Infrastructural Futures in the Ecological Emergency: Gray, Green, and Revolutionary.

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Abstract: *»Infrastrukturelle Zukünfte in ökologischer Notlage: graue, grüne und revolutionäre Infrastruktur«.* In this article, I discuss the three dominant models of conceiving infrastructural futures in the context of the contemporary ecological emergency and what kinds of futures each model enables and forestalls. Gray infrastructure conceives human-engineered material designs that are able to produce predictable, controllable effects, often at a mass scale. Gray infrastructure also conceives futures that by and large reproduce present Anthropocene relations (e.g., a strict nature/culture divide mediated by technology and human supremacy. Green infrastructure is a more diverse paradigm but generally speaking pursues naturecultural collaborations that seek to bend the Anthropocene trajectory. Still, much of what passes for green infrastructure today fails to challenge industrial-capitalist logics and in this way creates futures that are more reproductive of the Anthropocene trajectory than they intend. Finally, I discuss my concept of "revolutionary infrastructure" as an alternative to gray and green infrastructural imagination. Revolutionary infrastructure resists standardization and categorization but generally appears as local experimental enabling relations, as redirection of potential energy, and as transformational pathways toward non-ecocidal, non-genocidal futures.

Keywords: Climate emergency, ecology, infrastructure, revolution.

1. The Infrastructural Ecology of the Ecological Emergency

The word "infrastructure" conventionally conjures images of massive material assemblages: highways, railways, dams, data networks, power grids, and pipeline systems (see, e.g., Bakke 2016; Barry 2013; Edwards 2010; Harvey and Knox 2015). But what is striking about the concept of infrastructure is that it actually does not refer to things but rather to the relationship between things

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(Larkin 2013). More specifically, whatever infrastructure is, it is infrastructural to the extent that it enables something to happen (Boyer 2016, 2018).

In this way, infrastructure has a deictic character. Just as the meaning of the pronoun "we" varies depending on the context, the meaning of infrastructure depends entirely on a situated set of circumstances and relations such that even the same physical artifact or ensemble of things can manifest very different sorts of infrastructural relations. So, for example, in my partner's hometown of Santa Cruz, CA, there is a marvelous pier that stretches out into the Pacific Ocean. Built with thousands of Douglas fir pilings to a length of 2,745 feet (836 m), it is the longest wooden pier in the United States. In its early decades, the pier served predominantly as trade and storage infrastructure, allowing Santa Cruz's industries to host deep sea vessels for the first time. It also served (and continues to serve) as a productive infrastructure for local fishermen to improve their catch. Today the pier principally enables local tourism, allowing visitors to walk above water and to visit a variety of small restaurants and trinket shops while enjoying the ocean breeze. It is a leisure infrastructure not only for humans but for nonhumans too. Looking down at the base of the pier, one sees that a number of its platforms have been colonized by sea lions who clamber out of the water to rest and sun themselves in large overlapping jumbles. Meanwhile, the upper deck is popular with area shorebirds who share meals, not always consensually, with human tourists. At the water's edge, the pier pilings serve as a domestic infrastructure – home, in other words – for barnacles, hydroids, bryozoans, mussels, and many other creatures. Just one pier infrastructures a remarkable ecology. It achieves this through what we might call *an ecology of infrastructural relations* (Star and Ruhleder 1996).

The objective of this special issue is "to explore the meaning of infrastructures in the context of the multiple ecological crises and its implications for the diverse futures of sustainability" (Degens, Hilbrich, and Lenz 2022, in this volume). Since we know that the meaning of infrastructure is a deictic question, context is all important to understanding what ecology of infrastructural relations is responsible for our condition of ecological crisis. The ecological emergency, as I prefer to call it, is a question of infrastructural relations in two senses. First, the destabilization of Holocene earth systems has largely come about as a result of infrastructures enabling the expansion and intensification of industrial, imperial Euro-American Civilization (Scranton 2016). These infrastructures emitted enormous quantities of greenhouse gases while also disrupting the planetary metabolism through large-scale deforestation and monoculture, oceanic acidification, species extinction, and the chaotic distribution of waste and toxins into every ecosystem. Second, we are currently experiencing a phase of remarkable infrastructural experimentation and transition as nations and communities around the world seek to retrofit existing infrastructures and develop new ones with less ecocidal impacts (Howe et al. 2016).

