2. Treadmill of production

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The treadmill theory was first developed by Allan Schnaiberg in *The Environment: From Surplus to Scarcity*, published in 1980. Schnaiberg sought to explain the rising environmental degradation in the United States post-World War II. In a nutshell, he argued that higher levels of industrialization for capital accumulation have led to growing pressure on natural resource extraction, greater and more toxic waste disposals, and the replacement of workers by machines. He identified the pursuit for economic growth through technological innovation as the leading cause of ecological degradation and social inequality in contemporary societies.

The "treadmill of production" refers to the political-economic system of modern industrial societies such as the United States, organized around the belief that the pursuit of economic growth through the conquest of nature is the measure of social progress (Schnaiberg and Gould, 1994). The logic of this system, however, is fundamentally in conflict with society and the environment. Since the 1980s, the globalization of production has transnationalized the treadmill model (Gould et al., 2008, pp. 41–47). US investors have shifted production abroad, attracted by lower overseas wages and lesser environmental protections. In the Global South, increased investment in extractive industries such as agriculture, mining, and forestry has accelerated habitat destruction and species extinction. In addition, the exporting of hazardous waste and the transfer of high-risk technologies have increased occupational health problems and ecological degradation.

Globalization has meant that the power of transnational corporations has increased in relation to that of national governments, making treadmill values and dynamics more entrenched. Still, national-level politics matters, as this is the site where international arrangements are ratified or overturned. Environmental movements, however, need to think beyond the slogan "think globally, act locally" (Gould et al., 1996). To be successful, local opposition to protect workers and the environment would require movements to be networked and unified regionally, nationally, and transnationally. Otherwise, citizen-workers end up competing in a race to the bottom, forced to trade their health for fewer available jobs.

When *The Environment* was published, in the Reagan era, a political context dominated by anti-environmental and anti-social policies gave little support for the treadmill theory (Gould et al., 2004). Yet, Schnaiberg continued writing alongside his doctoral students, Kenneth Gould, David Pellow, and Adam Weinberg, further elaborating and empirically testing the theory (see Gould et al., 1996, 2004, 2008; Schnaiberg et al., 2002; Schnaiberg and Gould, 1994; Weinberg et al., 2000). Their collective work developed what is "arguably the single most important sociological concept and theory to have emerged within North American environmental sociology" (Buttel, 2004, p. 323). Since the turn of the 21st century, growing numbers of scholars have been drawing on their work to explain the links between rising social inequality and environmental degradation nationally and transnationally. Today, the treadmill theory is one of the most relevant and popular theories in environmental sociology.

This chapter reviews the treadmill of production theory. First, I describe its theoretical structure regarding the analysis of the relationship between inequality and the environment.

I identify the main dynamics, actors, and institutions promoting production expansion, the root cause of environmental problems. Next, I present solutions. I describe Schnaiberg's proposal for alternative structures of production and social organization that could solve the tension between economic expansion and ecological limits. Finally, I showcase the work of contemporary scholars and the ways they are further elaborating and testing the treadmill theory empirically.

THE THEORETICAL STRUCTURE OF THE TREADMILL THEORY

Inequality, power, and conflict lie at the core of how treadmill theorists understand social influence on the environment. Environmental problems—from how we define them to how we aim to solve them—are not considered as separate, but as interwoven with social inequalities. "From a sociological perspective," Schnaiberg (1980, p. 5) wrote, "it is never sufficient to point to the environment as having been protected. The question must always be asked, for whom and from whom has it been protected? Environmental quality and social welfare issues are not socially and politically separable." Schnaiberg (1980, p. 5) thus proposes a theoretical framework that is "strongly grounded in a perspective that sees [environmental] problems as inherently derived from a variety of social tensions and conflicts, and that anticipates still further tensions and conflicts."

What social tensions and conflicts create environmental problems? Schnaiberg (1980) identifies the origins of ecosystem disorganization in "sociocultural production," particularly in production and consumption patterns in the United States and Western Europe post-World War II. Production in advanced industrial societies has followed a particular economic logic of technological change, where economic elites (capitalists and investors) pursue profitability by increasing capital investment in new high-energy technologies geared towards expansion and rationalization (meaning growing scales and reducing labor) (Schnaiberg, 1980, p. 166). Increasing production, in ways I explain in detail later, has led to accelerated rates of natural resource extraction (the ecological problem of depletion, or "withdrawals" in Schnaiberg's terms) and the problem of pollution (or "additions").

