelines. Once conduits of extraction, these networks—largely invisible yet woven into the very fabric of modernity—could be transformed into agents of ecological and social regeneration, sites of repair in the Anthropocene.

If we consider pipelines as active design fields rather than passive remnants, their reuse becomes not just a question of repurposing but of reconfiguring their role within evolving landscapes. My approach to large-scale infrastructures underscores how territorial systems persist beyond their original function. Decommissioned pipelines do not simply disappear from the spatial order—they remain embedded within property rights, political inertia, and governance structures that dictate future interventions.[9] By recognizing the infrastructural network as a latent space of negotiation and intervention, this thesis explores how these corridors might be recoded as civic, ecological, and energy infrastructures, engaging with new economies, regulatory frameworks, and spatial typologies.

Pipelines, as much as they have been instruments of harm, also hold untapped potential within their embedded spatial, legal, and material systems. Keller Easterling, in Extrastatecraft: The Power of Infrastructure Space[10], argues that infrastructure is

---

[6] IPCC, Sixth Assessment Report: Mitigation of Climate Change (2021), Chapter 6. https://www.ipcc.ch/report/ar6/wg3/

[7] Ramsar Convention Secretariat, "The Economics of Ecosystems and Biodiversity for Water and Wetlands," 2013. https://www.ramsar.org/sites/default/files/documents/library/teeb_waterwetlands_report_2013.pdf

[8] U.S. National Oceanic and Atmospheric Administration (NOAA), "Coastal Zone Management Act," https://coast.noaa.gov/czm/act/

[9] Carola Hein, "Global Landscapes of Oil," in New Geographies 2: Landscapes of Energy, ed. Rania Ghosn (Cambridge, MA: Harvard Graduate School of Design, 2009), 33–42.

[10] Keller Easterling, Extrastatecraft: The Power of Infrastructure Space (London: Verso, 2014).

Fig. 0.3 _ The Trans-Alaska Pipeline snakes across tundra and mountain passes, elevated to prevent permafrost melt and zigzagged to absorb seismic shocks. This iconic image of engineered resilience reveals the tensions between technical ingenuity and environmental disruption in one of the planet's most sensitive regions. (Photo: Rashah McChesney/Alaska's Energy Desk)

Fig. 0.4 _ A gas transmission pipeline slices through the wetland terrain of St. Bernard Parish, Louisiana, forming a stark incision in the marsh. Taken on July 21, 2018, the image captures how this artificial corridor accelerates land erosion and saltwater intrusion, revealing how energy infrastructure reshapes—and often undermines—ecological systems vital to climate resilience. (Photo by Bonnie Jo Mount / The Washington Post)

not merely passive hardware but an active agent that governs flows of power, capital, and land use. Pipelines are not just remnants of a fossil-fueled past; they are operative spaces that can be reprogrammed, repurposed, and reactivated for new futures.

If infrastructure has the capacity to regulate extraction, it also has the capacity to facilitate repair. If pipelines once shaped energy economies, could they also shape decarbonization efforts?

If they have served as vectors of environmental harm, can they be reprogrammed as infrastructures of ecological and social regeneration?

This thesis proposes that rather than being dismissed as obsolete relics, pipelines can instead be viewed as latent infrastructures—active agents within the built environment that, through spatial intervention, can be integrated into new regenerative systems.
At the core of this research lies the question: How can pipelines be transformed from extractive conduits into ecological and social infrastructures? By integrating regenerative design principles, environmental justice frameworks, and speculative urbanism, pipelines can be reimagined as multifunctional systems that support reforestation, wetland restoration, carbon sequestration, and climate adaptation—while addressing social inequities.

Methodology: From Mapping to Reimagination

This thesis adopts an interdisciplinary methodology that moves from large-scale cartographic analysis to territorial classification and design speculation. At its core lies a belief that oil pipelines—once emblematic of extraction and ecological harm—can be reimagined as spatial frameworks for regeneration, repair, and climate adaptation.

The project begins with a geospatial study of the U.S. oil pipeline system, crisscrossing diverse landscapes—from wetlands and farmlands to industrial corridors and urban edges. These buried networks, largely invisible in public discourse, were rendered legible through GIS mapping that layered data on refineries, power plants, tribal lands, urban centers, waterways, and ecologically sensitive zones. This mapping revealed both the physical reach and the socio-environmental footprint of fossil infrastructure in the American landscape.

From this cartographic base, the thesis constructs a conceptual loop: a continuous path that traces pipeline segments across fourteen states, selected for their intersections with vulnerable ecologies, industrial intensity, and spatial opportunity. This loop is not an existing infrastructural line but a reconfigured territorial framework—one that reframes linear extraction as a circular scaffold for regeneration.

To analyze the loop's complexity and guide intervention strategies, a hexagonal spatial classification system was developed using 300 square kilometer H3 grid cells. Each hexagon was evaluated across five weighted dimensions: **pipeline density (25%), power infrastructure (20%), transportation access (15%), urban or tribal proximity (20%), and environmental sensitivity (20%).** This scoring framework enabled a comparative, layered understanding of where interventions might be most impactful—identifying not only sites of risk but territories of potential.

Emerging from this analysis are five distinct territorial typologies that capture the range of conditions along the loop: Hydro ecological zones, Urban Clean Energy Hub, Productive Agro-landscape, Industrial Energy core, and Mixed Transition zone. Each typology is examined as a situated condition—framing pipelines not only as physical artifacts but as embedded, often contested landscapes.

Design responses were developed for each typology through a speculative and generative methodology, where adaptive reuse strategies were tested through site-specific hubs. In one hub, waste heat from data centers is redirected through pipeline infrastructure to support agricultural greenhouses. Another converts the corridor into an elevated ecological bridge, restoring wildlife connectivity while offering pedestrian access. A third proposes a district heating network powered by the waste heat of the adjacent refinery, reducing in-phase fossil fuel dependence and covering the energy needs of new urban areas. In the final interventions, the pipeline itself is removed, replaced with rewilded memory corridors and trails that acknowledge past harm while inviting new civic uses.

To evaluate these scenarios, the thesis introduces a series of custom performance metrics that measure the ecological and social value of transformation. These include the **Ecosystem Services Recovery Score (ESRS), the Community Integration Rating, Carbon Sequestration Capacity, Multi-Functional Adaptation Index (MFAI), and the Regenerative Potential Index (RPI).** Together, these indicators offer both a quantitative and qualitative lens for assessing the viability and impact of pipeline reuse—shifting the focus from technical feasibility alone to questions of justice, resilience, and care.

The work culminates in a territorial masterplan of the loop, a policy diagram that outlines pathways for implementation, and a series of speculative drawings that narrate the afterlives of this vast, aging network. Through this process, the thesis moves beyond critique, offering instead a framework for how design can participate in shaping the infrastructural transitions of a decarbonizing world.

Structure Preview

The thesis unfolds across six chapters, each building upon the last to transition from system-wide critique to design invention and territorial strategy. The structure mirrors the methodology itself—beginning with invisibility and crisis, moving through spatial classification and speculative proposal, and ending with a collective vision for post-carbon infrastructures.

In Chapter 1, The Invisible Network, the U.S. pipeline system is mapped as a buried but territorial infrastructure—one that governs not only the flow of oil, but the organization of land, law, and settlement. Pipelines are revealed as political artifacts and spatial organizers, whose invisibility masks both their scale and systemic entrenchment.

In Chapter 2, The Pipeline Paradox, the contradictions of continued fossil fuel dependence in the face of ecological collapse are brought to the fore. Drawing on disaster records, lifecycle data, and current policy inertia, the chapter frames pipelines as both necessary and obsolete, vital and violent—foregrounding the urgency of their transformation.

Chapter 3, Threads of Repair introduces the conceptual loop and details the classification system used to understand it. Here, the thesis moves from critique to construction, offering a new cartographic lens through which to read the pipeline not as line but as loop, and not as fixed but as reprogrammable.

In Chapter 4, Speculative Futures, five site-specific design interventions are proposed, each tailored to a distinct territorial typology. These prototypes test what it means to remove, reuse, or reimagine infrastructure through a regenerative lens—proposals that range from ecological corridors and productive landscapes to civic commons and energy redistribution networks.

Chapter 5, The Afterlives scales these interventions into a territorial masterplan. It situates the loop within a broader policy and spatial framework, proposing legal, ecological, and financial tools for implementation. This chapter also reflects on the symbolic dimensions of reuse—how design might not only restore land but reshape collective memory.

Finally, Chapter 6, Conclusion reflects on the implications of infrastructural imagination and the role of speculative design in the age of climate transformation. Across its parts, the thesis argues that what begins as scar can, through design, become scaffold—supporting new territorial narratives rooted in reciprocity, repair, and resilience.

01 The Invisible network

Pipelines in a Post-Carbon Future

The Invisible Network

The Buried Architecture of Power

Pipelines are everywhere, yet rarely seen. They run beneath farmland, wetlands, forests, and towns—an invisible architecture of extraction that underpins the global energy economy. In the United States, this network spans more than 2.6 million miles, with over 86,000 kilometers dedicated to crude oil alone.[1] Built to transport the lifeblood of industrial modernity, pipelines are more than conduits—they are instruments of power, territorial tools, and economic drivers. They shape not only energy flows, but also land use, labor regimes, and ecological vulnerability. As Rania Ghosn writes, "the production of energy in the distant and the underground, coupled with an analysis of urbanism at a city-scale, contributed to keeping infrastructures of urbanization out of sight and severing the continuity between crude geographies and the refined world".[2] By rendering this infrastructure invisible, the fossil fuel system conceals not just the means of extraction, but its consequences—relegating environmental and social harm to the margins while embedding its benefits into everyday life.

Globally, oil circulates through a finely tuned choreography of extraction, refinement, and distribution. In many regions, this movement depends on maritime routes, with tankers navigating chokepoints like the Strait of Hormuz and the Suez Canal. But in the United States, the system is primarily terrestrial. Oil travels through a dense, interlocking web of pipelines that spans the continent—from the Alberta tar sands in the north to the Gulf of Mexico in the south—linking oil fields to refineries, ports, and power plants. This network, mapped in both geopolitical and logistical terms **(Fig. 1.2)**, reveals not just the infrastructural logic of flow, but the territorial logic of power. The U.S. is now the world's top oil producer, surpassing both Saudi Arabia and Russia—a position made possible not only by abundant reserves and extraction technologies, but by the spatial efficiency of its domestic pipeline system.[3] Pipelines allow oil to bypass the vulnerabilities of international waters and be embedded directly into domestic territory—dispersed, regulated, and largely invisible. As Mitchell reminds us, oil pipelines were deliberately designed to "reduce the ability of humans to interrupt the flow of energy," streamlining not only transport but the political and labor systems surrounding it.[4] This strategy of terrestrial embedding—of integrating control into land—transforms infrastructure into a tool of governance as much as of flow.

A Territory of Pipes

Where other nations rely on tankers, terminals, and seaborne routes, the United States has embedded oil directly into the land. Pipelines stretch across mountains, grasslands, wetlands, and neighborhoods—threading through ecologically sensitive and socially diverse

---

[1] Statista Research Department. "Length of Oil Pipelines Worldwide as of 2022, by Country." Statista, August 29, 2023. https://www.statista.com/statistics/1491015/length-of-oil-pipelines-by-country/.

[2] Rania Ghosn, "Where Are the Missing Spaces? The Geography of Some Uncommon Interests," New Geographies 2 (2010): 109–116

[3] U.S. Energy Information Administration (EIA), "U.S. Remains the World's Top Producer of Petroleum and Natural Gas Hydrocarbons," March 16, 2023, https://www.eia.gov/todayinenergy/detail.php?id=55960.

[4] Timothy Mitchell, Carbon Democracy: Political Power in the Age of Oil (London: Verso, 2011), 36.

territories with little visibility or resistance. Nowhere else is the energy system so thoroughly fused with national geography. This embeddedness is reinforced by design: unlike power plants, ports, or refineries, pipelines leave no skyline, no plume of smoke—only the structural certainty of their presence beneath our feet **(Fig. 1.3)**. Their routes bypass civic life, operating outside of public scrutiny. That invisibility is precisely what grants them political durability. By minimizing their spatial signature, pipelines are allowed to function without spectacle, without consent, and often without question. They traverse land through legal frameworks like eminent domain, not public deliberation, transforming everyday environments into corridors of extraction.[2]

Zooming into the U.S. oil system reveals a tightly coordinated geography of production, processing, and distribution. The Alberta tar sands in the north, the Gulf Coast refineries in the south, and the inland waterways of the Mississippi Basin form a continental triangle of crude flow—linked by pipeline corridors that span thousands of miles **(Fig. 1.4)**. These are not just logistical pathways; they are spatial instruments that reorganize land and infrastructure into a system of energy governance. Pipelines override ecological boundaries, state lines, and property parcels to create continuous corridors of control. Their linear form is deceptive—they do not simply connect sites, but carve out a new territorial logic. By stitching together extraction zones, refineries, ports, and power markets, pipelines produce a landscape of managed flow: optimized for capital,

Fig. 1.1 _ Labor at the Pipeline Seam
A pipeline worker welds a section of steel pipeline, highlighting the human labor behind the continuity of fossil fuel infrastructure. While pipelines are often portrayed as automated and invisible systems, their maintenance and expansion rely on skilled manual labor—reinforcing the entanglement of energy systems with local economies, identities, and embodied work. Photo: EY & Associés

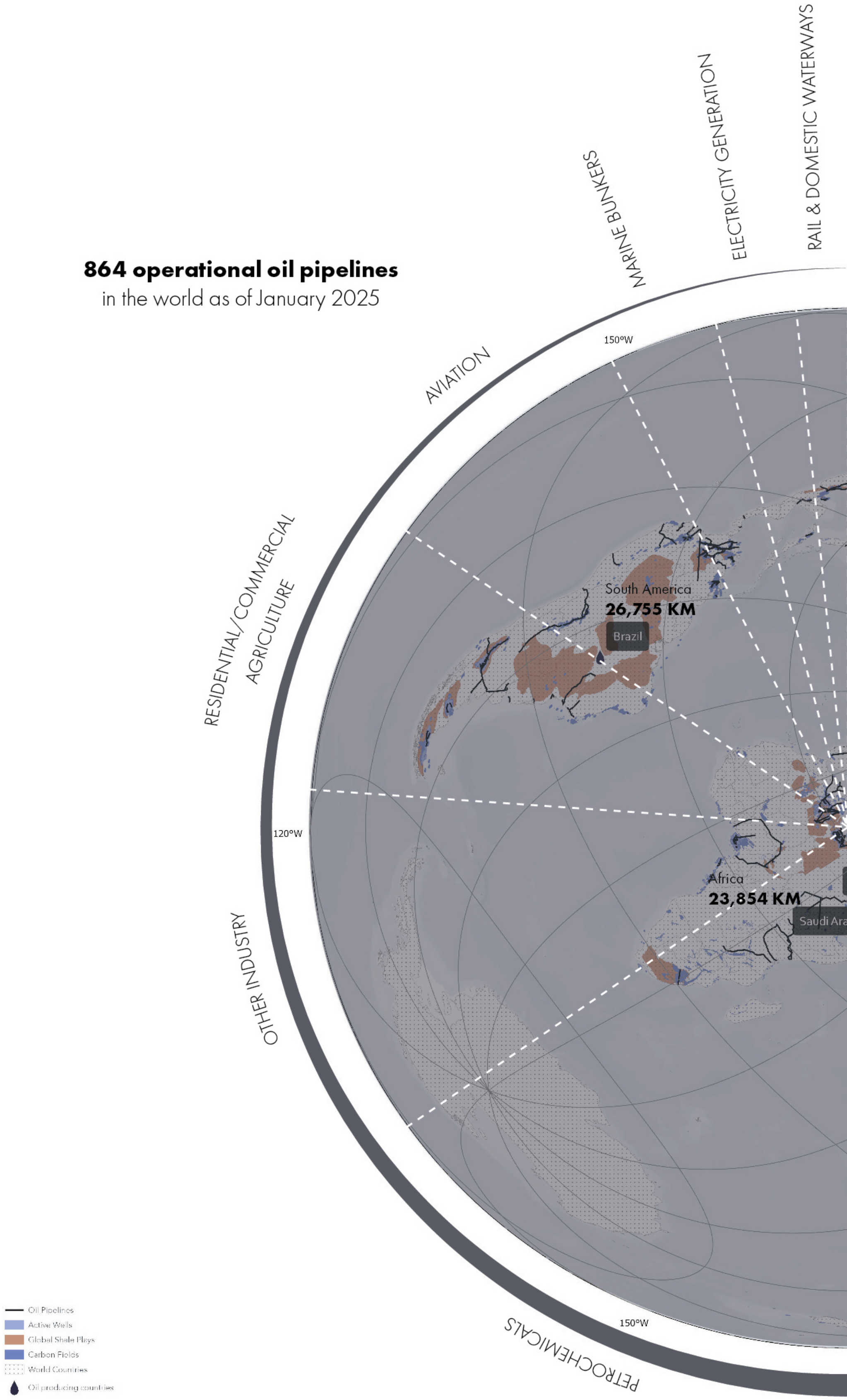
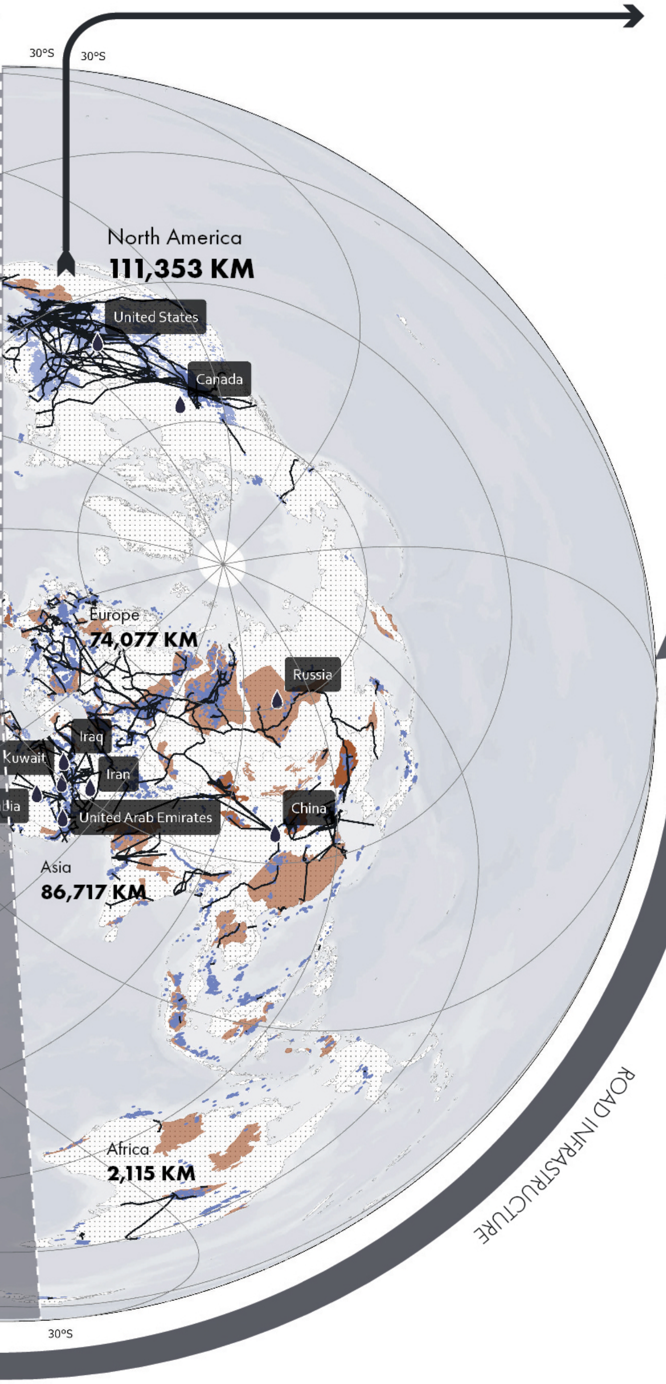


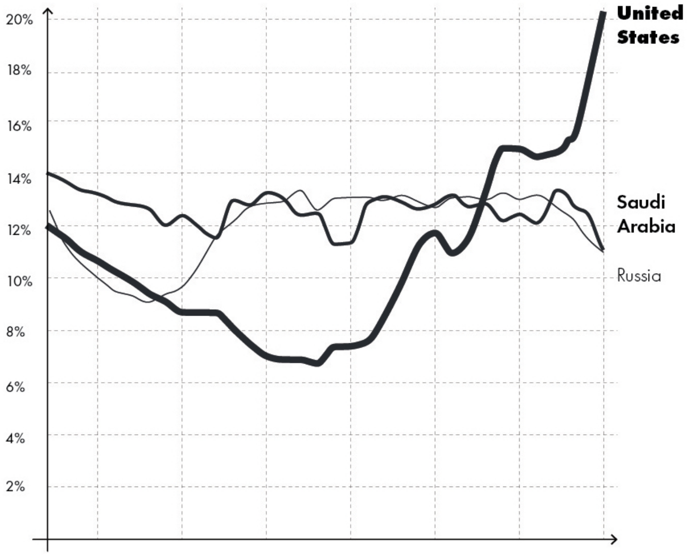
Fig. 1.2 _ Crude Oil Production and Geopolitical Influence

A polar projection of global oil-producing regions, infrastructure density, and a production graph showing the U.S. rise to top producer. This figure illustrates how spatial embedding of oil networks supports geopolitical and economic dominance.

As of May 2024, there were **195 operational oil pipelines in the US** and another **10 under development.**



Crude Oil Production (% of world)



Country	Million barrels per day
United States	**21.91**
Saudi Arabia	11.13
Russia	10.75
Canada	5.76
China	5.26
Iraq	4.42
Brazil	4.28
United Arab Emirates	4.16
Iran	3.99
Kuwait	2.91

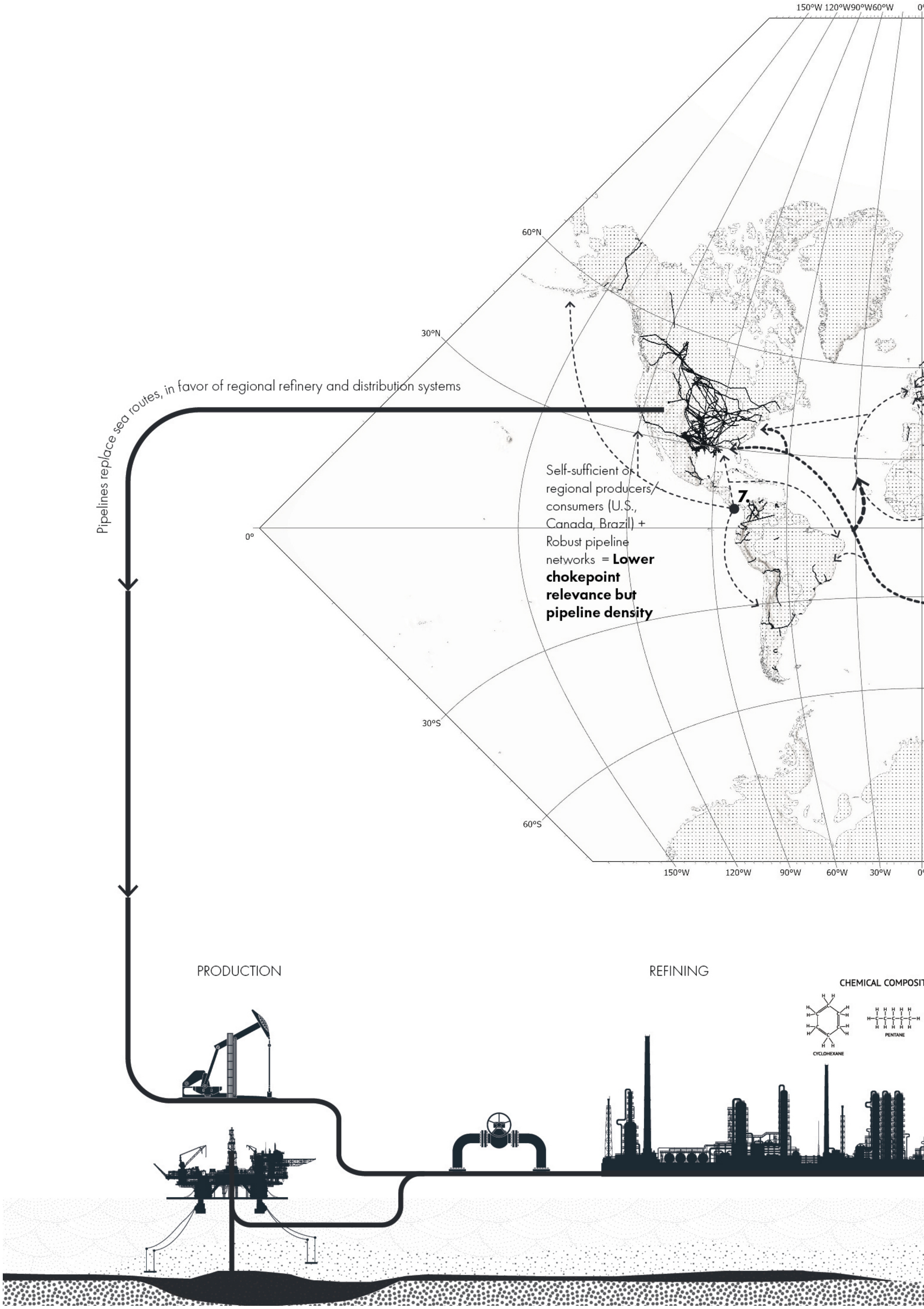
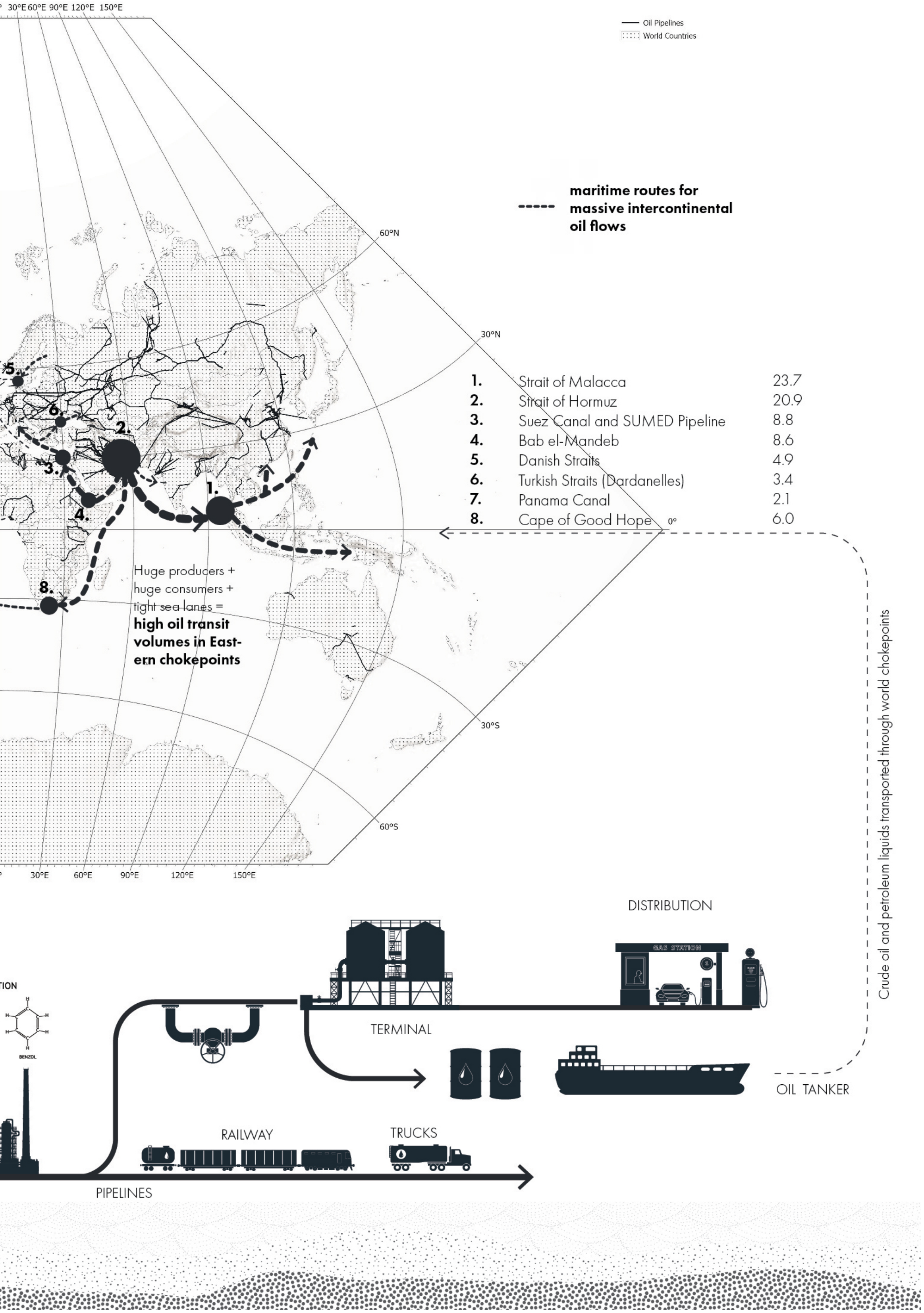


Fig. 1.3 _ Global Infrastructures of Oil

A world map of major oil pipelines and maritime routes, illustrating the spatial differentiation between pipeline-based and tanker-based oil logistics. U.S. and Canadian territories display denser terrestrial networks, while Eastern chokepoints—like the Strait of Hormuz—handle high oil transit volumes via maritime corridors.



maritime routes for massive intercontinental oil flows

1.	Strait of Malacca	23.7
2.	Strait of Hormuz	20.9
3.	Suez Canal and SUMED Pipeline	8.8
4.	Bab el-Mandeb	8.6
5.	Danish Straits	4.9
6.	Turkish Straits (Dardanelles)	3.4
7.	Panama Canal	2.1
8.	Cape of Good Hope	6.0

Huge producers + huge consumers + tight sea lanes = **high oil transit volumes in Eastern chokepoints**

Crude oil and petroleum liquids transported through world chokepoints resistant to accountability.

Boom, Spill, Repeat

The pipeline system did not emerge fully formed. Its development tracks closely with U.S. industrial history, rising and intensifying alongside the expansion of domestic oil production **(Fig. 1.5)**. Each major boom—whether from offshore drilling, fracking, or shale discoveries—was accompanied by new pipeline construction. But so too were these moments marked by failure: catastrophic spills, explosions, leaks, and ruptures that devastated ecosystems and exposed communities to long-term harm.

The timeline of oil infrastructure is also a timeline of policy reaction. Disasters have long served as triggers for regulatory creation—the Clean Water Act[5], the formation of the EPA,[6] and regional response systems all came in the wake of spills. And yet, while each rupture prompted a temporary increase in oversight, the underlying system remained intact. The logic of extraction endured, often rebranded but rarely rethought.

The Anatomy of Extraction

To understand the power of pipelines, one must look beneath the surface—literally and systemically. Pipelines are not just steel tubes; they are part of vast technical assemblages. Pressure regulation stations, corrosion monitoring systems, remote sensors, aerial surveillance, and internal inspection devices (“smart pigs”) all operate together to maintain flow **(Fig. 1.6)**. These systems are designed for efficiency, not transparency. Their complexity insulates them from public oversight, framing them as neutral utilities rather than political instruments.

Yet pipelines are also labor infrastructures. Thousands of workers—welders, surveyors, land agents, engineers, drivers, and inspectors—are economically entangled in their operation. In many regions, pipeline employment is framed not only as a source of income but as a matter of identity and pride. These attachments—both technical and cultural—make pipeline systems more than just logistical hardware. They are living infrastructures, maintained not only through capital investment but through ongoing social investment.

Stranded Value and the Cost of Inertia

Beyond technical and social complexity lies the question of cost. Building pipelines has always been justified through the language of long-term return. Materials, routing, right-of-way negotiations, and pump systems require enormous capital investment **(Fig. 1.7)**. But in a post-carbon future, these investments are at risk of becoming stranded. As demand for oil wanes and renewable systems scale up, many of these pipelines will lose their purpose—but not their physical footprint. They will remain embedded in land and policy, liabilities without a clear plan for

---

[5] The Clean Water Act was passed in 1972 in direct response to widespread public concern about water pollution, catalyzed in part by high-profile disasters like the 1969 Santa Barbara oil spill and the repeated fires on the Cuyahoga River.
U.S. Environmental Protection Agency, “History of the Clean Water Act,” https://www.epa.gov/laws-regulations/history-clean-water-act.

[6] The U.S. Environmental Protection Agency (EPA) was established in 1970 by executive reorganization under President Nixon, following the Santa Barbara spill and other environmental crises that galvanized the modern environmental movement.
U.S. EPA, “EPA History,” https://www.epa.gov/history.

