The Global Industrial Feedlot Matrix
A Metabolic Monstrosity

Katsikis, N.; Brenner, Neil; Ghosh, Swarnabh

Publication date
2022

Document Version
Final published version

Published in
Technical Lands

Citation (APA)
Katsikis, N., Brenner, N., & Ghosh, S. (2022). The Global Industrial Feedlot Matrix: A Metabolic Monstrosity. In *Technical Lands: A Critical Primer* (pp. 132-155). Jovis Verlag.

Technical Lands

editors
Jeffrey S Nesbit
Charles Waldheim

jovis

A Critical Primer

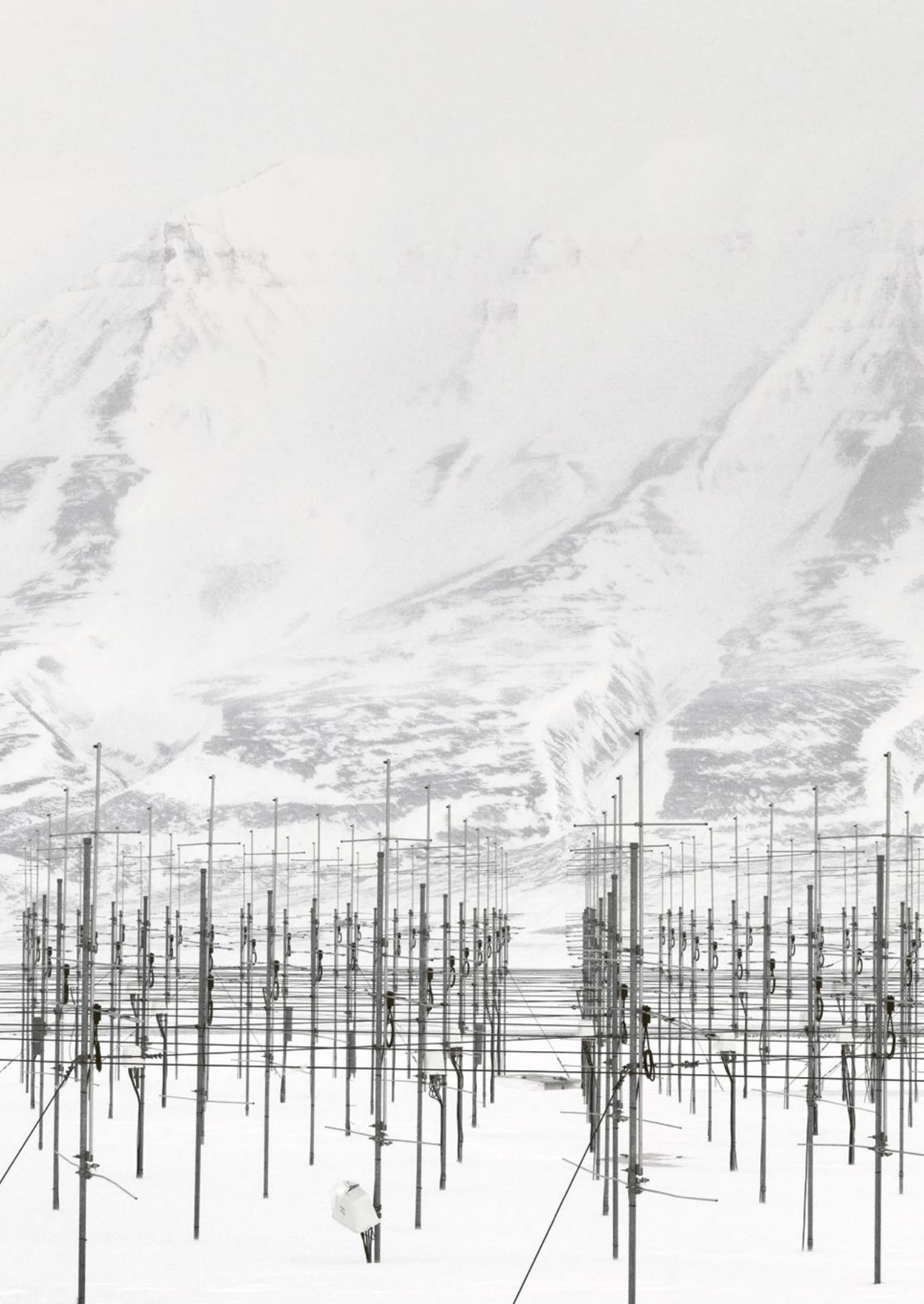
Technical lands are spaces united by their "exceptional" status – their remote location, delimited boundary, secured accessibility, and vigilant management. Designating land as "technical" is thus a political act. Doing so entails dividing, marginalizing, and rendering portions of the Earth inaccessible and invisible. An anti-visuality of technical lands enables forms of hypervisibility and surveillance through the rhetorical veil of technology. Including the political and physical boundaries, technical lands are used in highly aestheticized geographies to resist debate surrounding production and governance. These critical sites and spaces range from disaster exclusion and demilitarized zones to prison yards, industrial extraction sites, airports, and spaceports. The identification and instrumentalization of technical lands have increased in scale and complexity since the rise of neoliberalization. Yet, the precise theoretical contours that define these geographies remain unclear. *Technical Lands: A Critical Primer* brings together authors from a diverse array of disciplines, geographies, and epistemologies to interrogate and theorize the meaning and increasing significance of technical lands.

Technical Lands

editors
Jeffrey S Nesbit
Charles Waldheim

jovis

A Critical Primer



Contents

The Global Industrial Feedlot Matrix

A Metabolic Monstrosity

Swarnabh Ghosh, Neil Brenner, & Nikos Katsikis

1.

In a widely debated passage in Volume 3 of *Capital*, likely written in the 1870s, Marx offered a foundational observation about capitalist industrial agriculture. When the "industrial system" is "applied to agriculture," Marx argued, it not only imposes ruination upon the humans who use machines as their means of production but also depletes the soil of the nutrients required to sustain its fertility.[1] In this sense, strategies to increase agricultural productivity through the application of industrial machinery contain an inherent contradiction. They may increase commodity output by reducing the socially necessary labor time required to produce farm products, but in so doing, they destroy the material basis of agricultural production—human workers and the soil.[2]

In making this argument, Marx drew upon the work of German agricultural chemist Justus von Liebig, who decades earlier had famously documented the vampire-like processes through which early industrial agriculture in Britain had depleted the soil's nutrients, robbing it of its capacity to support productive cultivation. This led to a process of ecological imperialism where core agro-industrial regions sought to rejuvenate their soil by transferring the requisite nutrients (in forms such as human bones or guano) from other regions, whether through direct military violence, land grabbing, or other forms of economic subjection.[3]

These dynamics entail a relentless expropriation, long-distance circulation, and industrial recomposition of materials to sustain the accumulation process. However, they exacerbate rather than resolve the original contradiction. Strategies to repair the environmental plunder wrought through capitalist operations serve, quite literally, to *displace* them by transferring their environmental load to more distant regions.[4] It is the spatial separation of industrial production from its metabolic conditions of possibility that permits agro-industrial accumulation to continue. This separation is also a rearticulation of metabolic interconnections and a rescaling of their geographies. High-throughput agro-industrial production is sustained in some regions precisely by intensifying processes of environmental degradation in other zones, including the biosphere as a whole.

A contradictory dialectic is thus revealed. Agro-industrial intensification hinges upon the appropriation of material inputs (raw materials, fertilizers) from distant locations, their circulation to the zone of industry (a complex problem of logistics, energy, and labor), *and* the ecological degradation of the spaces in which those processes occur, from the local to the planetary. Indeed, it can be argued that all forms of capitalist industrial production—extraction, agriculture, manufacturing, and logistics—hinge simultaneously upon the appropriation of "cheap natures" and the relentless destruction of their environmental foundations.[5] Even if they are sited far beyond the high-throughput industrial field, mine, or factory, processes of environmental load displacement and the exhaustion of ecological surpluses are constitutive of capitalist industrial development. These dynamics are not, as mainstream economists claim, mere market failures or "externalities," but

[1] Karl Marx, *Capital, Vol. III*, (London: Penguin Classics, 1993), 637.

[2] John Bellamy Foster, "Marx's Theory of Metabolic Rift: Classical Foundations for Environmental Sociology," *American Journal of Sociology* 105, no. 2 (1999): 366–405.

[3] Brett Clark and John Bellamy Foster, "Ecological Imperialism and the Global Metabolic Rift: Unequal Exchange and the Guano/Nitrates Trade," *International Journal of Comparative Sociology* 50, no. 3–4 (June 2009): 311–34.

[4] Alf Hornborg, *Global Ecology and Unequal Exchange. Fetishism in a Zero-Sum World* (London: Routledge, 2011).