Two ecologies of infrastructural relations have been particularly consequential in enabling conditions of ecological emergency: transportation and production. Ever since the steam-power locomotive, high carbon transportation has been one of the key drivers of cultural modernity. The emergence of high-speed, long-distance mobility gave 19th-century contemporaries the impression that human science and industry had developed quasi-divine powers that were capable of overcoming both space and time. This impression of transcendental technological capability became a key pier pile for the civilizational conceit that human intelligence and culture were separable from, and superior to, nature (Marx 1964). Transportation experientially materialized modern liberal beliefs in freedom by permitting rapid translocal travel at a whim. Nowhere was this more obvious than with automobility, which began with a steam-power standard but transitioned to gasoline, catalyzing the rise of oil dependency and petroculture. Accommodating automobility meanwhile radically transformed the landscape of human settlements across the world. Walkable, bikeable density was eschewed in favor of sprawl that required gas engines to navigate. At the same time, energy-efficient public transportation was usually suppressed in favor of inefficient private transportation. Think of how perfectly functional streetcar networks were decommissioned and torn out of the ground in favor of expanded automobility in the United States between the 1920s and the 1950s. Cities were, in effect, redesigned to burn more oil. Road travel currently accounts for roughly 15% of greenhouse gas emissions globally. In the era of aviation and fossil-fueled shipping, transportation offered new speeds and pathways for global commerce as well as an opportunity for high-carbon leisure. The massive container ships that now constitute 90% of global trade contribute roughly 3% of carbon emissions, more or less on par with the greenhouse gas footprint of the aviation industry, which currently services only the ~10% of the world population with the resources to fly.

Production represents an even more significant ecology of infrastructures responsible for the ecological emergency, but their totality is dizzying. A historical perspective helps pinpoint how production infrastructures came to undergird and indeed epitomize today's ecocidal trajectory. Everything roots back to the New World plantation culture, whose slave-driven economies for tobacco, coffee, and, above all, sugar laid the rails for global capitalism (Patel and Moore 2018; Boyer, forthcoming). Sidney Mintz (1985) argues that Caribbean sugar plantations constituted the first truly modernized societies in the world where people mobilized through violence and oppression were "thrust into remarkably industrial settings for their time." The plantation industries in turn enabled European merchant and commercial classes to accumulate the social and economic power needed to gradually overthrow the feudal aristocratic order. For this reason, many historians have depicted plantations as a curious blend of industrial and agricultural, capitalist, and feudal logics (e.g., Williams 1944). The contradiction disappears when one considers plantations as a kind of embryonic form of the industrial-capitalist order that would later flourish in the 19th century. This argument has been made recently by Donna Haraway, who sees the plantation heralding many aspects of modern economic life from monoculture to exploitative labor and machinic relations:

> The plantation disrupts the generation times of all the players. It radically simplifies the number of players and sets up situations for the vast proliferation of some and the removal of others. It's an epidemic friendly way of rearranging species life in the world. It is a system that depends on forced human labor of some kind because if labor can escape, it will escape the plantation. The plantation system requires either genocide or removal or some mode of captivity and replacement of a local labor force by coerced labor from outside, either through various forms of indenture, unequal contract, or out-and-out slavery. The plantation really depends on very intense forms of labor slavery, including also machine labor slavery, a building of machines for exploitation and extraction of earthlings. (in Mitman 2019)

Whether one wishes to name our current trajectory as Anthropocene, Capitalocene, or Plantationocene, its original infrastructural ecology was New World colonial relations.

We normally, and for the most part rightly, conceive of the steam engine as the historical culprit most responsible for spreading high-carbon productive relations around the world. Less known is that the first application of steam power to the operation of manufacturing machinery occurred in a Jamaican sugar mill in 1768, almost a decade before the Watt engine was commercialized in Europe (Deerr and Brookes 1940). It was also neither obvious nor inevitable that the age of machines would be dominated by steam power. Britain, by far the most advanced industrial economy of its time, opened the 19th century with waterwheels established as the primary source of machine energy for early industrial manufacture, particularly textile mills. British textiles were already fully interwoven into global trade networks by that point. No cotton grew in Britain itself, but Britain was an industrial epicenter for creating cloth and clothing from cotton grown in its American, Egyptian, and Indian colonies and then exporting those goods to its colonies and elsewhere in Europe. The artisanal spinning and weaving cultures of mid-18th century Britain, expansive though they were, constituted a cottage industry whose limits to productivity inhibited the expansion and intensification of global trade. When Richard Arkwright founded his first hydro-powered cotton spinning mill at Cromford in 1771, it was quite literally a watershed moment in what we retrospectively call the "industrial revolution." Not only was Cromford the first fully machine-powered mill, but it was also the first to operate continuously, round-the-clock in two twelve-hour shifts. Modern capitalism was powered first by slaves and then by water before fossil fuels ever became part of the mix.