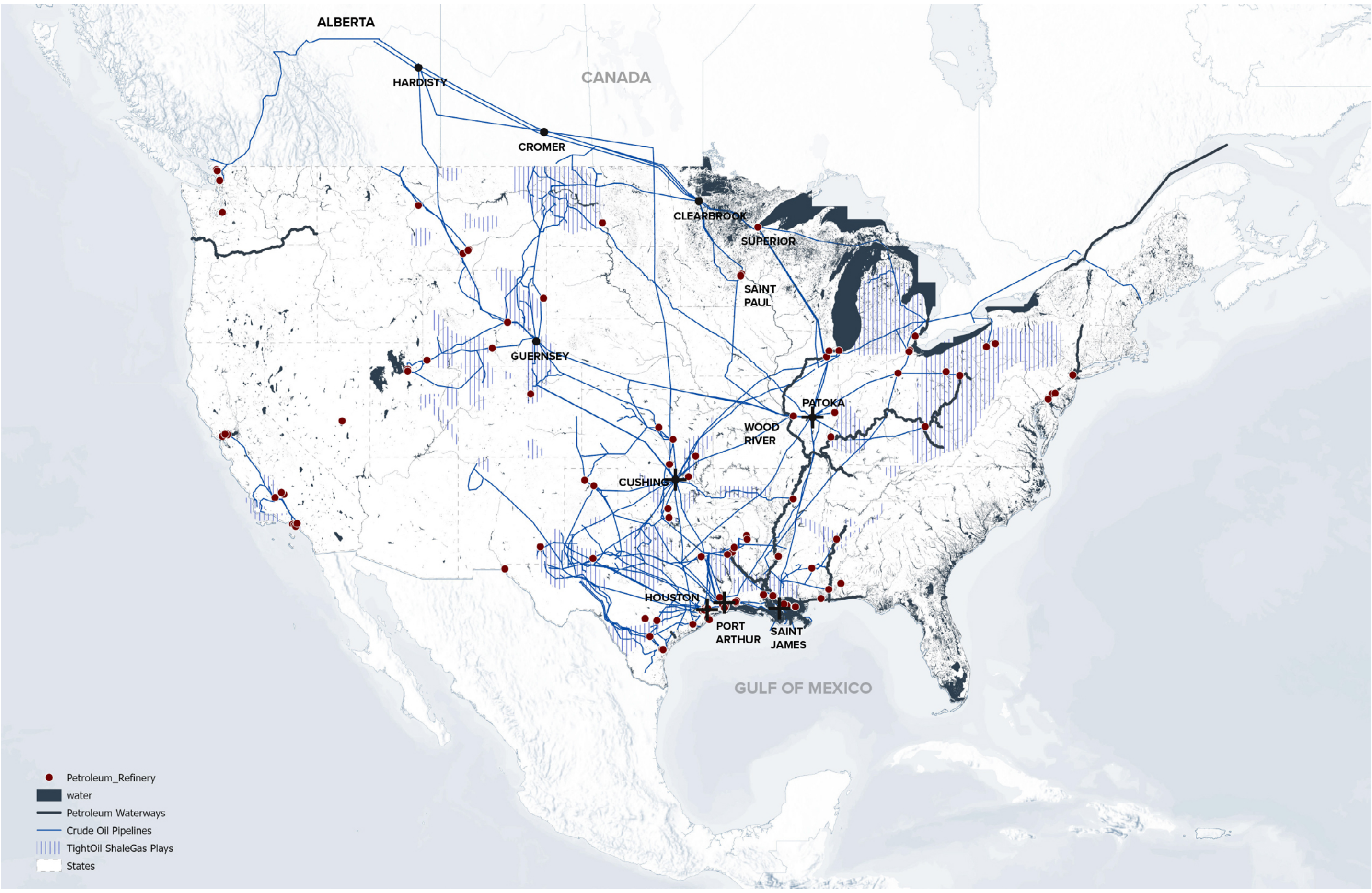


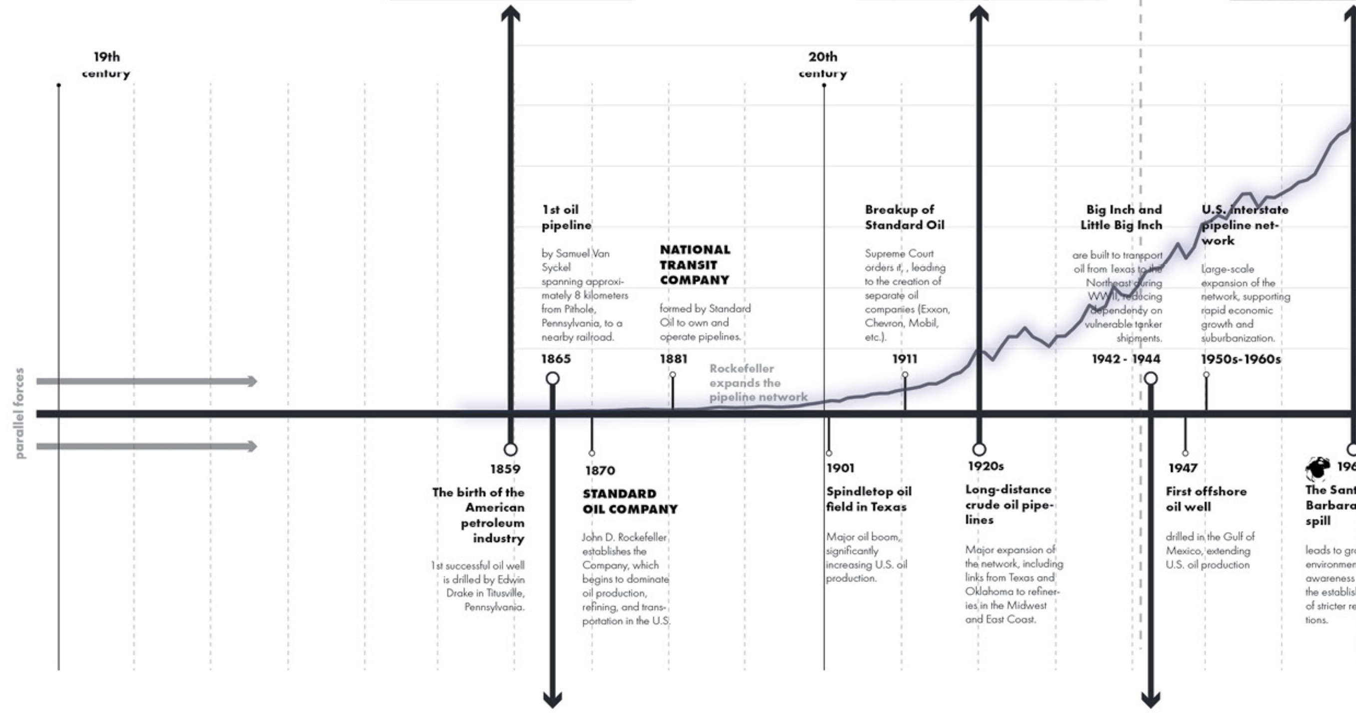
Fig. 1.4 _ Continental Oil Flow: North American Pipeline System

A detailed map of crude oil pipelines, refineries, and shale gas plays in the United States and Canada. The figure highlights the territorial saturation of pipeline infrastructure, anchored by refinery hubs such as Port Arthur, Houston, and Wood River.

1.5 a

1.5 c

1.5 e



1859
The birth of the American petroleum industry
1st successful oil well is drilled by Edwin Drake in Titusville, Pennsylvania.

1865
1st oil pipeline
by Samuel Van Syckel spanning approximately 8 kilometers from Pithole, Pennsylvania, to a nearby railroad.

1870
STANDARD OIL COMPANY
John D. Rockefeller establishes the Company, which begins to dominate oil production, refining, and transportation in the U.S.

1881
NATIONAL TRANSIT COMPANY
formed by Standard Oil to own and operate pipelines.

1901
Spindletop oil field in Texas
Major oil boom, significantly increasing U.S. oil production.

1911
Breakup of Standard Oil
Supreme Court orders it, , leading to the creation of separate oil companies (Exxon, Chevron, Mobil, etc.).

1920s
Long-distance crude oil pipelines
Major expansion of the network, including links from Texas and Oklahoma to refineries in the Midwest and East Coast.

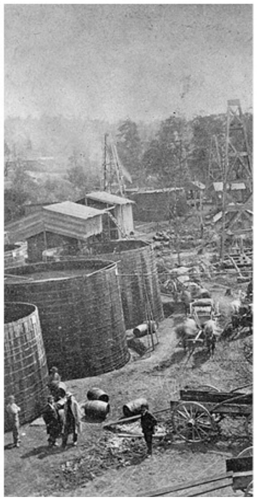
1942 - 1944
Big Inch and Little Big Inch
are built to transport oil from Texas to the Northeast during WWII, reducing dependency on vulnerable tanker shipments.

1947
First offshore oil well
drilled in the Gulf of Mexico, extending U.S. oil production

1950s-1960s
U.S. interstate pipeline network
Large-scale expansion of the network, supporting rapid economic growth and suburbanization.

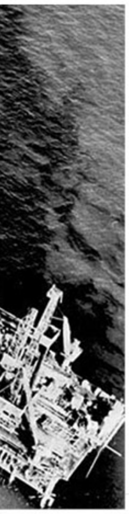
196
The Sant
Barbara
spill
leads to gr
environmen
awareness
the establis
of stricter re
tions.

1.5 b

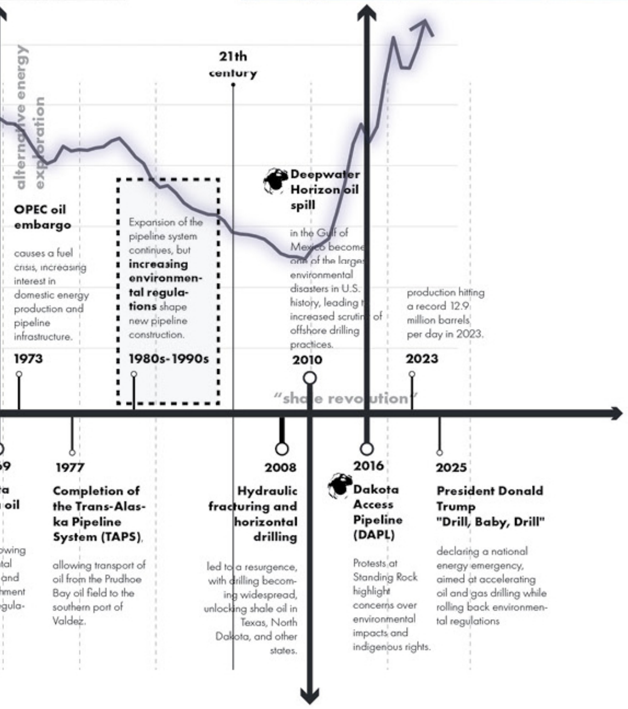


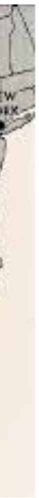
1.5 d

Fig. 1.5 _ Timeline of Oil Infrastructure and Regulatory Response
A visual chronology of oil development in the U.S., from early extraction and monopolies to pipeline expansion and environmental disasters. Events like the Exxon Valdez and Deepwater Horizon spills are contextualized alongside policy responses such as the Clean Water Act and EPA formation.



1.5 g





1.5 f

Image citations:

1.5 a: Edwin Drake, right, stands with friend Peter Wilson of Titusville, Pennsylvania, at the drilling site. Photo courtesy Drake Well Museum.

1.5 b: Tanks holding oil in Pithole, Pa., in 1868. Drake Well Museum/Courtesy of PHMC

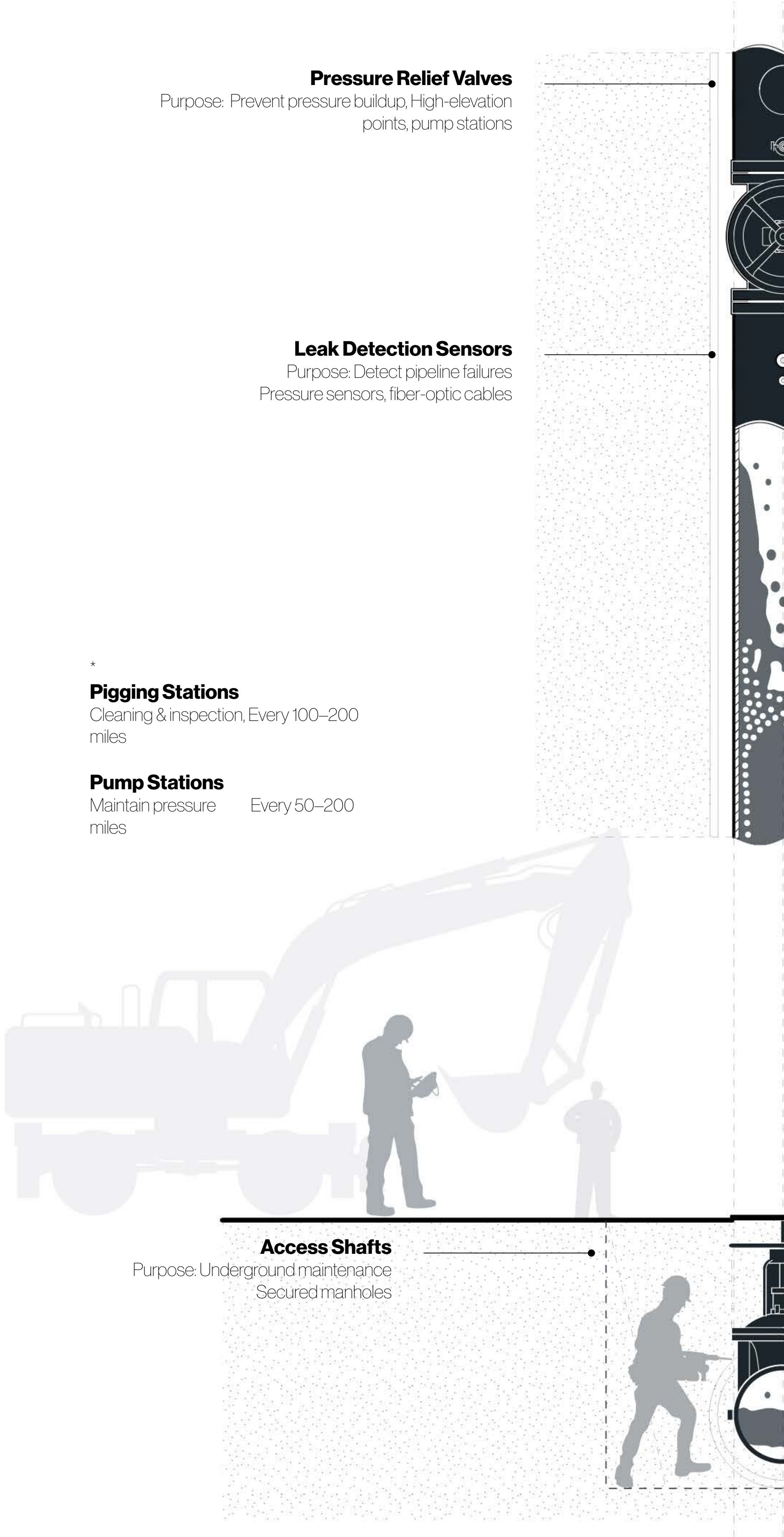
1.5 c: Oil fields in southern California. Getty Images/Forest Of Derricks

1.5 d: The Big Inch and Little Big Inch were two pipelines laid during World War II from East Texas to the northeast states. Photo: Enbridge_ History in the making: A walk through Enbridge's past, present and future

1.5 e: Oil leaks from beneath Platform A at Santa Barbara OIl rig. Photo: Los Angeles Times.

1.5 f: The Deeptwater Horizon drilling platform after the initial explosion on April 20, 2010. Courtesy of USCG

1.5 g: Blizzard conditions at the Standing Rock Sioux reservation, where activists have been opposing the pipeline for almost a year. Photo: Scott Olson/Getty Images



Pressure Relief Valves
Purpose: Prevent pressure buildup, High-elevation points, pump stations

Leak Detection Sensors
Purpose: Detect pipeline failures
Pressure sensors, fiber-optic cables

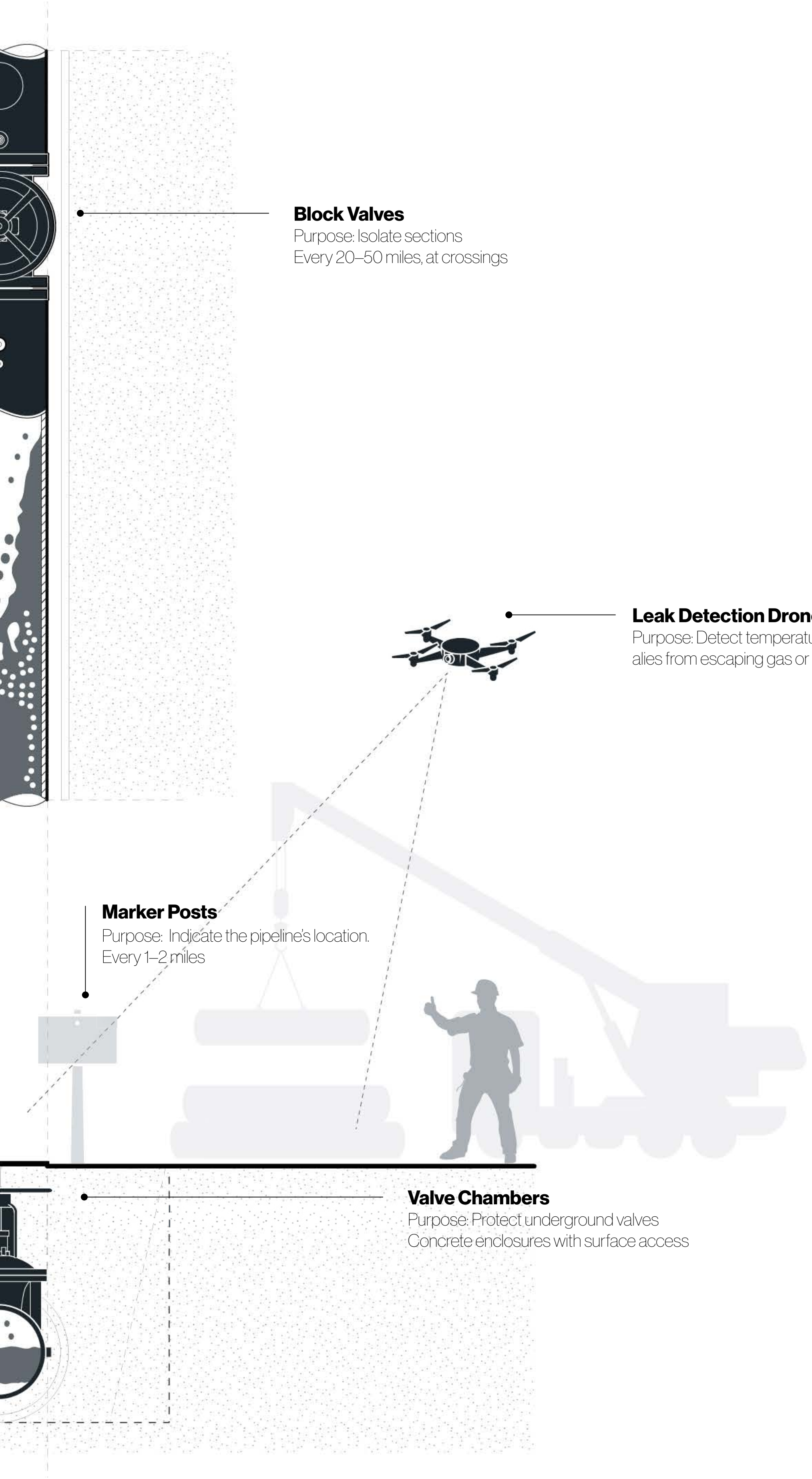
*

Pigging Stations
Cleaning & inspection, Every 100–200 miles

Pump Stations
Maintain pressure Every 50–200 miles

Access Shafts
Purpose: Underground maintenance
Secured manholes

Fig. 1.6 _ Anatomy of the Pipeline System
A cross-sectional diagram showing the technical components of pipeline infrastructure—including block valves, pressure relief systems, smart pigging stations, drones, and access shafts. This diagram reveals the hidden complexity of systems designed for high efficiency and low public visibility.



Block Valves
Purpose: Isolate sections
Every 20–50 miles, at crossings

Leak Detection Drones
Purpose: Detect temperature anomalies from escaping gas or oil.

Marker Posts
Purpose: Indicate the pipeline's location.
Every 1–2 miles

Valve Chambers
Purpose: Protect underground valves
Concrete enclosures with surface access

reuse or removal.

At stake is not only environmental integrity, but financial foresight. The cost of inaction—or of assuming that market forces alone will resolve the energy transition—is already becoming visible. If dismantling or repurposing is not planned for proactively, communities will be left managing the fallout of decaying infrastructure.

The Fossil Lock-In

Despite growing urgency around decarbonization, oil pipeline systems persist not simply because of demand, but because of a complex entanglement of forces that reproduce fossil fuel infrastructure. These forces are not singular, but interdependent—composed of political, economic, institutional, technological, cultural, and market-based barriers. **(Fig. 1.8)** Together, they form what scholars like Timothy Mitchell call a hydraulic lock-in: a system designed not only to transport fuel, but to distribute political and financial power in ways that make alternatives difficult to imagine, let alone implement.

Political and institutional barriers include the policy lag inherent in regulatory systems built to support fossil expansion. Pipelines are entangled in long-standing governance structures—national security doctrines, land use law, eminent domain—that make them strategically and symbolically resilient. As Mitchell has written in Carbon Democracy[7], oil infrastructures deliberately displace political vulnerability: “The technical characteristics of oil helped to insulate the networks of energy production from democratic pressures” In the U.S., fossil infrastructure is often framed as a patriotic necessity, not a discretionary choice. The influence of powerful lobbies, pro-fossil energy platforms, and campaign financing only compounds this inertia.

Economic and financial barriers are equally structural. Pipelines are multi-billion dollar investments expected to yield returns over decades. Their construction is justified by long-term contracts and often subsidized through favorable tax regimes, insurance structures, and federal loan guarantees. Fossil fuel assets are deeply embedded in pension portfolios, sovereign wealth funds, and inflation hedges. As Matthew Huber argues,

> **“Oil is not just a commodity; it is a social relation—a ‘class project’ that naturalizes capitalist forms of energy consumption.”**[8]

—one that aligns capitalist interests with working-class job dependency through the ideology of affordable energy and national growth. Any proposed transformation must confront this deeply seated economic logic, where stranded infrastructure represents not just material waste but symbolic loss.

Technological and infrastructural lock-in reinforces this entrenchment. Pipelines are not isolated assets but nodes in a tightly interdependent system that includes refineries, ports, terminals, and petrochemical clusters. These systems are built to operate at massive, optimized scales that resist downscaling. As Gavin Bridge notes, a resource “necessarily ‘becomes’ rather than ‘is,’ as it requires a large technical system of exploration,

---

[7] Timothy Mitchell, Carbon Democracy: Political Power in the Age of Oil (London: Verso, 2011), 39.

[8] Matthew T. Huber, Lifeblood: Oil, Freedom, and the Forces of Capital (Minneapolis: University of Minnesota Press, 2013), 5,13.

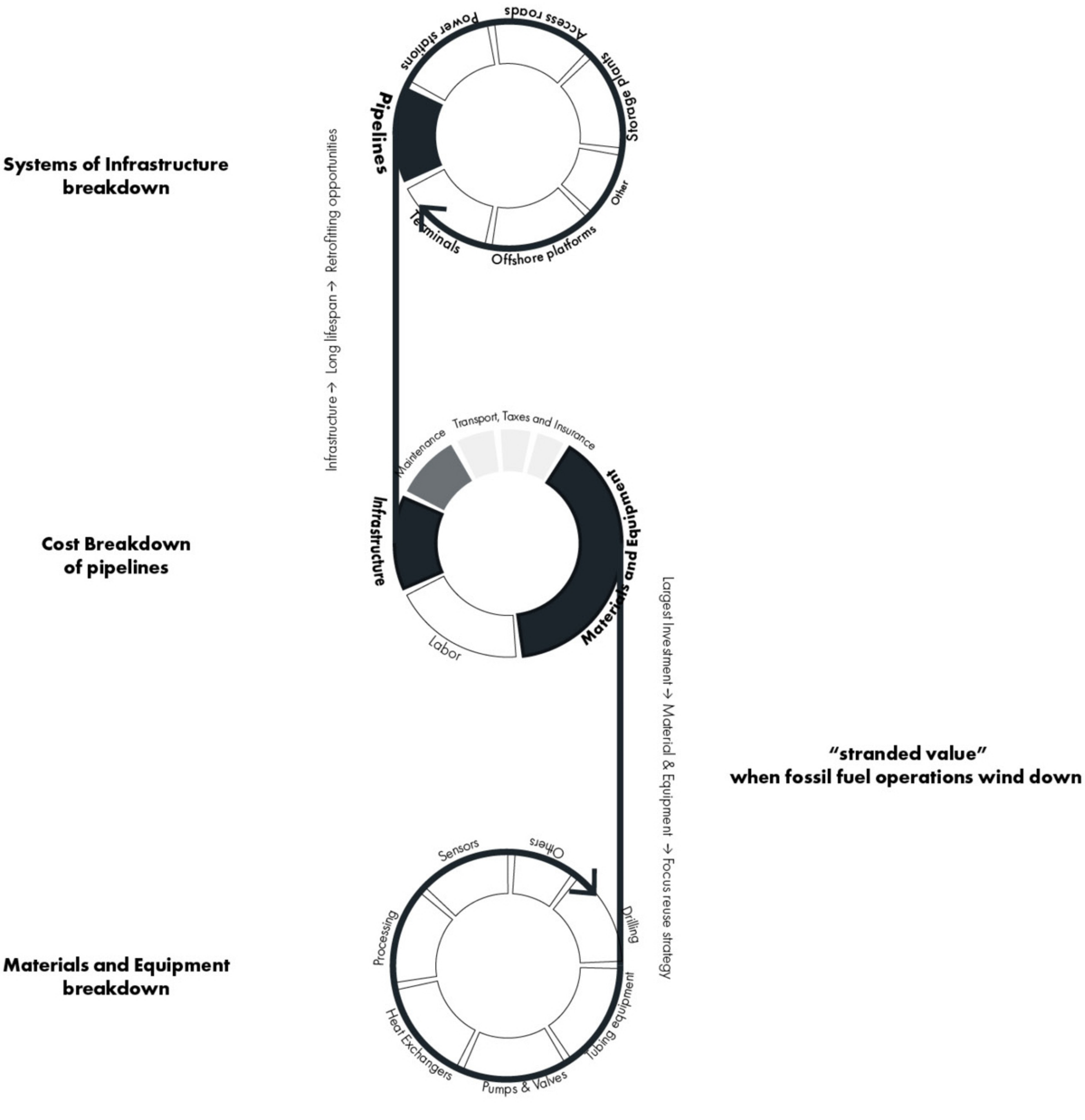


Fig. 1.7 _Stranded Value and Pipeline Lifespan

Charts showing the cost breakdown, infrastructural components, and degradation timelines of pipeline systems. As fossil fuel operations wind down, these systems risk becoming stranded assets with no clear plan for reuse or removal.

Date source: Crude Oil Procurement Intelligence Report, 2023 - 2030 (Revenue Forecast, Supplier Ranking & Matrix, Emerging Technologies, Pricing Models, Cost Structure, Engagement & Operating Model, Competitive Landscape) production, distribution, and financial exchange."[9] Fossil infrastructure does not merely serve the flow of energy—it constructs the territorial, economic, and institutional architecture through which that flow is governed. Their longevity—physical and regulatory—means they outlive policy cycles, shifting public opinion, and even market logic. Their very permanence becomes a political strategy.

Cultural and social barriers are often underestimated but deeply powerful. In extractive regions, pipelines are woven into cultural narratives of labor, pride, masculinity, and freedom. Whole communities are structured around their presence—not only economically but emotionally. Pipeline work, from welding to inspection to trucking, offers a sense of purpose and identity, particularly in areas where other employment is precarious. The fossil industry has also mastered the construction of "energy common sense," shaping public perception through messaging about affordability, national security, and job creation. As Huber notes, "The car, suburban house, and consumer lifestyle are lived, felt, and experienced as personal freedom…" [6] It is not just infrastructure; it is lifestyle.

Market and transition challenges further complicate matters. Reuse of existing infrastructure—such as repurposing pipelines for hydrogen, CO_2, or district heating—faces significant financial uncertainty.[10] There are few legal or financial precedents for adaptive infrastructure, and little incentive in current investment structures to value long-term ecological returns over short-term profit. Without regulatory mandates or state-backed guarantees, the risk profile of infrastructure reuse remains high. This favors business-as-usual investments, further delaying decarbonization.

Together, these five dimensions create a multi-scalar lock-in that goes beyond technicality. They form a kind of systemic inertia—an infrastructural imagination gap—in which the fossil network is seen as too big, too important, or too complicated to change. In this context, the role of design is not to naively assume transformation is inevitable, but to intervene in these very layers of resistance. Design must expose, reframe, and reconfigure—not only material systems, but the narratives, norms, and institutional structures that sustain them.

The pipeline, then, is not merely a buried conduit. It is a channel through which power, value, labor, and identity flow. To transform it is to confront not just the steel in the ground, but the systems that keep it there. And this begins by making those systems visible—spatially, historically, politically.

Pipelines as Political Architecture

In 2017, Donald Trump's first term began with a promise to revive the American fossil fuel industry—fast-tracking pipeline approvals, rolling back environmental protections, and declaring oil and gas infrastructure the backbone of national security. By 2025, despite years of climate

---

[9] Gavin Bridge, "The Hole World: Scales and Spaces of Extraction," in New Geographies 2: Landscapes of Energy, ed. Rania Ghosn (Cambridge, MA: Harvard University Graduate School of Design, 2009), 43–48.

[10] Stantec. "Repurposing Pipelines for the Energy Transition." Stantec, accessed February 13, 2025. https://www.stantec.com/en/ideas/topic/stantec-era/repurposing-pipelines-for-energy-transition.

agreements and decarbonization pledges, his rhetoric remains unchanged. Once again, he has vowed to expand drilling, fracking, and pipeline development—signaling the persistence of fossil fuel dependency, economic inertia, and political resistance to climate adaptation.

> **“We will drill, we will frack, we will build pipelines, and we will make America energy dominant again!”**
> —Donald Trump, 2025 statement on U.S. energy policy

The persistence of pipeline networks, even in the face of decarbonization, suggests that these infrastructures have already transitioned from purely material artifacts into spatial-political constructs. Their legal, financial, and territorial implications make them resistant to removal—thus positioning them as sites where power, land use, and environmental policy collide. Instead of treating pipelines as isolated industrial relics, this thesis considers them as part of a larger urban metabolism, where infrastructural reuse can challenge entrenched economic paradigms and introduce new territorial imaginaries. These infrastructures are not just conduits of energy, but key agents of territorial formation—and their transformation necessitates a systemic, rather than piecemeal, approach.

This moment presents a paradox. If pipelines continue to dominate the political and economic landscape, what happens when the fossil fuel era ends? Should they be dismantled, left as abandoned scars across the land? Or could they serve an entirely different role, repurposed as tools for regeneration rather than extraction?

Pipelines are not just industrial relics—they are spatial systems embedded in landscapes, economies, and ecological networks. While pro-carbon advocates see them as symbols of energy dominance, this thesis argues that they hold latent potential for transformation—as corridors for climate adaptation, ecological restoration, and new forms of post-extraction infrastructure.

The goal of this research is not just to critique the politics of pipelines but to propose concrete, design-based strategies for their adaptive reuse. Instead of reinforcing outdated fossil networks, this thesis explores how pipelines could be reimagined as tools of regeneration rather than extraction.

Political & Institutional Barriers

Policy and Governance Challenges

- Strong Fossil Fuel Lobbying
- Regulatory Complexity & Legal Uncertainty
- Strategic National Interests
- Slow Policy Adaptation

Technologic Infrastructu

Structural Challeng

- Technical Inert
- Interdependen Energy Grids
- Hazards & Cor
- Geographical

Economic & Financial Barriers

Dependence on Oil Revenues

- Sunken Costs & Infrastructure Lock-in
- Global Oil Market Dominance & Petro-State Economies
- Fossil Fuel Subsidies & Financial Incentives
- Oil as a Hedge Against Inflation & Financial Speculation

Fig. 1.8 _ Forces of Inertia: The Lock-In of Fossil Infrastructure
An illustrated breakdown of the systemic barriers to pipeline transition. Political, economic, technical, cultural, and market forces create a multidimensional lock-in, making the fossil network resistant to change despite climate imperatives.

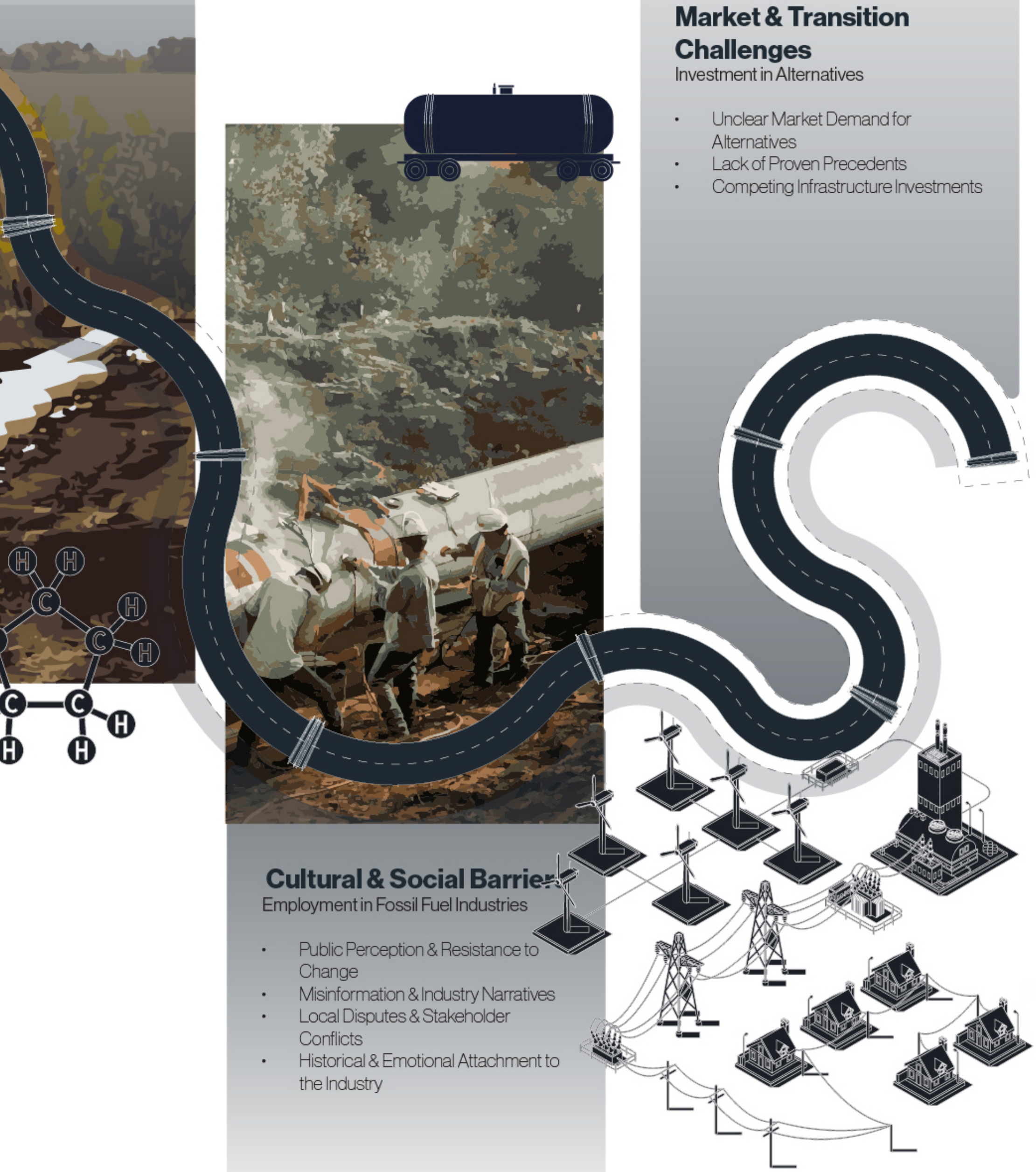
cal &
ural Lock-in
es

ia
cies with Existing

tamination Issues
Constraints

Market & Transition Challenges
Investment in Alternatives

- Unclear Market Demand for Alternatives
- Lack of Proven Precedents
- Competing Infrastructure Investments



Cultural & Social Barriers
Employment in Fossil Fuel Industries

- Public Perception & Resistance to Change
- Misinformation & Industry Narratives
- Local Disputes & Stakeholder Conflicts
- Historical & Emotional Attachment to the Industry

02 The Pipeline Paradox

Power, Crisis and Connection

The Pipeline Paradox

Infrastructures that Organize Territory

Pipelines are not passive conduits—they are instruments that reshape territory. Rather than simply transporting oil, they carve through forests, wetlands, croplands, and urban settlements, inscribing extractive logics into both land and law. With more than three million miles of active lines, the United States possesses the densest and most expansive pipeline network in the world. This system manifests in multiple forms: some pipes are buried beneath farmland, others run exposed above ground, some are elevated on stilts across permafrost, while others dive beneath rivers and seabeds **(Fig. 2.1)**.