Allan Schnaiberg developed the treadmill theory deductively, beginning by observing the laws of thermodynamics, the basic principles governing ecosystems (Schnaiberg, 1980, p. 13). The first law of thermodynamics, the Law of Conservation, states that matter and energy cannot be created or destroyed, only transferred or transformed. The second law, the Entropy Law, states that all energy transfers are degradations: some energy is always lost in an unusable form. The environment sustaining human societies, regardless of their historical shape, is organized by these basic principles. Advanced industrial societies may seem immune to these threats and constraints—particularly to energy scarcity—but this is not always the case.

All human societies draw upon the ecosystem and the biosphere for sociocultural production. The environment provides the economy's material base: we extract natural resources and transform them, using energy and chemicals, to make the stuff we need in everyday life. We farm crops for food and clothing. We mine coal for energy, copper for wires, and lithium for batteries. What we do not consume or use in extraction and production, we dispose of as waste products. Economic processes are a series of environmental withdrawals and additions, or forms of depletion and pollution of the environment.

Schnaiberg focuses on the environmental effects of technological innovation in advanced industrial societies such as the United States. He observes that production in industrial economies has changed both qualitatively and quantitatively. Technologies, as methods of production, have become: (1) more energy-intensive; (2) labor-saving, replacing workers with machines; and (3) more reliant on petrochemicals, substituting natural resources with new synthetic, oil-derived chemicals (Schnaiberg, 1980, p. 120). The example of producing a simple consumer product such as frozen orange juice illustrates these claims:

> Start in the citrus grove, where orange trees are protected by petrochemicals. Pesticides keep insects away from oranges. Herbicides allow full growth of trees. Fertilizer is also added, which may be manufactured from deposits of potash or phosphate rock. All of these factors of production of oranges today are manufactured and then shipped great distances, involving high levels of energy consumption (usually fossil fuels). Moreover, their application in the groves is often energy intensive as well, being sprayed by ground or aircraft equipment that relies on fossil fuels. Picking of these oranges may be by hand or by machine. The latter involves more energy.
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> Next, oranges are shipped to a processing plant by truck (energy-intensive). They are cut, squeezed, evaporated by vacuum processes to reduce water content, and packed by machines into containers that are made of paper, plastic, and tin and steel—the latter three being very energy-intensive goods. High energy is involved in machine processing as well. Packaged juice is frozen by energy-intensive refrigeration equipment, shipped by refrigerated truck to a supermarket, where it remains refrigerated until purchase. In the home, it continues to be refrigerated (frozen) until use. The need to keep the juice frozen (a need arising from the deterioration of the taste and vitamin content of orange juice otherwise) requires a continuous expenditure of energy, from the time of packing to the time of consumption. Finally, the consumer thaws the juice, mixes it with water, and drinks it. The container is disposed of. The paper is theoretically biodegradable, but neither the plastic nor the tin lids are. Generally, all three would go into local landfills, withdrawing land from other uses. Alternatively, they might be dumped in various bodies of water, disrupting the physical structures and changing the chemical composition of the water, thus leading to alterations in plant and animal species compositions. (Schnaiberg, 1980, pp. 117–118)

We may not drink much frozen orange juice anymore, yet the example still holds. We drink concentrated juice from cartons, mechanically squeezed from oranges sprayed with countless agrochemicals. Paper cartons are layered with plastic and aluminum to maintain freshness, making the entire container unrecyclable. If we choose to hand-squeeze them, the fresh oranges we buy in the supermarket have likely traveled thousands of miles, shipped from distant places such as Chile or South Africa in refrigerated containers, demanding massive amounts of fossil fuels for energy. Despite the specific commodity, the theoretical emphasis is on the shift from more traditional low-risk technologies to higher-risk industrial technologies, mainly on its energy-intensive and synthetic chemical aspects.