[5] Jason W. Moore, *Capitalism in the Web of Life: Ecology and the Accumulation of Capital*, 1st edition (New York, NY: Verso, 2015); John Bellamy Foster, Brett Clark, and Richard York, *The Ecological Rift: Capitalism's War on the Earth* (New York, NY: Monthly Review Press, 2010).

are the very conditions of possibility for capitalist operations—socioecological "hidden abodes" that directly support and sustain the accumulation process while being obscured from view.[6]

This chapter explores the implications of this proposition with reference to the hidden abodes and monstrous environmental contradictions of industrial livestock production since its origins in the late nineteenth century. We offer a metabolic genealogy of the livestock mega-factories known as Concentrated Animal Feeding Operations (CAFOs) and their conditions of possibility within broader circuits and political ecologies of capital. These spaces of hyper-rationalized, securitized, and militarized animal slaughter and processing are among the most iconic expressions of the contemporary industrial livestock regime. In world-ecological terms, however, CAFOs are nodes within a planet-encompassing metabolic circuit fueled by fossil energy, voracious land-use intensification, colossal infrastructural investment, and rampant environmental destruction.[7] Industrial livestock production is, therefore, not only premised upon the operationalization of the bounded technical lands in which CAFOs are situated. But, more importantly, it also hinges upon the construction of multiscalar *operational landscapes* that support this circuit of capital and onto which its socio-environmental contradictions are projected.

We refer to the worldwide network of such operational landscapes as the Global Industrial Feedlot Matrix (GIFM). The GIFM includes labor relations, land-use systems, industrial infrastructures, relays of fossil-based energy, logistics grids, plumes of carbon emissions, as well as technoscientifically mediated multispecies entanglements between human worker-consumers, commodity animals, and pathogens. The GIFM is the product and medium not only of corporate accumulation strategies but also of geopolitical power, state spatial strategies, and regulatory projects. As we argue below, national governments and multilateral agencies are important institutional animators of the technological, political-economic, territorial, and environmental transformations that underpin the GIFM's operations. Drawing upon a tradition of critical agrarian studies known as food regime theory, we seek to articulate the GIFM and its changing geographies to the geohistory of capitalist industrial agriculture—in particular, the "political construction of agrifood orders shaped by, and shaping, specific accumulation dynamics."[8]

Although some of its elements emerged during the British-centered imperial food regime of the late nineteenth century, the GIFM was consolidated with the intensification of industrial meat production in the United States Corn Belt during the postwar, US-led global food regime, where it encompassed a fossil-fueled, regional economic geography of mechanized slaughterhouses, monofunctional feed croplands, industrial fertilizer plants, storage facilities and railroads. In the post-1980s period, with the crystallization of the neoliberal food regime, the constitutive elements of the GIFM have been dramatically upscaled to form an intercontinental system that includes monocrop soy feed plantations in South America and new zones of high-throughput industrial agribusiness concentration in erstwhile "rural"

[6] Nancy Fraser, "Behind Marx's Hidden Abode: For an Expanded Conception of Capitalism," *New Left Review*, no. 86 (2014): 55–72.

[7] Tony Weis, *The Ecological Hoofprint: The Global Burden of Industrial Livestock* (London: Zed Books, 2013); Mindi Schneider, "Developing the Meat Grab," *The Journal of Peasant Studies* 41, no. 4 (2014): 613–33.

[8] Philip McMichael, *Food Regimes and Agrarian Questions* (Rugby: Practical Action Publishing, 2014), 8, passim.

zones of China. These links of the industrial livestock commodity chain are meshed together via transcontinental logistics circuits (including shipping lanes, ports, roads, and rail networks) and the global financial networks through which investments on commodity futures are speculatively channeled into land, labor, and infrastructure. This upscaled, neoliberalized formation of the GIFM involves new patterns of carbon-intensive land-use simplification, infrastructural consolidation, long-distance commodity transport, hypertrophic mega-concentration of industrial animals, and the consequent degradation and wasting of land, bodies, soil, water, and air on a planetary scale.

2.

Technologies for the large-scale production of commodity animals were pioneered in the Central Slaughterhouse of La Villette in Haussmann's Paris during the 1860s. As Sigfried Giedion noted in his mid-century exploration, even in the absence of extensive mechanical infrastructures, La Villette represented an unprecedented centralization, technical rationalization, and spatial systematization of the constituent processes of animal slaughter and processing.[9] In contrast to later, Taylorist-Fordist models of mechanized livestock production, La Villette preserved an ethos of individualized supervision of each animal, from farmyard to abattoir and butcher.

fig 1

La Villette's metabolic circuitry was relatively localized. The commodity animals it processed were drawn from proximate farming hinterlands, and its products were primarily oriented towards metropolitan consumption within Paris through newly expanded city markets. In his *Mèmoires*, Haussmann characterized La Villette as "one of the most considerable works accomplished by my administration ... paralleling the great sewer constructions."[10] Much like Haussmann's more widely celebrated boulevards, squares, and gardens, La Villette became an important infrastructural prototype—in this case, for emergent approaches to commodity-animal slaughter in major nineteenth-century European metropolitan centers.[11]

Crucially, La Villette was not only an infrastructural model but a metabolic one. It was embedded within a regional agrarian system where previously fallow land had been "replaced by a N2 fixing fodder crop such as clover, alfalfa, peas or horse beans."[12] This form of land-use rotation produced "a considerable increase in livestock density and hence in manure availability and cereal yield," but without imposing "a significant change either in farm size or the structure of the landscape."[13] La Villette was a production node and infrastructural conduit embedded within this relatively "autotrophic" agrarian system. As such, it demonstrated how the slaughter and processing of commodity animals could be rationalized for local consumption while sourcing the latter through an intermeshed system of land use, labor deployment, and feed-crop production in relatively contiguous hinterland zones.

The development of large-scale industrial slaughterhouses and meatpacking plants was consolidated and significantly upscaled during the

[9] Sigfried Giedion, *Mechanization Takes Command: A Contribution to Anonymous History* (New York, NY: Oxford University Press, 1948), 209–11.

[10] Haussmann, quoted in Giedion, *Mechanization Takes Command,* 209.

[11] Giedion, *Mechanization Takes Command,* 210.

[12] Gilles Billen, Sabine Barles, Josette Garnier, Joséphine Rouillard and Paul Benoit, "The Food-Print of Paris: Long-term Reconstruction of the Nitrogen Flows Imported into the City from its Hinterland," *Regional Environmental Change* 9 (2009): 19.

[13] Gilles Billen et. al, "The Food-Print of Paris," 19.

fig 1 Pig slaughterhouse in La Villette, Paris, 1874. Tilly Smeeton, et al, woodcut illustration, Journal Universel, no. 1640, volume LXIV, August 1, 1874, Paris Musées/ Musées Carnavalet

last decades of the nineteenth century in the US Midwest. This process was initiated in Cincinnati (the original "Porkopolis") and was subsequently articulated across an intermetropolitan, pig-production network that included Chicago, Kansas City, St. Louis, Milwaukee, and Omaha. Across this emergent regional system of industrial pig production, massive mechanical infrastructures and territorial enclaves were constructed in which millions of animal-bodies were processed according to a purely calculative, profit-oriented logic, as the raw material in a complex relay of mechanized production, packaging, storage, and transport.[14] In his chapter "Mechanization and Organic Substance," Giedion surveys the chief elements of the high-throughput "disassembly line" that was set into motion in the metropolitan industrial stockyards of the Midwest. Its elaborate technical infrastructure included equipment for such gruesomely specialized tasks as hog-cleaning, pig-scraping, spine-cleaving, and mechanical skinning.[15] The horrific spectacle of mass animal death was normalized, Giedion posits, through the construction of elaborate technical spaces in which industrial machinery could process the organic substance of animal bodies with maximal precision and speed to enhance material throughput and, by consequence, commodity outputs. The tightly choreographed assemblage of technology, infrastructure, and spatial organization in the Chicago stockyards forecast the subsequent generalization of mass production systems across other leading sectors in the emergent, US-centric accumulation regime of the twentieth century.[16] Henry Ford modeled the automobile assembly line of his fabled Highland Park car factory on "moving lines [of animals] that had been operating at least since the 1850s in the vertical abattoirs of Cincinnati and Chicago, with deadly efficiency and to deadly effect."[17]

Despite its extensive deployment of industrial equipment, the slaughterhouses of Cincinnati were mainly supplied with cattle and pork that were herded into the city from the proximate agricultural region. With the advent of the railroad in the second half of the nineteenth century, Chicago's livestock supply zone expanded from contiguous prairie regions outwards to the Great Plains, stretching from Texas to the Canadian border, where Indigenous lands had been enclosed through the genocidal violence of settler colonialism, and where pasturelands now replaced the once plentiful herds of bison.[18] For Giedion, the colossal infrastructural equipment of Chicago's Union Stockyards was directly connected to the "free tracts of grassland" on the Great Plains, where livestock herds could be raised and shipped by rail to centralized hubs for slaughter and packaging.[19] The popular mythology of the free and open range, perpetuated uncritically by Giedion, was belied by the brutal slaughter of Native American peoples through which the Great Plains pasturelands had been established, and by the accretion of landscape interventions through which the supposed "free tracts" of open range had been engineered. Moreover, their primary nonhuman inhabitants—the rapidly expanding cattle herds—were likewise direct products of settler colonialism; they had been imported to the Americas by the Spanish, and subsequently by the English, creating a "bovine melting pot."[20]

[14] William Cronon, *Nature's Metropolis: Chicago and the Great West* (New York, NY: Norton, 1992), 207–62.