These configurations are not just engineering choices—they are spatial responses, allowing the network to remain uninterrupted as it threads across shifting ecologies, jurisdictions, and climate zones. That adaptability reinforces a deeper invisibility: pipelines are often hidden in plain sight, yet their influence on land is anything but subtle. These forms enable the pipeline system to extend seamlessly across ecologies and jurisdictions—mountains, permafrost, wetlands, and coastal zones—without requiring sustained public scrutiny.[4]

As Rania Ghosn notes, the spatial abstraction of energy infrastructures "severs the continuity between crude geographies and the refined world," displacing environmental consequences to peripheral territories.[1] Furthermore, Keller Easterling's conception of "infrastructure space" as a form of soft governance further underscores how these systems encode power, not through architecture alone, but through

the spatial operating systems they establish. A spatial system that governs without spectacle, regulating land through codes, easements, and right-of-way.[2]

Transmission pipelines stretch for thousands of miles under extreme pressure, with diameters reaching up to 42 inches.[4] From these arterial lines, smaller gathering and distribution pipes extend into industrial zones, power plants, and neighborhoods—embedding the energy system into the granular fabric of everyday life.[3] These distinctions are not merely technical; they reflect a spatial logic of control. Pipelines do not just serve markets—they shape territories. The pipeline, in this light, is a mechanism that governs space through circulation, invisibility, and enclosure. Its presence organizes land ownership, dictates permissible uses, and constructs a legal corridor that suspends the norms of the surface. While much of this infrastructure remains buried, its impacts—ecological, social, territorial—are deeply inscribed into the landscape.

The Space Between

Every pipeline corridor comes with a right-of-way—an enforced strip of land, often 15 to 60 meters wide, that guarantees operators access for construction, inspection, and emergency repair.[4] **(Fig. 2.2)** But this designation is not just functional;

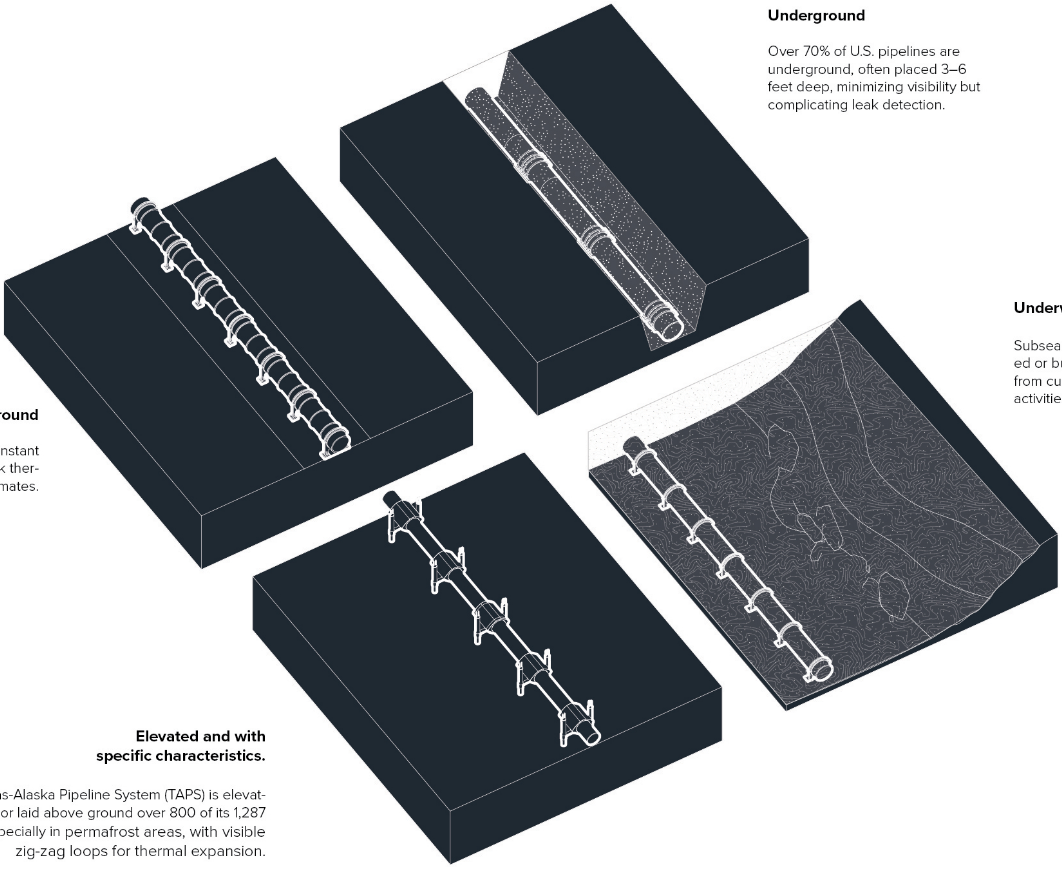
---

[1] Rania Ghosn, "Where Are the Missing Spaces? The Geography of Some Uncommon Interests," New Geographies 2: Landscapes of Energy (Cambridge, MA: Harvard Graduate School of Design, 2010), 110.

[2] Keller Easterling, Extrastatecraft: The Power of Infrastructure Space (London: Verso, 2014), 15–36.

[3] Transportation Research Board, Transmission Pipelines and Land Use: A Risk-Informed Approach (Washington, D.C.: National Academies Press, 2004).

[4] E. Shashi Menon, Pipeline Planning and Construction Field Manual (Waltham, MA: Gulf



Underground

Over 70% of U.S. pipelines are underground, often placed 3–6 feet deep, minimizing visibility but complicating leak detection.

Underwater

Subsea pipelines must be ballasted or buried to avoid damage from currents, anchors, or fishing activities.

Aboveground

Above-ground pipelines require constant exposure monitoring and often lack thermal insulation unless in extreme climates.

Elevated and with specific characteristics.

The Trans-Alaska Pipeline System (TAPS) is elevated or laid above ground over 800 of its 1,287 km, especially in permafrost areas, with visible zig-zag loops for thermal expansion.

- **prevent melting permafrost and**
- **allow wildlife to pass underneath**

Fig. 2.1 _ Typologies of Pipeline Construction
Diagrams illustrating four main construction types across U.S. pipelines: underground, aboveground, elevated (with thermal expansion allowances), and underwater. These configurations reflect adaptive responses to terrain, climate, and maintenance constraints, shaping visibility and ecological impact.

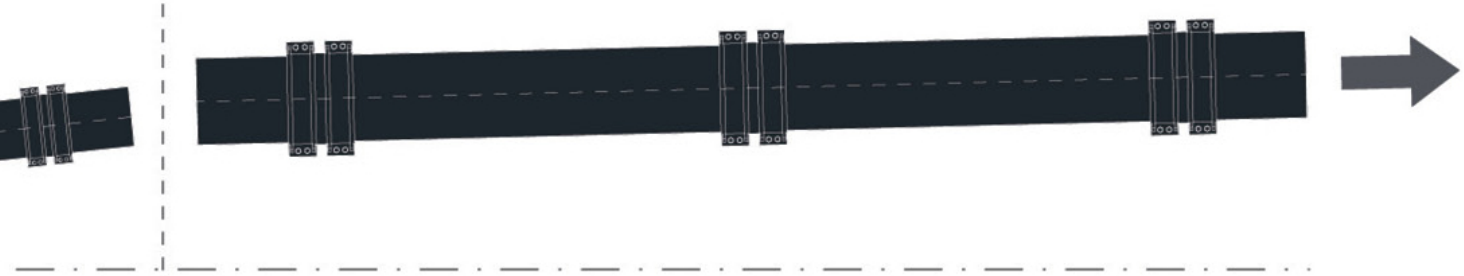
Total mileage: over 86,000 kilometers of crude oil pipelines as of 2024

Fig. 2.2 _ Legal Mechanisms and Pipeline Right-of-Way
Diagram of right-of-way (RoW) designations for four categories of pipelines—from gathering lines to high-capacity transmission systems. Rights-of-way span 15 to 60 meters and govern access, development limitations, and jurisdictional control over the surrounding land.

Major Pipelines (High-Capacity Transmission Lines)

Function: International crude oil transport from major production zones.:

Trans-Alaska Pipeline – 48 inches (122 cm)



Length: Over 3,000 miles (4,800 km)
Diameter: 48 inches
(120 cm) and above

it is territorial. Rights-of-way impose long-term spatial restrictions, overriding existing land uses and fragmenting the continuity of ecological systems, farms, and even communities. In forests, they clear swaths through tree cover; in wetlands, they interrupt hydrological flows; in agricultural lands, they dissect fields and hinder planting. These corridors produce a strange condition: neither public nor truly private, they are governed by legal arrangements that prioritize infrastructural access while constraining most other uses. Over time, the right-of-way becomes not only a physical scar, but a regulatory zone—where land is governed differently, monitored remotely, and subordinated to the uninterrupted flow of energy. As Gavin Bridge argues, global extractive systems transform land into logistical space—engineered to facilitate production, regardless of ecological or social consequence.[5]

Systems That Fail as Designed

Despite their structural endurance, pipelines are failing. Since 2010, more than 5,500 failures have been reported in the U.S. alone, leading to the release of millions of gallons of crude oil and hazardous liquids into rivers, wetlands, aquifers, and croplands **(Fig. 2.4)**. These are not exceptional moments of breakdown; they are systemic.[6]

Corrosion is the dominant cause. It can occur both internally, from sediment and chemical residues inside the pipe, and externally, from waterlogged or acidic soils. Corrosion weakens steel over time, especially in older pipelines built before protective coatings were mandated.[7] The Keystone Pipeline's 2022 rupture—resulting in a spill of 14,000 barrels—shows how delayed maintenance and material fatigue intersect.[8]

When failure occurs, the consequences unfold spatially. Crude oil does not remain at the rupture point; it seeps into soil, spreads through groundwater, and migrates with rainfall **(Fig. 2.5)**. Contamination travels across terrains—forest, farmland, wetland—and through systems—storm drains, irrigation lines, aquifers. It disrupts root systems, microbial communities, and food webs. In populated areas, it can compromise drinking water and public health.

The infrastructural decay is amplified by regulatory

Professional Publishing, 2011).

[5] Gavin Bridge, "Global Production Networks and the Extractive Sector: Governing Resource-Based Development," Journal of Economic Geography 8, no. 3 (2008): 389–419.

[6] Pipeline and Hazardous Materials Safety Administration (PHMSA), accessed March 5, https://www.phmsa.dot.gov/news/phmsas-proposed-pipeline-penalties-hit-all-time-high-serious-pipeline-incident-count-hits-all-0

Statista Research Department. "Most Common Causes of Oil Pipeline Incidents in the United States from 2010 to 2022." Statista, June 2023. https://www.statista.com/statistics/1271803/most-common-us-oil-pipeline-incident-causes/.

[7] Pipeline and Hazardous Materials Safety Administration (PHMSA). "Pipeline Failure Causes." U.S. Department of Transportation, accessed May 13, 2025. https://www.phmsa.dot.gov/incident-reporting/accident-investigation-division/pipeline-failure-causes.

[8] Reuters Staff. "Keystone Pipeline Shut After 14,000-Barrel Oil Spill in Kansas." Reuters, December 8, 2022. https://www.reuters.com/business/energy/keystone-pipeline-shut-after-oil-spill-into-kansas-creek-2022-12-08/.

Fig. 2.3 _ Leak at the Keystone pipeline operated by TC Energy in rural Washington county, Kansas. A satellite image shows emergency crews working to clean up a crude oil spill along Mill Creek in Washington county, Kansas. Photo: Maxar Technologies/Reuters

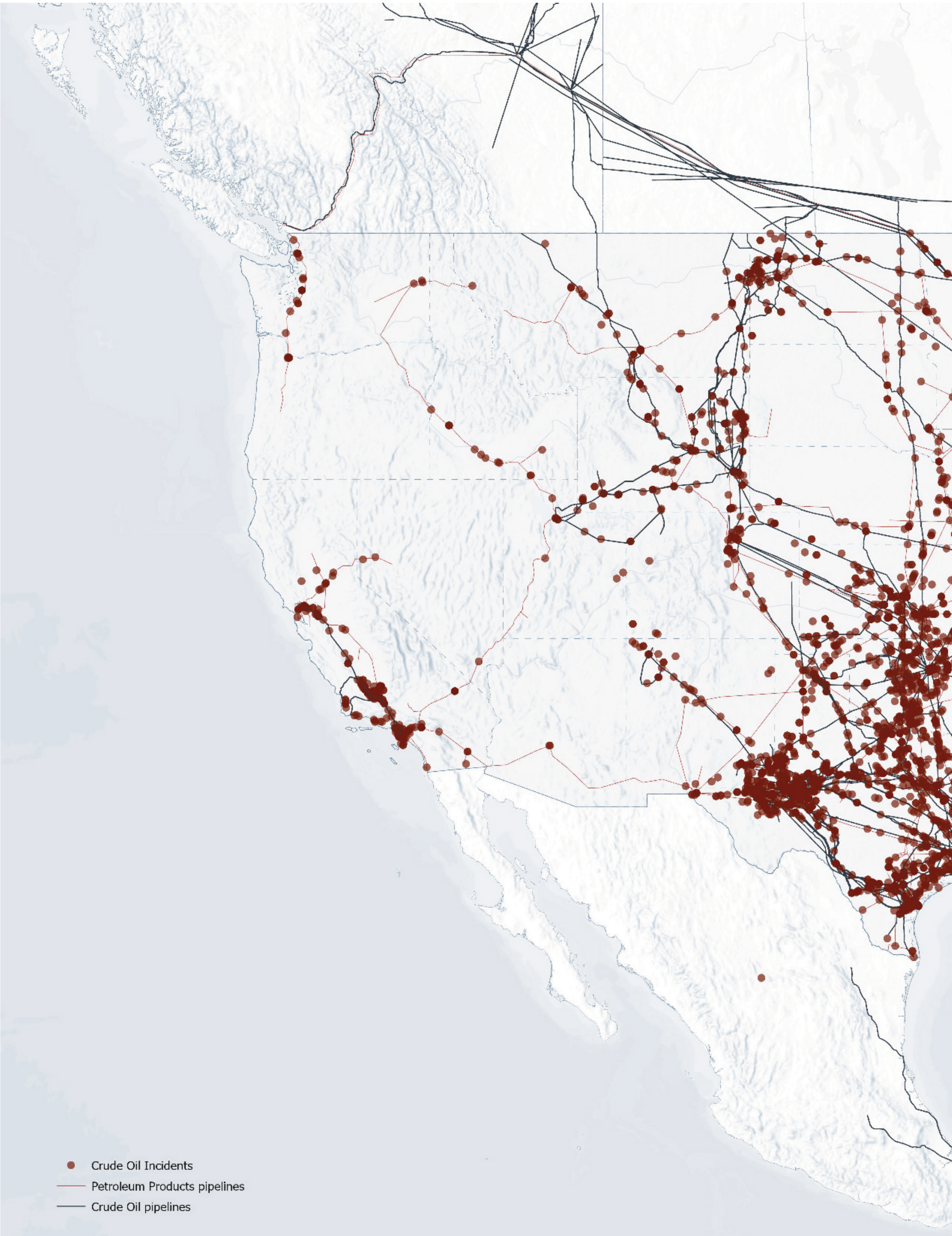


Fig. 2.4 _ Crude Oil Incidents Across the United States (2002–2022)

Map of significant crude oil pipeline incidents over two decades, showing spatial correlation with network density and infrastructure age. The accompanying breakdown highlights corrosion as the leading cause of failure, underscoring systemic maintenance vulnerabilities. Source: PHMSA.

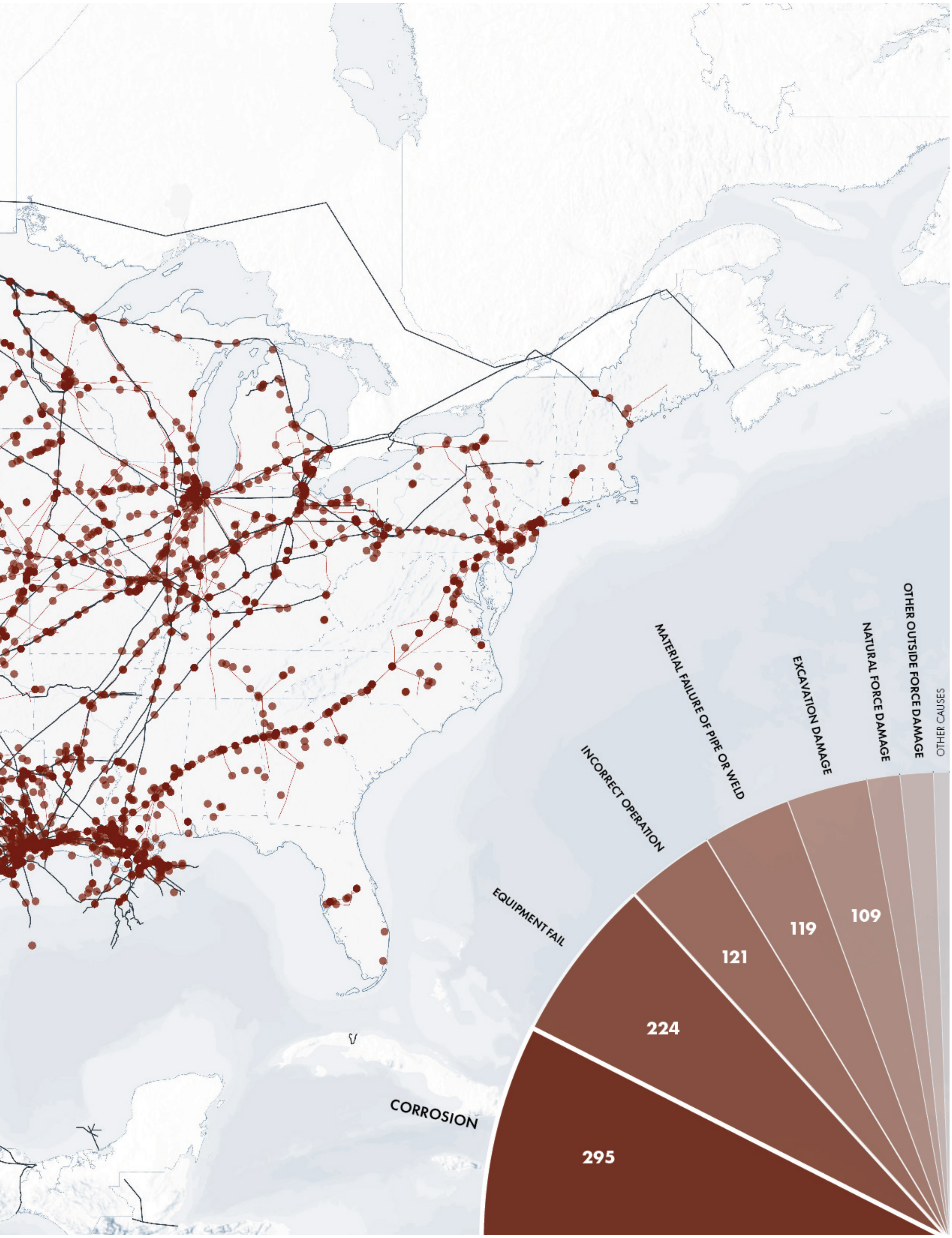
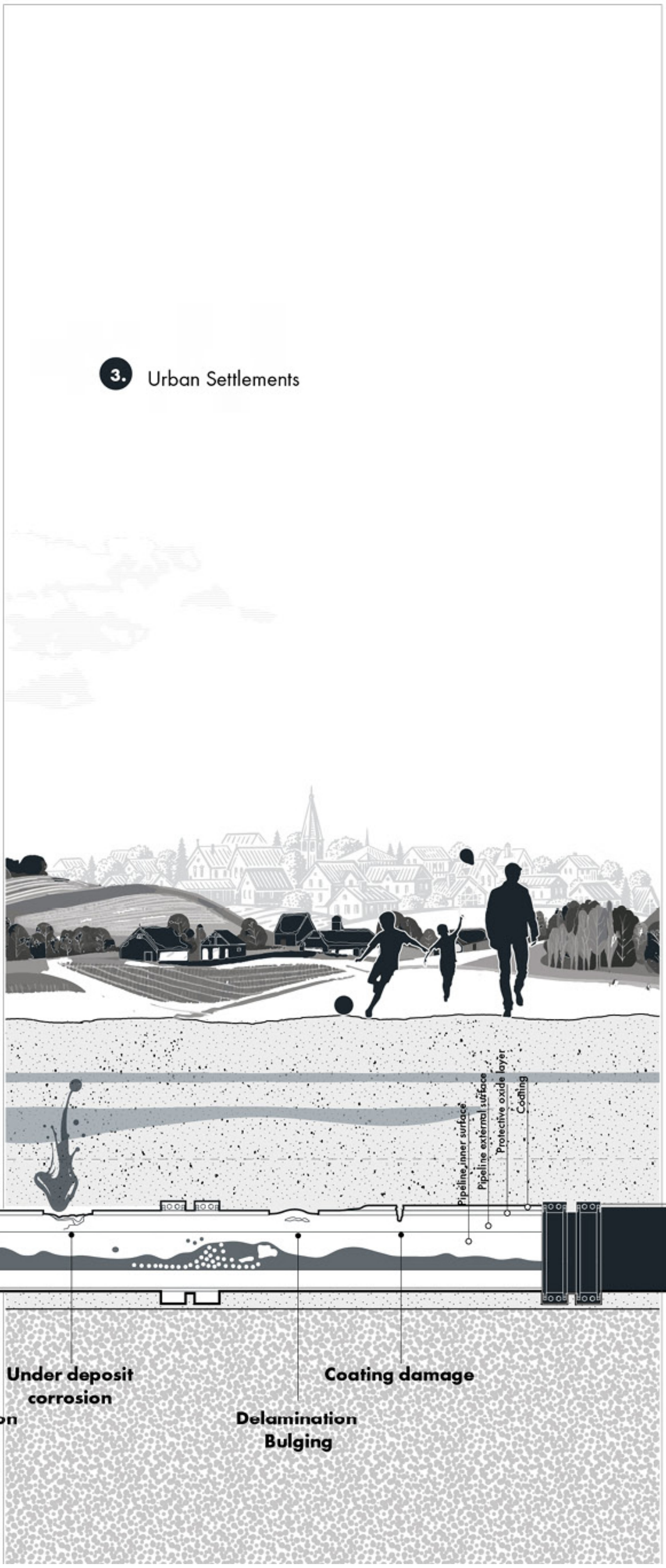

CORROSION
295
EQUIPMENT FAIL
224
INCORRECT OPERATION
121
MATERIAL FAILURE OF PIPE OR WELD
119
EXCAVATION DAMAGE
109
NATURAL FORCE DAMAGE
OTHER OUTSIDE FORCE DAMAGE
OTHER CAUSES

Fig. 2.5 _ Environmental Interfaces and Corrosion Patterns
Sectional illustrations showing how pipelines intersect with wetlands, croplands, urban settlements, and transportation corridors. Each typology reveals distinct vulnerability to external and internal corrosion processes—from pitting and coating failure to microbial degradation and delamination.



3. Urban Settlements

4. Infrastructure

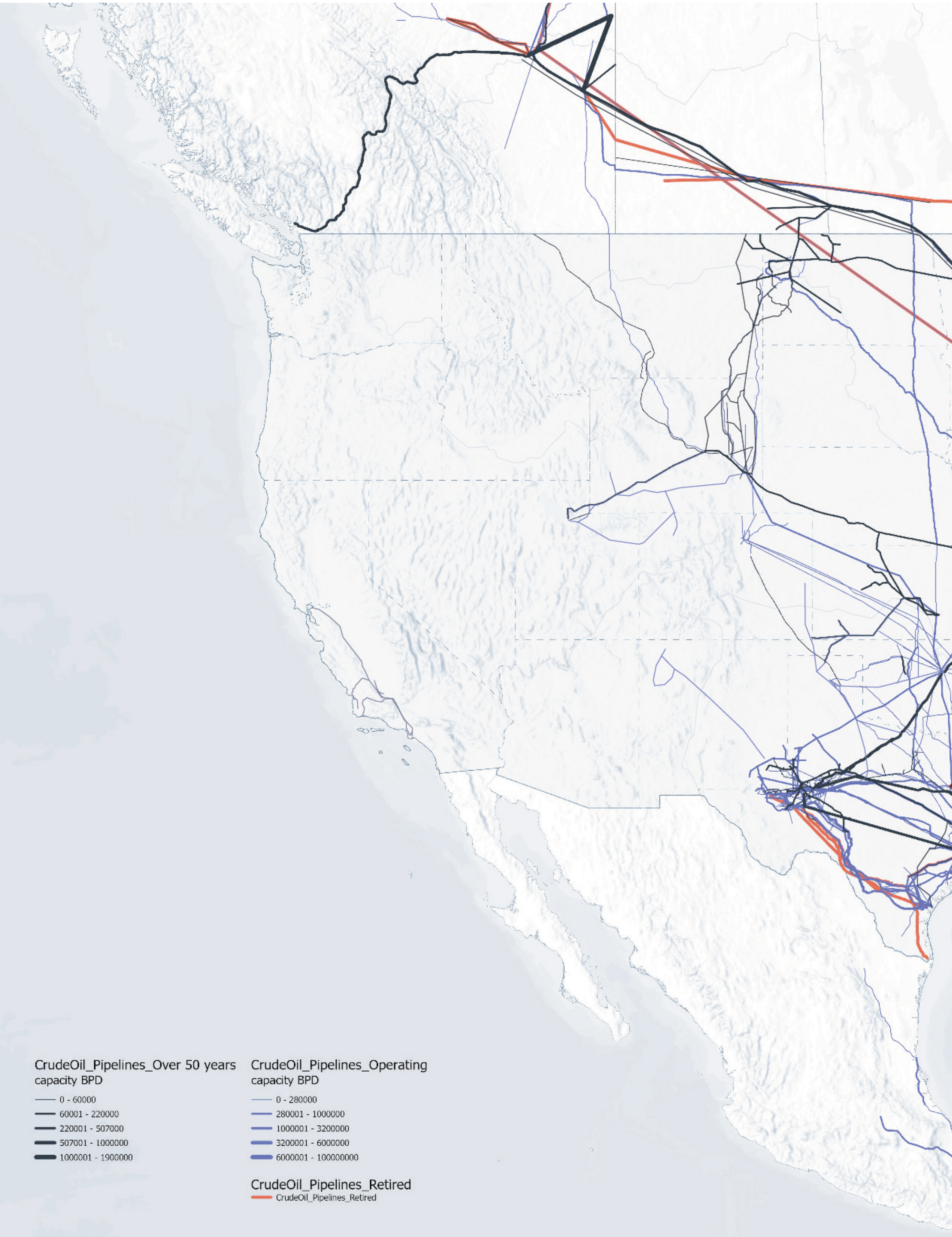
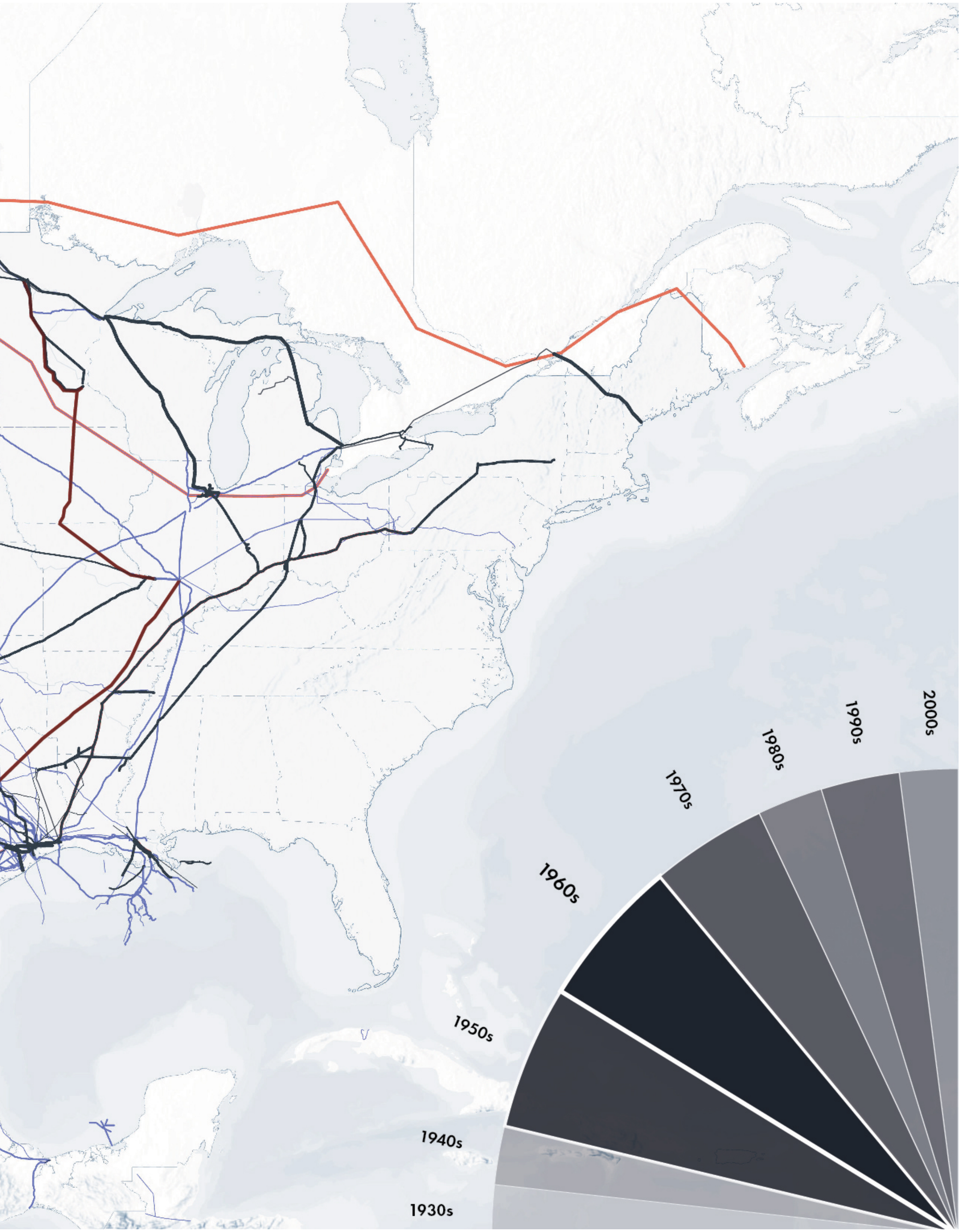


Fig. 2.6 _ Age and Capacity of U.S. Crude Oil Pipelines

Mapping the operational and retired pipeline network, this figure categorizes systems by capacity and age. Over 30% of the U.S. pipeline network is more than 50 years old, highlighting the critical infrastructure challenge facing the energy transition. Source: Statista, PHMSA, and Global Energy Monitor.


2000s
1990s
1980s
1970s
1960s
1950s
1940s
1930s

inertia. Many pipelines are over 50 years old, operating well beyond their intended lifespan **(Fig. 2.6)**.[9] Yet replacement is rare, in part due to cost, and in part due to the legal and economic protections extended to pipeline companies.[10] The result is a system that privileges continuity over care—where flow is preserved until rupture forces response.

Ecologies of Contamination

What emerges from these failures is not only environmental degradation but ecological fragmentation. A rupture is not simply a leak—it is a spatial event that produces a cascade of effects. In a wetland, it might suffocate benthic life and collapse oxygen cycles. In cropland, it might destroy yield for years. In forests, it may alter understory growth or block animal movement.

These effects are not evenly distributed. Low-income communities, Indigenous territories, and rural areas are often located along pipeline routes but receive none of the energy's benefits. They inherit the risk but lack the power to contest it. This asymmetry—between energy consumed and risk imposed—makes pipelines key actors in environmental injustice.

The geometry of the pipeline system reinforces this. Its right-of-way fragments habitats, prevents migration, and exposes wildlife corridors to spill risks. From an ecological standpoint, the pipeline is not a line—it is a field of disturbance. Its spatial effects radiate outward, amplified by wind, water, and soil movement.

The Paradox of Permanence

Yet, paradoxically, the very linearity that causes harm may offer a basis for repair. As decommissioning begins—driven by declining fossil demand, stranded assets, and environmental regulation—these corridors are becoming spatial vacancies in need of redefinition.

Unlike other infrastructures, pipelines already possess legal continuity, territorial reach, and institutional presence. This gives them an unusual potential as platforms for transformation. They can support rewilding, carbon sinks, urban greenways, or decentralized energy networks. In urban areas, they could be converted into linear parks, pedestrian and bike trails, or cooling corridors planted with dense vegetation. In rural and coastal areas, they could become flood buffers, pollinator habitats, or reforested migration paths. Designing for this reuse requires more than technical feasibility—it requires political imagination. As Erik Swyngedouw argues, infrastructures are not neutral technologies but components of hybrid urban metabolisms, co-produced by political, ecological, and technological forces.[11] To reimagine them is to

---

[9] Statista Research Department. "Length of Oil Pipelines in North America as of September 2022, by Status." Statista, September 2022. https://www.statista.com/statistics/1135198/north-america-oil-pipelines-by-status/.

[10] Pipeline and Hazardous Materials Safety Administration (PHMSA). "Pipeline Safety: Safety of Gas Distribution Pipelines and Other Pipeline Safety Initiatives." Federal Register 88, no. 172 (September 7, 2023): 61568–61613. https://www.federalregister.gov/documents/2023/09/07/2023-18585/pipeline-safety-safety-of-gas-distribution-pipelines-and-other-pipeline-safety-initiatives.

[11] Erik Swyngedouw, "The City as a Hybrid: On Nature, Society, and Cyborg Urbanization," Capitalism, Nature, Socialism 7, no. 2 (1996): 65–80; Erik Swyngedouw, "Circulations and Metabolisms: (Hybrid) Natures and (Cyborg) Cities," Science as Culture 15, no. 2 (2006): 105–121.

engage not only with spatial form, but with the systems of governance, equity, and metabolic circulation they sustain or disrupt. We must not only ask what the pipeline can become, but also what spatial, regulatory, and ecological tools are needed to enact that shift.