Waterwheels had advantages over steam engines in that while both involved significant capital outlays for construction, waterwheels ran for free while steam engines needed a constant supply of coal to burn. Plus, waterwheels ran cleanly without the nuisance of smoke. Yet, watermills had to be built where rivers were most advantageous, and these were often in areas far removed from labor supply, necessitating the costly building and maintenance of company colonies. Steam engines, comparatively, could be situated anywhere and when they were positioned near dense urban settlements, they brought labor and capital into convenient proximity that drove down labor costs dramatically. Moreover, whereas rivers both run dry and flood, "coal was utterly alien to seasons," allowing capital to disentangle itself from natural limits and variations, guaranteeing productive powers that could match the round-the-clock ethos of productivity that waterwheels had pioneered (Malm 2016). Coal thus proved decisively advantageous to capitalism in extending its control over time, space, and labor.

It was not until the 1830s that steam engines really displaced waterwheels in Britain. But once they did, European industrial capitalism did not look back. The fossil fuel era was truly born. By pairing machinic labor with the impressive energy density of coal, infrastructures emerged for new scales, speeds, and intensities of productive growth (Daggett 2019). Plus, they offered a doubled revenue stream since fossil fuels are a rent in addition to an energy source. While the sun and wind and water cannot be commodified, with fossil fuel one can sell both the machine itself and then the means to power the machine separately, dramatically increasing the wealth accumulation of purveyors of coal and oil.

The productive bounty of this expanding machine world left no aspect of daily life in the mid-19th century untouched. Ian Barbour et al. (1982) write of a new "democracy of things" suffusing the American standard of living during this period:

> The yardstick of a superior standard of living included not only basic necessities, but increasingly items that made life convenient, comfortable, and "progressive." Items unimagined in 1800, or extremely expensive in 1815, were soon taken for granted as the rightful possessions of a large middle class. Bent pieces of iron were replaced by safety pins, wax paper was superseded by large cheap panes of window glass. The traditional flint and steel fire starter was replaced by the newfangled safety match. Machinery now turned out cotton textiles, carpeting, shoes, "patent" furniture, and table-ware; wallpaper became the style instead of paint or leather wall covering. To the list must be added cast-iron stoves, spring mattresses, flush toilets, gaslights, silver-plated tableware, and even rollershades for windows. Americans of all classes came to believe they were entitled to these benefits produced by machines run by steam and water, and they wanted more. (1982, 17)

A feeling of entitlement to more and better machine-produced commodities has characterized modern northern life ever since. Consumerism was naturalized long before more sinister innovations like planned obsolescence and fast fashion accelerated the treadmill of consumption. The "democracy of things" interlocks with the cultural acceptance of the premise that massive expenditures of energy are both necessary and desirable to allow the machine world to produce more and improved commodities. Sadly, this sensibility was rarely questioned in the century that followed. Both production and consumption increased unchecked. It was not until the 1970s and the publication of the Club of Rome's *Limits to Growth* report that there was any serious political conversation about the need to limit the sprawl of fossil-fueled productivity. And those few like André Gorz (1980) who advised the need to "degrow" high-carbon industrial emissions were nonetheless still laughed out of mainstream politics. High-carbon production infrastructure remains the largest single greenhouse gas emissions vector according to most analyses. High-carbon transportation is not far behind. Taken together, this infrastructural assemblage enables our conditions of emergency today. And, if they are allowed to endure, they will enable ecological catastrophe in the not-too-distant future, instantiating worst-case scenarios of misery and extinction.

Now that we have a firmer sense of the infrastructural ecology of ecological emergency, the remainder of this article will focus on the range of infrastructural transformations that are emerging in response and the various kinds of futures that they promise to enable (Anand, Gupta, and Appel 2018). To make the immense field of infrastructural experimentation easier to navigate, I present three ideal types for consideration and analysis: gray infrastructure, green infrastructure, and revolutionary infrastructure. Gray and green infrastructure will be familiar concepts if you have any experience in the fields of stormwater management, flood control, or urban design. Revolutionary infrastructure is a concept that I have developed (Boyer 2016, 2018) as a way of distinguishing infrastructure projects that seek to separate ecological restoration and political-economic restoration from those that understand that ecological and political-economic transformation are necessarily entwined.