[15] Giedion, *Mechanization Takes Command*, 228–40.

[16] Cronon, *Nature's Metropolis*, 229.

[17] Nicole Shukin, *Animal Capital: Rendering Life in Biopolitical Times*, Posthumanities 6 (Minneapolis, MN: University of Minnesota Press, 2009), 87.

[18] Giedion, *Mechanization Takes Command*, 218–19; Cronon, *Nature's Metropolis*, 207–30.

[19] Giedion, *Mechanization Takes Command*, 211–14.

[20] Chris Otter, *Diet for a Large Planet: Industrial Britain, Food Systems, and World Ecology* (Chicago, IL: The University of Chicago Press, 2021), 27.

With the consolidation of the industrial meat system, the plains themselves underwent a further round of large-scale landscape transformation.[21] Especially in closer proximity to Chicago, pastureland grasses were superseded by industrially produced corn as the main feed for livestock, along with "tame" hay as feed for hogs.[22] The subsequent parcelization of the plains through railroads, barbed-wire fencing, feedlots, and other rangeland-management techniques contributed to new patterns of intensive grazing and livestock concentration. These practices led, in turn, to a biological transformation of cattle into more docile animals suitable for industrial processing.[23] The conversion of grassland to pasture and then cropland and feedlot, and the concomitant replacement of bison with industrial animals, drastically reconfigured the "substrate" of inherited webs of life.[24] The result of these "sweeping environmental manipulations" of the Great Plains landscape and the commodity animals it produced was, as William Cronon argues, not only the accelerated industrial development of Chicago but the consolidation of an "integrated system of meat production that reached from the Rockies across the tallgrass prairies of Iowa and Illinois all the way to Chicago and beyond."[25]

The incipient industrial production of livestock during this period was thus inextricably linked to broader transformations in the metabolism of capitalist agriculture and its geographies. For much of the nineteenth century, the dominant agricultural model in the US Midwest had involved a mixed farming system based on the rotation between corn, which was used for animal feed; wheat, which was used for household consumption and, to a lesser extent, as a cash crop sold to local mills; and oats, which were used to feed draft animals such as horses. Livestock were fed in open feedlots, while animal waste was used as manure to fertilize proximate fields. Much like in the regional hinterland of Haussmann's Paris, feed for livestock and food for household consumption were largely produced on the same land parcel and through a set of locally managed metabolic circuits. Commodified relationships were, to a significant degree, restricted to the buying and selling of livestock, grains, tools, and land itself.

With the consolidation of the first global food regime under British imperial hegemony in the late nineteenth century, this agrarian system was severely destabilized and eventually superseded. The introduction of fossil energy—in the spheres of circulation (through the railways) and production (through coal-powered industrial slaughterhouses)—contributed not only to the concentration of meat production in major cities, but to a dramatic expansion, upscaling, and subsequent specialization of primary production areas across the Midwestern region. These shifts also entailed the development of extensive agrarian zones oriented exclusively towards the production of animal feed monocrops. The cash nexus was increasingly generalized as commodity outputs were reoriented towards extraregional markets, from the US East Coast to Britain and, to a lesser extent, Europe. The lineaments of a grain-livestock "complex" were thus established in which concentrated industrial livestock production and monoculture feed

[21] Cronon, *Nature's Metropolis*, 218–24.

[22] Cronon, *Nature's Metropolis*, 247.

[23] Cronon, *Nature's Metropolis*, 221; Otter, *Diet for a Large Planet*, 27–28.

[24] Cronon, *Nature's Metropolis*, 223.

[25] Cronon, *Nature's Metropolis*, 248, 221–22.

landscapes were at once functionally and spatially intermeshed.[26] The contemporary commodity chains and political ecologies associated with the GIFM are an outgrowth of this mid-century intermeshing in the US Midwest.

The emergent metabolic circuitry of the GIFM was also subject to relatively circumscribed, yet consequential versions of the environmental contradictions that would, during the subsequent century, cascade across the planet. First, whereas the expansion of the US industrial livestock system had been fueled in significant measure due to the exhaustion of meat and grain landscapes in imperial Britain, the problem of declining ecological surplus soon began to afflict the settler-colonial territories as well, including the US Midwest. This burgeoning soil-fertility crisis led to a massive intensification of capitalization processes during the post-1930s period, primarily through the extensive deployment of machinery and industrial fertilizer. Second, the intensification of industrial livestock production involved the unchecked discharge of fetid waste directly into adjacent urban environments—soil, air, and water. The Union Stockyards of Chicago are a notorious example of such toxic industrial externalizations, which were pervasive in mechanized slaughterhouses across Midwestern cities during the latter half of the nineteenth century.[27] Its sewage, consisting of manure, offal, blood, and wastewater, was channeled directly into the South Fork of the Chicago River, creating a noxious stench that pervaded surrounding neighborhoods.[28]

fig 2

A series of colossal infrastructural investments—the construction of the Illinois and Michigan Canal (the 1860s) and the Sanitary and Ship Canal (1900)—enabled the reversal of the Chicago River's flow direction. Although these emergent strategies of industrial landscape remediation channeled the effluence of industrial waste from the stockyards further downstream, they severely exacerbated the problems they were meant to resolve, both in the stockyard district and in downstream locations, including some as distant as Louisiana.[29] During the following century, the further consolidation of industrial livestock as a leading global agricultural commodity would at once intensify and upscale this toxic ecological "hoofprint," with devastating consequences for landscapes and their myriad forms of life, both human and nonhuman, across the planet.[30]

3.

The post-1930s period witnessed the emergence of a new formation of industrial animal slaughter and processing—the vertically integrated broiler chicken industry. Between 1934 and 1994, the number of broiler chickens produced annually in the United States increased from 34 million to over 7 billion, and annual per capita consumption increased from around 0.7 pounds to nearly 70 pounds.[31] This unprecedented explosion in chicken production and consumption was propelled in part by a series of technological innovations designed to subsume the entire life cycle of chickens—from their genetic material and breeding to their feeding, fattening, and eventual slaughter—to the dictates of industrial commodity production. William

[26] Harriet Friedmann, "Distance and Durability: Shaky Foundations of the World Food Economy," *Third World Quarterly* 13, no. 2 (1992): 371–83.

[27] Sylvia Hood Washington, *Packing Them In: An Archeology of Environmental Racism in Chicago, 1865–1954* (Bloomington: Lexington Books, 2004).

[28] Michael Chieffalo, *Dung, Death and Disease: Livestock and Capitalist Urbanization in the United States from the Early Nineteenth Century to the Present*, PhD thesis, Graduate School of Design, Harvard University (Cambridge, MA: Harvard University, 2021).

[29] Chieffalo, *Dung, Death and Disease*, 122.

[30] Weis, *The Ecological Hoofprint*.

[31] William Boyd and Michael Watts, "Agro-Industrial Just-in-Time: The Chicken Industry and Postwar American Capitalism," *Globalising Food: Agrarian Questions and Global Restructuring*, eds., David Goodman and Michael Watts, 139–65 (Oxford: Routledge, 1997), 140.

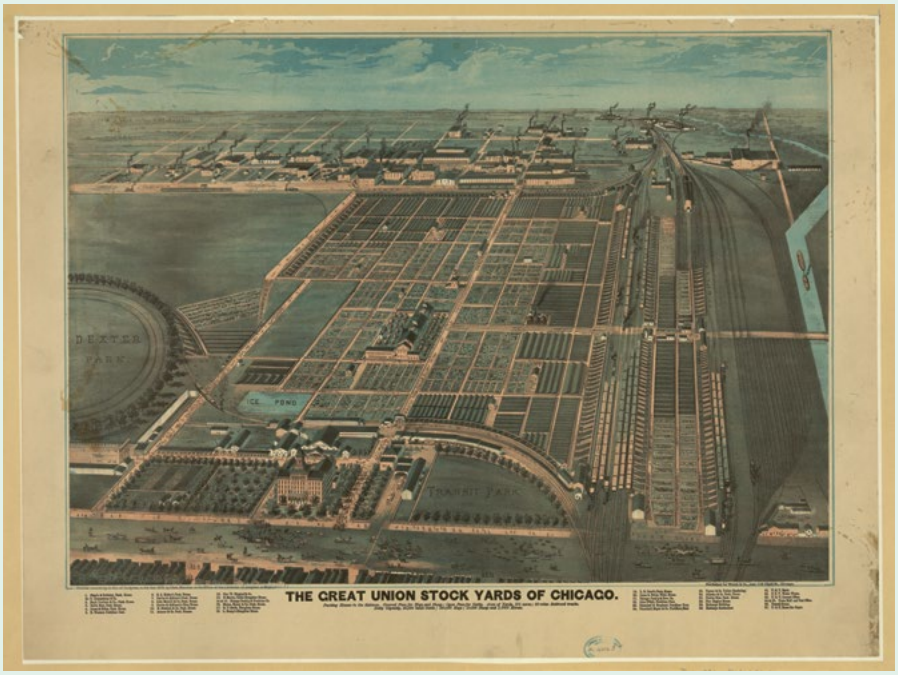


fig 2 Union Stockyards, Chicago, USA, 1878.
Charles Raschler, color lithograph, published by Walsh & Co, c. 1878, Chicago, Library of Congress

Boyd aptly describes this transformation as a form of "biological intensification."[32] It included extensive state-supported experimentation in the use of antibiotics (such as penicillin and tetracycline) and monoculture-derived feed, as well as the selective breeding of industrial chickens—metabolically "efficient," fast-growing poultry whose life cycles were engineered to increase throughput, reduce costs, and maximize profits.