A Framework for Transition

To rethink the pipeline is to engage a systemic design problem. The challenge is not to erase infrastructure, but to recodify it. This means understanding pipelines as spatial legacies, as systems with embedded power, ecological consequence, and latent capacity.
In a post-carbon future, these corridors may no longer serve extraction. But they can still serve connection—between landscapes, species, infrastructures, and publics. This requires reclassifying them as part of the territorial commons, where design, policy, and community stewardship converge.

Infrastructures are not fixed—they are territorial processes. If pipelines have shaped the carbon economy by controlling land and flow, they can also shape decarbonization—by linking ecology, equity, and infrastructure.

The next chapter begins that task, proposing a loop—a speculative reconnection of aging pipelines into a system of repair. But before that, we must understand one thing: the paradox of the pipeline is not its failure. It is that what was built to last may yet be used to heal.

03 Threads of Repair

Power, Crisis and Connection

Threads of Repair

Rewriting the Pipeline: Documented and Emerging Models of Adaptive Reuse

As the fossil fuel era enters decline, a growing number of countries and institutions are exploring ways to repurpose oil and gas pipeline infrastructure rather than dismantle it outright. This shift reflects both material pragmatism and climate urgency. Pipelines—once single-purpose conduits of extraction—are increasingly seen as assets to be retrofitted for post-carbon use. The reuse of these systems is no longer speculative: it is happening, though unevenly, across the globe.

A primary focus has been the conversion of natural gas pipelines to carry hydrogen, especially in Europe. The European Hydrogen Backbone initiative, led by a consortium of gas transmission operators, has proposed converting over 69,000 kilometers of existing natural gas pipelines across 28 countries into hydrogen-ready infrastructure by 2040. Pilot projects are already underway in Germany and the Netherlands, where retrofitting gas lines for green hydrogen is seen as cost-effective—estimated at 60% cheaper than building new pipelines.[1]

Other reuse typologies focus on embedding new systems within existing pipeline corridors. In the United States, companies like Distributed Acoustic Sensing (DAS) providers have begun deploying fiber-optic monitoring systems inside pipeline rights-of-way, turning them into linear sensors capable of detecting leaks, seismic activity, and pressure anomalies. This effectively transforms the pipeline corridor into a data conduit, part of a growing interest in what some refer to as “smart infrastructure.”[2]

Beyond energy and sensing, several regions have tested geothermal heating networks that circulate fluids through retrofitted pipelines for district energy. In Reykjavík, Iceland, while not a reuse case per se, the city’s extensive geothermal distribution system illustrates how linear subterranean infrastructure can provide long-term, low-carbon thermal services.[3] In theory, decommissioned pipelines—especially insulated ones—can be adapted for similar purposes, particularly in northern U.S. cities.

Ecological reuse strategies have emerged in parallel. In Alberta, Canada, and parts of North Dakota, abandoned pipeline easements have been turned into linear ecological corridors, allowing wildlife movement across previously fragmented habitats.[4] In more urbanized settings, like Austin’s Walnut Creek Trail or the High Line in New York, the logic of linear reuse—though born from railways—has been adapted to pipeline corridors, particularly where surface access is available. These spaces become multi-use community assets, merging recreation, biodiversity, and climate adaptation.

More speculative applications include using pipelines as conduits for biogas transport, slurry-

---

[1] Guidehouse. European Hydrogen Backbone: Analysing future demand, supply, and transport of hydrogen. European Hydrogen Backbone Initiative, 2020. https://gasforclimate2050.eu

[2] Hartog, Hans et al. “Distributed Fiber-Optic Sensing for Pipeline Monitoring.” Journal of Pipeline Engineering 19, no. 4 (2020): 219–233.

[3] Tester, Jefferson W. et al. Sustainable Energy: Choosing Among Options, 3rd ed. MIT Press, 2020. See also: Reykjavík Energy, https://www.or.is/en.

[4] Government of Alberta. Linear Disturbance Restoration Guidelines, Alberta Environment and Parks, 2021. https://www.alberta.ca.

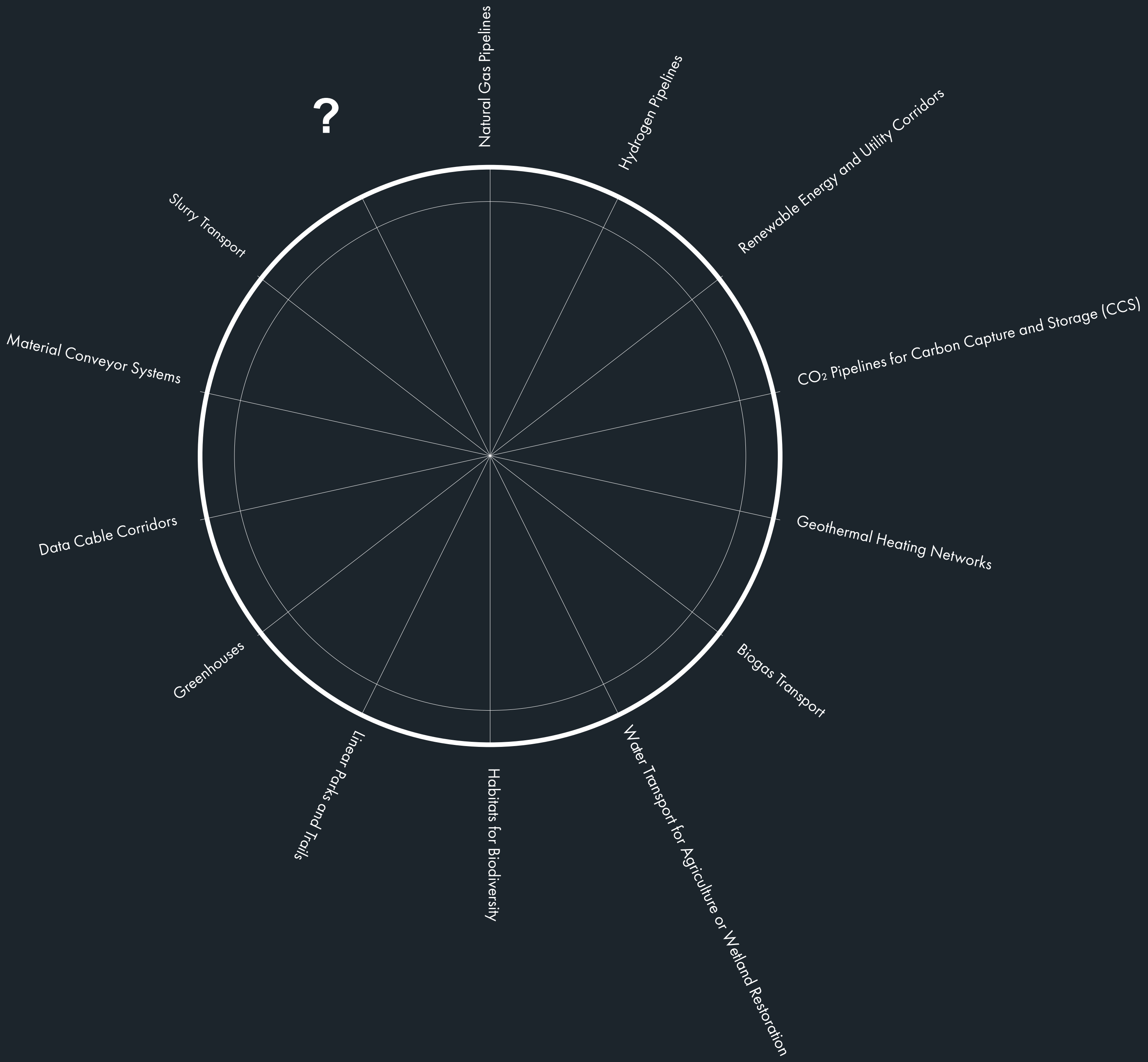


Fig. 3.1 _ Adaptive Reuse of pipelines
A typological inventory of adaptive reuse strategies for pipelines, ranging from implemented to speculative.

based material transfer, or even compressed air energy storage (CAES)—the latter being tested in pilot forms in Alabama and Texas.[5] Concepts like subterranean greenhouses or climate-controlled grow tunnels remain largely theoretical but could be proposed as viable uses for pipelines in colder climates or food-insecure regions.[6] These ideas, while less prevalent in the literature, suggest a latent potential for agro-ecological reuse embedded in infrastructure that spans both urban and rural territories.

The Loop as Scaffold

While many proposals for adaptive reuse focus on single decommissioned pipelines or localized segments, this thesis constructs a broader operative fiction—one that is spatially continuous and conceptually recursive. At its center is the Pipeline Loop: a territorial figure composed by linking segments of aging, abandoned, or inactive crude oil pipelines into a closed infrastructural circuit. Rather than isolate reuse to opportunistic parcels, the loop foregrounds systemic reuse at scale, situating pipeline adaptation within the metabolic, logistical, and ecological frameworks it historically disrupted.

The assembly of this loop began with a geospatial analysis of the U.S. crude oil and petroleum products pipeline network, using datasets from the U.S. Energy Information Administration (EIA), the Pipeline and Hazardous Materials Safety Administration (PHMSA), and national geodatabases. Segments were selected based on age (with a focus on pipelines exceeding 50 years in operation), status (abandoned or inactive), and proximity to other key infrastructures. Where necessary, gaps were filled using actively flowing segments identified as nearing the end of their life cycle—allowing the loop to complete a contiguous figure across multiple states.

The resulting loop traverses 14 U.S. states and interlinking regions with vastly different urban, ecological, and economic profiles.

This infrastructural geometry is not merely cartographic—it is strategic. By transforming a historically linear and extractive system into a circular and connective one, the loop inverts the pipeline's original logic: from unidirectional flow to recursive redistribution; from segmented utility to territorial scaffold. **(Fig.3.3)**

Surrounding this infrastructural spine is a buffer zone of 40 kilometers on either side—drawn to acknowledge the complex adjacency of the pipeline corridor. This transitional band operates both as a site of analysis and as a platform for future interventions. Within this zone lie not only physical overlaps—such as highways, railroads, and energy plants—but also socio-environmental thresholds: wetlands, croplands, Indigenous lands, and post-industrial towns shaped by the pipeline's past. By framing this zone as a field of action, the project moves beyond speculative drawing and into a multi-scalar model of design—where infrastructural reuse becomes a strategy of repair, redistribution, and reorientation.

The loop is thus neither a mere figment nor a fixed object. It is a methodological construct, one that enables testing of adaptive reuse strategies at the interface of systems—ecological, urban, and

---

[5] U.S. Department of Energy. Compressed Air Energy Storage (CAES) Demonstration Projects, 2021. https://energy.gov.

[6] Ali, Lorraine Weller. "From Food Desert to Crop Oasis: The Native American Community Growing Their Own Healthy Future." The Guardian, December 3, 2022. https://www.theguardian.com/environment/2022/dec/03/south-dakota-reservation-food-desert-residents-transforming-crop-oasis.

energetic. Just as the pipeline once synchronized extraction with circulation, the loop proposes to re-synchronize repair with redistribution, serving as a scaffold for the spatial, ecological, and political afterlives of oil.

By framing this loop as both a geographic zone and a design scaffold, the project claims a wide operational field. It allows for layered analysis, context-specific interventions, and an exploration of distributed transformation—moving from the infrastructural line to the systems and ecologies it touches.

Territorial Patterns: Urban Systems, Energy, Biodiversity, and Land Use

The pipeline loop cuts through a densely entangled geography—one shaped by overlapping systems of urban growth, energy infrastructure, ecological corridors, and agricultural production. Understanding this territorial matrix is essential not only to position reuse strategies but also to highlight the stakes of inaction. The loop does not traverse an empty corridor—it slices through some of the most infrastructurally and ecologically active land in the United States. The total length of the loop spans approximately 6,266 kilometers, making it longer than a U.S. coast-to-coast drive. At an average highway speed, it would take over 70 hours to traverse **(Fig. 3.6)**. Along this corridor lie over a dozen metropolitan areas with significant population density and legacy infrastructure tied to petrochemical economies. Cities such as Chicago (2.66 million residents), Indianapolis (0.88 million), Memphis (0.61 million), and Milwaukee (0.56 million) anchor the loop's territorial system.

Fig. 3.2 _ Suburban Devastation: The Mayflower Oil Spill, Arkansas (2013)
A ruptured ExxonMobil Pegasus Pipeline released over 200,000 gallons of diluted bitumen into a residential neighborhood in Mayflower, Arkansas. Crude oil flooded streets, driveways, and yards—turning a quiet cul-de-sac into a toxic zone. The incident underscores the proximity of aging pipeline infrastructure to inhabited spaces, revealing the catastrophic risks embedded within the everyday suburban landscape. Courtesy of KARK-TV

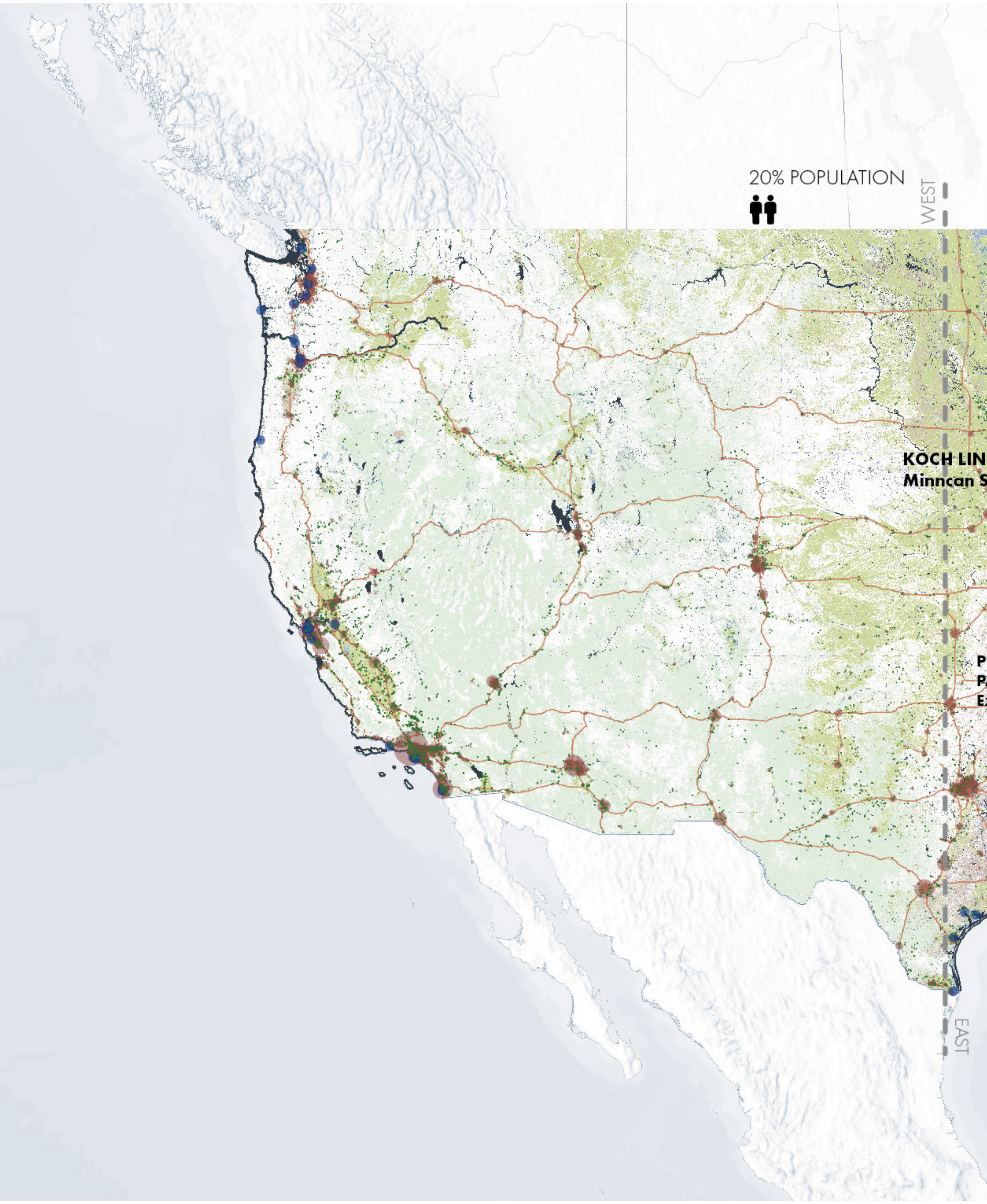
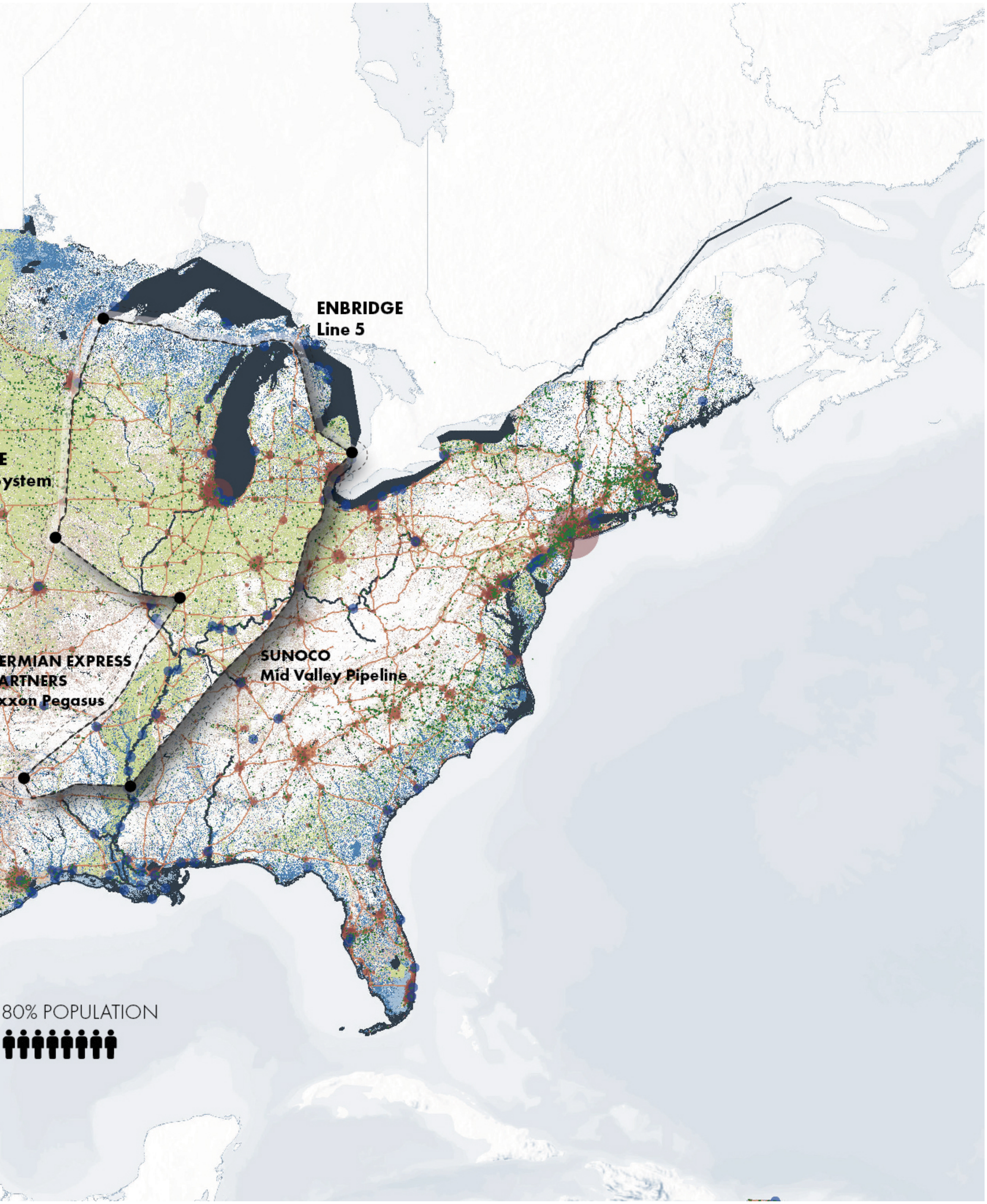


Fig. 3.3 _ The Pipeline Loop
The proposed loop is assembled by connecting aging and decommissioned crude oil pipeline segments. A 40 km buffer zone on either side defines the transitional territory for analysis and intervention across urban, rural, and ecological contexts.


ENBRIDGE
Line 5
E
ystem
ERMIAN EXPRESS
ARTNERS
xxon Pegasus
SUNOCO
Mid Valley Pipeline
80% POPULATION

Mid-sized urban nodes including Detroit, Toledo, Cincinnati, and St. Louis extend the reach of this urban network, many historically tied to oil refineries, port terminals, or heavy industry.

This urban footprint is tightly integrated with the national logistics system. Major highways crisscross the loop, connecting inland cities to oil shipping waterways such as the Mississippi, Ohio, and Illinois Rivers. These inland ports have historically served as gateways for crude oil transport between the Gulf Coast and the Midwest. The result is a deeply infrastructuralized terrain, one where mobility and energy systems have long reinforced regional urbanization.

Energy mapping within the loop reveals both opportunity and contradiction **(Fig. 3.7)**. Despite the presence of 38,525.8 megawatts of installed renewable energy—comprising 24,633.2 MW of wind, 9,860.6 MW of solar, and nearly 3,000 MW of hydro—the total annual energy demand within the loop is a staggering 713.7 terawatt-hours (TWh). A closer look at urban energy use reveals how skewed this balance is: Chicago alone consumes 32 TWh per year, with cities like Indianapolis (10.5 TWh), Memphis (7.4 TWh), and Milwaukee (6.7 TWh) following closely. If the loop were to be entirely retrofitted for wind energy using standard 2.4 MW turbines spaced every 0.84 km, it could host roughly 7,460 turbines, generating only ~54.89 TWh/year—meeting less than 8% of current demand.

Yet this imbalance also signals potential. The loop traverses multiple high-capacity wind corridors in Iowa, Missouri, and northern Illinois, as well as solar zones across Arkansas, Tennessee, and Kentucky. With strategic reinvestment and grid reconfiguration, the loop could act as an energy redistribution system—moving from centralized fossil generation to distributed renewables.

Overlaying the energy and urban systems is a dense ecological substrate **(Fig. 3.8)**. Three biodiversity corridors intersect the loop, each tied to a distinct biome. In the north, Corridor A follows the Northern Hardwood and Boreal Forests, encompassing wetlands, pine stands, and national forests such as Ottawa, Hiawatha, and Huron, along with the territory of the Forest County Potawatomi and Bad River communities. This corridor also includes critical wetlands and environmental areas surrounding the Great Lakes, particularly around Lake Michigan and Lake Superior, which serve as migratory habitats and freshwater ecological reserves. In the central zone, Corridor B aligns with the Interior Highlands, threading through the Ozark Plateau, Ouachita Mountains, and Arkansas Valley—regions of high resilience, fire-adapted vegetation, and carbon sequestration potential. To the south and east, Corridor C captures the Mississippi Valley Lowlands and the Appalachian Plateau, hosting mixed hardwood forests and some of the country's most significant alluvial floodplains.

Each of these corridors offers more than just ecological value—they represent opportunities for hydrological repair, wildlife reconnection, and carbon capture at landscape scale. The pipeline loop, long a vector of fragmentation, could now operate as a platform for territorial reconnection—an engineered route that begins to mend what it once divided.

Finally, the loop intersects some of the most productive agricultural land in the U.S. **(Fig. 3.9)**. Croplands dominate the Midwest portion, with corn, soybeans, wheat, cotton, rice, and specialty fruits and vegetables forming the agricultural base of states like Illinois, Indiana, and Ohio. The southern segment crosses expansive pasture systems—from cool- and warm-season grasslands to floodplain grazing areas—supporting cattle, dairy, sheep, goats, and horses. These lands are not only deeply embedded in the food economy but also play a key role in soil carbon sequestration and regional resilience.

Taken together, these overlapping layers—urban systems, energy infrastructures, biodiversity corridors, and productive landscapes—define the operational field of the loop. They underscore the impossibility of thinking about pipeline reuse in isolation. Any intervention must be multivalent and site-specific, capable of navigating between infrastructural, ecological, and social demands. The loop, rather than a fixed object, becomes a reading device—one that reveals how territory functions and how it might be rewired.

Evaluating Conditions, Scoring Potential, and Strategizing Repair

Having established the physical, ecological, and infrastructural conditions along the loop, the project turns to evaluation: how can such a vast territory be systematically assessed and categorized to guide meaningful interventions?

To make sense of the loop's heterogeneity, a hexagonal spatial grid was applied across its entire 6,266 km length, extending into the 40 km buffer zone on either side. Each hexagon—uniform in size at 300 km^2—became a unit of analysis. Within each cell, a set of five spatial indicators was measured, drawn from intersecting geospatial layers:

Pipeline density (25%): incorporating crude oil, petroleum product, and natural gas lines

Fig. 3.4 _ Containment at Horse Creek: Oil Spill in Tennessee (2023).
A containment boom installed in a tributary of Horse Creek, Tennessee, following a pipeline spill. The incident highlights the vulnerability of small waterways and forested riparian zones—where even minor ruptures can lead to long-lasting ecological damage. Restoration efforts in these regions are complicated by access constraints and the persistence of oil in sediment and vegetation. Courtesy Protect Our Aquifer

Power infrastructure (20%): including refineries, power plants, and transmission networks

Transportation access (15%): based on proximity to major highways and freight rail

Urbanization (20%): measuring overlap with urbanized areas and proximity to tribal communities

Environmental sensitivity (20%): assessing presence of water bodies, wetlands, or ecologically critical zones.

Each indicator was normalized and weighted, producing a composite score per hexagon **(Fig. 3.10)**.
This scoring system allowed the classification of territory into five dominant categories:

Urban Clean Energy Hubs (score > 0.8): Highly urbanized areas with dense clean energy infrastructure and transit overlap. These sites present the most viable conditions for civic-oriented reuse—district heating, data centers, and decentralized renewables.

Industrial-Energy Cores (score > 0.6): Regions with intense fossil infrastructure—pipelines, refineries, and grid nodes—but with low to moderate urban presence. These are critical for energy transition strategies, retrofits, and emissions mitigation.

Productive Agro-Landscapes (score > 0.4): Primarily cropland and pasture with minimal infrastructure overlap. While rural and dispersed, they offer opportunity for agrivoltaics, regenerative farming, and clean energy co-location.

Hydro-Ecological Zones (score > 0.2): Areas of high ecological sensitivity—wetlands, rivers, forests, and Indigenous lands—where pipeline interventions must prioritize restoration, reconnection, or removal.

Mixed Transition Zones (score < 0.2): Territories with diffuse land uses and moderate infrastructure levels, forming liminal sites for multi-functional, experimental reuse.

These typologies are not fixed categories but operational platforms. Rather than prescribing singular outcomes, they establish a flexible scaffold for aligning interventions with local capacities and ecological priorities. The hexagonal grid becomes a spatial tool not just for classification, but for decision-making, linking design potential to territorial logic.

From this framework, a set of three strategic diagrams **(Fig. 3.11)** constructs a design narrative for the loop's transformation.

Firstly, the forest-wetland zones (0.96 million km^2) are identified where pipeline removal can coincide with ecological repair—reconnecting biodiversity corridors, strengthening riparian buffers, and rewilding fragmented zones.

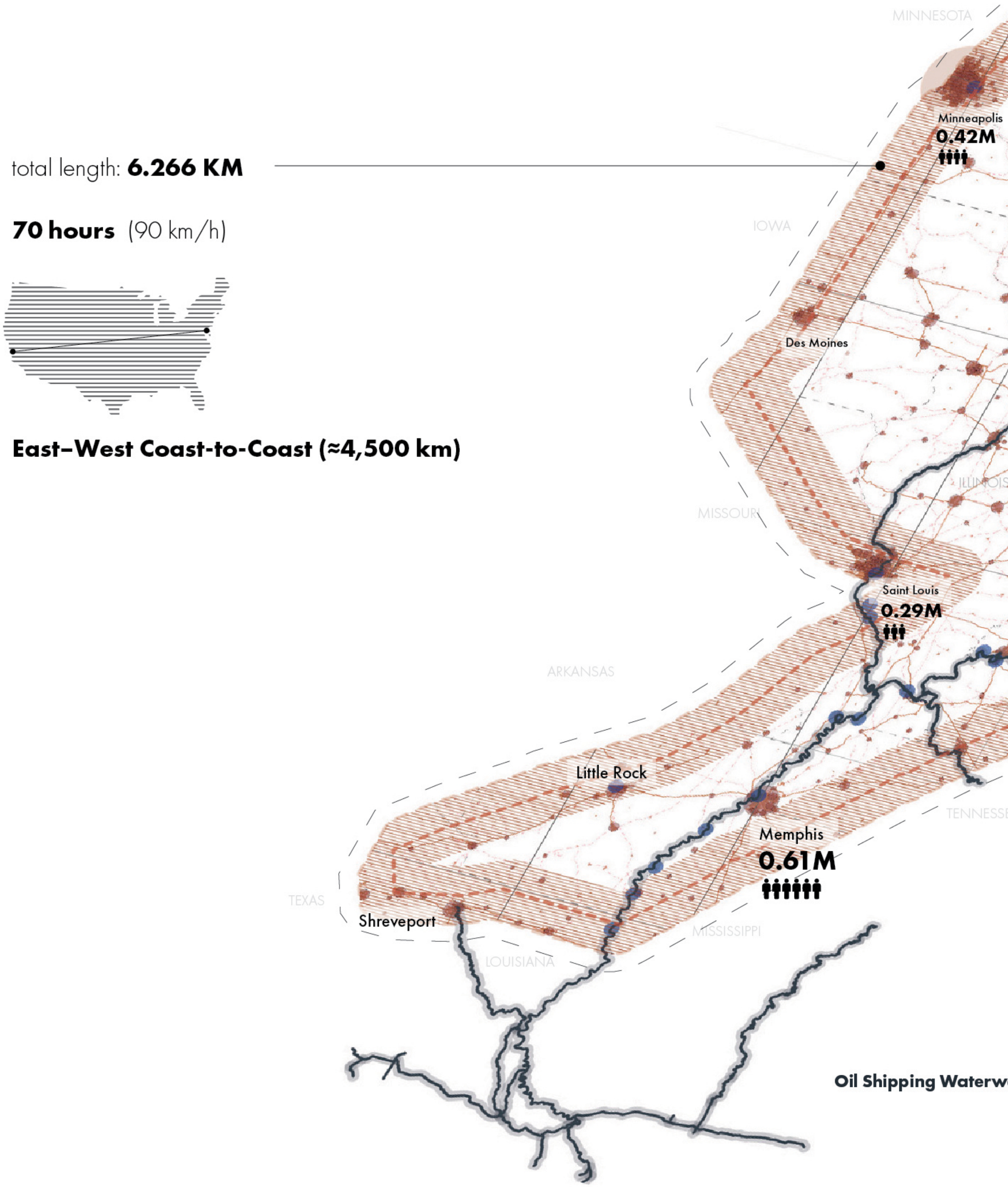
Secondly, the productive zones (1.06 million km^2) with high agro-energy potential are indicated. Here, agrivoltaic systems, solar paths, and extended grid infrastructure propose a new kind of working landscape—where energy and food production cohabitate.

Thirdly, community hubs at 5 “character points” along the loop are defined. These are envisioned as nodes of distributed infrastructure and public amenity—hosting greenhouses, clean energy microgrids, environmental trails, and hybrid typologies.

Together, these diagrams frame the loop as a distributed system of adaptive reuse. They do not propose a unified masterplan, but a tactical choreography of localized transformations—responsive to condition, scale, and urgency. The loop becomes an infrastructural and ecological backbone, capable of guiding systemic repair across degraded, urbanized, and industrialized territory.
As such, this framework reclaims the pipeline not only as a technical artifact, but as a spatial medium—one that binds together energy, equity, ecology, and economy. In its second life, the pipeline is no longer a conduit of extraction, but a platform for transition.

What emerges is not a singular solution, but a field of opportunities: for reconnection, redistribution, and regeneration. The following chapter shifts from territorial analysis to architectural expression, zooming into selected hubs along the loop where speculative design interventions give material form to these broader strategies—where infrastructure becomes civic, and where extraction gives way to care.

Fig. 3.5 _ Line 5 Underwater: Flooding on Bad River Band Territory, Wisconsin (April 2022)
An aerial view of extreme flooding along the Bad River in northern Wisconsin, where the Enbridge Line 5 pipeline cuts through tribal territory. Accelerated erosion during the April 2023 flood exposed segments of the aging pipeline, prompting the Bad River Band of Lake Superior Chippewa to file urgent papers in federal court. The image reveals both the fragility of buried infrastructure and the ecological risks it poses to sovereign wetlands and culturally significant landscapes. Photo: David Joe Bates.

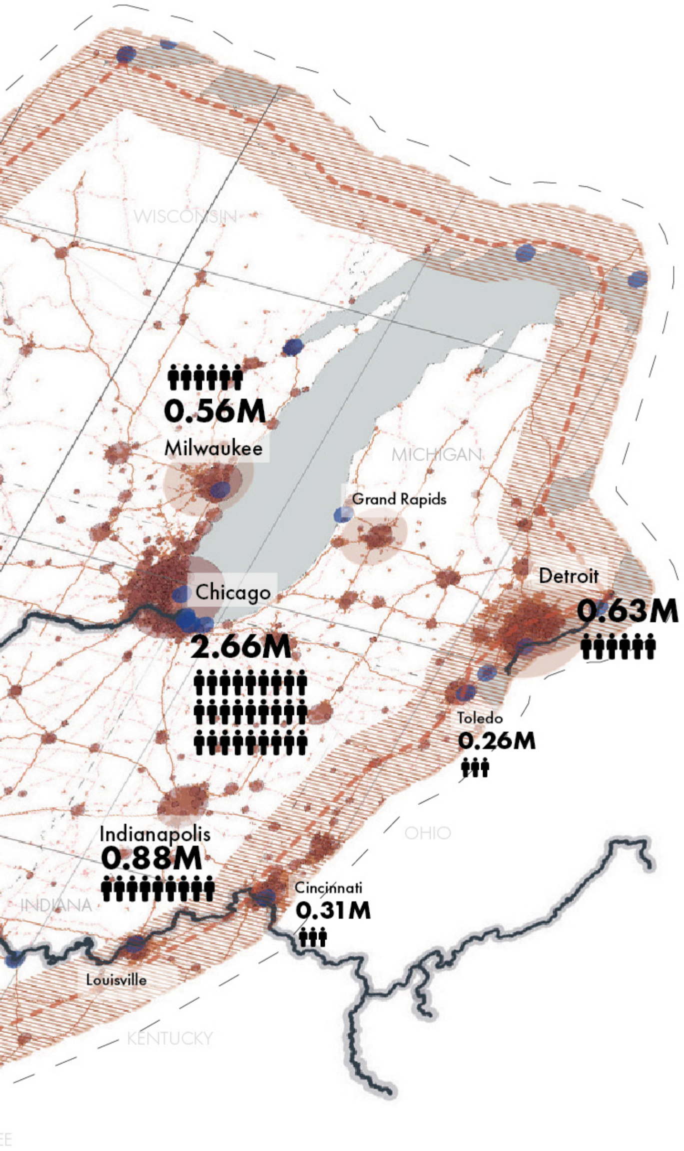


total length: **6.266 KM**

70 hours (90 km/h)

East–West Coast-to-Coast (≈4,500 km)

Fig. 3.6 _ Urban Areas and Mobility Networks
Population densities and major infrastructure systems within the loop, including 8+ million residents, 6,266 km of pipeline, and critical oil shipping waterways. The loop intersects inland ports and highway networks that historically distributed petroleum across the region.