2. Gray Infrastructure

In the field of stormwater management, the distinction between gray and green infrastructure tends to be defined by infrastructural materials used and by the relation imagined between infrastructure and "nature." Here is a representative example from one of the many websites that exist to explain the differences between the two:

> Essentially, green versus gray infrastructure comes down to a simple matter of whether the infrastructure tries to control nature or use its natural processes to design solutions.
>
> Dykes and levees, for instance, are gray infrastructure. Through massive feats of engineering, stormwater is directed away from certain locations and toward others. These change nature's natural processes, not only in terms of where the water goes, but also regarding how it gets from A to B.
>
> That's a problem. In a natural system, water does not travel over miles and miles over land without soaking into the ground, except in a river. With gray infrastructure, though, stormwater may travel long ways over impermeable surfaces before it reaches a river, lake or sea – by which time it has picked up untold pollutants, toxins and nasty critters (like E. coli, harmful to both humans and animals).
>
> Often, when gray infrastructure gives water nowhere natural to go, that water has no choice but to head toward a destination that can't handle the volume, such as sewers, which then overflow and poison the environment.
>
> Green infrastructure, on the other hand, consists of elements that help nature do its job. They allow water to soak into the ground, filtering pollutants naturally. They retain or detain water just as nature does, keeping it roughly in place when it falls rather than funneling it immediately onward. (Ecogardens, n.d.)

Gray infrastructure, then, has certain distinguishing features: 1) it involves human-engineered material designs conceived as being able to produce predictable, controllable effects (for example, moving water from point A to B); 2) its designs are typically materialized via high-energy materials like concrete and steel to create stable channels for its effects to unfold along; 3) it typically operates at a translocal scale via some kind of integrated design. One storm grate or sewer does not make an infrastructure gray. It is always a *system* of sewers and grates that is imagined. Finally, 4) though this particular website does not mention it, gray infrastructure projects are invariably expensive to finance and 5) they take time, often a lot of it, to become functional.

There are problems with the conceptualization of "nature" that this discourse associates with green infrastructure and I will discuss those in the next section. For the moment, it is evident that gray infrastructure is a command-and-control apparatus, reproducing the modernist conceit that humanity can predictably control both nonhuman and human forces through its highly intelligent design work and technological prowess. Gray infrastructure conceives futures that by and large reproduce the present modern trajectory, only more efficiently and effectively.

As an ideal type, gray infrastructure is useful for thinking beyond stormwater too. A power grid meets the criteria of gray infrastructure, as does a highway system. If we want to push the concept further, any kind of bureaucratic organization (a government, a corporation, a school, a religion) exhibits gray infrastructural qualities. One can think of historical examples too. Egyptian and Mayan pyramids, for example, were gray infrastructure: massive prestige projects that sought to materialize a particular vision of power hierarchy at a sublime, greater-than-human scale encouraging both deference and acceptance. Contemporary gray infrastructure works similarly. There is something about a massive concrete dam or electric substation that inspires awe and dread and that paralyzes a sense of "response-ability" (Haraway 2016). It makes one feel: better to leave the future to the experts – the engineers and financiers – who are capable of constructing such impressive edifices.

Yet the major problem with gray infrastructure projects from the point of view of ecological emergency is that while they tend to do a good job of enabling the reproduction of political hierarchy and authority, they are only rarely effective at solving the problems that they ostensibly exist to solve. This is in no small part because gray infrastructure logics tend to create the problems that ostensibly trouble them. An excellent example of this phenomenon is the sympoietic relationship between flooding and flood control in my adoptive home: Houston, Texas.

Houston, a perplexing swampland megalopolis, has been an infrastructural center since its inception in 1836. Although nominally founded as the state capitol of Texas, mosquitos, yellow fever, and floods soon drove politics west toward Austin. Houston thrived instead because of the way its watery lands and landish waters allowed for a unique combination of transportation infrastructure (railroads and shipping), making it the key processing point for the proceeds of the plantation slave economies in the region. Houston was spared destruction during the Civil War, becoming instead an important hub of military manufacture. Its booming lumber, cotton, and sugar exports attracted and concentrated other kinds of manufacturing and administrative labor – cotton compresses and cotton oil seed mills, brass and iron foundries, car wheel works, railroad shops – during the last decades of the 19th century, making it the urban industrial center of Texas by 1905 as well as what contemporaries described as "the chief cotton concentration point in the world" (Carroll 1911).

The next phase of Houston's infrastructural ecology was summoned and shaped by two fateful events. The "Great Storm of 1900" left Galveston in ruins and rendered Houston by default the major port in Southeastern Texas. The discovery of unprecedented oil resources at Spindletop in 1901 then paved the way for Houston to become the nation's largest petroleum and petrochemical export hub over the course of the 20th century. Already by 1911, Houston was described by contemporaries as "the center of the oil industry." In 1914, a deep-water port was completed southeast of Houston's city center capstoning the 50-mile Houston Ship Channel. The Ship Channel would grow over the course of the next four decades into the largest complex of petroleum refining and petrochemical manufacturing in the Western Hemisphere (Melosi and Pratt 2007).