An iconic example of the latter was the hybrid "meat-type" broiler chicken, an outcome of the "Chicken of Tomorrow" breeding contests promoted by the poultry firm A&P and the US Department of Agriculture between 1948 and 1951.[33] By the late 1950s, these and related efforts had transformed the backyard chicken into a "highly efficient machine for converting feed grains into cheap animal-flesh protein."[34] These strategies also enabled the systematic confinement of chicken populations within fossil energy-guzzling industrial processing facilities throughout their entire life cycle. The technology of intensive confinement was fundamental to the upscaling of poultry production and the temporal rescaling of the chicken life cycle. In her pioneering *Animal Machines*, Ruth Harrison offered a powerful description of intensive confinement:

> The day-old chicks are installed, eight or ten thousand at a time ... in long, windowless houses punctuated only with extractor fans in serried rows along the ridge of the roofs, and air intake vents along the side walls. In a big establishment, these sheds will be ranked side by side each with its giant feed storage hopper standing as if on guard at one end, the whole array looking like an incongruous factory, sprouting, for no apparent reason, in the middle of some remote field.[35]

Since the 1960s, the "incongruous factories" in which chickens are raised, slaughtered, and processed have grown to unimaginably gigantic proportions. In April 2021, Tyson Foods, one of the world's largest producers of broiler chickens, inaugurated a new "poultry complex" in Humboldt, Tennessee. With a cost of nearly half a billion dollars, this production facility is spread over 370,000 square feet, contains a hatchery, feed mill, and processing plant, and has the capacity to produce more than 1.2 million chickens per week.[36] The transformation of poultry production during the post-World War II period was thus inextricably linked to the bio-industrial and genetic transformation of the chicken itself: "[T]he amount of time required to turn a day-old chicken into a full-grown broiler decreased by about 20 percent between 1947 and 1951 alone."[37] By the late twentieth century, broiler chickens matured to marketable weights in just six to seven weeks, nearly three times faster than in the 1940s.[38] In the same period, feed requirements were reduced by more than one half per chicken. Through an elaborate system of industrial engineering, more commodity chickens were being produced more rapidly based on lower caloric inputs.

The rapid industrialization of chicken production in the postwar period was inextricably linked to the consolidation of a "distinctively American,

[32] William Boyd, "Making Meat: Science, Technology, and American Poultry Production," *Technology and Culture* 42, no. 4 (2001): 652.

[33] H. L. Shrader, "The Chicken-of-Tomorrow Program: Its Influence on 'Meat-Type' Poultry Production," *Poultry Science* 31, no. 1 (1952): 3–10.

[34] Boyd, "Making Meat," 638.

[35] Ruth Harrison, *Animal Machines: The New Factory Farming Industry* (London: Vincent Stuart, 1964), 43.

[36] Tyson Foods, "Tyson Foods Invests $425 Million in New Tennessee Poultry Complex."

[37] Steve Striffler, *Chicken: The Dangerous Transformation of America's Favorite Food* (New Haven, CT: Yale University Press, 2005), 16.

[38] H. D. Griffin and C. Goddard, "Rapidly Growing Broiler (Meat-Type) Chickens: Their Origin and Use for Comparative Studies of the Regulation of Growth," *International Journal of Biochemistry* 26, no. 1 (1994): 20.

flexible, just-in-time production system," dominated by large agribusiness corporations like Tyson, Perdue, and Holly Farms.[39] These "regional integrators" pursued the vertical integration of various stages of chicken production, including feed manufacturing, under a unified corporate structure. This presaged the broader reorganization of livestock production into vertically integrated agribusiness commodity chains in the late twentieth century, a process that further increased the quantity of material throughput in production and ratcheted up the environmental devastation unleashed through its metabolic relays.[40]

The proximate origins of the much-discussed contemporary "Livestock Revolution" are to be found in the upscaling of industrial poultry production in the postwar United States.[41] The integration of poultry production chains by large agro-industrial capital was constitutive of the broader restructuring of the US and, by extension, the transnational agrifood system in the 1950s and 1960s. As Harriet Friedmann and Phillip McMichael note in their classic study of global food regimes, the vertical integration of production led to "a new specialization at farm and regional levels between livestock production on one side and on the other, the components of manufactured composite feeds."[42] The broiler chicken industry, for instance, first emerged in the Delmarva Peninsula on the eastern seaboard of the United States in the 1920s and was subsequently consolidated in the American South, where it was intensively concentrated within specialized agro-industrial districts in northwestern Arkansas, northern Alabama, and northern Georgia. By the late 1960s, this "southern production complex" had expanded to incorporate subregions in Mississippi and North Carolina.[43]

The organizational and spatial recomposition of poultry production also drove a concomitant restructuring of commodity agriculture in the United States and beyond, in significant measure due to the sector's overarching dependence upon industrially sourced feed crops such as soybean and maize. According to Friedmann, feed crop production zones "were as important to the emergence of the livestock complex as factory production of poultry and pork, and the growth of cattle feedlots."[44] The restructuring of feed crop agriculture across the United States coincided with a shift from low-input agricultural *expansion* to high-input agricultural *intensification*. The former was characterized by relatively small increases in crop yields based mainly on the territorial expansion of farmland, a process that was exhausted by the early twentieth century. By contrast, high-input agro-industrial intensification was premised upon strategies to increase productivity through the generalized application of inorganic, synthetic (nitrogen) fertilizers and herbicides, and through the introduction of hybrid (genetically modified) plants. Together with continuing mechanization, these developments allowed the concentration and densification of processing facilities in conjunction with an aggregate explosion of feed crop yields.

These intertwined processes of operational intensification and spatial centralization were, in turn, premised upon a similarly dramatic increase in the use of fertilizer, from less than 3 million pounds in the 1950s to more

[39] Boyd and Watts, "Agro-Industrial Just-in-Time," 145–46.

[40] Michael J. Watts, "Are Hogs like Chickens? Enclosure and Mechanization in Two 'White Meat' Filières," *Geographies of Commodity Chains*, eds., Alex Hughes and Suzanne Reimer (London: Routledge, 2004), 39–62; Pew Commission on Industrial Farm Animal Production, "Putting Meat on the Table: Industrial Farm Animal Production in America" (United States: Pew Commission on Industrial Farm Animal Production, 2008); J. L. Anderson, *Capitalist Pigs: Pigs, Pork, and Power in America* (Morgantown, WV: West Virginia University Press, 2019).

[41] On the "Livestock Revolution" see Christopher Delgado et al., "Livestock to 2020: The Revolution Continues," International Agricultural Trade Research Consortium, International Trade in Livestock Products Symposium, Auckland, New Zealand, January 18–19, 2001.

[42] Harriet Friedmann and Philip McMichael, "Agriculture and the State System: The Rise and Decline of National Agricultures, 1870 to the Present" *Sociologia Ruralis* 29, no. 2 (1989): 107.

[43] Boyd and Watts, "Agro-Industrial Just-in-Time," 148.

[44] Friedmann, "Distance and Durability," 376.

than 10 million in the late 1970s, and an even more immense increase in the use of herbicides and pesticides.[45] The growth of corn yields was accomplished through an intensification of production rather than through an expansion of territorial acreage (some of which was, in any case, being shifted to soybean production during this period). Soybeans also replaced other feed crops previously cultivated to support draft animals, whose function was now largely obsolete due to mechanization. After World War II until the 1970s, soybean acreage steadily expanded, and this plentiful supply of cheap feed crops underwrote a massive increase in poultry and livestock production.[46] Much of the new soybean production occurred in specialized agrarian regions, notably in the Corn Belt, where it was planted in rotation with corn, resulting in a composite "Corn and Soy Belt." Soy crop yields more than tripled between the 1950s and the late 1970s, and industrial inputs into the latter increased even more rapidly: fertilizer application grew tenfold; herbicide application increased by a factor of thirty.[47]

fig 3 fig 4

The United States was, therefore, the originary site of the Livestock Revolution, and as such, it was also the world's first "Soybean Republic."[48] The mutual upscaling of livestock and feed crop production and the consolidation of a transnational "livestock complex" were distinctive features of the postwar agrifood system.[49] While the industrial livestock sector remained nationally circumscribed in the United States and Western Europe, the feed sector assumed increasingly transnational dimensions during the postwar period. As Friedmann explains, "once crops and livestock producers were linked by corporations, inputs could in principle come from anywhere."[50] Until the 1970s, a series of favorable regulatory arrangements provided US soybean producers privileged access to European markets. Subsequently, however, North Atlantic agribusiness firms began to source feed components, including oilseeds and feed grains, from Third World regions. Following the 1972–73 food price spike, when United States soybean exports were drastically curtailed by the national government, several Latin American countries—notably Brazil and Argentina—entered the global soybean trade, increasing their soybean acreage at an unprecedented pace. As we will see below, this set the stage for a major recomposition in the global political economy of export-driven commodity agriculture during the closing decades of the twentieth century.