WISCONSIN
0.56M
Milwaukee
MICHIGAN
Grand Rapids
Chicago
2.66M
Detroit
0.63M
Toledo
0.26M
OHIO
Indianapolis
0.88M
INDIANA
Cincinnati
0.31M
Louisville
KENTUCKY
EE

ays

TOTAL GREEN ENERGY PRODUCTION

38,525.8 MW (Megawatts) ●

Solar: 9,860.6 MW ●

Wind: **24,633.2 MW** ●

Hydro: 2,989.8 MW

Other renewable sources: 1,042.2 MW

Refineries ●

Steel pipe (average weight ~90 kg/m) = over **564,000 metric tons of steel**, equating to:

Over 1.2 million metric tons of CO_2 just for production.

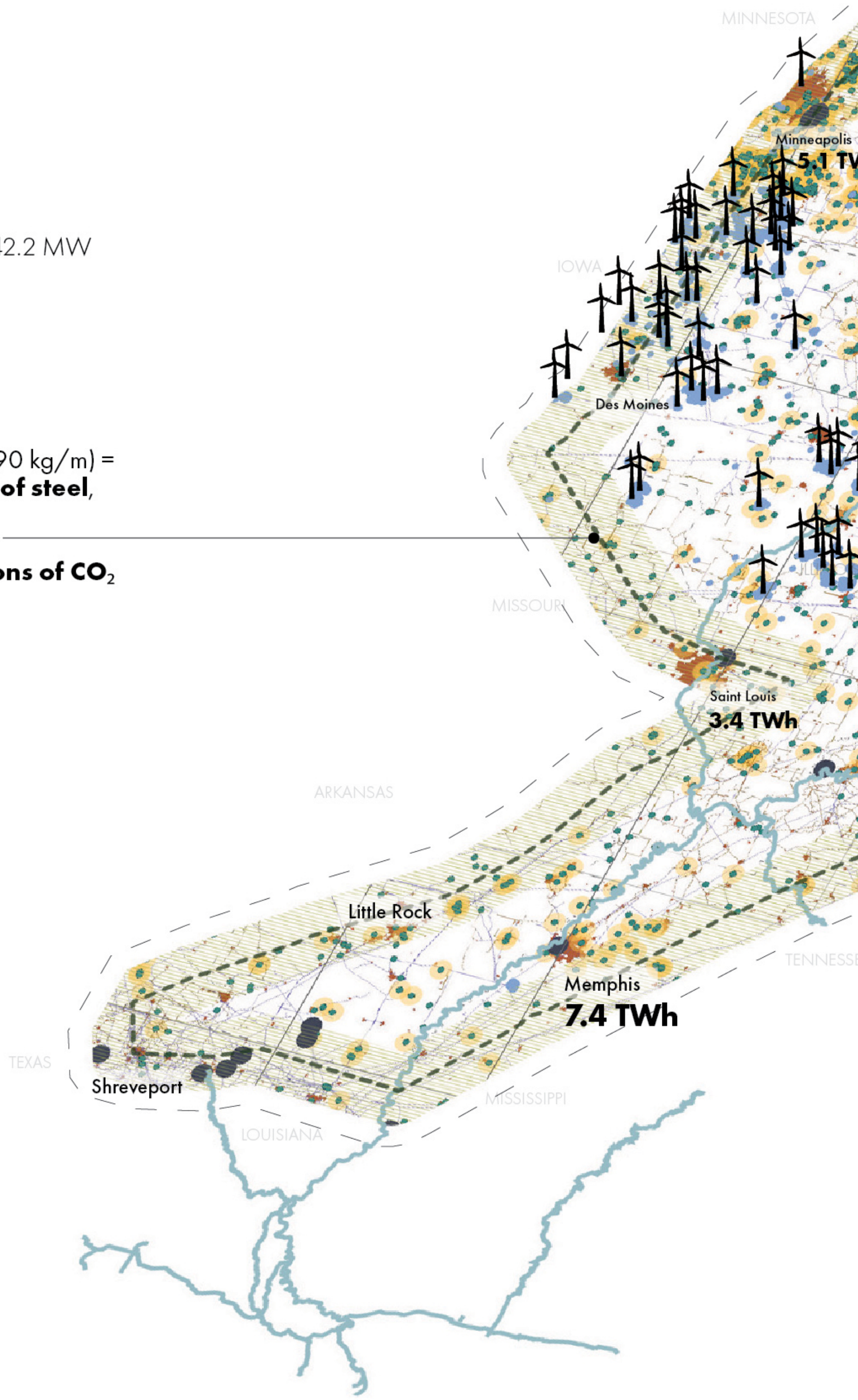
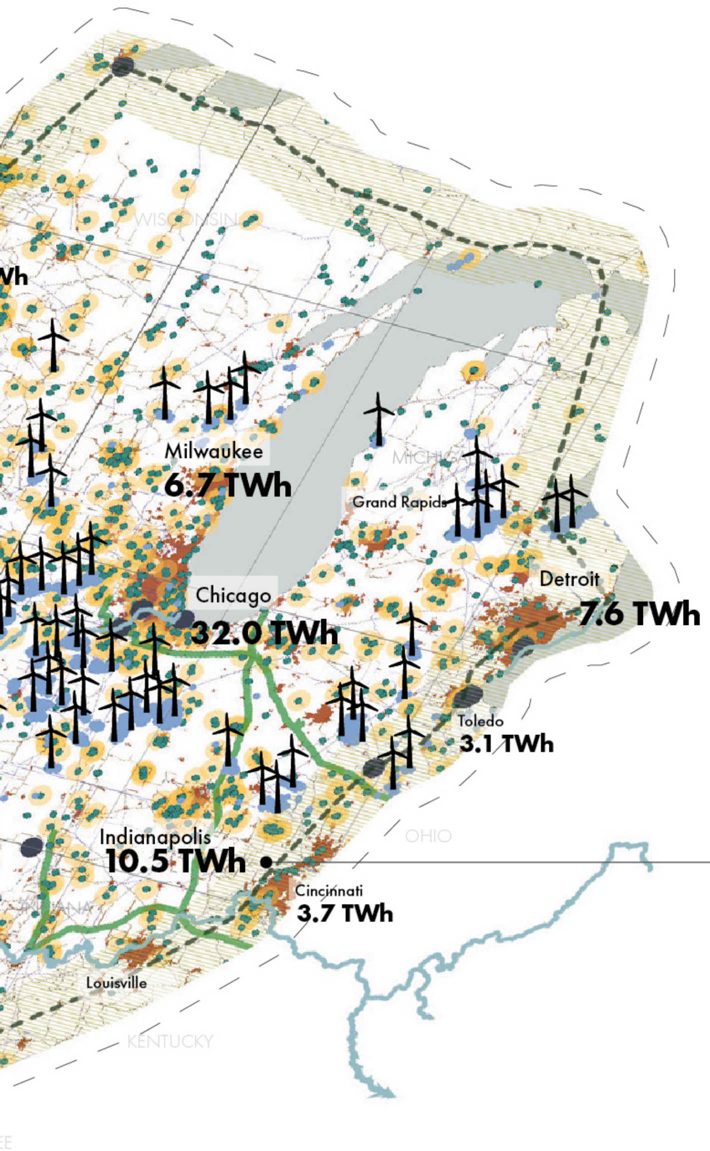


Fig. 3.7 _ Energy Demand, Production, and Potential
Energy infrastructure within the loop includes over 38 GW of installed renewable capacity but falls short of meeting the total urban demand of 713.7 TWh/year. Wind corridors, solar zones, and grid nodes suggest untapped potential for distributed energy transition.



ENERGY DEMAND PER CITY

TOTAL ENERGY DEMAND INSIDE THE LOOP

713.7 TWh/year

† Standard (**2.4 MW**)

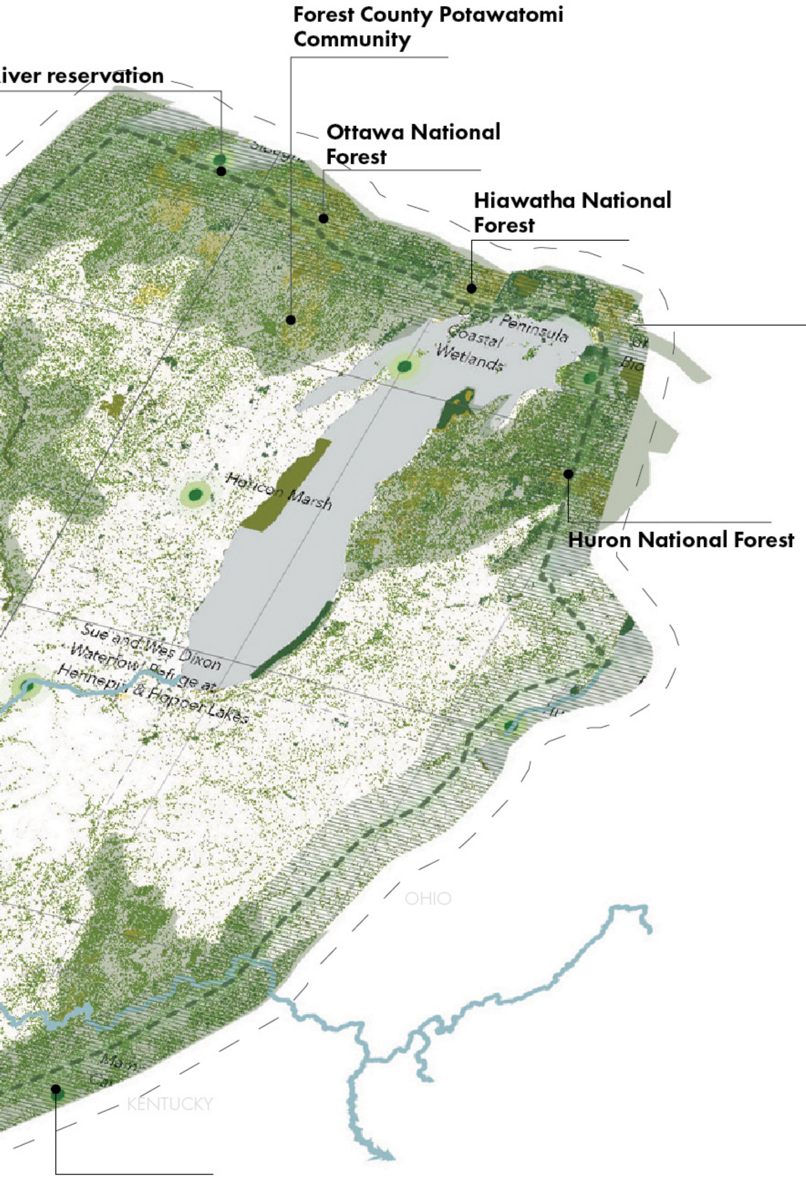
Loop length = 6,266 km
Spacing = 0.84 km per turbine
~7,460 turbines
~54.89 TWh/year

- + High resilience (Fire-adapted systems)
- + High biodiversity
- + High hydrological services
- + High interconnectedness
- + CO_2 sink potential

BIODIVERSITY CORRIDOR B.
Interior Highlands

Oak-hickory, shortleaf pine, maple, and dogwood.

Fig. 3.8 _ Biodiversity Corridors and Ecological Zones
Three overlapping biodiversity corridors—northern forests, interior highlands, and Mississippi lowlands—intersect the loop. These areas offer high ecological value and carbon sink potential, making them critical zones for restoration and pipeline removal.



BIODIVERSITY CORRIDOR A.

Northern hardwoods, mixed pine, boreal forests, conifers, and wetlands. The Great lakes.

BIODIVERSITY CORRIDOR C.
West boundary: Mississippi Valley lowlands (alluvial).
East boundary: Appalachian Plateau

Central Hardwood Forests and Mixed Mesophytic Forests
Oak-hickory, sugar maple, beech, tulip poplar, oak-Pine Forests, bottomland hardwood Forests

PASTURE FARMS

Cool-Season Grass Pastures

Warm-Season Grass Pastures

Native Prairie and Mixed Pasture

Floodplain and Bottomland Pastures

Cattle (beef and dairy), sheep,goat, horses

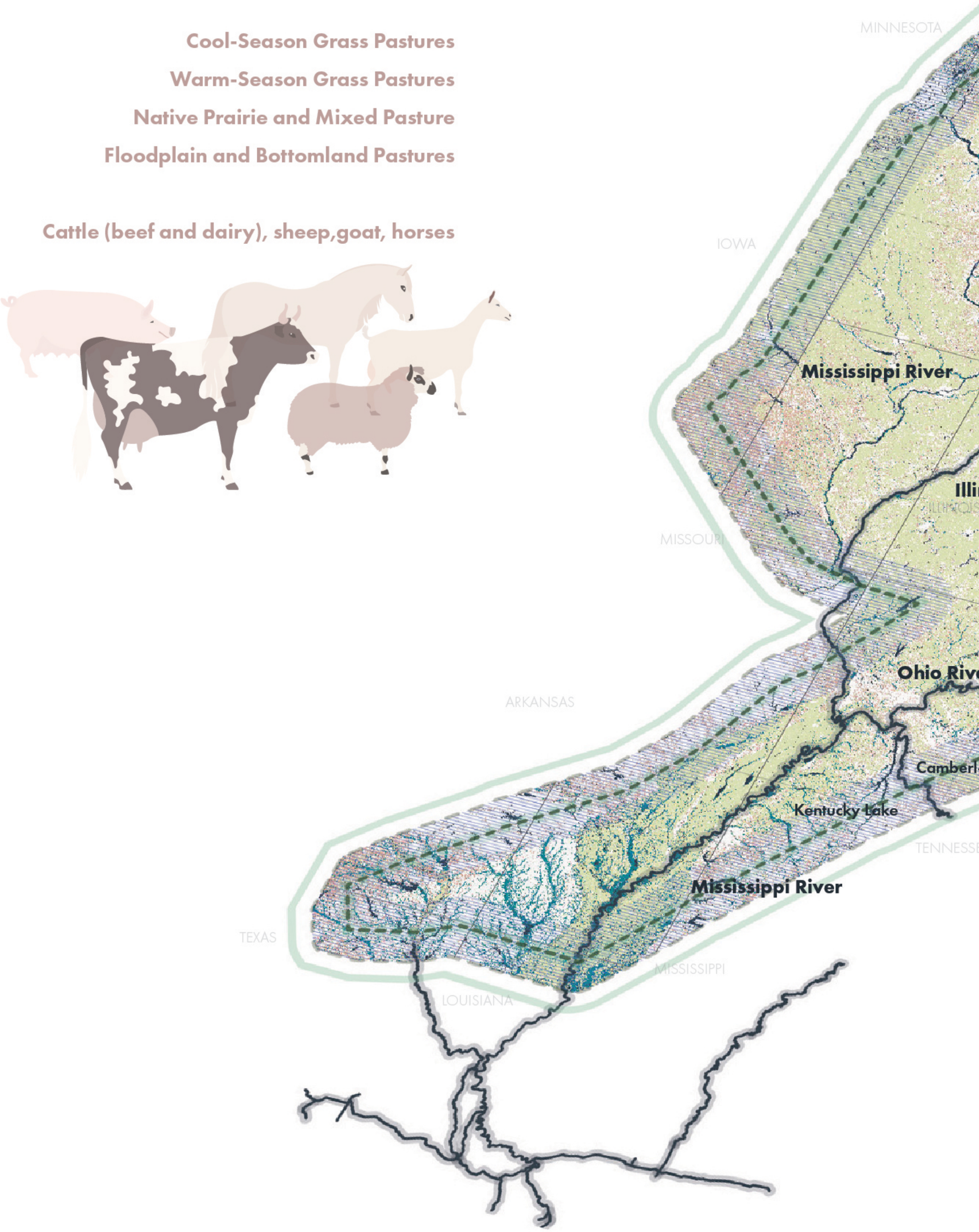


Fig. 3.9 _ Agricultural Systems: Croplands and Pastures

The loop crosses some of the most productive farmland in the U.S., including corn, soy, cotton, and rice belts. Pasture systems support cattle, dairy, and mixed grazing, positioning these zones for agro-ecological transitions and bio-based energy applications.

CROPLANDS AGRICULTURE

Corn (Maize)

Soybeans

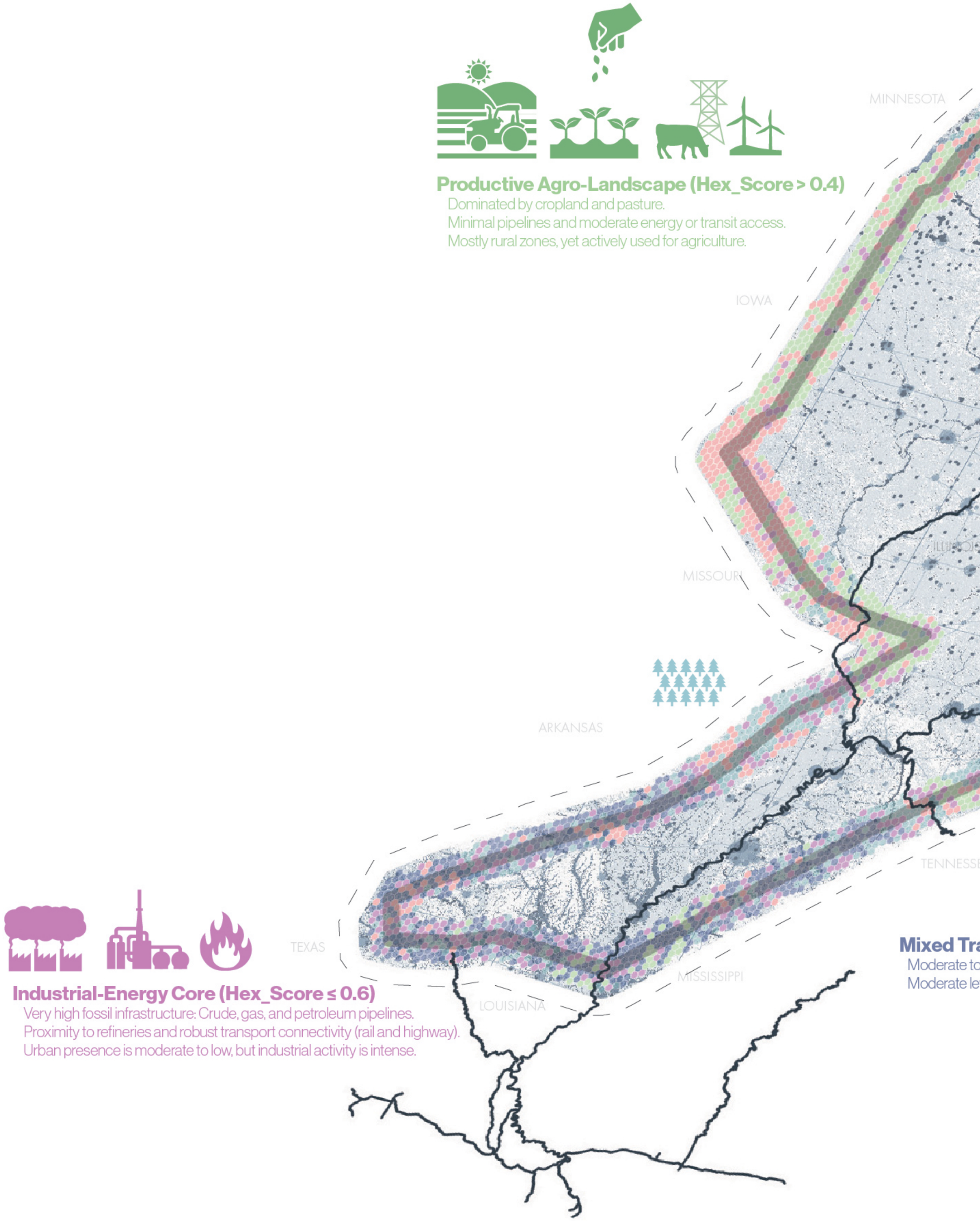
Specialty Crops and Vegetables

Fruits

Cotton

Rice

Hay and Forage Crops

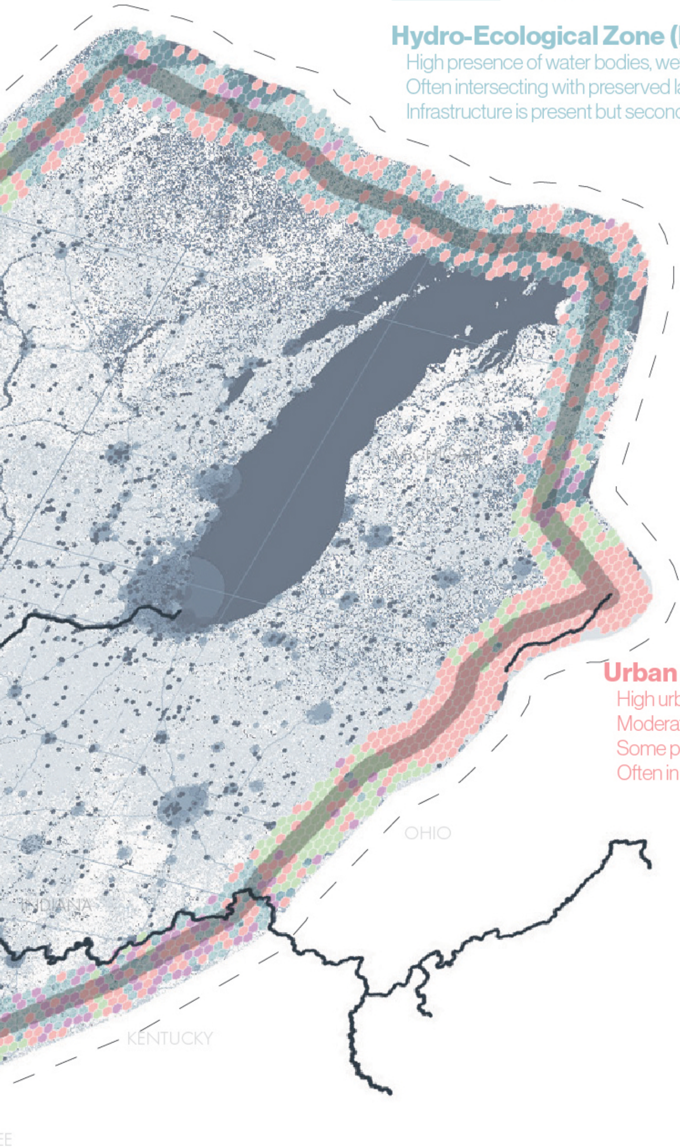


Productive Agro-Landscape (Hex_Score > 0.4)
Dominated by cropland and pasture.
Minimal pipelines and moderate energy or transit access.
Mostly rural zones, yet actively used for agriculture.

Industrial-Energy Core (Hex_Score ≤ 0.6)
Very high fossil infrastructure: Crude, gas, and petroleum pipelines.
Proximity to refineries and robust transport connectivity (rail and highway).
Urban presence is moderate to low, but industrial activity is intense.

Mixed Tra
Moderate to
Moderate le

Fig. 3.10 _ Typological Classification of the Loop Corridor
Each hexagon within the 40 km buffer zone is scored and categorized based on five weighted indicators—pipeline density, energy infrastructure, transportation access, urbanization, and environmental sensitivity. The resulting typologies reveal five dominant conditions.



Hydro-Ecological Zone (Hex_Score > 0.2)

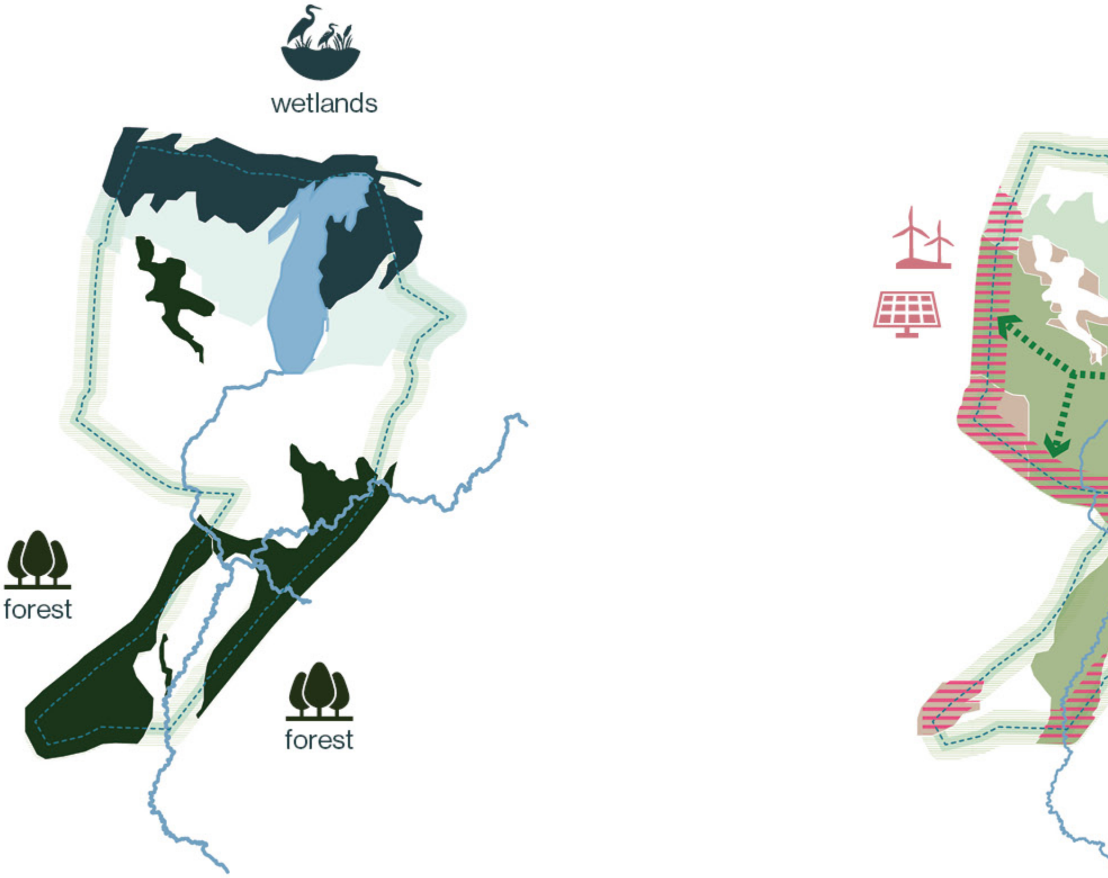
High presence of water bodies, wetlands, or tribal lands.
Often intersecting with preserved land covers: forests, ecological corridors.
Infrastructure is present but secondary.

Urban Clean Energy Hub (Hex_Score > 0.8)

High urban footprint: Located near or within urban zones.
Moderate clean energy infrastructure: Dense transmission lines and multiple renewable power plants.
Some pipeline/transit overlap, but clean energy and urban presence dominate.
Often in regions transitioning from traditional grids to distributed clean energy.

ansition Zone (Hex_Score < 0.2)

low urban footprint.
vels of pipelines, transit, urbanization, and land diversity.



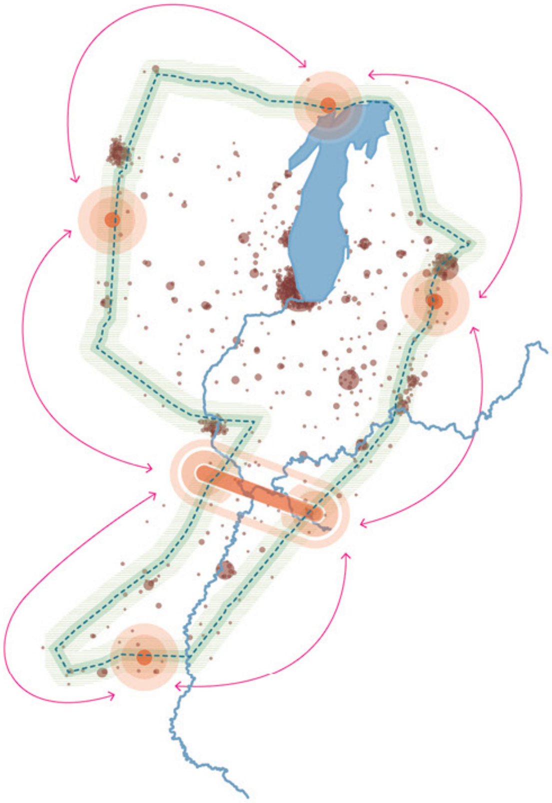
ECOSYSTEM/FOREST AREA
0,96M km²

Remove pipeline
Repair biodiversity corridor

AGRICULTURE & ENERG
1,06M

Agrivol
Solar P
Extend the high vol

Fig. 3.11_ Three Territorial Logics for Pipeline Transformation
Three territorial strategies guide the transformation of the pipeline loop: ecological zones for forest and wetland restoration, productive landscapes for agrivoltaics and grid extensions, and community hubs for integrated civic and energy infrastructure. Together, they frame the loop as a distributed system of adaptive reuse—balancing repair, production, and public benefit.



Y PRODUCTION AREA

km²

ltaics

Paths

tage electric grid

COMMUNITY HUBS

5 Character points

Greenhouses and Data-center

Food and Energy production

Eco-city and district heating

Wetlands & Environmental trails

04 Speculative Futures

Remove, Repurpose, Rewire, Relieve

Speculative Futures

Before moving into the speculative design proposals, this chapter shifts from analysis to intervention. If the previous chapters examined the pipeline's territorial footprint, environmental risks, and socio-political entanglements, what follows explores how those same corridors might be reimagined—not as liabilities to erase, but as latent infrastructures to repurpose, reveal, and regenerate. To evaluate these spatial propositions, the thesis introduces a set of custom metrics designed to measure more than feasibility: they assess how well each project performs ecologically, socially, climatically, and symbolically in the wake of extraction.

These metrics are not definitive tools, but working instruments—conceptual frameworks that reflect the values of adaptability, care, and regeneration embedded in this project. While not yet fully quantified, and in need of further development and interdisciplinary testing, they offer a speculative methodology for understanding the layered performance of post-carbon infrastructure. In this way, the evaluation becomes not only a measure of feasibility, but a form of inquiry into what it means to design with futures in mind.

These metrics reflect the project's core values of adaptability, and systemic thinking in a post-carbon era:

Ecosystem Services Recovery Score (ESRS) measures how effectively each intervention restores vital ecological functions, including soil health, water filtration, biodiversity support, and habitat resilience.

Community Integration Rating evaluates the degree to which proposals are accessible, inclusive, and responsive to surrounding populations—fostering social infrastructure, equity, and local participation.

Carbon Sequestration Capacity quantifies the site's potential to absorb and store carbon through reforestation, wetland restoration, and soil regeneration—advancing climate-positive design.

Multi-Functional Adaptation Index (MFAI) captures the number and quality of functions each site supports—such as energy reuse, food production, recreation, and ecological repair—highlighting spatial intelligence and systems layering.

Regenerative Potential Index (RPI) serves as an integrative score, reflecting each proposal's capacity to generate long-term transformation—ecologically, culturally, and infrastructurally—beyond the lifespan of the pipeline itself.

The following pages present five design hubs sited along a continuous pipeline loop, each responding to its own territorial context, ecological condition, and infrastructural opportunity. These proposals are not isolated interventions but linked experiments—prototypes for how legacy infrastructure might be transformed into agents of social and environmental regeneration. Each site is evaluated using the metrics outlined above, revealing not only how they perform, but how they speculate on new forms of living, provisioning, and coexistence in the aftermath of extraction.

Thermal Commons: Data to Food
Situated between the mid-sized cities of Toledo and Dayton, this intervention leverages its proximity to a relatively high-density population zone, as identified through the thesis's Chapter 3 territorial mapping. The location falls within a band of infrastructural richness and digital demand—making it a logical site for a ground-level data center, an energy-intensive typology typically positioned near urban cores for connectivity and latency efficiency. Rather than viewing this digital facility as a passive backend structure, the design activates its thermal byproduct—transforming data waste into social and ecological value.

The existing crude oil pipeline is retrofitted to carry waste heat generated by the data center toward a linear array of elevated greenhouses. Suspended along the former pipeline corridor, these greenhouses create a new productive and communal spine in the landscape. The elevation preserves agricultural activity and circulation below while making visible the transformation of buried infrastructure into an agent of renewal.

The hub includes community gathering zones, workshop spaces, and food processing and distribution nodes integrated along the spine. At the base, the data center itself becomes a part of the public realm through controlled transparency, educational programming, and shared infrastructure (such as shared cooling or backup power systems). The entire intervention promotes local food resilience and energy-loop urbanism, inviting nearby communities into an active role in the stewardship and operation of the site.

This proposal performs particularly well in Multi-Functional Adaptation (MFAI) and Community Integration, as it bridges high-tech infrastructure with everyday needs. It delivers productive landscapes, thermal reuse, and civic programming in a single continuous system. The Ecosystem Services Recovery Score (ESRS) is modest but present—native planting buffers, improved soil quality beneath greenhouses, and pollinator pathways contribute to ecological uplift. Carbon Sequestration Capacity is lower due to the hardscape-heavy greenhouse footprint, but the system offsets emissions by reducing food miles and using waste heat, creating indirect carbon benefits.

Its Regenerative Potential Index (RPI) is high. Not only does the intervention propose a novel post-carbon typology, but it also models how decommissioned energy infrastructure can be folded back into urban metabolic systems. It exemplifies a closed-loop approach where infrastructure is not just re-used, but fundamentally re-scripted to support life.

Where energy once flowed silently underground, it now circulates above in service of nourishment and gathering. This is a new kind of urban metabolism: one in which pipelines no longer extract, but sustain.