Ninety percent of Houston's growth occurred during the automobile era. Houston sprawled like no city before it, hyperactively lengthening its spines, ignoring infill, eschewing density, swallowing smaller surrounding settlements with relish, eventually reaching 1,600 km^2, the largest surface area of any major U.S. city. Houston is also the only large U.S. city without a zoning ordinance. The effect on urban space has been profound, enabling a metastasizing mass of centers and peripheries guided by no design other than the competing opportunisms of various real-estate developers. As local architect and urban designer Larry Albert put it so well, "the more seemingly placeless Houston grows, the more it can seem like Houston. If the generic colonization of sprawling settlements with little regard for local conditions can be said to have a hometown, here it is" (Albert 1997). With the construction of the Johnson Space Center in 1961, Houston became the gateway of sprawl to the stars. Between oil, petrochemicals, and space-related R&D, Houston's energo-astro-industrial complex today represents about 40% of the local economy, greater than the economic impact of finance in New York or entertainment in Los Angeles. Houston has been estimated as the city with the second most engineers per capita after Silicon Valley.

Perhaps because of these legions of experts, gray infrastructure logics dominate the politics of Houston. This is nowhere more evident than in the local hydropolitics of flood control. Truth be told, Houston is a wet place, one that has flooded nearly every year since the first settlers arrived. And flood control has been an area of intense political interest since the 1930s. Nonetheless, the floods continue at a remarkably steady pace. "Houston floods" is a statement of fact one hears all the time in Houston, often with a certain sense of resignation. Yet "flood" is itself a problem that also *originates* in gray infrastructural logics of human command and control over nonhuman elements and forces. "Flood" denotes water out of place, usually water that has exceeded its containment structures and inundated human settlements and transportation corridors. Anuradha Mathur and Dilip da Cunha (2009) have argued that the concept of flooding is a symptom of colonial, cartographic power. That is, it is difficult to disentangle the idea of flooding from the historical, often colonial work of controlling wetness, of confining it to certain abstractly determined river landscapes, thus rendering all other space as "dry" and fit for human ownership and occupation. This is certainly the case with Houston, which has been steered by extractive industries for its entire history and has internalized the colonial mentality associated with resource frontiers the world over: including beliefs in human technological mastery over nature, in the supremacy of some (white) humans over others, and in labor and commerce as the essence of moral community. Built over coastal prairie, woodlands, and swamplands, Houston's search for dry land has been a constant yet precarious enterprise since the beginning. As Albert writes (1997, 144), efforts to "divide swampland into solid ground and watercourse" have been the central infrastructural struggle of the city's history, "to live, we separate something dry and something wet from the undifferentiated muck."

After three so-called "500-year storms" visited the city within the space of 24 months between 2015 and 2017, the stakes of this struggle heightened. Hurricane Harvey alone resulted in $125 billion worth of damage and trillions of cubic feet of flood waste. At one point during the storm, 18 inches of water covered 70% of the surface area of Harris County, home to more than 4.5 million people. Floodwaters damaged 204,000 homes – 75% of them outside the official floodplain. In the storm's aftermath, Harris County voters approved an unprecedented $2.5 billion dollar flood bond to pay for 181 gray infrastructure projects to help reduce flood risks. The projects ranged from home buyouts to widened, channelized watercourses, new bridges, expanded upstream detention systems and so on. This sounds impressive and it will likely reduce flood risks temporarily for some residents. However, the largest gray infrastructure project Houston has seen since the 1930s – Project Brays – cost $550 million and took over 20 years to complete. And yet Harvey inundated the neighborhoods it was meant to keep dry all the same.

The cost and temporality of gray infrastructure almost always guarantee that it orients to some past vision of adequate flood control even as the accelerated pace of climate change makes future intensities of rainfall and cyclonic activity into moving targets. Gray infrastructure does not learn lessons from its past failures though, at least not those that challenge its fundamental ideology. There is always some new massive technological solution just over the horizon. The current gray infrastructural fascination in Houston is the idea of constructing a network of deep tunnels, 20-30 feet wide, 200 feet below ground that could evacuate floodwater from Houston at the cost of $100 million per mile (or hundreds of billions of dollars to equitably defend the whole of Harris County). Yet, engineers working for the Harris County Flood Control District have confided in me that in a Harvey type event this tunnel network might only reduce floodwater flow by as little as 1%, a staggering commitment of time, labor, and expense for almost no solution whatsoever.

We can consider gray infrastructure then as a materialization of what Lauren Berlant (2011) terms the "cruel optimism" in which the object of one's desire actually compromises one's possibility of flourishing. Unless of course we recognize that the real purpose of gray infrastructure in this instance is less managing water than asserting the power and authority to do so. Lest we think the horizon of Houston is hopelessly gray, I promise to discuss a better infrastructural ecology below. Meanwhile, let us turn to green infrastructure.