The postwar consolidation of industrial poultry in the United States reflected a broader transformation of the metabolic organization of capitalist livestock production and its compounding biophysical contradictions. Just as the broiler industry was emblematic of the technological innovations central to large-scale industrial livestock production, so did it offer an early illustration of its devastating environmental consequences. Industrialized poultry production generates vast amounts of organic and chemical waste—blood, feathers, bones, feces, offal, unhatched eggs, carcasses, and so forth—whose "disposal" exerts immense pressure on local, regional, and, ultimately, planetary ecosystems. Citing the early example of Gainesville,

[45] Biing-Hwan Lin, Merritt Padgitt, Len Bull, Herman Delvo, David Shank, Harold Taylor, "Pesticide and Fertilizer Use and Trends in US Agriculture," *Agricultural Economic Report*, no. 717 (Washington, DC: USDA Economic Research Service, 1995).

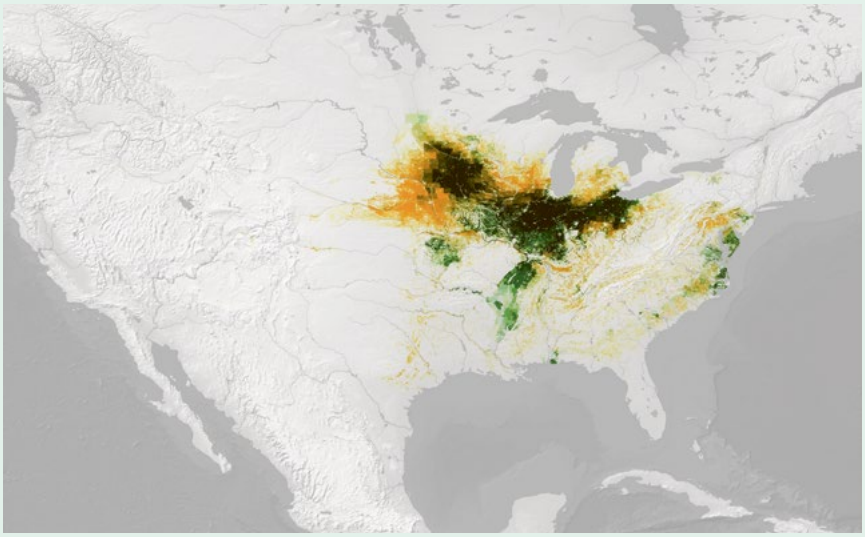
[46] Jean-Pierre Berlan, Jean-Pierre Bertrand, and Laurence Lebas, "The Growth of the American 'Soybean Complex'," *European Review of Agricultural Economics* 4, no. 4 (1977): 395–416; Matthew Roth, *Magic Bean: The Rise of Soy in America* (Lawrence, KS: University Press of Kansas, 2018).

[47] James M. MacDonald and William D. McBride, "The Transformation of U.S. LiveStock Agriculture: Scale, Efficiency, and Risks," *Economic Information Bulletin No. 43* (Washington, DC: USDA Economic Research Service, 2009); Lin et al., "Pesticide and Fertilizer Use."

[48] Turzi, "The Soybean Republic."

[49] Friedmann, "Distance and Durability."

[50] Friedmann, "Distance and Durability," 377.



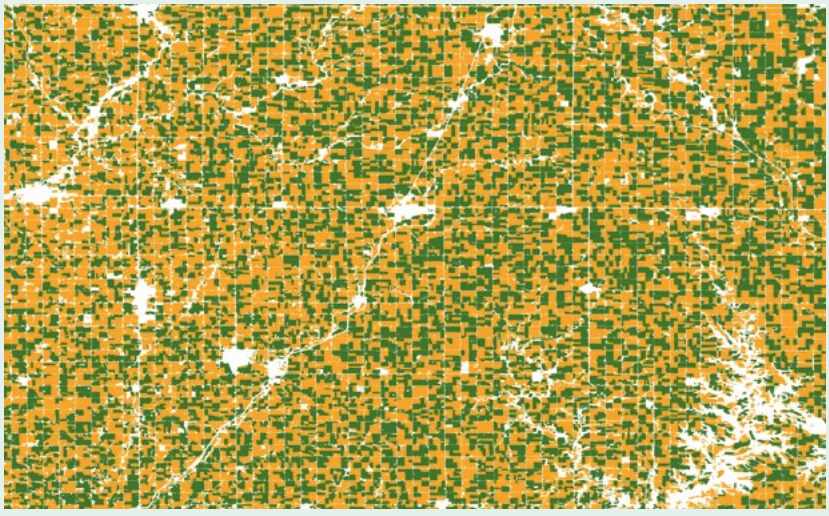


fig 3 The corn and soy belt, 1950. National one-kilometer rasters of selected Census of Agriculture statistics allocated to land use for the time period 1950 to 2012, released in 2016. US Census and USGS

fig 4 Corn and soybean cultivation patterns in northwest Iowa, 2018. National Agricultural Statistics Service Cropland Data Layer, USGS and USDA

Georgia, Paul Josephson documents how the upscaling of poultry production in the late 1940s and 1950s generated a profusion of waste byproducts that overwhelmed the regional sewerage system.[51] The streams, wetlands, and waterways of its natural drainage area rapidly deteriorated, filling up with "muck, guts, blood, feathers, and wastewater."[52] Subsequent efforts to manage this deluge of waste, including the construction of a sewage treatment plant, proved ineffective as the sheer volume of waste quickly overwhelmed the treatment plant "with grit and feather, and with suspended and precipitating solids."[53] The Delmarva Peninsula, where industrial poultry production first emerged in the 1920s, still produces more than 600 million chickens annually. Here, the "regional environment must contend with some 1.5 billion pounds (680,000 metric tons) of manure every year—*more chicken shit than the waste load from a city of 4 million people*."[54]

In the second half of the twentieth century, strategies to manage unusable biowaste involved the construction of new infrastructural spaces—including, perhaps most prominently, the "slurry lagoon." These "lagoons" are containment and storage structures where "slurry," a mixture of biowaste and water produced by spraying immense quantities of freshwater in animal enclosures, is gathered and treated with bacteria. However, slurry lagoons have proven utterly ineffective at "containing" their toxic contents—a combination of fecal matter, bodily fluids, pathogens, antibiotics, and trace elements of metals and salts. An NRDC report documents a litany of cases in which slurry lagoons owned and operated by some of the largest livestock corporations in the world have catastrophically failed, releasing millions of gallons of contaminated biowaste into aquifers, waterways, coastal wetlands, agricultural fields, and water supply systems.[55]

The systemic ecological instabilities generated by industrial livestock production extend far beyond the factory farm and its proximate surroundings. As radical geographer Toni Weis succinctly notes, "the biophysical overrides used in factory farms and feedlots cannot contain all of the problems they create, and over time new and greater risks are established."[56] The intensification of feed production in the second half of the twentieth century has further exacerbated the progressive exhaustion of soil fertility that Justus von Liebig had investigated in the mid-nineteenth century. Attempts to overcome soil exhaustion through the application of increasing quantities of synthetic nitrogen fertilizers have not only locked in the reliance of feed production on fossil energy, specifically natural gas, but also contributed to the generalized disruption of the nitrogen cycle and the concomitant degradation of regional ecosystems, with nitrogen and phosphorous discharge from croplands poisoning aquifers and waterways across the United States national territory.

4.

One of the most consequential transformations in the global agrifood system since the late 1970s has been the multiplication, upscaling, and reterritorialization of industrialized meat production and consumption. This "new" Livestock Revolution has entailed the expansion of the US model

[51] Paul R. Josephson, *Chicken: A History from Farmyard to Factory* (Cambridge; Medford, MA: Polity, 2020).

[52] Josephson, *Chicken: A History*, 131.

[53] Josephson, *Chicken: A History*, 131.

[54] Josephson, *Chicken: A History*, 132; emphasis added.

[55] Robin Marks, "Cesspools of Shame: How Factory Farm Lagoons and Sprayfields Threaten Environmental and Public Health" (National Resources Defense Council and the Clean Water Network, 2001).