Production in late industrial societies has changed in composition and volume. High-risk technologies are applied far and wide. Think of DDT, nuclear energy, and hydraulic fracturing. Petrochemicals have sped up natural resource extraction and production. Any of these technologies, if applied on minimal scales, could have minimal ecological impacts. But as production expands, so does its impact. "Since technology, by definition, always involves some processes of ecosystem withdrawals and additions," Schnaiberg (1980, p. 115) wrote, "unlimited expansion of these processes will generate significant, widespread, and permanent damages." That follows from the first law of thermodynamics. New rounds of industrialization only create more widespread and long-lasting ecological disorganization.

Why has production taken this course? Treadmill scholars are sociologists, thus compelled to investigate the social basis of technological change. They ask: which actors and institutions have decision-making power over production? In capitalist societies such as the United States, decisions about production expansion are located within the firm, in the hands of managers and investors (Schnaiberg and Gould, 1994, Ch. 3). Their decisions are motivated by increasing profitability and maximizing the value of their shares. To keep the firm competitive, managers work towards cutting costs and expanding production and markets, which negatively impact workers and the environment. To cut labor costs, managers seek to reduce benefits, keep wages low, or move production offshore, hiring cheaper workers in poorer countries. In addition, production expansion often involves new rounds of technological innovation that permit extracting natural resources faster and over larger areas, increasing ecological disorganization.

Corporations control production but are not all-powerful. Capital is encouraged and constrained by political decisions (Schnaiberg, 1980, pp. 209–212). The state promotes production expansion to attract political support as well as taxation dollars. In democratic societies, politicians need votes to remain in power. Citizen-workers, understandably, vote for candidates who promise economic growth, because they believe growth will bring more jobs, higher wages, and a better quality of life. Citizen-workers can also pressure the state for better living conditions, for example by withholding their vote or through social mobilization, limiting corporate activity. To satisfy citizen demands, the state may impose, for example, environmental regulations to maintain clean air or water, or labor regulations to raise minimum wages. The state also constrains accumulation through taxation. Governments can fund infrastructure and social programs such as building roads, schools, and hospitals by taxing private capital. Paradoxically, therefore, the state commits to support capital expansion, and by redistributing some of its gains it can maintain social peace by helping workers and the poor.

Capital, labor, and the state are the three constituencies of the growth coalition that keeps the treadmill moving (Schnaiberg, 1980, p. 208). Despite the conflictive relationship between capital accumulation and the wellbeing of citizen-workers and the environment, both labor and the state have been historically committed to production expansion and economic growth (Schnaiberg, 1980, Ch. V). Why is that? Schnaiberg (1980, pp. 215–217) points out how economic growth, rationalization, and efficiency are considered social goods in capitalist societies such as the United States. The belief that economic growth translates into social wellbeing is shared and unquestioned. It is an ideology.

As a theory of political economy, the ideological underpinnings of the treadmill of production are often not what is highlighted as the main characteristic of the theory (see, e.g., Rudel et al., 2011). Yet, treadmill scholars never failed to stress the significance of the value system that sustains treadmill expansion.[1] To slow down or even dismantle the treadmill of production, it is of utmost importance to redefine development, our shared belief that social progress comes from accumulation through natural resource extraction (Schnaiberg and Gould, 1994, p. 70). We must propose a value system that centers on social welfare maximization instead (Schnaiberg, 1980, p. 218).

SOLUTIONS TO THE ENVIRONMENTAL CRISIS

Treadmill theorists argue that the cause of environmental problems is rooted in the structure and dynamics of production expansion in capitalist societies. Solutions, therefore, require con-

Table 2.1 Potential future scenarios / synthesis of socio-environmental dialectics

Synthesis	Core features	Social future
Economic	Continued production expansion, with future labor vulnerability	*The Rich Rob the Poor*: future society likely to be authoritarian and unequal if environmental degradation increases quickly
Managed scarcity	Limited environmental protection: pollution control and recycling	*Business as Usual*: persistence or expansion of present inequalities, with reduced production expansion
Ecological	Appropriate technology and increased surplus share to labor	*Left Social Distribution*: increased equalities and decreased commodity consumption and production

Source: Schnaiberg (1980, p. 425).

fronting the political and economic forces that sustain (and benefit from) treadmill expansion. This is an arduous task. Where to begin? What alternative structures of production and social organization do treadmill theorists propose? And what kinds of obstacles do they anticipate?