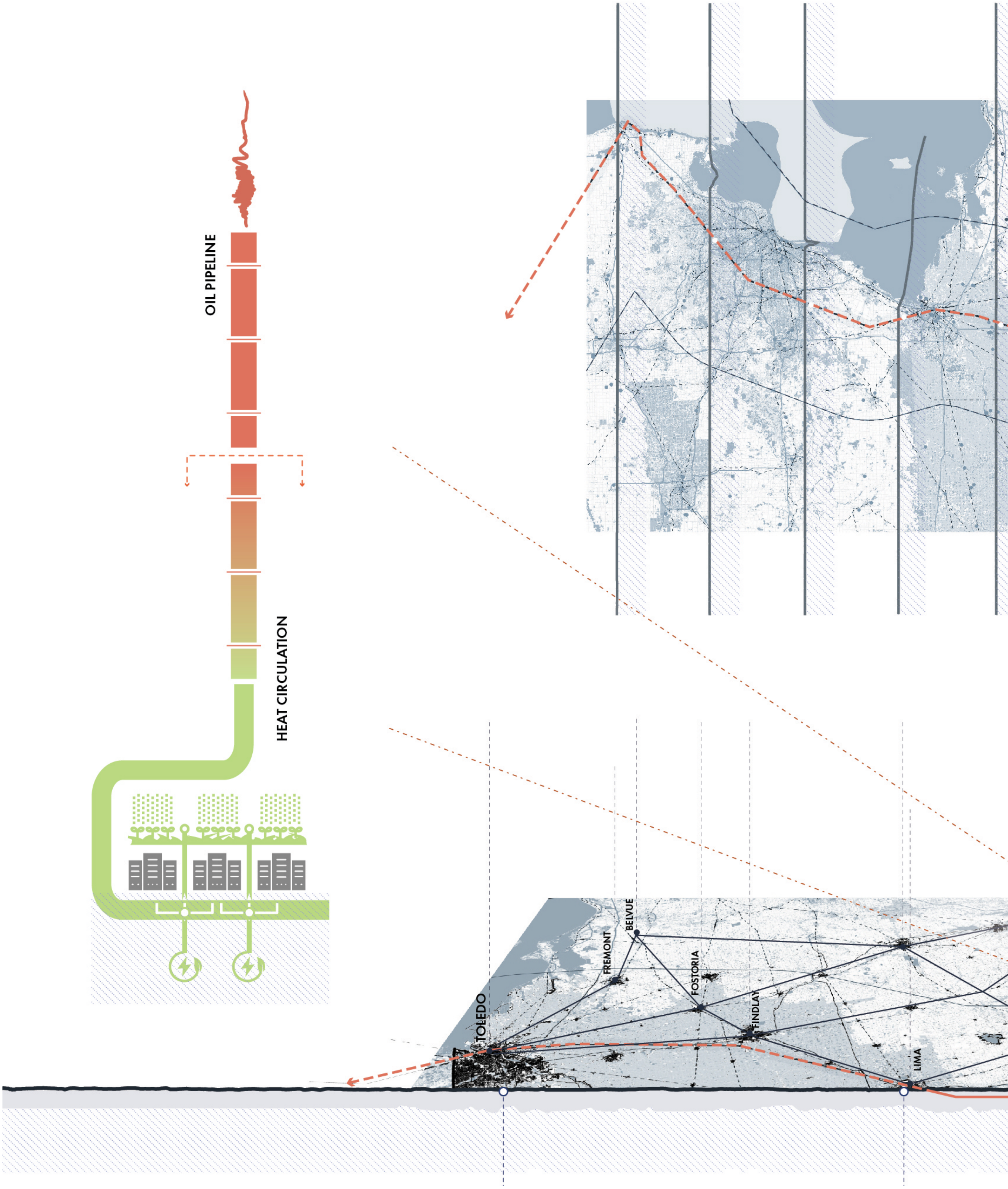
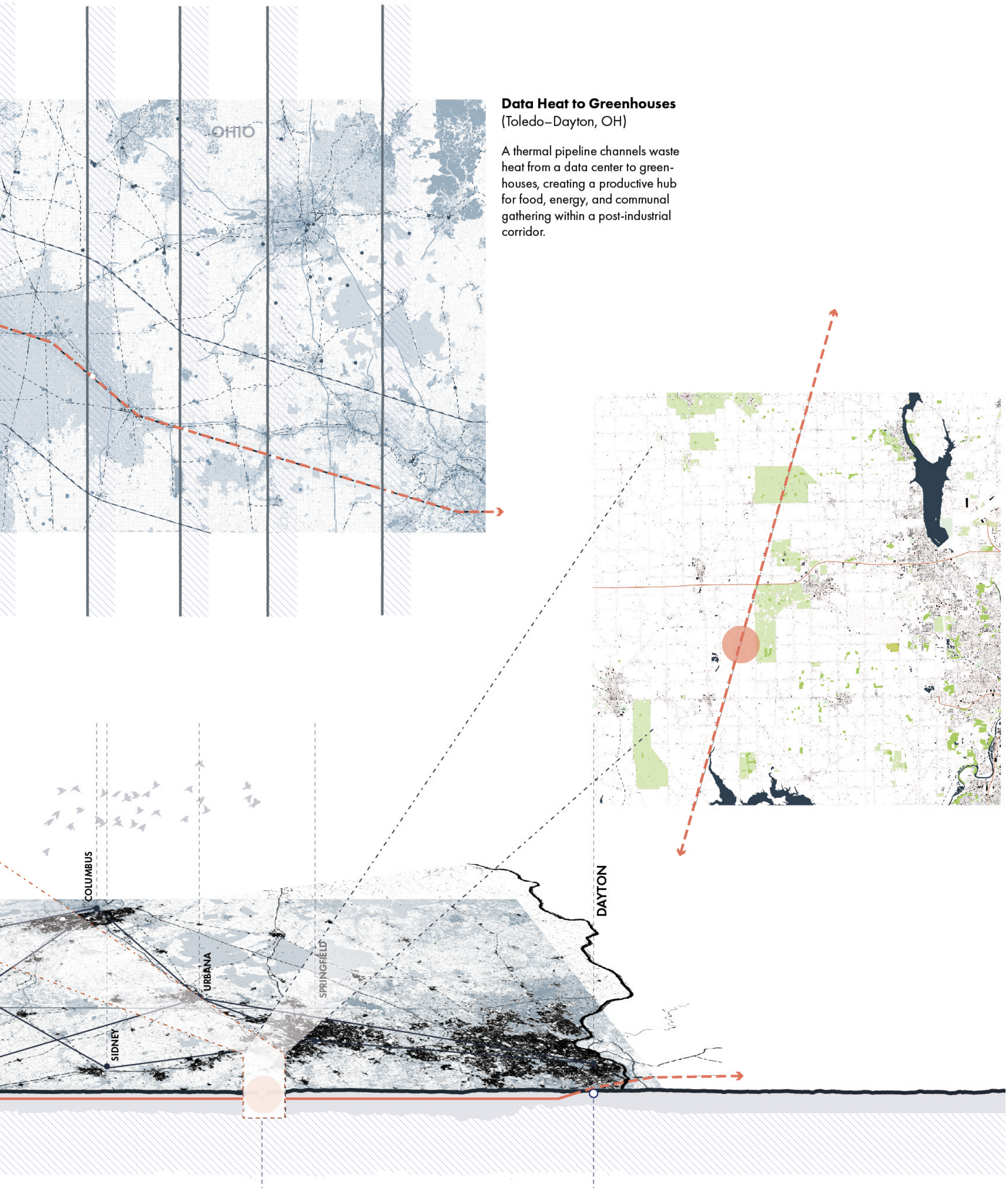
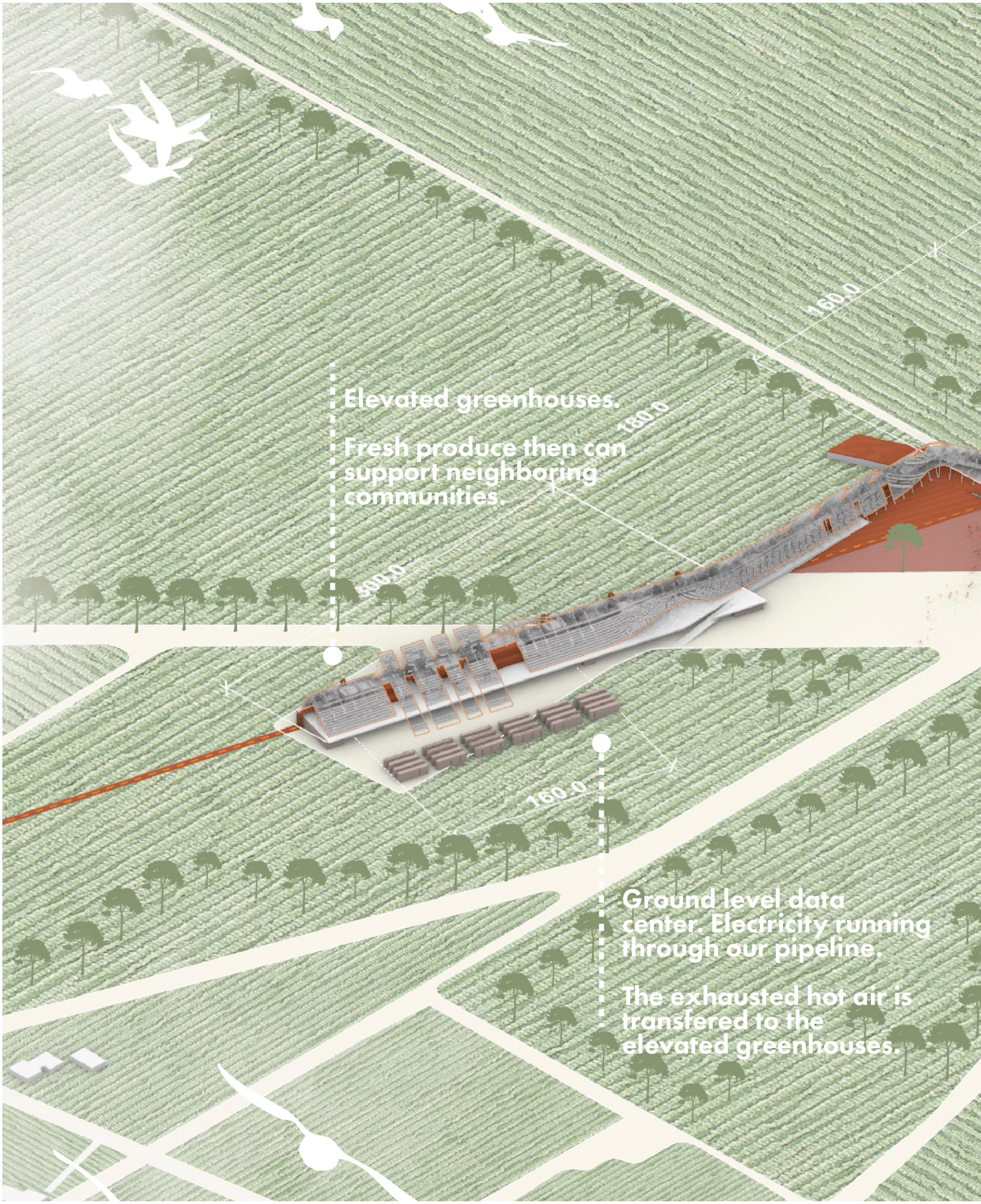


Fig. 4.1 _ Site Analysis. Thermal Commons: Data to Food.

Data Heat to Greenhouses
(Toledo–Dayton, OH)

A thermal pipeline channels waste heat from a data center to greenhouses, creating a productive hub for food, energy, and communal gathering within a post-industrial corridor.





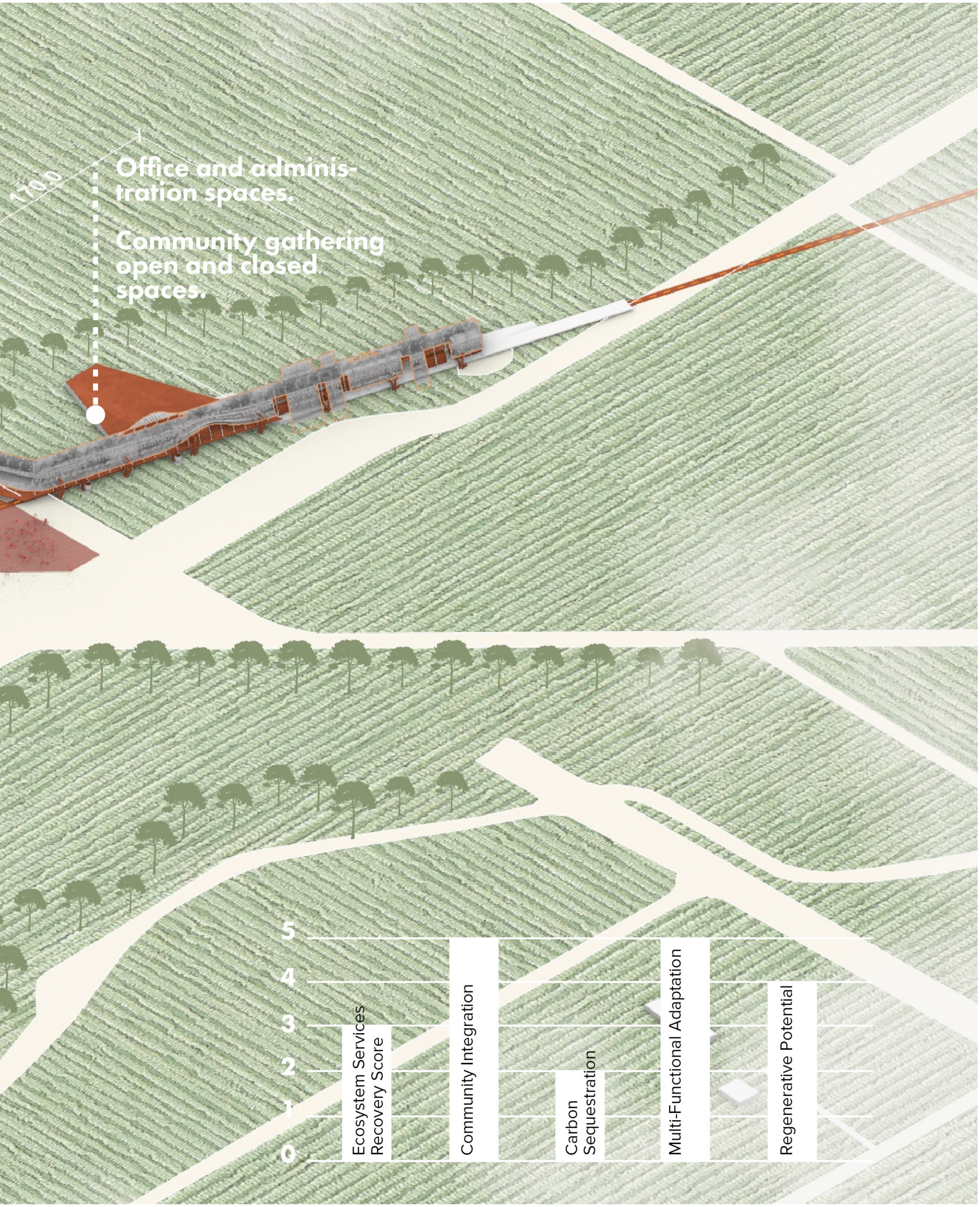
Elevated greenhouses.

Fresh produce then can support neighboring communities.

Ground level data center. Electricity running through our pipeline.

The exhausted hot air is transfered to the elevated greenhouses.

Fig. 4.2 _ Axonometric view. Thermal Commons: Data to Food.



Office and administration spaces.

Community gathering open and closed spaces.

Fig. 4.3 _ Perspective view. Thermal Commons: Data to Food.

Bridge of Coexistence: A Layered Passage for Species and People

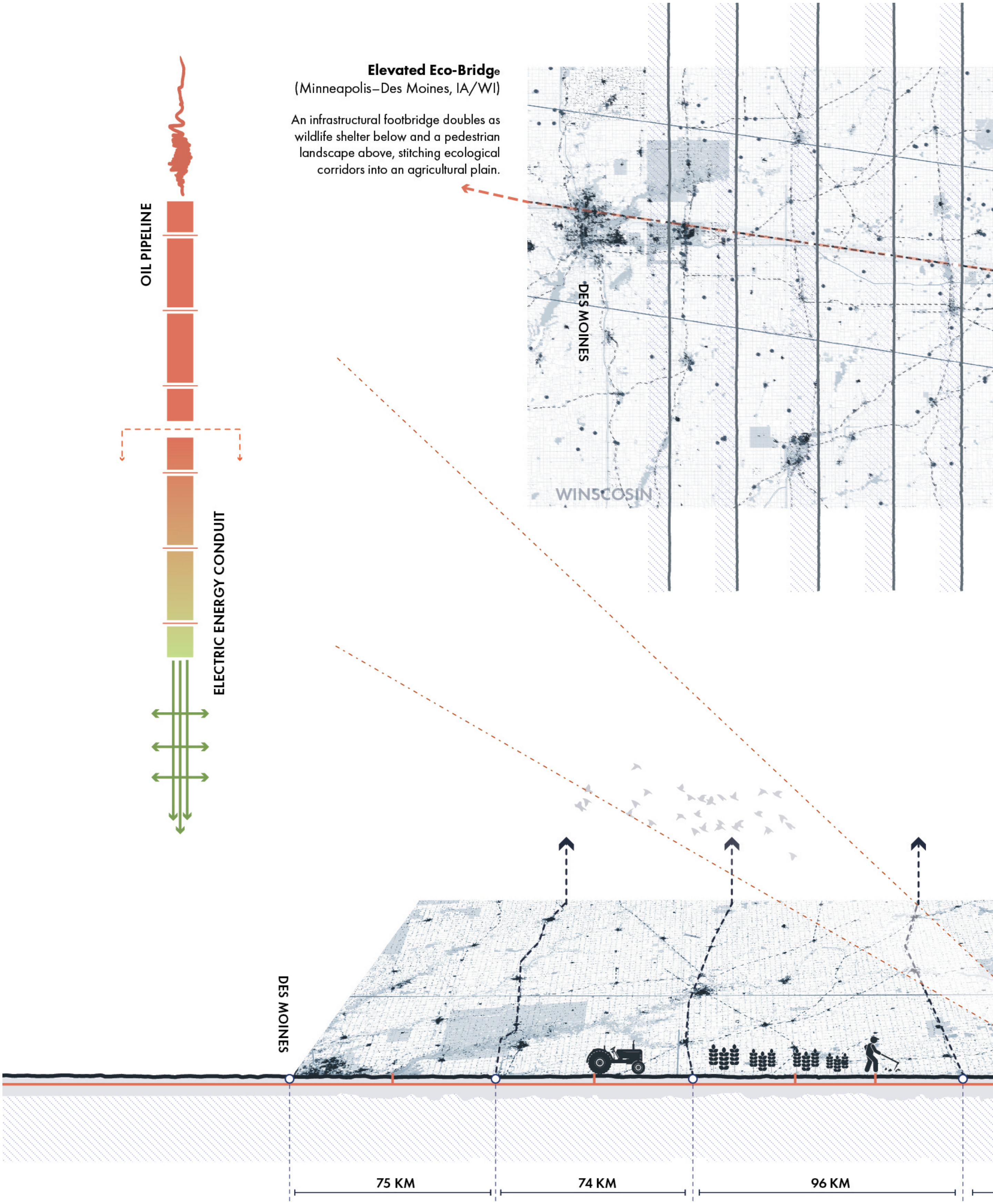
In a predominantly agricultural landscape stretching between Minneapolis and Des Moines, this hub reimagines the pipeline corridor as an elevated infrastructural bridge that serves both ecological restoration and community access. Here, the pipeline itself is lifted and repurposed as the structural spine of a multi-level passage. On the upper level, a continuous footpath supports walking, cycling, and seasonal activity. Below, the shaded undercroft becomes a protected space for animal movement, pollinator habitat, and rotational pasture. This dual-function system physically separates human circulation from ecological flows, yet binds them within the same spatial framework—a literal and conceptual bridge of coexistence.

The structure acts as a connective tissue across fragmented land: linking forest edges, hedgerows, and restored prairie corridors. The design carefully threads through the landscape, lightly touching the ground to minimize disruption while offering points of access and gathering at key intersections. Timber pavilions and canopy platforms punctuate the upper walkway, offering moments for rest, learning, and observation. Interpretive elements embedded in the path narrate the history of the corridor—from extraction to repair—reframing the pipeline not only as infrastructure but as a memory trace and future commons.

Importantly, this site is located within a region where extensive agricultural land use and transportation corridors have deeply fragmented ecological connectivity. The elevated strategy bypasses much of the privatized ground plane, re-stitching ecological routes and offering new community engagement without displacing existing land use. Beneath the bridge, native plantings, wet meadows, and wildlife crossings are designed to support species migration—particularly for small mammals, amphibians, and pollinators—while experimental grazing systems allow for rotational use by livestock without fencing.

The hub scores particularly high on the Ecosystem Services Recovery Score (ESRS) due to its active role in rewilding, soil healing, and wetland insertion beneath the elevated structure. It also performs well in Community Integration, thanks to its public accessibility, visibility, and invitation to both everyday and recreational use. Multi-Functional Adaptation (MFAI) is strong, with its layering of mobility, education, ecology, and agricultural cooperation. Its Carbon Sequestration Capacity is moderate, improved by extensive planting, but limited by the linear and elevated structure's footprint. The Regenerative Potential Index (RPI) is high: the intervention doesn't simply restore, it reimagines how infrastructure can host life—across scales, species, and histories.

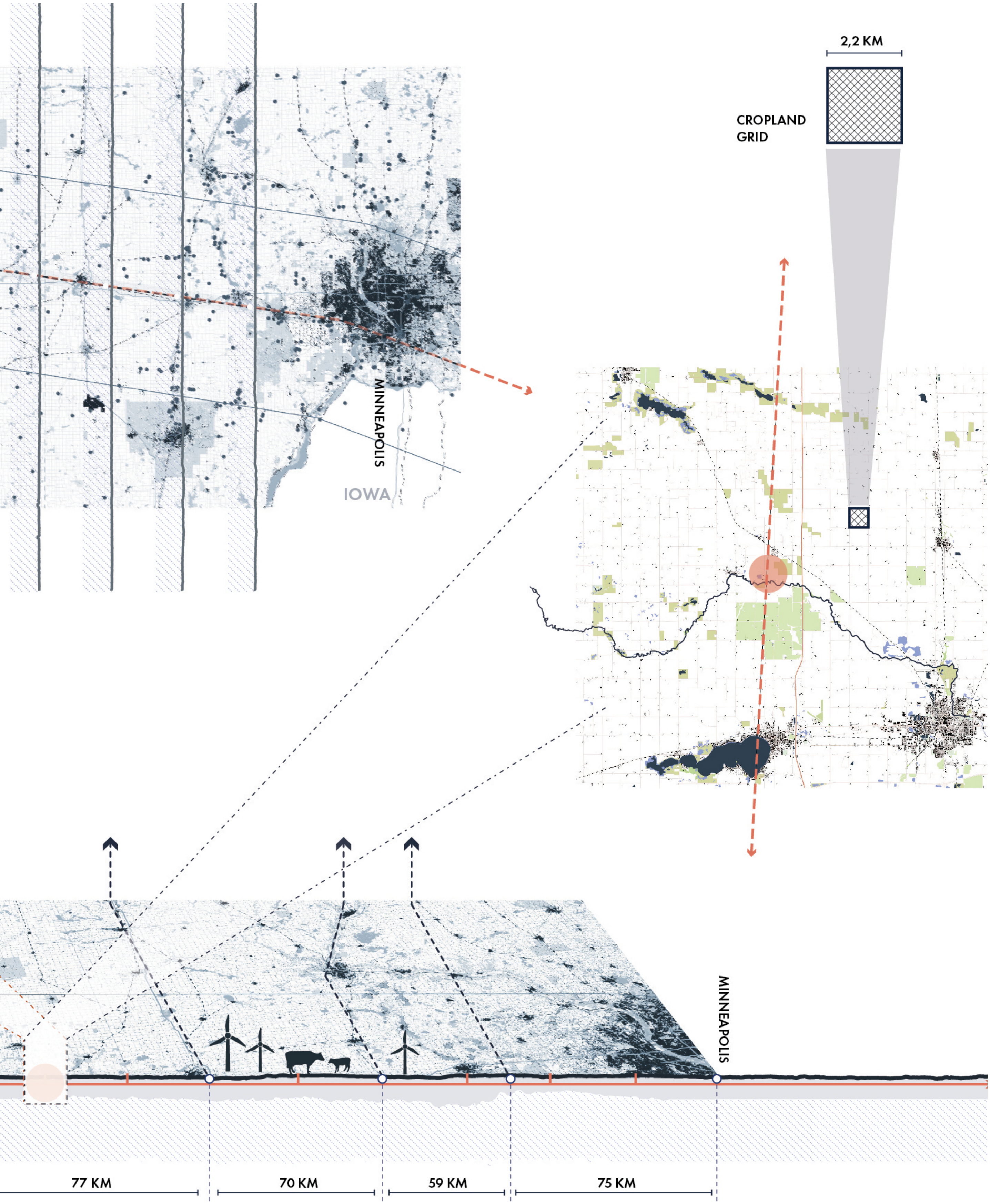
This is not a bridge between two fixed points. It is a bridge between ways of living—between human access and animal movement, between memory and anticipation, between the ground and the sky.



Elevated Eco-Bridge
(Minneapolis–Des Moines, IA/WI)

An infrastructural footbridge doubles as wildlife shelter below and a pedestrian landscape above, stitching ecological corridors into an agricultural plain.

Fig. 4.4 _ Site analysis. The Bridge of Coexistence: A Layered Passage for Species and People.


2,2 KM
CROPLAND GRID
MINNEAPOLIS
IOWA
MINNEAPOLIS
77 KM
70 KM
59 KM
75 KM

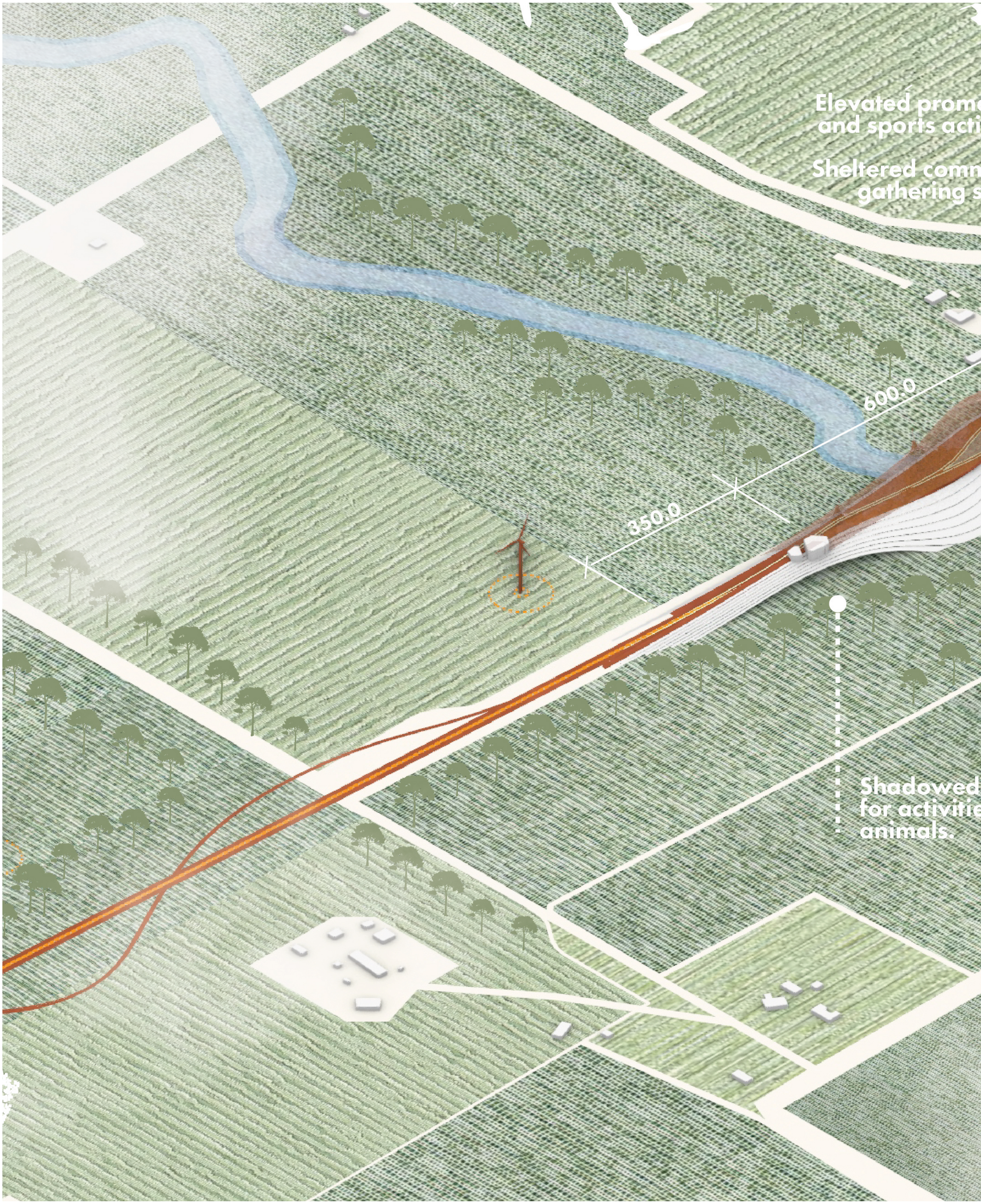


Fig. 4.5 _ Axonometric view. Bridge of Coexistence: A Layered Passage for Species and People.


enade
vities.
nunify
paces
350.0
spaces
es and
5
4
3
2
1
0
Ecosystem Services Recovery Score
Community Integration
Carbon Sequestration
Multi-Functional Adaptation
Regenerative Potential

Fig. 4.6 _ Perspective view. Bridge of Coexistence: A Layered Passage for Species and People.

The eco-village: Heat to Living

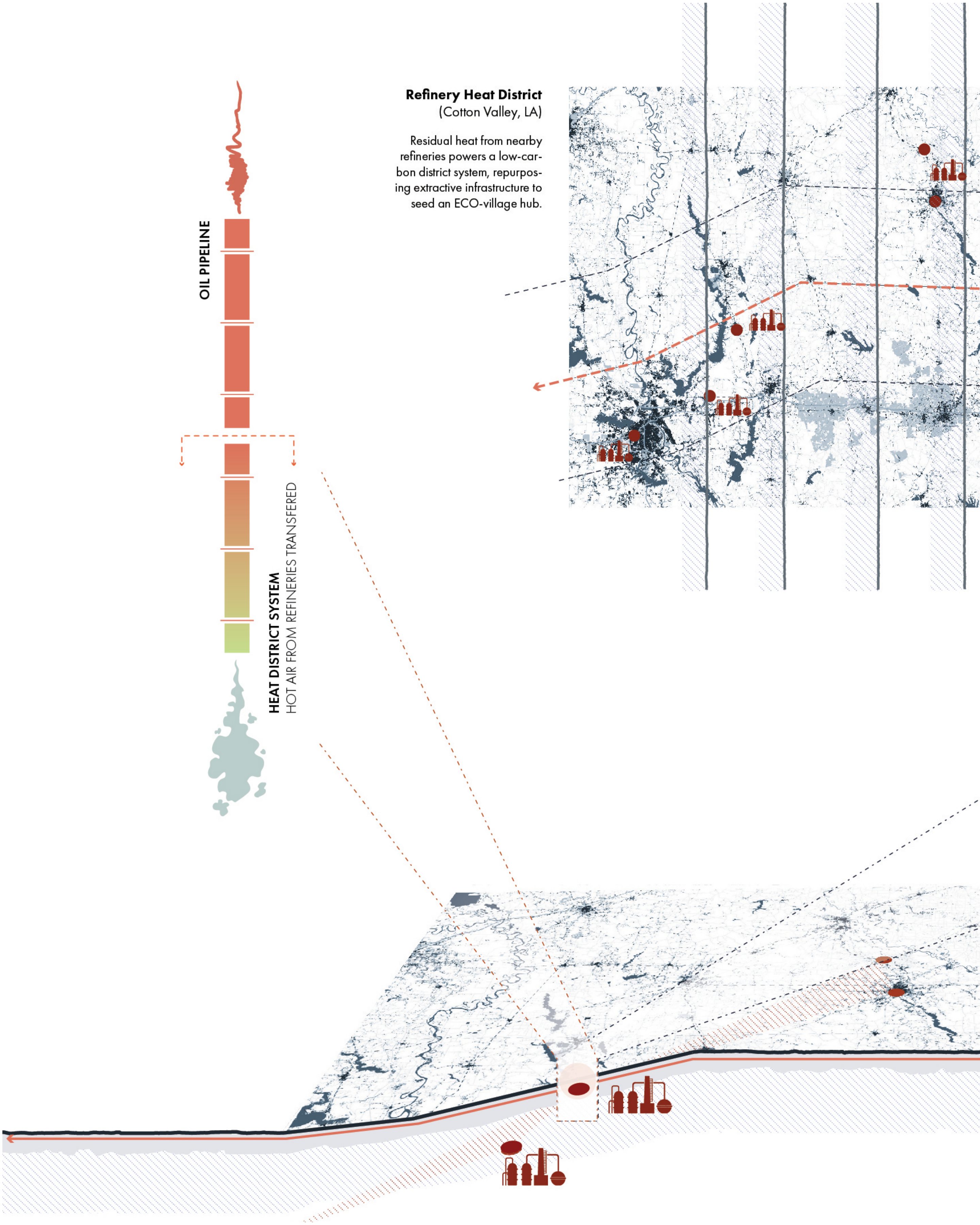
Located near Cotton Valley, Louisiana—a region historically shaped by the presence of oil and gas refineries—this hub proposes a radical reprogramming of industrial thermal waste. Rather than decommissioning the pipeline in isolation, the design uses its embedded energy pathway to link the extractive past to a regenerative future. Here, the pipeline is retrofitted not to carry oil, but to redistribute residual heat from nearby refineries to power a new eco-district: a mixed-use, low-carbon settlement organized around food, housing, and shared infrastructure.

The hub introduces a decentralized "eco-village" organized in linear bands, with its densest activity at the core and branching modules of residential units and food production facilities extending outward. The pipeline becomes the infrastructural spine of this new settlement. It transfers otherwise-wasted thermal energy to heat water, support passive temperature control, and facilitate greenhouse and aquaponic systems embedded within the village itself. The settlement is conceived not as an isolated utopia but as a new spatial logic for just transition—one that reclaims extractive zones for productive and communal life.