[56] Weis, *Ecological Hoofprint*, 138.

of intensive livestock production across the industrializing global South, a shift that has had devastating environmental consequences on a planetary scale.[57] Perhaps the most iconic expression of this process has been the industrialization and upscaling of livestock production in China, which overtook the United States as the world's leading meat-producing country in the early 1990s. While the liberalization of the Chinese livestock sector commenced in the early years of the reform era, the 1990s witnessed the rapid transformation of livestock production, propelled by state and private investments in industrial technology, advanced production facilities, and large-scale transport and utilities infrastructure.[58] Consequently, over the past three decades, traditional smallholder and backyard forms of commodity-animal production have been widely superseded by heavily capitalized, vertically integrated, high-throughput systems of industrial livestock processing. These sectoral realignments have produced what Mindi Schneider has characterized as a "party-state led and agribusiness-operated industrial meat regime."[59]

The development of China's industrial meat regime represents a world-historically significant upscaling of the "industrial grain-oilseed-livestock complex"—the "dominant system of agriculture across the temperate world" whose planetary landscape, in Tony Weis's vivid imagery, resembles "islands of concentrated livestock within seas of grain and oilseed monocultures, with soaring populations of a few livestock species reared in high densities, disarticulated from surrounding fields."[60] In China, the proliferation of these "disarticulated islands" of livestock production has contributed to a cascade of interrelated socioecological crises, including (a) the drastic increase in environmental pollution resulting from greenhouse gas and ammonia emissions; (b) the degradation, contamination, and eutrophication of aquifers, rivers, lakes, and coastal waters due to the discharge of reactive nitrogen, phosphorous, heavy metals, feed additives, and animal excrement; and (c) the chronic recurrence of infectious disease outbreaks and epidemics.[61] Despite these proliferating crises, the Chinese state continues to promote industrialized meat production as a central basis of food security for its domestic bourgeoisie and, thus, a major component of national industrial development strategy. As Schneider argues, "the development of industrial meat and the meatification of Chinese diets is a political and economic objective for creating and sustaining urban middle and upper classes, and for economic growth and capital accumulation for domestic state and private agribusiness firms."[62]

In recent years, the Chinese state has instituted regulations to mitigate environmental pollution from CAFOs and other large-scale livestock operations.[63] In addition to stipulating procedures for waste disposal, the so-called CAFO Law of 2014 prohibits the construction of such facilities near "urban residents, areas of cultural, educational, or scientific research, or near a population intensive area."[64] This regulation appears to signal growing official disquiet regarding the environmental dangers of industrial livestock production, and to promote a new economic geography of this

[57] In China and Brazil, for instance, per capita meat consumption between 1977 and 2017 increased ninefold and threefold, respectively; see Hannah Ritchie and Max Roser, "Meat and Dairy Production," *Our World in Data* (August 2017), https://ourworldindata.org/meat-production.

[58] Guanghong Zhou, Wangang Zhang, and Xinglian Xu, "China's Meat Industry Revolution: Challenges and Opportunities for the Future," *Meat Science* 92, no. 3 (2012): 188–96.

[59] Mindi Schneider, "Wasting the Rural: Meat, Manure, and the Politics of Agro-Industrialization in Contemporary China," *Geoforum* 78 (January 2017): 89; see also Zhaohai Bai et al., "China's Livestock Transition: Driving Forces, Impacts, and Consequences," *Science Advances* 4, no. 7 (2018), https://doi.org/10.1126/sciadv.aar8534.

[60] Weis, *The Ecological Hoofprint*, 8.

[61] Bai et al., "China's Livestock Transition," 7; Pierre Gerber et al., "Geographical Determinants and Environmental Implications of Livestock Production Intensification in Asia," *Bioresource Technology* 96, no. 2 (2005): 263–76; Hanxi Wang et al., "Study on the Pollution Status and Control Measures for the Livestock and Poultry Breeding Industry in Northeastern China," *Environmental Science and Pollution Research* 25, no. 5 (2018): 4435–45; FAO, "Guidelines to Control Water Pollution from Agriculture in China," FAO Water Reports (Rome: Food and Agriculture Organization of the United Nations, 2013).

[62] Schneider, "Wasting the Rural," 62.

[63] Ministry of Ecology and Environment, People's Republic of China, "Regulations on Prevention and Control of Pollution by Scaled Livestock and Poultry Breeding Industry Officially Enforced" (2013), http://english.mee.gov.cn/News_service/infocus/201401/t20140115_266435.shtml.

sector in erstwhile "rural" zones of smallholder agriculture, fragmented wilderness areas, and other putatively "remote" landscapes. The state-mediated dispersal of large-scale livestock operations from urban and peri-urban regions into "rural" or extrametropolitan territories is significantly intensifying the processes of smallholder and agrarian dispossession that have underpinned the development of the industrial livestock sector in China since the late 1990s, while also reterritorializing its wide-ranging environmental impacts.[65]

The infrastructural and spatial expressions of these ongoing transformations are starkly illustrated in major recent investments by large Chinese agribusiness firms to create new sites of high-throughput livestock production, at some remove from human population centers. Currently, the "world's largest pig farm" is under construction by Muyuan Foods in a relatively remote location in the southwestern region of Henan province.

fig 5

This "mega-farm" is reported to be "roughly ten times the size of a typical breeding facility in the United States" and aims to produce over 2 million pigs annually.[66] To achieve this startling production turnover, the mega-farm will mobilize a complex network of monitoring devices and processing equipment, including "'intelligent' feeding systems, manure-cleaning robots, and infrared cameras to detect when pigs have a fever."[67] Meanwhile, in Yaji Mountain Forest Park, located in the Guangxi region of southern China, Guangxi Yangxiang Co Ltd is constructing the "tallest pig farm in the world," a mega-structure that is eerily reminiscent of the speculative proposal for "Pig City" advanced two decades ago by Dutch design office MVRDV.[68]

fig 6

This eleven-hectare facility is configured as a massive complex of multistory production units, a kind of "vertical" CAFO, with the capacity to produce 840,000 pigs annually. One news report dryly notes that the pigs in this facility "are restricted to one floor for their whole lives to avoid mixing animals." In addition to dedicated ventilation systems, each "housing" unit is being equipped with "elevators for transporting animals and a specific pipeline to direct dead piglets to internal incineration areas."[69]

Although they are embodied in extreme technospatial forms that evoke scenes from science fiction dystopias, these and similar agribusiness strategies represent the simultaneous generalization and continuation of livestock production techniques that were pioneered by US agribusiness firms under the postwar, US-led, global food regime. The relentless drive to achieve economies of scale through the hyper densification of animal populations and the hyper-rationalization of production serves to amplify—and further disperse—the myriad socio-environmental risks associated with the industrial meat regime. For example, as radical epidemiologist Rob Wallace has demonstrated with reference to emergent infectious diseases such as avian flu (H5N1), SARS, and COVID-19, agribusiness strategies of "biosecurity" and "biocontainment" are devastatingly ineffective at containing the unruly viral ecologies that are incubated within CAFOs. Pathogens

64 Rebecca Smith and Xiao Mingxin, "CAFOs in the US and China: A Comparison on the Laws That Protect Water Quality from Factory Farming" (USAID Asia and Vermont Law School, 2014), 21.

65 Schneider, "Developing the Meat Grab."

66 Dominique Patton, "Flush with Cash, Chinese Hog Producer Builds World's Largest Pig Farm," Reuters, December 7, 2020, https://www.reuters.com/article/us-china-swinefever-muyuanfoods-change-s-idUSKBN28H0MU.

67 Patton, "World's Largest Pig Farm."

68 MVRDV, *Pig City*, Design Proposal for Stroom Den Haag, Centre for Visual Arts, The Hague (2001).

69 Michael Standaert and Francesco De Augustinis, "A 12-Storey Pig Farm: Has China Found the Way to Tackle Animal Disease?", *The Guardian*, September 18, 2020, https://www.theguardian.com/environment/2020/sep/18/a-12-storey-pig-farm-has-china-found-a-way-to-stop-future-pandemics-.

fig 5 “World’s largest pig farm” in Henan province, China, before and during construction, 2018–2020. Google Earth, accessed on January 14, 2022

fig 6 MVRDV's 2001 proposal for "Pig City" and the "tallest pig farm in the world" currently under construction in Yaji Mountain Forest Park, Guangxi, China. MVRDV, 2022; Reuters, 2018

fig 7 The planetary expansion of soybean production areas, 1980-2016. Toshichika Iizumi, Global Dataset of Historical Yields v1.2 and v1.3, 2019

that emerge from such facilities are frequently projected into surrounding populations and ecosystems, both human and nonhuman, where they may engender severe public health risks.[70]

In this sense, the sprawling pig city on the fields of Henan and the massive pig skyscrapers on the forested mountaintops of Guangxi are not merely bizarre architectural spectacles that have appeared in otherwise pristine, "rural" landscapes. Both sites must be understood as contextually specific infrastructural assemblages enmeshed within the broader operational landscapes, metabolic circuits, and political ecologies of the GIFM, whose spatial parameters have now been extended to a transcontinental scale. Rather than protecting the populations of dense metropolitan areas from the environmental dangers of CAFOs, the new economic geography of industrial livestock production in China may serve to destabilize the general conditions of production and reproduction far beyond these facilities, creating new political ecologies of degradation, danger, and disease that are not likely to be contained effectively within the "wasted" rural zones in which they are situated.[71]