3. Green Infrastructure

Unlike gray infrastructure, whose intents and meanings are relatively monopolized, green infrastructure means many things to many people and there are lively debates as to how best to define and refine its promise. Nonetheless, generally speaking, green infrastructure differentiates itself from gray infrastructure by promising a mode of "naturecultural" collaboration (Haraway 2003) in accomplishing infrastructural ends. In the website cited above, for example, green stormwater infrastructure is defined as consisting "of elements that help nature do its job. They allow water to soak into the ground, filtering pollutants naturally. They retain or detain water just as nature does, keeping it roughly in place when it falls rather than funneling it immediately onward" (Ecogardens, n.d.). In this vision, green-ness is less a question of materiality since even a cement structure could be designed to detain water temporarily. Green-ness is instead about sharing agency between natural filtration processes and human water management techniques. At the end of the day, water is still supposed to go where humans want water to go. But "nature" is recruited as an ally in helping humans to accomplish their cultural purposes.

There are two main issues with green infrastructure in this sense. First, nature is conceptualized as something that "does a job." Gray infrastructure thinks nature does a job too, only often more pointlessly and inefficiently than humans could do the same job. Green infrastructure simply argues that nature is actually the better engineer in some situations. But ultimately nature becomes a kind of robo-engineer in this model, an ensemble of materials and forces that can easily be co-opted by humanity to achieve its goals. Nature is not really granted intent or consent; its own goals are meaningless. The popular yet highly contested concept of "ecosystem services" has a similar flaw (Lele et al. 2013). Plus, "nature" is all one thing; there is no consideration as to, say, how an earthworm might experience water retention differently than a tuft of coastal prairie grass. This singular conceptualization of "nature" as an object for manipulation by human "culture" has inspired widespread philosophical critique in recent years, prompting Isabelle Stengers (2015) and Bruno Latour (2017) to reanimate the Gaia concept, and Timothy Morton to call for an "ecology without nature," among other interventions. More than just ontological challenges, these interventions point toward the need for new ethics that appreciates, as Haraway puts it, the "sympoietic tangling [...] of earthly worlding and unworlding" (2016, 97). The second problem is that the entire human social complexity of a situation of, in this case, water retention is blurred out in the conventional green infrastructure model. Who is designing green stormwater infrastructure according to what understandings and experiences of water? For whose benefit are these infrastructures being materialized? Who gets to say where they go and how and when? Who finances these projects with what expectations attached? Such questions are rarely central to green infrastructure programs if they are asked at all. Silencing social complexity allows for a consolidated generic "human" subject to emerge in its place that almost always defaults to the epistemic predispositions of white, male, well-educated, socially-privileged humans.

It is for these reasons that much green infrastructure is really gray infrastructure at heart. Perhaps the best example of the masquerade can be found in the domain of green energy infrastructure where low-carbon renewable energy typically plays a salvational role with respect to global warming. The promise of "energy transition" within a green capitalist design framework is that through technology we can maintain massive levels of energy expenditure and industrial expansion without the pollution problem of high emissions. There is almost no evidence that this "decoupling" is actually possible, however, and a growing body of evidence that it is not (Parrique et al. 2019). Meanwhile, what conventional energy transition thinking ignores is how easy it is for renewable energy development to repeat the same kinds of extractivist, command-and-control relations that made it necessary to build solar farms and wind parks in the first place. My case in point is the fieldwork that I completed together with Cymene Howe on the "aeolian politics" of southern Mexico. In the Isthmus of Tehuantepec, a highly Indigenous region developed into the densest corridor of onshore wind parks anywhere in the world in the late 2000s and early 2010s (Boyer 2019; Howe 2019).

Facing the twilight of its petrostate, during the presidency of Felipe Calderón (2006–2012), Mexico established some of the most far-reaching and comprehensive climate legislation in the world. This legislation included setting legally binding targets for renewable energy sources to provide 35% of the nation's electricity by 2024. With over half that electricity projected to come from wind power, state and transnational investor attention turned toward the southern Isthmus of Tehuantepec, home to some of the best onshore wind resources anywhere in the world. There, a narrow gap in the Sierra Madre mountains, combined with the barometric pressure differential between the Gulf of Mexico and the Pacific Ocean, creates a natural wind tunnel that flirts with tropical storm force winds in the winter months. The first wind parks were proof of concept prototypes developed by Mexico's parastatal electricity utility, CFE. Their extraordinary plant capacity of 51% – the measurement of actual electricity production relative to potential energy production – was enough to convince a number of transnational developers (mostly Spanish) to begin investing in the region, facilitated by the mediation of the Oaxacan state government. The pace of development was very rapid. In 2008, there were still only two CFE parks with a combined capacity of 84.9

megawatts; only four years later there were 15 parks producing over 1,300 megawatts, a 1,467% increase that made Mexico the second largest wind power producer in Latin America after Brazil. Today, there are 2,749 gigawatts of installed wind power capacity in the Isthmus in an area of only roughly 450 km^2.