Green roofs, pollinator corridors, and low-impact stormwater systems are woven through the fabric of the village, supporting both ecological recovery and human habitability. The placement of the hub responds to both infrastructural logic and socio-economic urgency: Cotton Valley lies at the intersection of rural disenfranchisement, energy dependency, and ecological degradation. By rerouting energy from pollution to provision, this project creates a model of spatial justice that reclaims the right to environmental quality and spatial dignity.

In performance terms, the hub ranks high on the Multi-Functional Adaptation Index (MFAI)—uniting energy, food, housing, and community-building functions in one system. Its Ecosystem Services Recovery Score (ESRS) is moderate: while the ecological baseline is low due to decades of industrial activity, the intervention brings new life to the soil, air, and ecological processes through integrated landscapes and waste reuse. Community Integration is strong, particularly in the way the site is designed for cooperative living and local self-sufficiency. Carbon Sequestration Capacity remains modest but is supported by the extensive use of green roofs and landscape buffers. Crucially, the Regenerative Potential Index (RPI) is high—this hub doesn't simply repair; it proposes a new typology for life in the wake of extraction.

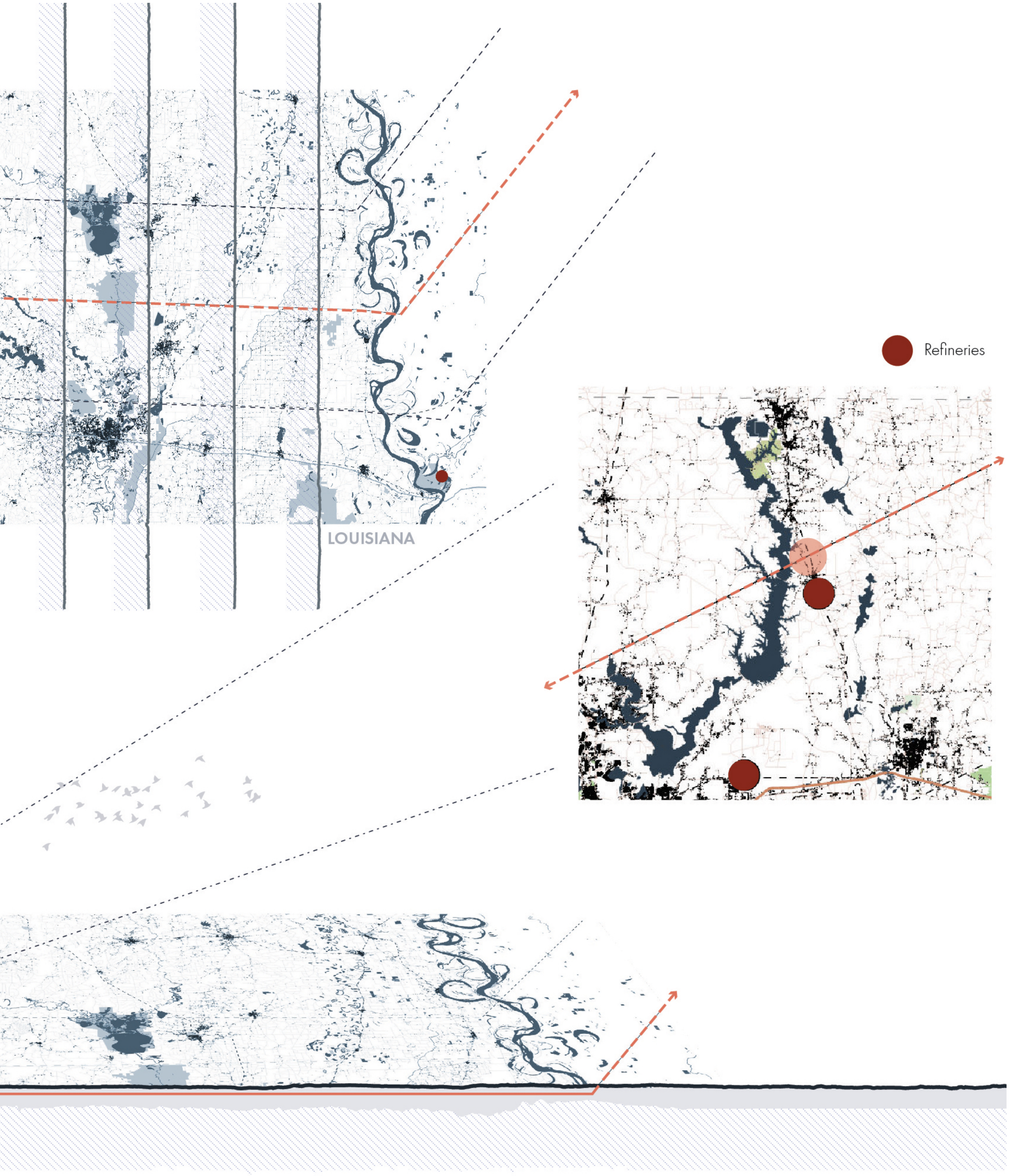
Rather than displacing industry, the site metabolizes it. It turns the pipeline from a symbol of harm into a circulatory system of renewal—offering not just shelter, but a spatial ethic for surviving and thriving in the post-oil transition.



Refinery Heat District
(Cotton Valley, LA)

Residual heat from nearby refineries powers a low-carbon district system, repurposing extractive infrastructure to seed an ECO-village hub.

Fig. 4.7 _ Site analysis. The eco-village: Heat to Living.


● Refineries
LOUISIANA

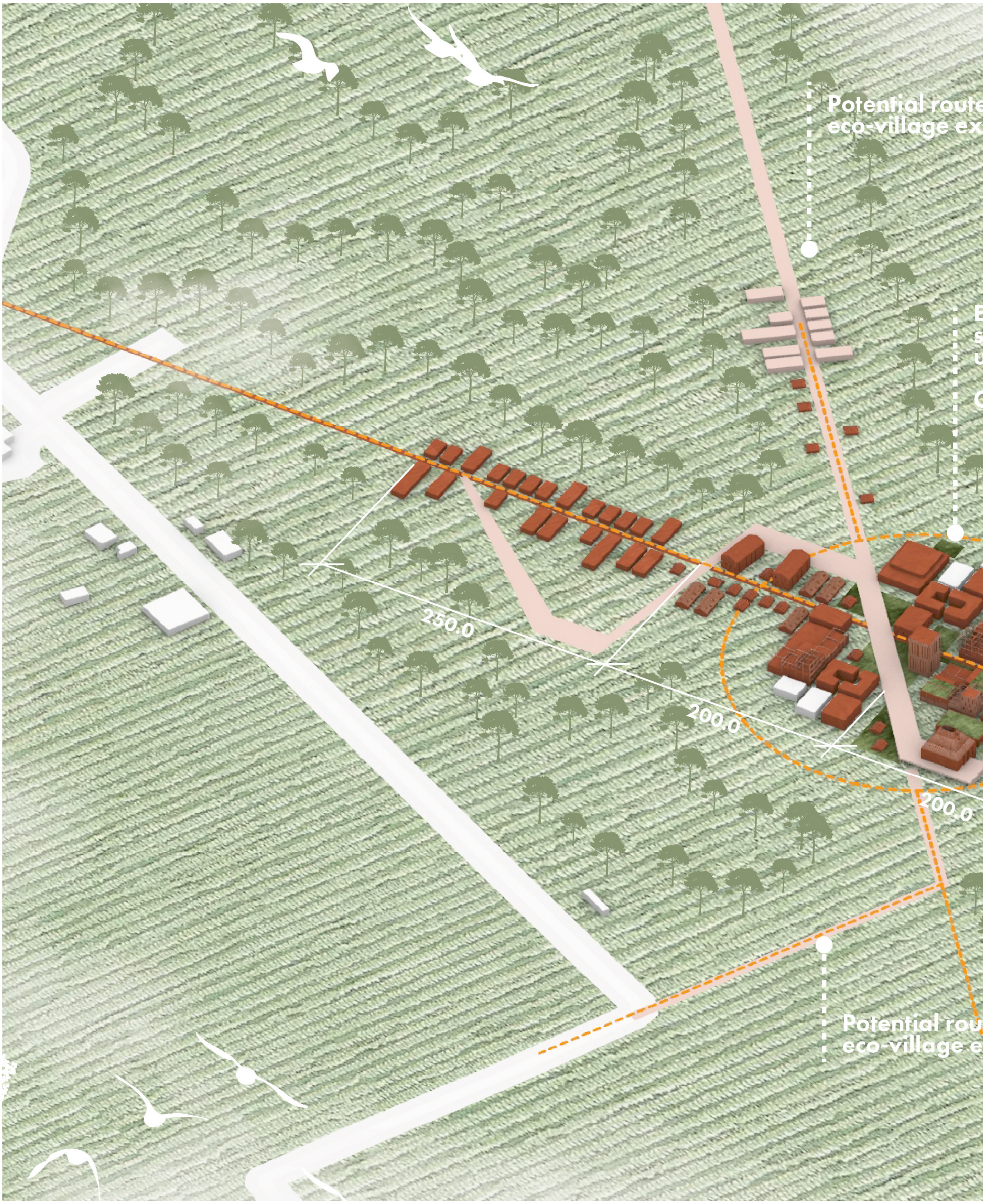


Fig. 4.8 _ Axonometric view. The eco-village: Heat to Living.

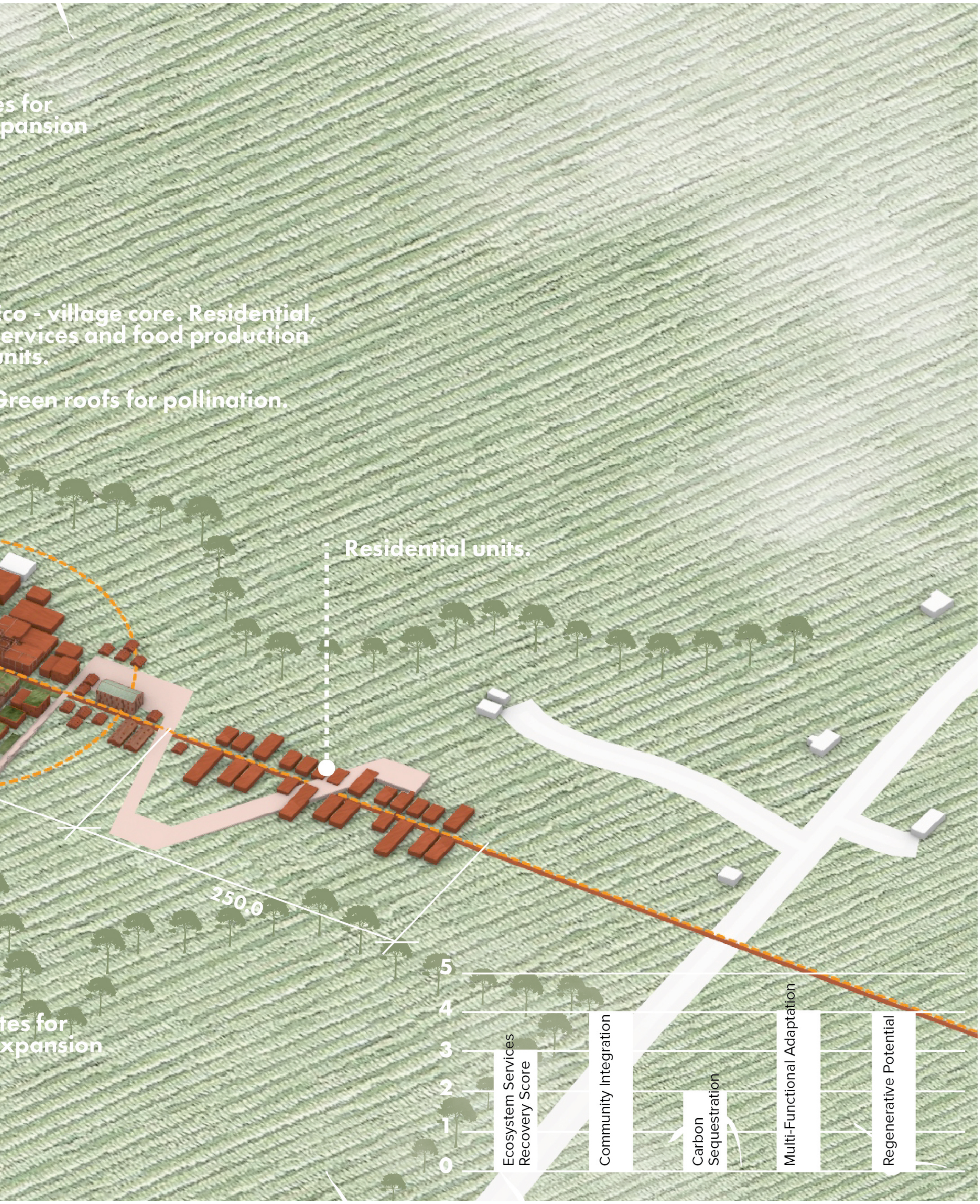

es for
pansion
co - village core. Residential,
ervices and food production
nits.
Green roofs for pollination.
Residential units.
250.0
tes for
xpansion
5
4
3
2
1
0
Ecosystem Services Recovery Score
Community Integration
Carbon Sequestration
Multi-Functional Adaptation
Regenerative Potential

Fig. 4.9 _ Perspective view. The eco-village: Heat to Living.

The Memory Corridor: Unburying the Line, Restoring the Land

Stretching from the highlands of the Ozark Plateau to the low-lying Mississippi Alluvial Plain and into the mixed-transition zone of Tennessee, Hubs 4 and 5 propose a long, continuous act of landscape transformation through removal. Rather than being repurposed or buried further, the pipeline here is unearthed and dismantled, giving way to a restored ecological corridor that traces its former path with trails, native plantings, wetlands, and memory pavilions. This is the most materially reductive intervention in the loop—and arguably the most radical—transforming a line of fossil extraction into a living archive of repair.

Hub 4, near Cape Girardeau, lies within the Ozark Plateau, a geologically distinct upland region characterized by forested ridges, limestone outcrops, and shallow groundwater systems. In this setting, the intervention is deliberately minimal. Trails follow the existing canopy clearings and pipeline scars, with light-touch grading and reforestation guiding ecological recovery. The aim is to avoid imposition and let the forest reclaim the corridor on its own terms. Wildlife habitat is reconnected, understory planting is reestablished, and small timber platforms are inserted only where necessary to aid human movement through sensitive ground.

By removing the pipeline, these hubs allow groundwater flows to be restored, wetland basins to regenerate, and habitats to re-form without the risk of rupture, corrosion, or buried toxicity. The act of deconstruction is not only technical, but symbolic: a gesture of accountability and care that turns a fossil corridor into an evolving ecological archive.

Throughout the newly formed corridor, a network of soft paths meanders through forest clearings and wetland restorations. These paths follow the historical trace of the pipeline and are punctuated by a series of open-air pavilions—light, timber structures designed to host rest, storytelling, and local gatherings. In some places, the pipeline's rusted remnants are partially exposed and preserved, forming sculptural elements that frame the landscape as a site of both ruin and renewal. Informational markers share the history of the pipeline, the environmental transformations it triggered, and the ongoing work of restoration—making visible the infrastructures that so often remain hidden beneath our feet.

As the trail continues eastward, it crosses into the Mississippi Alluvial Plain—a fertile but fragmented landscape of wetlands, agriculture, and flood-prone lowlands. Here, the pipeline's absence becomes a gesture of hydrological healing: swales and flood basins are reintroduced, allowing the land to absorb and filter water once more. The corridor continues into Benton, Tennessee, where Hub 5 anchors the trail's terminus in a mixed-transition zone—an ecotone between forest, pasture, and wetland systems. In contrast to the restraint of Hub 4, the intervention here takes on a more curated, park-like character: trails widen into gathering clearings, and open-air pavilions offer space for pause, storytelling, and ecological education. The design engages local residents while celebrating the site's layered histories of settlement, extraction, and renewal.

These hubs perform especially well in Ecosystem Services Recovery (ESRS) and Carbon Sequestration, due to their commitment to rewilding, habitat restoration, and hydrological repair. Multi-Functional Adaptation (MFAI) is quiet but nuanced—expressed in the blending of ecological, recreational, and cultural layers. Community Integration varies: modest and contemplative in Hub 4, more interactive and accessible in Hub 5. Their Regenerative Potential Index (RPI) is among the highest in the loop, representing a complete spatial and conceptual reversal—from buried infrastructure to exposed history, from controlled flow to seasonal rhythms, from harm to repair.

This corridor does not impose; it listens. It traces a scar and lets it grow over—not to erase, but to heal. In doing so, it reclaims the pipeline not as a conduit for oil, but as a pathway of memory, movement, and ecological return.

Memory Trail
(Cape Girardeau, MO)

With the pipeline removed, the site is transformed into a rewilded trail of ecological restoration and historical memory through forested terrain.

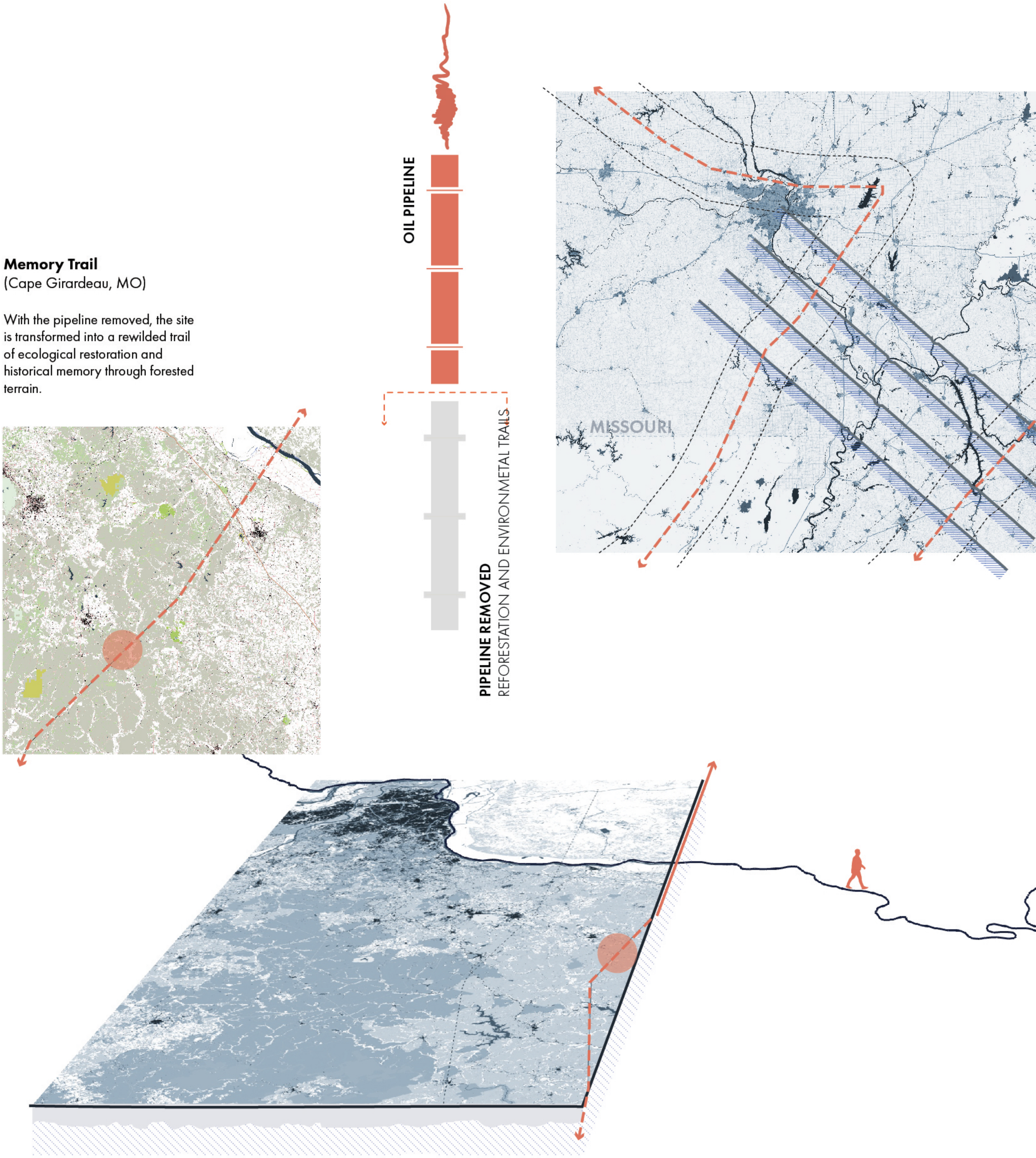
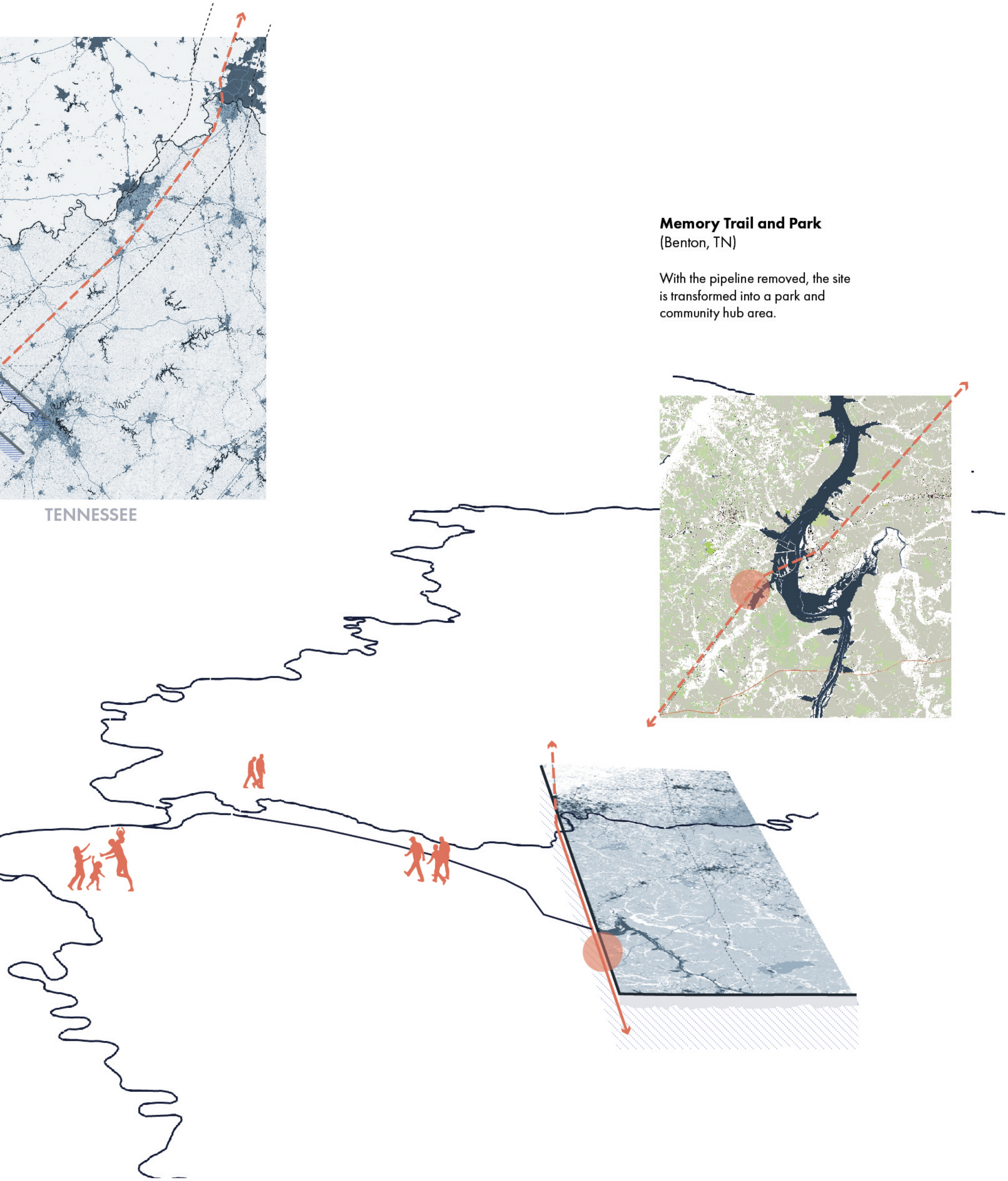


Fig. 4.10 _ Site analysis. The Memory Corridor: Unburying the Line, Restoring the Land.



Memory Trail and Park
(Benton, TN)

With the pipeline removed, the site is transformed into a park and community hub area.

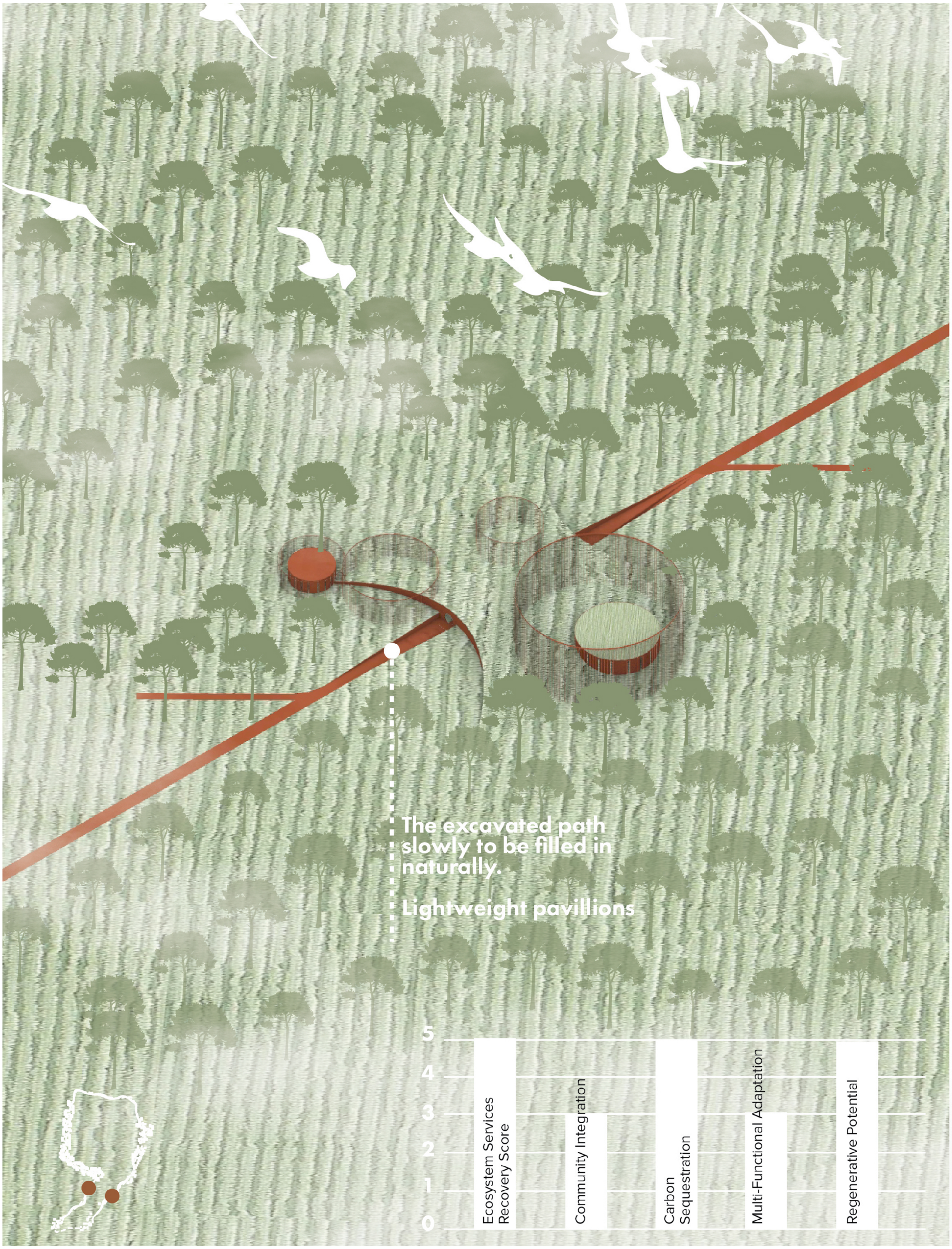
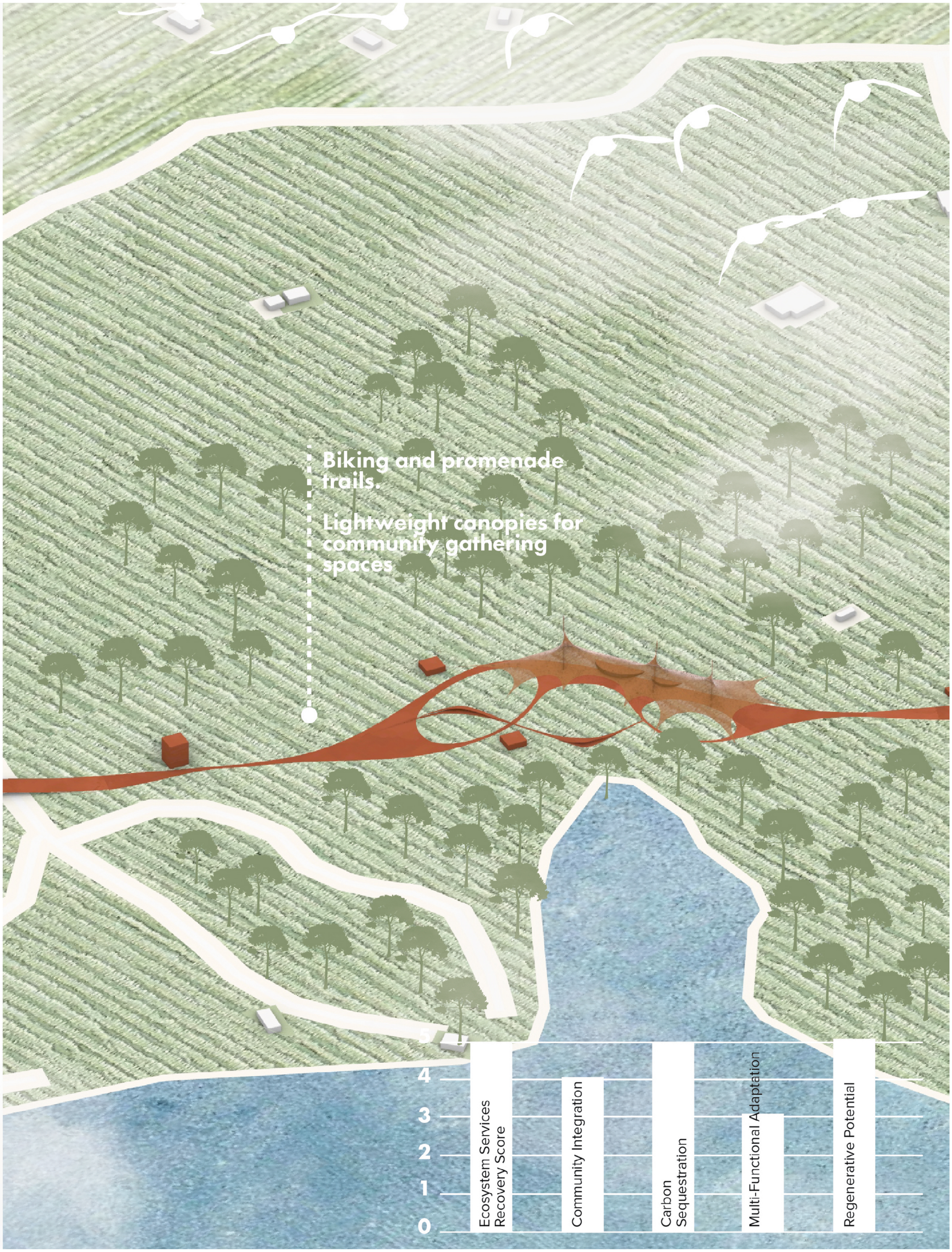


Fig. 4.11 _Axonometric views. The Memory Corridor: Unburying the Line, Restoring the Land.



Biking and promenade trails.

Lightweight canopies for community gathering spaces

Fig. 4.12 _ Perspective view. The Memory Corridor: Unburying the Line, Restoring the Land.

05 The Afterlives

From Extraction to Regeneration

The Afterlives

As the global energy transition accelerates, the question of what to do with thousands of kilometers of aging oil pipelines becomes increasingly urgent. Rather than allowing these linear relics of the fossil era to remain buried hazards, this chapter imagines their deliberate transformation—into ecological corridors, civic infrastructure, and regenerative systems of care. What follows is a timeline of implementation that articulates how this vision might unfold through layered design strategies, cross-scalar governance, and long-term investment in public good. The afterlives of these pipelines are not singular or static. They are phased, adaptive, and intertwined with broader cultural, ecological, and economic shifts.

The Loop and its Islands

At the heart of this project lies a reimagining of the pipeline not as a single utility corridor but as a territorial loop—a thickened, multifunctional band that traverses fourteen U.S. states. This loop is both spatial and conceptual. It proposes a shift from throughput to feedback, from linear extraction to circular regeneration.

The total masterplan **(Fig.5.1)**, renders the loop not as an uninterrupted line but as a dynamic and flexible field of intervention. Distributed along its course are a series of spatial "islands"—zones of concentrated activity that test, activate, or remediate the surrounding territory. Some islands host renewable energy clusters; others focus on wetland restoration, food cultivation, or public gathering. Their form and function respond to local conditions: proximity to refineries, water stress, population vulnerability, or energy infrastructure. Together, they form a network of distributed interventions—each autonomous yet interlinked, forming a metabolic constellation within the broader pipeline band. The figure foregrounds this modularity of intervention, showing how moments of activation are both grounded in local specificity and linked through infrastructural continuity.

The pipeline loop thus becomes more than a site of remediation—it becomes a scaffold. One capable of supporting secondary loops: of food production (community agroforestry, distributed composting), of material circularity (reuse of extracted steel, bioswale construction, regenerative soil systems), and of energy exchange (solar fields connected to local microgrids, wind corridors aligned with transmission lines). These layered systems do not erase the legacy of extraction—they metabolize it.

Phases of transformation

The transformation begins with a kind of listening. Between 2025 and 2028, a diagnostic effort unfolds—not to design, but to understand. This phase is marked by mapping: not only the material condition of the pipelines, but the layered ecologies and histories they traverse. Flood zones, tribal lands, degraded wetlands, and peripheries of abandonment begin to emerge as sites of latent potential. These are not blank slates. They are terrains of entanglement, where infrastructure meets land, memory, and metabolism. Using the hexagonal classification system developed in this research, intervention areas are stratified according to environmental vulnerability, infrastructural intensity, and socio-political complexity. What results is not a masterplan, but an atlas—a spatial imagination of possible futures.