Industrialized livestock production in China is systemically reliant upon the import of massive quantities of animal feed from other parts of the world, notably North and South America. Despite recent attempts by the Chinese state to increase domestic feed production, the demand for feed crops vastly outstrips national production capacity. One study estimates that in 2010, "feed import was equivalent to 16 million hectares of arable land, which is equal to 45% of China's arable land used for feed production."[72] In this sense, the technical appellation "landless production system," often used as a corporate shorthand for CAFO-based production systems, is an ideological obfuscation. These disarticulated islands of concentrated livestock must be situated within a world-ecological context that now centrally includes the South American "seas of grain and oilseed monocultures" that directly support their high-throughput industrial metabolism.[73]

Since the 1990s, the growing demand for animal feed has led to the formation of what Philip McMichael has characterized as an "East Asian import complex."[74] This transcontinental political-economic and metabolic matrix is grounded upon new North-South and South-South interregional commercial relations in which feed crops and flex crops such as soybeans, corn, and palm oil are produced, circulated, and channeled into industrial operations. In tandem with the construction of these new transnational circuits of agricultural commodity trade, state-aided Chinese agribusiness firms have begun to compete more directly with Euro-American agribusiness corporations for access to resource frontiers in South America, Central Asia, and Africa.[75] The upscaling of industrial livestock production in East Asia has thus been a leading driver of global commodity frontier expansion and new infrastructural investments across Latin America, especially in the feed crop sector.[76]

The soybean commodity chain is among the leading edges of livestock-induced agro-industrial restructuring and landscape simplification in Latin

[70] Robert G. Wallace, *Big Farms Make Big Flu: Dispatches on Infectious Disease, Agribusiness, and the Nature of Science* (New York, NY: Monthly Review Press, 2016). For further elaboration on the link between the GIFM and emergent infectious disease, see Neil Brenner and Swarnabh Ghosh, "Between the Colossal and the Catastrophic: Planetary Urbanization and the Political Ecologies of Emergent Infectious Disease," *Environment and Planning A: Economy and Space* (2022), https://doi.org/10.1177/0308518X221084313.

[71] Tony Weis, "The Accelerating Biophysical Contradictions of Industrial Capitalist Agriculture: The Contradictions of Industrial Capitalist Agriculture," *Journal of Agrarian Change* 10, no. 3 (2010): 315–41; Schneider, "Wasting the Rural."

[72] Bai et al., "China's Livestock Transition," 6.

[73] Weis, "The Accelerating Biophysical Contradictions."

[74] Philip McMichael, "A Global Interpretation of the Rise of the East Asian Food Import Complex," *World Development* 28, no. 3 (2000): 409–24; see also Jostein Jakobsen and Arve Hansen, "Geographies of Meatification: An Emerging Asian Meat Complex," *Globalizations* 17, no. 1 (2020): 93–109.

[75] Gustavo Oliveira and Mindi Schneider, "The Politics of Flexing Soybeans: China, Brazil and Global Agroindustrial Restructuring," *The Journal of Peasant Studies* 43, no. 1 (2016): 167–94; Philip McMichael, "Does China's 'Going Out' Strategy Prefigure a New Food Regime?" *The Journal of Peasant Studies* 47, no. 1 (2020): 116–54.

[76] On commodity frontiers see Moore, *Capitalism in the Web of Life*; see also Sven Beckert et al., "Commodity Frontiers and the Transformation of the Global Countryside: A Research Agenda," *Journal of Global History* 16, no. 3 (2021): 435–50.

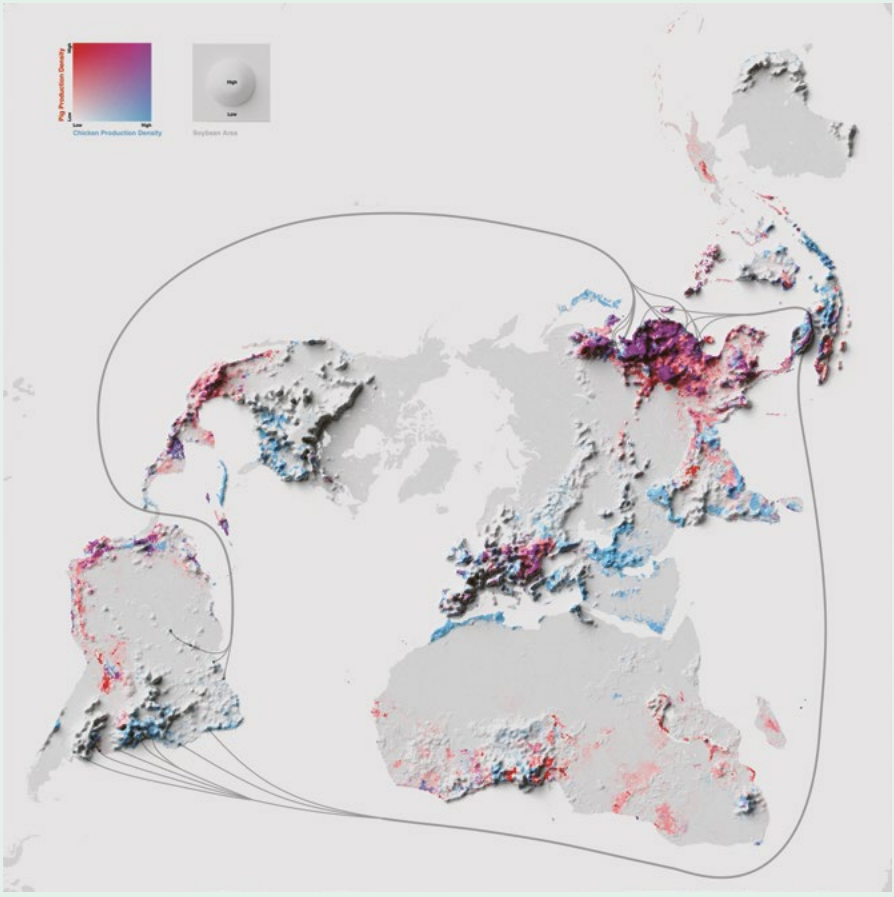


fig 8 Elements of the Global Industrial Feedlot Matrix with populations of industrial chickens shown in blue and pigs shown in red. Grga Basic and Nikos Katsikis

America. Since 1990, global soybean acreage and output have increased by over 118 percent and 220 percent, respectively. In 2018, global soybean production exceeded 380 million tons, around three-fourths of which were used for livestock feed.[77] In South America, where about half of the world's soy is produced, one of the most consequential geographical transformations in recent decades has been the dramatic expansion of soybean production across vast cropland zones of Brazil, Argentina, Bolivia, and Paraguay. Much of this expansion was led by US and Western European agribusiness corporations whose involvement in soy production significantly intensified during the 1990s, a period of neoliberal regulatory reform in which major Latin American states sought to revolutionize agrarian economies by facilitating foreign direct investment and reorienting production towards cash-crop exports. As a result, transnational agribusiness conglomerates such as ADM, Cargill, and Bunge acquired regional firms and made large-scale investments in land, equipment and spatial infrastructure to support the expansion of export-oriented soy production.[78] During the last decade, as North American and Western European corporations further consolidated their position as leading exporters of soybean from South America, Chinese "dragon head"—companies aligned with or partly owned by regional governments such as COFCO, Beidahuang, and the Chongqing Grain Group—have likewise begun to play an increasingly important role in organizing several key export-oriented feed-crop commodity chains.[79]

fig 7

The agribusiness-led expansion of soybean production has hinged upon large-scale land grabs, enclosure, and expropriation facilitated by neoliberalizing South American national governments. This has meant, on the one hand, a significant intensification and acceleration of depeasantization processes, as smallholders are dislodged from inherited forms of agrarian life and often displaced to metropolitan centers in search of waged or informalized subsistence labor. Equally constitutive of this transformation is a new wave of large-scale infrastructural investment—much of it financed by multilateral institutions and development banks—to support monocrop soy production; the procurement and distribution of fertilizer; the processing and storage of soy; and its long-distance circulation as freight via roads, rivers, and rail lines to ports and transcontinental systems of container shipping.[80] For instance, several projects recently initiated as part of Brazil's Investment Partnership Program (Programa de Parcerias de Investimentos) are principally oriented toward expanding and upgrading rail and road connections from its agribusiness regions to both the southern and "Northern Arc" ports. These projects include the Norte-Sul Railroad, the East-West Integration Railroad, and the BR-163 highway, which connects the soy-producing regions of northern Mato Grosso to Miritituba Port on the Tapajós river.[81] In this sense, the spatial configurations of the GIFM today stretch from the mega-fields, "soybean cities," processing facilities, agrochemical laboratories, distribution warehouses, and logistics systems of Latin America to the variegated industrial meat production infrastructures

[77] Hannah Ritchie and Max Roser, "Forests and Deforestation," *Our World in Data*, 2021, https://ourworldindata.org/soy.

[78] Gustavo Oliveira and Susanna Hecht, "Sacred Groves, Sacrifice Zones and Soy Production: Globalization, Intensification, and Neo-Nature in South America," *The Journal of Peasant Studies* 43, no. 2 (2016): 251–85; Oliveira and Schneider, "The Politics of Flexing Soybeans"; Gastón Gordillo, "The Metropolis: The Infrastructure of the Anthropocene," in *Infrastructure, Environment, and Life in the Anthropocene*, ed. Kregg Hetherington (Durham NC: Duke University, 2019), 66–96.