Yet, wind development plateaued in the Isthmus a few years later because of local political resistance. At one level, the rapid transformation of what was hitherto a predominantly agricultural, ranching, and fishing region into a dense industrialized landscape of wind parks was existentially unsettling even to those who supported wind development. But those opposed to wind parks had specific grievances. They saw the green capitalist model of wind development as very similar in form and purpose to previous models of economic imperialism. As one resistance leader explained,

> Maybe we are seeing a transition in the forms of energy [...] but there is a clear continuity in the form of resource exploitation. These huge companies we have here, sure, they are investing [in the region] but they are taking our raw materials without paying for them. Resources that should be going toward social benefits for people in the region, all of these benefits are going to the multinational corporations [...] One of the things we question is the fact that it is all the same companies that have plundered the world for millennia and which have now contaminated it. The fact that there is a phenomenon called "global climate change" is because of [their] externalization of costs. These same companies have now gotten hold of renewable energy. And so, I have to ask what "transition" is there?

It is not uncommon to this day to hear wind development described as a *segunda conquista* (second conquest) of foreign invaders over the Isthmus.

Many outside the organized resistance observed that the the promised collective benefits to impacted communities never materialized. And where they materialized, they were done on the cheap, like paving roads without proper drainage systems installed so that neighboring homes would then flood during rainstorms. We often heard that the parks actually increased local social inequality as local landowners earned great wealth through usufruct rents while local political bosses and elected politicians received what were by local standards staggering sums of kickbacks to make sure that the development process proceeded smoothly. Many worried about food security as the enclosure and industrialization of good agricultural land drove up prices for basic staples like corn. Enclosure itself chafed against a complex local land tenure regime in which communal land rights endured despite decades of state efforts at privatization. And, in some communities, questions about Indigenous sovereignty and *campesino* (farmers') rights also loomed large; indeed, so much so that the wind parks catalyzed new autonomous political institutions and a regional movement to restore Indigenous traditional political institutions. The point is that the wind parks were built in a place with a great degree of social complexity, much of it with deep historical and cultural roots. But none of this nuance seemed to concern project developers and financiers whose frameworks of interpretation and action were dominated instead by megawatt hours of electricity and financial return on investment (ROI).

Still, even despite the eventual loss of their social license to do business in the Isthmus, wind power boosters like the Mexican trade organization AMDEE continue to describe the Istmeño experience as a win-win-win success story. To them, wind power in southern Mexico epitomizes how a world-class resource can – provided ambitious government plans plus generous inputs of transnational capital and expertise – rapidly achieve multiple goals: improving local economic opportunities and infrastructure, meeting national energy transition targets and aspirations for economic development, all while addressing global challenges of decarbonizing electricity generation and remediating climate change. When AMDEE spoke with us about the resistance, they attributed it to a combination of local ignorance and the malign influence of "professional troublemakers."

Yet, to reiterate, local critics of wind power made it very clear to us that they were not criticizing renewable energy *per se*. They were criticizing the extractivist politics through which wind power had been developed. They also highlighted the paradox of trying to achieve energy transition and environmental sustainability within a model of expansionary industrial-consumerist sprawl. As one young man put it, "All this supposed clean energy is going to power more Walmarts and cement factories, and those are the true problem." The U.S. Energy Information Administration projects a 50% increase in world energy use by 2050, which renewables will only be able to partly cover, thus leaving the world in still worse emissions shape than it is today.

If much green infrastructure today is the metaphorical equivalent of concrete spray-painted green, that does not mean that there is no hope for a true naturecultural alliance. But to achieve that alliance, the Global North, and especially its elites, need to meet the world halfway, unlearning their high-energy, high-carbon, otherworldly habits. Instead of the increasingly frantic scale and temporality of gray infrastructure, the North must reorient itself toward a humbler, less anthropocentric and degrowth-oriented mode of engaging planetary ecology. This mode is what I term "revolutionary infrastructure."