By the late 2020s and early 2030s, this understanding gives rise to action. In a handful of pilot sites, pipelines are cut open, examined, redefined. Wetlands are rehydrated where oil once flowed. In other zones, the steel is repurposed or removed altogether, its absence filled by soil, seeds, and civic programs. These are not large-scale interventions yet, but prototypes. Community land trusts are established; ecological tax credits are tested; co-governance frameworks with Indigenous groups begin to take shape. The transformation is infrastructural, but also institutional. It is legal, economic, and emotional.

As momentum grows, the idea of the pipeline as a fixed linear element gives way to a more generative form. What was once a line becomes a loop. Not only spatially—circling back through restored ecosystems and low-carbon mobility corridors—but metabolically. Loops of food, energy, and material flow begin to attach themselves to the corridor. Agroforestry belts link to composting stations; solar arrays feed into microgrids that power district cooling; mycelium networks and regenerative soil systems replace concrete slabs. Some segments become solar and wind energy spines, while others serve as ecological membranes for pollinators, amphibians, and migrating species. The corridor evolves into a dynamic interface, linking planetary processes with local resilience. Where oil once moved in one direction, now multiple flows—nutrients, electrons, stories—move reciprocally.

In the 2030s and early 2040s, the question shifts from how to design to how to govern. What began as an isolated intervention must now be institutionalized. This means embedding pipeline reuse into national and regional climate strategies, ensuring land value gains are redistributed, and rethinking land tenure altogether. Community stewardship, tribal co-ownership, and new commons governance mechanisms begin to formalize. Fiscal tools—ecological service valuations, circular economy bonds—are deployed to ensure long-term maintenance and accountability. Crucially, the loops remain adaptive. Their form is never finished, only continually reconfigured in response to changing climate, policy, and community needs.

By mid-century, the pipeline corridor no longer carries oil. Instead, it carries meaning. It becomes connective tissue in a landscape once severed by extraction. It functions as a territorial archive and a living system—a platform for new forms of habitation, cultivation, and coexistence. And it is not limited to the U.S. The methodology—grounded in ecological entanglement, spatial justice, and adaptive reuse—extends beyond national borders. In post-coal valleys in Europe, in the agro-industrial belts of the Global South, in coastal regions where retreat is inevitable, the lessons travel. It is transferable not because of a universal design language, but because of its core principles: territorial specificity, modular intervention, co-governance, and metabolic feedback. These values allow the framework to be reinvented in radically different contexts, without losing its generative potential.

Instruments and Institutions

Infrastructure does not transform itself. It is reconfigured through layered agreements, evolving commitments, and the coordination of many hands. Transforming a fossil pipeline into a regenerative corridor is not simply a matter of spatial design—it requires governance design, legal redesign, and rethinking the actors entitled to shape the future of land. This transformation must unfold across different scales and rhythms, engaging distinct forms of expertise and stewardship at each phase.

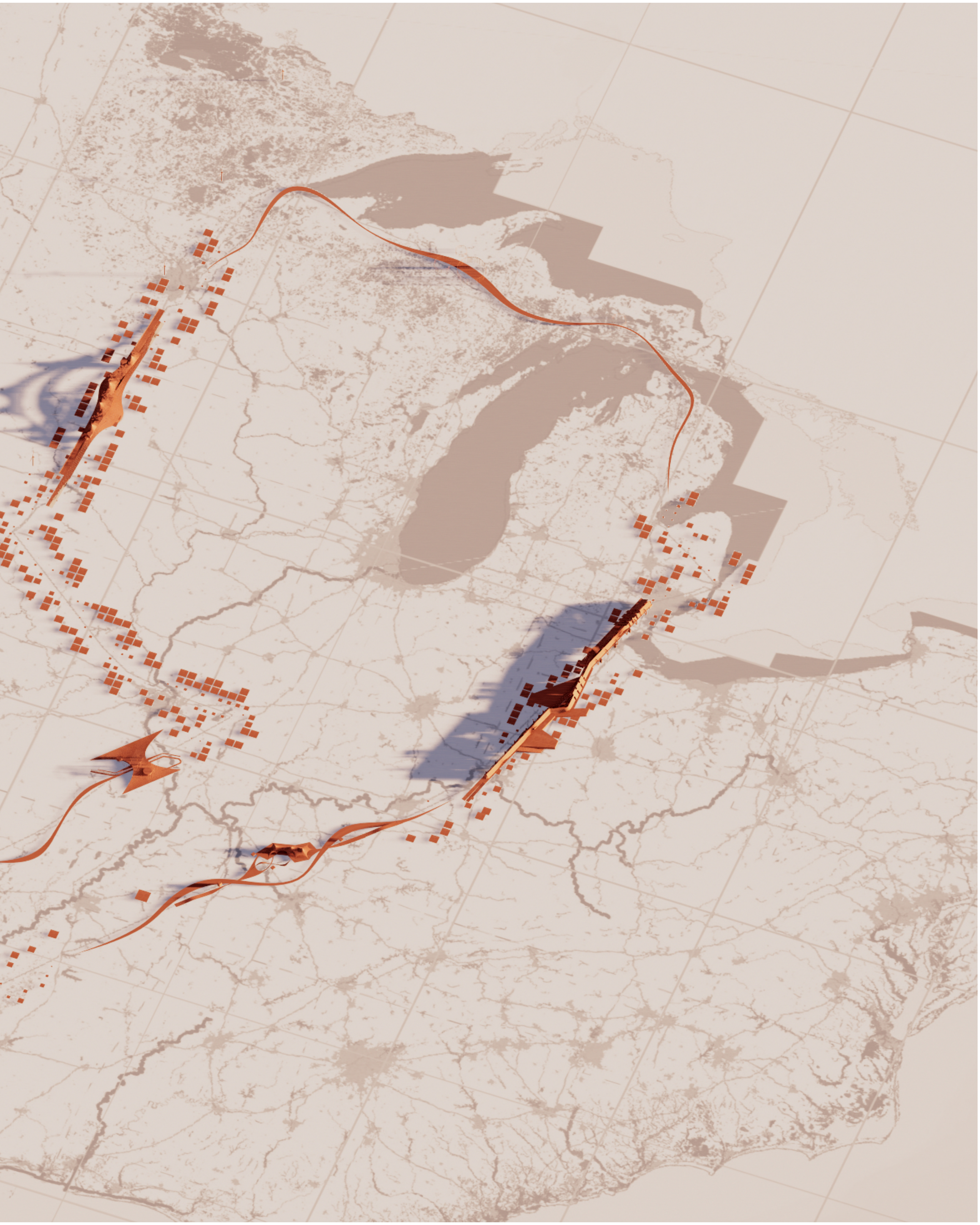
In the early stages, it is local communities, tribal governments, and environmental coalitions who begin the work—mapping vulnerabilities, recovering histories, and identifying possibilities for repair. As the process moves into prototyping, designers, planners, and engineers translate these territorial imaginaries into spatial interventions. Institutions then step in—agencies like the U.S. Environmental Protection Agency (EPA), the Department of Energy (DOE), the Department of Housing and Urban Development (HUD), and regional planning authorities—laying the policy and funding groundwork to stabilize and scale these efforts. Foundations such as the Ford Foundation, Kresge, and ClimateWorks may catalyze community-owned projects, while legal advocates and environmental justice alliances ensure protections remain in place. Over time, land ownership diversifies, governance structures adapt, and fiscal instruments—

like climate resilience bonds or ecological service credits—are introduced to secure long-term viability **(Fig. 5.2)**.

This is not a top-down model of implementation. It is a distributed and iterative framework—one that emphasizes shared authorship, ongoing negotiation, and the need for context-specific solutions. Rather than scaling through replication, this approach multiplies through variation. Policy becomes a design instrument. Finance becomes a spatial mechanism. Tools such as community land trusts, ecosystem service valuations, and cooperative management plans become the levers that make transformation possible.

The pipeline, once a symbol of extraction and enclosure, becomes a platform for shared agency and environmental justice. Its afterlife is not managed by any single institution but sustained through cooperation across difference: between federal and local actors, between grassroots organizers and technical agencies, between public interest and ecological repair.

Fig. 5.1 _ The Pipeline Loop and its Islands
The pipeline is reimagined as a territorial loop—thickened, adaptive, and layered with multifunctional nodes. Along its path, site-specific "islands" emerge as spaces for ecological restoration, energy transition, food production, and collective gathering. These interventions are shaped by local conditions—hydrology, infrastructure, population vulnerability—and form a distributed network of metabolic attachments. The loop becomes not a line of extraction, but a scaffold for circular systems and territorial repair.



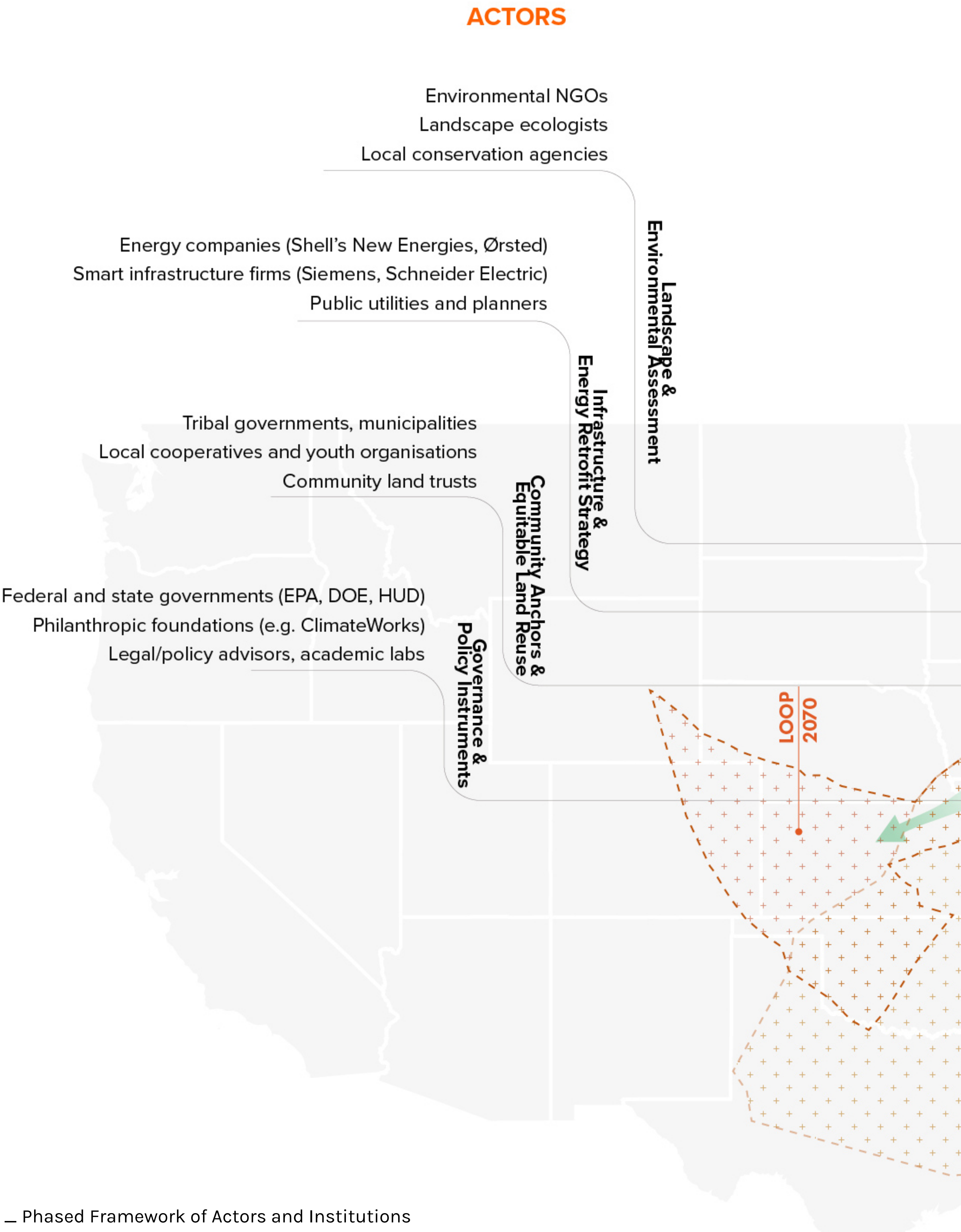
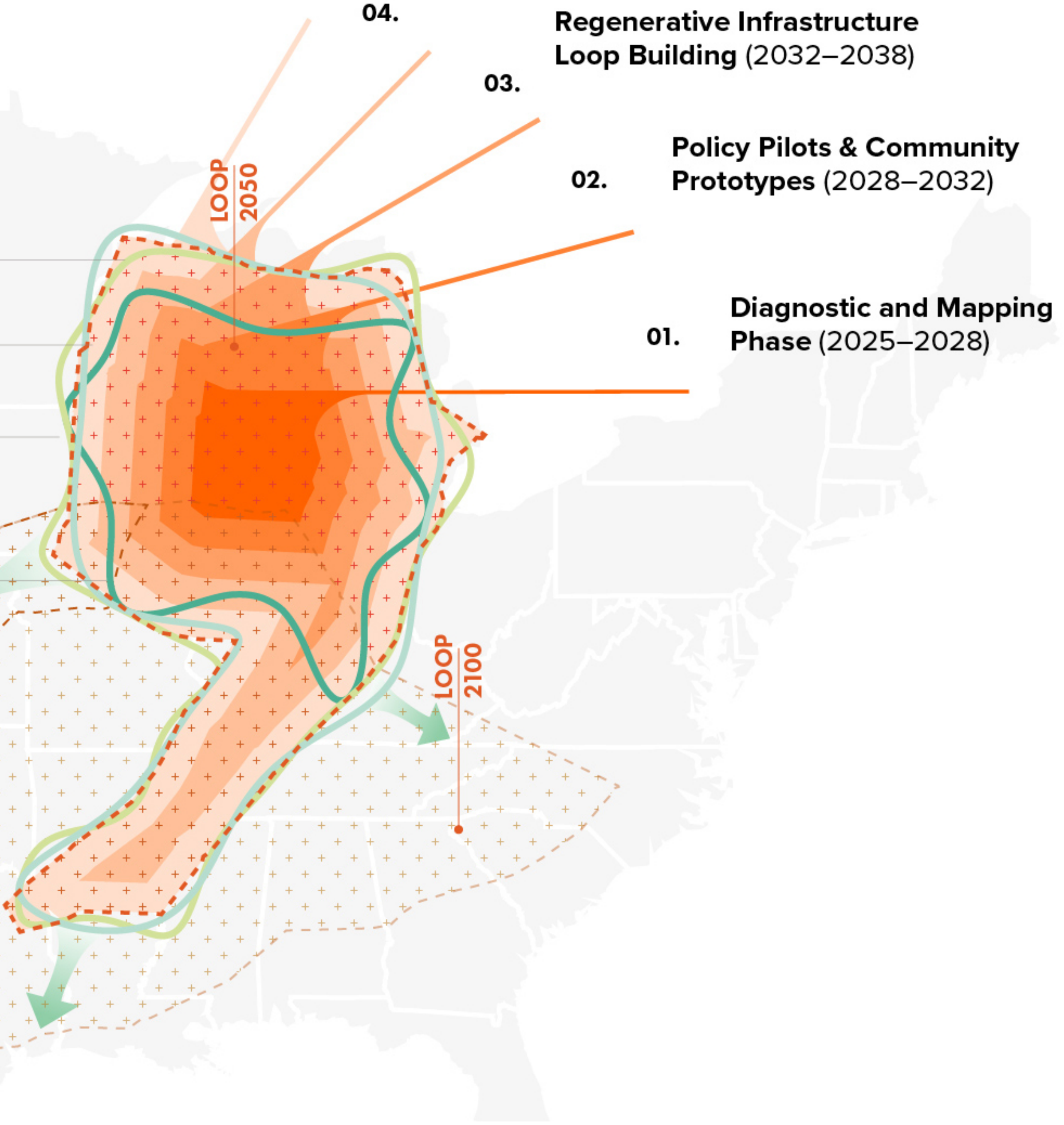


Fig. 5.2 _ Phased Framework of Actors and Institutions
Transformation unfolds through a choreography of actors across five overlapping phases—from diagnostics to global adaptation. The framework highlights the evolving roles of Indigenous communities, civil society, designers, public agencies, infrastructure firms, and legal institutions. Rather than centralizing control, it proposes distributed governance, where responsibility and authorship shift over time, allowing the pipeline's afterlife to remain adaptive, situated, and collectively held.

PHASES OF IMPLEMENTATION



05. **Planetary Urban Regeneration** (2045–2050)

04. **Institutionalization & Redistribution** (2038–2045)

03. **Regenerative Infrastructure Loop Building** (2032–2038)

02. **Policy Pilots & Community Prototypes** (2028–2032)

01. **Diagnostic and Mapping Phase** (2025–2028)

06 Conclusion

Conclusions

Oil pipelines, once hailed as marvels of engineering, have become haunting symbols of a waning era. They thread invisibly through land, policy, and psyche—binding together spaces of extraction with centers of consumption. Their linear logic was designed for permanence, yet today, they reveal deep temporal contradictions: engineered for indefinite use, they now stand as decaying veins of a system in collapse. But what if these scars could become scaffolds? What if, instead of erasure, we pursued radical reuse?

This thesis has argued that decommissioned and aging pipelines are not merely relics of the fossil age but spatial opportunities—latent infrastructures capable of being repurposed for ecological restoration, territorial justice, and post-carbon futures. Through mapping, classification, and speculative design, the project reframes pipelines not as inert hardware but as living spatial systems embedded within environmental, political, and cultural networks.

To reimagine the pipeline as a territorial scaffold is to challenge the dominant narratives of infrastructural progress. Drawing on Neil Brenner's theory of planetary urbanization, this thesis situates pipelines within broader systems of territorial metabolism—where resource flows shape the spatial production of urban and non-urban landscapes alike.[1] Pipelines are not peripheral; they are central to the urban condition in the Anthropocene. They govern not just where energy flows, but how land is claimed, how settlements are organized, and how ecologies are fragmented or controlled.

Yet these infrastructures are not immutable. As Shannon Mattern reminds us, infrastructure is not just material—it is epistemological.[2] It encodes systems of value, vision, and power. If infrastructures are "world-making," then to reprogram them is to revise the terms of engagement between society, technology, and the environment. This thesis takes that call seriously, proposing that pipelines be understood not as technical detritus but as spatial palimpsests—sites of inscription and re-inscription, where new meanings and functions can emerge.

Of course, to propose design where others see abandonment is a political act. The transformation of pipelines into regenerative corridors is not neutral; it demands confrontation with histories of harm. Andreas Malm, in How to Blow Up a Pipeline, forces us to reckon with the structural violence embedded in fossil fuel infrastructures—and the urgency of disrupting them.[3] While this thesis does not advocate sabotage, it does stand in solidarity with the desire to dismantle systems that perpetuate ecological collapse and inequality. But rather than blow up the pipeline, it asks: how might we rebuild it differently?

The speculative proposals in this thesis—community energy hubs, rewilded corridors, agrivoltaic loops, and civic infrastructures—are not utopian blueprints. They are scaffolds for dialogue, imagination, and intervention. They call on architects, planners, ecologists, and policymakers to engage with the afterlives of infrastructure as sites of healing and negotiation, not just decay. The pipeline loop proposed here is both a conceptual framework and a real spatial proposition: a distributed system of

---

[1] Neil Brenner, Implosions/Explosions: Towards a Study of Planetary Urbanization (Berlin: Jovis, 2014).

[2] Shannon Mattern, Code and Clay, Data and Dirt: Five Thousand Years of Urban Media (Minneapolis: University of Minnesota Press, 2017).

[3] Andreas Malm, How to Blow Up a Pipeline: Learning to Fight in a World on Fire (London: Verso, 2021).

ecological repair, energy redistribution, and social reconnection.

But this project is not only theoretical—it offers a concrete methodology for transformation. The construction of a 6,266-kilometer territorial loop from decommissioned and aging crude oil pipeline segments, the implementation of a typological classification system based on spatial indicators, and the territorial analysis of energy, biodiversity, and agricultural systems together form a replicable approach to infrastructure reuse. The hexagonal scoring framework created in this research enables site-specific assessment of transformation potential, while the resulting typologies—ranging from urban clean energy hubs to hydro-ecological zones—provide a spatial logic for intervention.

By combining design speculation with geospatial analysis and multi-scalar mapping, the thesis builds a bridge between theory and application. It shows how post-carbon infrastructures can emerge not from blank slates, but from the very systems that have long defined fossil-fueled landscapes. In doing so, it reframes pipeline decommissioning as a design opportunity—one that intersects environmental repair, spatial justice, and infrastructural imagination.

In the end, this project argues for a shift in perspective: from extraction to regeneration, from permanence to adaptability, from linear to circular. It asks us to confront the infrastructures we've inherited—and to imagine how they might yet serve futures we haven't dared to build.

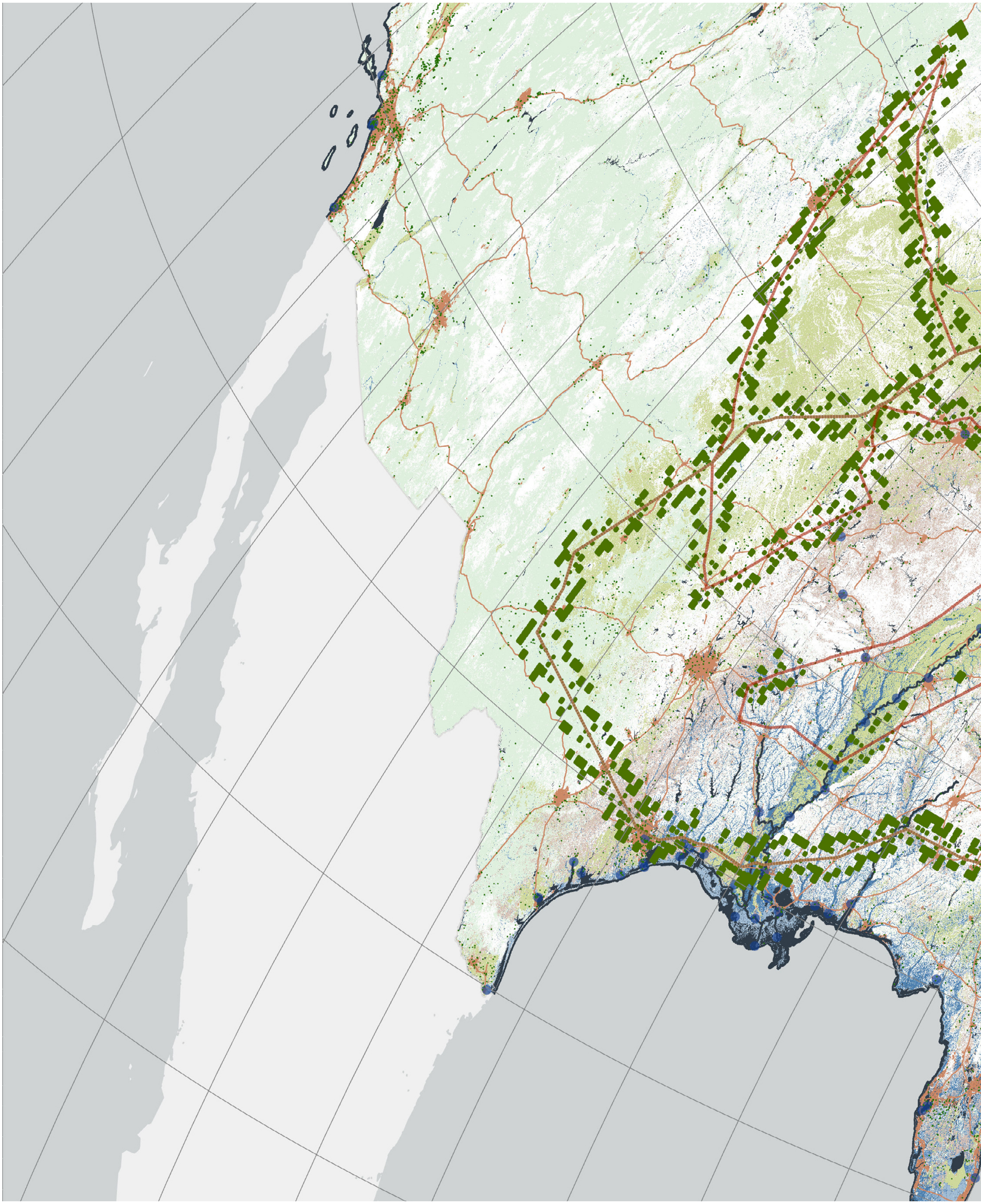
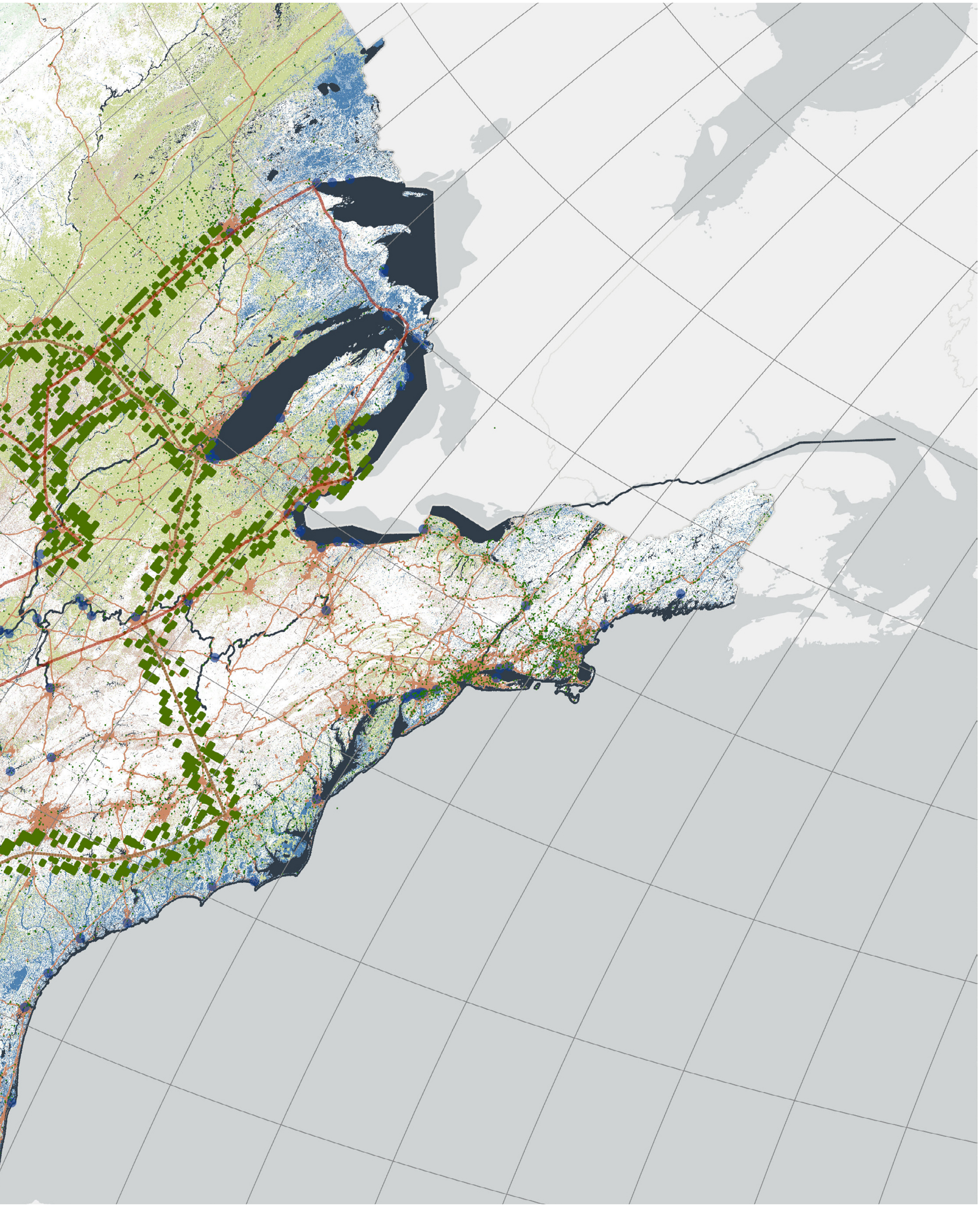


Fig. 6.1 _ Loops Expanding across the US.



Bibliography

Ali, Lorraine Weller. “From Food Desert to Crop Oasis: The Native American Community Growing Their Own Healthy Future.” The Guardian, December 3, 2022. https://www.theguardian.com/environment/2022/dec/03/south-dakota-reservation-food-desert-residents-transforming-crop-oasis.

Brenner, Neil, Implosions/Explosions: Towards a Study of Planetary Urbanization (Berlin: Jovis, 2014).

Bridge, Gavin. “The Hole World: Scales and Spaces of Extraction.” In New Geographies 2: Landscapes of Energy, edited by Rania Ghosn, 43–48. Cambridge, MA: Harvard Graduate School of Design, 2009.

———. “Global Production Networks and the Extractive Sector: Governing Resource-Based Development.” Journal of Economic Geography 8, no. 3 (2008): 389–419.

Easterling, Keller. “Extrastatecraft: The Power of Infrastructure Space”. London: Verso, 2014.

Environmental Protection Agency (EPA). “EPA History.” https://www.epa.gov/history.

Environmental Protection Agency (EPA). “History of the Clean Water Act.” https://www.epa.gov/laws-regulations/history-clean-water-act.

European Hydrogen Backbone Initiative. Analysing Future Demand, Supply, and Transport of Hydrogen. Guidehouse, 2020. https://gasforclimate2050.eu.

Ghosn, Rania, ed. Landscapes of Energy: New Geographies 2. Cambridge, MA: Harvard Graduate School of Design, 2009.

Ghosn, Rania. “Where Are the Missing Spaces? The Geography of Some Uncommon Interests.” New Geographies 2 (2010): 109–116.

Global Energy Monitor. Global Oil and Gas Infrastructure Tracker, April 2024. https://globalenergymonitor.org/projects/global-oil-and-gas-infrastructure-tracker/.

Government of Alberta. Linear Disturbance Restoration Guidelines. Alberta Environment and Parks, 2021. https://www.alberta.ca.

Hartog, Hans, et al. “Distributed Fiber-Optic Sensing for Pipeline Monitoring.” Journal of Pipeline Engineering 19, no. 4 (2020): 219–233.

Hein, Carola. “Global Landscapes of Oil.” In New Geographies 2: Landscapes of Energy, edited by Rania Ghosn, 33–42. Cambridge, MA: Harvard Graduate School of Design, 2009.

Huber, Matthew T. Lifeblood: Oil, Freedom, and the Forces of Capital. Minneapolis: University of Minnesota Press, 2013.

Intergovernmental Panel on Climate Change (IPCC). Sixth Assessment Report: Mitigation of Climate Change, 2021. https://www.ipcc.ch/report/ar6/wg3/.

Larkin, Brian. “The Politics and Poetics of Infrastructure.” Annual Review of Anthropology 42, no. 1 (2013): 327–343. https://doi.org/10.1146/annurev-anthro-092412-155522.

Malm, Andreas. How to Blow Up a Pipeline: Learning to Fight in a World on Fire. London: Verso, 2021.

Mattern, Shannon. Code and Clay, Data and Dirt: Five Thousand Years of Urban Media. Minneapolis: University of Minnesota Press, 2017.

Menon, E. Shashi. Pipeline Planning and Construction Field Manual. Waltham, MA: Gulf Professional Publishing, 2011.

Mitchell, Timothy. Carbon Democracy: Political Power in the Age of Oil. London: Verso, 2011.

National Oceanic and Atmospheric Administration (NOAA). “Coastal Zone Management Act.” https://coast.noaa.gov/czm/act/.

Nixon, Rob. Slow Violence and the Environmentalism of the Poor. Cambridge, MA: Harvard University Press, 2011.

Pipeline and Hazardous Materials Safety Administration (PHMSA). “Pipeline Incident 20-Year Trends.” U.S. Department of Transportation, 2022. https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-incident-20-year-trends.

———. “Pipeline Safety: Safety of Gas Distribution Pipelines and Other Pipeline Safety Initiatives.” Federal Register 88, no. 172 (September 7, 2023): 61568–61613. https://www.federalregister.gov/documents/2023/09/07/2023-18585/pipeline-safety-safety-of-gas-distribution-pipelines-and-other-pipeline-safety-initiatives.

———. “Pipeline Failure Causes.” U.S. Department of Transportation. https://www.phmsa.dot.gov/incident-reporting/accident-investigation-division/pipeline-failure-causes.

Ramsar Convention Secretariat. The Economics of Ecosystems and Biodiversity for Water and Wetlands, 2013. https://www.ramsar.org/sites/default/files/documents/library/teeb_waterwetlands_report_2013.pdf.

Reuters. “Keystone Pipeline Shut After 14,000-Barrel Oil Spill in Kansas.” December 8, 2022. https://www.reuters.com/business/energy/keystone-pipeline-shut-after-oil-spill-into-kansas-creek-2022-12-08/.

Statista Research Department. “Length of Oil Pipelines Worldwide as of 2022, by Country.” August 29, 2023. https://www.statista.com/statistics/1491015/length-of-oil-pipelines-by-country/.

———. “Most Common Causes of Oil Pipeline Incidents in the United States from 2010 to 2022.” June 2023. https://www.statista.com/statistics/1271803/most-common-us-oil-pipeline-incident-causes/.

———. “Length of Oil Pipelines in North America as of September 2022, by Status.” September 2022. https://www.statista.com/statistics/1135198/north-america-oil-pipelines-by-status/.

Stantec. “Repurposing Pipelines for the Energy Transition.” Accessed February 13, 2025. https://www.stantec.com/en/ideas/topic/stantec-era/repurposing-pipelines-for-energy-transition.

Statista Research Department. “Length of Oil Pipelines Worldwide as of 2022, by Country.” Statista, August 29, 2023. https://www.statista.com/statistics/1491015/length-of-oil-pipelines-by-country/.

Swyngedouw, Erik. “The City as a Hybrid: On Nature, Society, and Cyborg Urbanization.” Capitalism, Nature, Socialism 7, no. 2 (1996): 65–80.

———. “Circulations and Metabolisms: (Hybrid) Natures and (Cyborg) Cities.” Science as Culture 15, no. 2 (2006): 105–121.

Tester, Jefferson W., et al. Sustainable Energy: Choosing Among Options. 3rd ed. Cambridge, MA: MIT Press, 2020.

Transportation Research Board. Transmission Pipelines and Land Use: A Risk-Informed Approach.

Washington, D.C.: National Academies Press, 2004.
U.S. Department of Energy. Compressed Air Energy Storage (CAES) Demonstration Projects, 2021. https://energy.gov.
U.S. Energy Information Administration (EIA). "U.S. Remains the World's Top Producer of Petroleum and Natural Gas Hydrocarbons." March 16, 2023. https://www.eia.gov/todayinenergy/detail.php?id=55960.