[79] Schneider, "Dragon Head Enterprises and the State of Agribusiness in China," 16–17.

[80] Peter Richards and Leah VanWey, "Where Deforestation Leads to Urbanization: How Resource Extraction Is Leading to Urban Growth in the Brazilian Amazon," *Annals of the Association of American Geographers* 105, no. 4 (2015): 806–23; Gordillo, "The Metropolis."

[81] Delmy L. Salin, "Soybean Transportation Guide: Brazil 2020," USDA Agricultural Marketing Service (2021).

of China, from container shipping ports and multimodal logistics hubs in coastal cities to CAFOs and associated packaging, storage, and distribution systems across the Chinese metropolitan system, now stretching deep into erstwhile "rural" zones where new strategies of agro-industrial intensification are being mobilized.

fig 8

The political ecologies of the GIFM extend still more broadly: they encompass the wide-ranging environmental impacts of industrial livestock production at each step of this planet-encompassing, fossil-fueled commodity chain. These include, for example, intensified deforestation, forest and land degradation, habitat fragmentation, and biodiversity loss in the Brazilian Amazon, the Argentinian Gran Chaco, and other zones of monocrop expansion in South America; the greenhouse gas emissions associated with the production and circulation of feed crops and processed meat across vast swathes of the world economy; and wide-ranging flows of toxic waste—from fertilizer, wastewater and manure to offal and carbon—that is accreted and discharged but never truly externalized, through the operations of the industrial meat regime, whether in the monoculture landscapes of Mato Grosso, the mega-ports of the Pearl River Delta, the CAFO landscapes of Henan, or the pig skyscrapers of Guangxi.[82] Further still, the political ecologies of the GIFM encompass the flows of unpaid work/energy that are appropriated from animal and human bodies, fossilized biomass, and organic matter and then channeled into the circuit of capital, leaving behind vectors of world-ecological devastation that are rendered invisible in the growth-centric ideologies of mainstream economics.[83] Thus, as Weis notes, while "the inequality associated with cycling grains and oilseeds through livestock might appear less conspicuous than with cycling them through cars," it is in practice a multiscalar cascade of intermeshed forms of appropriation, plunder, and destruction.[84] The economies of scale pursued through the GIFM "hinge on many unaccounted, non-renewable and actively destructive fixes" and, in this sense, rest upon a dangerous fantasy of endless, fossil-fueled agro-industrial growth.[85]

From this perspective, the post-1980s upscaling of China's industrial livestock sector, the acceleration of agribusiness-led landscape standardization in Latin America, and the consolidation of new, transcontinental logistics circuits connecting Brazilian, Argentinian and Chinese ports are interconnected elements of a worldwide system of productivity and plunder that produces myriad "sacrifice zones" of toxic waste, heightened ecological risk, and severely degraded public health conditions. At each link within this variegated commodity chain, elaborate (and increasingly costly) technoscientific strategies are rolled out to secure "biophysical overrides"—that is, to externalize (spatially) and displace (temporally) the environmental dislocations induced by this process, and thus to enhance economic growth and profitability.[86] Throughout the *longue durée* of the GIFM tracked in this essay, such strategies have served mainly to canalize the brutality of the industrial meat regime onto nonhuman animals, devalued workers, racial-

[82] N.I. Gasparri, H.R. Grau, and J. Gutiérrez Angonese, "Linkages between Soybean and Neotropical Deforestation: Coupling and Transient Decoupling Dynamics in a Multi-Decadal Analysis," *Global Environmental Change* 23, no. 6 (2013): 1605–14; Elizabeth Barona et al., "The Role of Pasture and Soybean in Deforestation of the Brazilian Amazon," *Environmental Research Letters* 5, no. 2 (2010): 024002; Henning Steinfeld et al., "Livestock's Long Shadow: Environmental Issues and Options" (Rome: Food and Agriculture Organization of the United Nations, 2006), Weis, "The Accelerating Biophysical Contraditions," passim.

[83] Moore, *Capitalism in the Web of Life*; Fraser, "Behind Marx's Hidden Abode."

[84] Weis, "The Accelerating Biophysical Contradictions," 329.

[85] Weis, "The Accelerating Biophysical Contraditions," 321.

[86] Weis, "The Accelerating Biophysical Contraditions," passim.

ized Others, and both proximate and distant ecosystems. And while they inflict devastating violence upon human populations, nonhuman species, the earth, and the biosphere, such attempted externalizations recurrently fail. Strategies to territorialize the biophysical contradictions of capital prove futile, whether within slurry lagoons, "biosecure" CAFOs, or other biocontainment enclaves. In an interconnected web of planetary life, the socioenvironmental destruction induced by the GIFM further proliferates and intensifies, eroding the general conditions of production, and indeed of life itself, from the field and the factory-farm to the biosphere as a whole.

The "cheapness" of industrial meat is thus revealed not only as costly but, in world-ecological terms, as *deadly*. As Weis explains, the stakes of this "costly cheapness" could not be more grave:

> Yet however capitalist agriculture might be reconstituted beyond fossil energy—in a world in which roughly one in seven are already malnourished, the class-based competition for grains and oilseeds is intensifying, rising food costs and climate change impacts loom portentously and unevenly, and world population continues to grow towards 9 billion—there is much reason to believe that any such reconstitution will only speed the world towards capitalism's ultimate precipice: revolution or barbarism.[87]

[87] Weis, "The Accelerating Biophysical Contraditions," 333–34.

The GIFM is a metabolic *monstrosity* in precisely this sense. Behind the veneer of its colossal infrastructural equipment, its complex systems of landscape engineering, its massive capacity to extract, process, and circulate materials, and its finely tuned, intercontinental choreography lurks a wretched, brutalized world—of degraded life, colonized territories, poisoned environments, and foreclosed futures. It is only through the radical politicization of such technical systems—by revealing the systemic violence through which they are reproduced—that we can begin to envision and to construct alternative frameworks of socioecological coexistence that prioritize solidarity, comradeship, care, and mutual aid (human and nonhuman alike) over the capitalist imperative of endless growth.

Contributors

Caitlin Blanchfield is a PhD candidate in architectural history at Columbia University's Graduate School of Architecture, Planning, and Preservation and visiting assistant professor at the Pratt Institute.

Neil Brenner is an urban theorist, sociologist, geographer, and Lucy Flower Professor of Urban Sociology at the University of Chicago.

Jay Cephas is an architectural and urban historian and assistant professor of history and theory of architecture at Princeton University School of Architecture.

John Dean Davis is an environmental and architectural historian and assistant professor at the Knowlton School of Architecture at Ohio State University.

Billy Fleming is a landscape architect, city planner, founding Wilks Family Director of the Ian L. McHarg Center at the Weitzman School of Design, and cofounder of the Climate + Community Project.

Peter Galison is a historian and philosopher of science and is the Joseph Pellegrino University Professor in history of science and physics at Harvard University.

Swarnabh Ghosh is a critical geographer, architect, and a PhD candidate at Harvard University.

Rania Ghosn is an architect, geographer, associate professor of architecture and urbanism at the Massachusetts Institute of Technology and cofounding partner of Design Earth.

Stephen Graham is an academic, author, and professor of cities and society at the School of Architecture, Planning, and Landscape at Newcastle University.

Florian Hertweck is an architect, professor, and chair of the Master in Architecture at the University of Luxembourg.

Richard L Hindle is a designer, innovator, educator, and associate professor of landscape architecture and environmental planning in the College of Environmental Design at the University of California, Berkeley.

Eric Robsky Huntley is a geographer and designer who is currently a lecturer in urban science and planning in the Department of Urban Studies and Planning at the Massachusetts Institute of Technology and a visiting lecturer in landscape architecture at the Harvard Graduate School of Design.

Nikos Katsikis is an urbanist and assistant professor of urbanism at the Delft University of Technology and affiliated researcher at the Urban Theory Lab in Chicago and Future Cities Laboratory in Zurich.

Marija Marić is an architect, researcher, and postdoctoral research associate of the Master in Architecture at the University of Luxembourg.

Shannon Mattern is an educator, theorist, and professor of anthropology at The New School for Social Research.

A L McCullough is a landscape architect and member of the Climate + Community Project.

Jeffrey S Nesbit is an architect, urbanist, and assistant professor in history and theory of architecture and urbanism at Temple University.

Robert Gerard Pietrusko is an architect, landscape theorist, and associate professor of landscape architecture at the University of Pennsylvania.

Roi Salgueiro Barrio is an architect, urbanist, and founder of the design office RSAU, and a lecturer at Massachusetts Institute of Technology School of Architecture and Planning.

Desiree Valadares is a landscape architect, architectural historian, and assistant professor in the Department of Geography at the University of British Columbia.

Charles Waldheim is an architect, urbanist, and John E. Irving Professor at the Harvard University Graduate School of Design where he directs the Office for Urbanization.

Matthew W Wilson is a cultural and political geographer, researcher, and associate professor of geography at the University of Kentucky and associate at the Center for Geographic Analysis at Harvard University.