4. Revolutionary Infrastructure

To return to Houston's flooding, I was recently speaking to a well-known landscape architect, Keiji Asakura, who offered me a fundamental way of rethinking the problem. Once upon a time, the legendary Harris County public infrastructure czar, Art Storey, told Keiji that if every building in Houston had an adjacent rain catchment or rain garden it would put the local flood control district out of business. What is a rain garden? A very humble infrastructure that consists of digging a hole or trench in the ground a few feet deep. Into the dugout, you place logs, branches, sticks, leaves, mulch, pretty much anything at hand. And then you fill back in the soil and plant it over, ideally with local coastal prairie vegetation whose root systems can run meters deep and are excellent at sponging up water. As a rain garden ages, the logs and leaves decompose creating new, excellent soil that can be harvested in a periodic process of rain garden renewal. Meanwhile, the rain garden prevents rainwater from becoming runoff by holding it until it can absorb into the soil. This addresses a large part of Houston's situation; the city is covered by too much impermeable concrete while the underlying soil has a lot of dense clay in it, which needs more time to absorb wetness.

In a way, a rain garden is what green infrastructure imagines itself to be. But what makes a rain garden different than an Istmeño wind park or a solar farm is that it requires very little technology, time, and expense to accomplish. All the tools that are needed to make a rain garden are no more than medieval technology: shovels and wheelbarrows. Depending on the size of the project, a rain garden can take as little as a few hours or as much as a few days to create. The main cost is finding people willing to dig and fill and plant. So, here is a revolutionary idea. What if Houston were to declare a rain garden week and ask its citizens to do nothing other than dig and fill and plant the green areas around their buildings? At the end of the week, Houston's flooding problem would largely be solved, all without channelizing bayous and installing giant storm sewers and digging massive detention ponds and, most importantly, without waiting for decades for a concrete and steel engineering solution that will never come.

Rain gardens are terrific examples of what I call "revolutionary infrastructure." Revolutionary infrastructure projects are experiments in creating new relations and enabling alternative future trajectories to the long, linear timelines of the gray infrastructure status quo. Projects of revolutionary infrastructure are diverse, locally attuned, and typically invisible to conventional infrastructural politics. The radical rain garden plan outlined above has absolutely no traction in mainstream Houston politics, at least not yet <wink>. Yet, because it is hard to make something out of nothing, revolutionary infrastructure often captures and redistributes the materials and energies within existing infrastructural ecologies to do its work. The modern shovel co-evolved with the resource extractive economy of mining, for example. But in a rain garden, those shovels inhabit a new set of relations that Timothy Morton and I have called "subscendence" (2021). Subscendence is the inverse of the transcendental attitudes and habits that both created the modern world and brought it to the brink of planetary ruin. Transcendence is essentially the hierarchical control freak relation to the world that informs strategies of command and control. It holds that some humans are better than other humans because of their genetics and technology and that all humans are superior to the nonhuman. Maybe the worst thing transcendence does is to try to corset the total excessive marvelous abundance of nonhumanity into that six-letter word: nature. The modern shovel was designed as a tool for the mastery of the nonhuman. But in the case of a rain garden, you can feel how those same shovels are now meshing deeply into ecological relations to try to create more balanced, respectful, and sustainable alliances between human and nonhuman forces. Addressing the ecological emergency will take a lot of this subscendent spadework.

In any case, there is no grand codex or twelve-point master plan for revolutionary infrastructure. It has no general typology or theory. No one is in charge of it or particularly expert about it. Experiments that flourish in one context and set of relations might not fare so well in another. I like to say we discover its most advantageous forms as we feel our way forward on non-ecocidal, non-genocidal pathways.

Revolutionary infrastructure may sound very grand but nothing could be further from the truth. Revolutionary infrastructure is not the kind of heroic intervention of which statues are made; it is just paddling and wriggling to escape the mire of the Anthropocene/Capitalocene/Plantationocene condition. Revolutionary infrastructure is composed of humble materials and energies leveraged with the determination of knowing you are small in a world built for the pleasure and convenience of excessive transcendence-seeking humans (hypersubjects is what Tim and I call them). But as the beloved comic character Moominpapa says, you do not have to be big to be brave.

Subscendence means realizing that big things are less than they purport to be. And that the revolution is already happening even though it is nowhere to be found (cf. Schiller-Merkens 2022, in this volume). A massive coastal dune would be nothing without the humble beachgrass enabling its accumulation of wind-born sand. Revolutionary infrastructure nurtures and cherishes the subscendent relations that deflate bloated transcendent attitudes, behaviors, and institutions. Revolutionary infrastructure is like a weir for gathering ambient forces and materials and shaping them into new scales and purposes. Happily, revolutionary infrastructure offers a much more expansive and undetermined vision of the future than gray infrastructure ever has. Revolutionary infrastructure does not make you wait, endlessly, for its payoff. You can do it right now. You should do it right now. Put this essay down and get organized. Rather than try to tell you what revolutionary infrastructure could mean in your environment, I would encourage you to try to figure it out together with your allies. And then tell me. I want to hear about your rain gardens!

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