Schnaiberg advanced three potential future scenarios in the concluding chapter of *The Environment.* These scenarios result from seeking to reduce the ongoing tension between production expansion and ecological limits. That is, they are potential syntheses to the socio-environmental dialectic. Ranging from most regressive to progressive, they are: (1) the economic synthesis; (2) managed scarcity; and (3) the ecological synthesis (see Table 2.1).

The economic synthesis scenario presents a future where capital seeks to expand indefinitely, despite the high social and environmental costs. Producers invest in high-energy technology to increase their profitability, accelerating the treadmill of production. In this scenario, some social benefits may come in the short term, but they will arrive at the expense of future social vulnerability for workers and the poor. Then, the state will be pressed to expand the safety net of social welfare provision, which demands further economic expansion. When social welfare provisions are exhausted, citizen-workers' demands will intensify, which may require the state to respond though authoritarian initiatives. A contemporary example of the economic synthesis is the neoliberal extractivist model of development adopted in many Latin American countries during the 1990s, such as Chile and Ecuador (Leguizamón, 2023; Lewis, 2019).

The managed scarcity synthesis represents business as usual. This is the contemporary scenario in advanced capitalist societies such as the United States, where state policy alters production processes to ameliorate some ecological costs. Here, the role of the state is to guide production reform towards environmentally friendly technologies. While not in Schnaiberg's terms, this is the model proposed by ecological modernization theorists as the solution for the environmental crisis. According to ecological modernization theorists, state environmental policy is necessary to kick-start production reform (Buttel, 2000). The state should create incentives for corporations to adopt technologies that increase efficiency and minimize pollution and waste. The competition will lead corporations to transition to a stage of super-industrialization, where production is green and companies self-regulate (Spaargaren and Mol, 1992).

In contrast to ecological modernization, treadmill scholars argue that even if corporations were to adopt environmentally friendly technologies, the problem of production expansion remains. The environmental impact per unit produced may be lower with green technologies, but the total production volume offsets these gains. This is called the Jevons paradox. As Schnaiberg and Gould (1994, p. 53) wrote:

> the greatest threat of the treadmill of production may not lie in deficient technologies that pollute, but in the competitive logic of maximization of share values without limits. For no matter how much technology may improve in reducing additions (or withdrawals) per unit produced, it is likely to be offset by the pressures to expand production in order to increase returns to investors.

Under the managed scarcity scenario, state policy may succeed in "greening" the treadmill. Still, reform is technical, insufficient, and with little regard for social justice and wellbeing. "The environment is thus partly protected," Schnaiberg (1980, p. 426) wrote, "but for whom is never clear."

Schnaiberg advocates for the ecological synthesis, a fundamental restructuring of the treadmill of production geared towards expanding environmental protections and social wellbeing. This third synthesis proposes a scenario where production is organized around biospheric flows and capacities, and equally distributed risks and benefits. The transition towards ecological synthesis will not be simple. Treadmill scholars anticipate many tensions and obstacles, including conflict with political and economic elites.

The most significant political obstacle to dismantling the treadmill of production is the democratization of technological innovation decisions. Other barriers to slowing down the treadmill include corporations refusing to internalize the externalities of technological developments, and addressing the ideology of development (the unquestioned and generalized belief that economic growth via natural resource extraction translates into social wellbeing). In Chapter 6 of *The Environment*, Schnaiberg identifies the many barriers to research on the environmental impact of sociocultural production. To increase awareness of the urgency of socio-environmental reform, it is vital to expand and support socio-environmental impact research. Findings will help to make production costs visible, a necessary step for the transformation of consciousness required for collective action.

While treadmill scholars anticipate that this transition will be difficult, they do not deem it to be impossible. Schnaiberg (1980, pp. 431–432) proposed a "simple and feasible policy" to transition towards ecological synthesis. His socio-environmental program presents a series of fiscal and legislative changes aiming to shift production from the current high-energy, low-labor form to alternative forms of production that are higher in labor and lower in capital. This proposed policy includes incentives to encourage labor intensity, such as allowances to liquify depreciating, fixed high-energy, low-labor capital, and tax credits for employment and labor training. It also includes incentives for environmental protection, such as tax relief and credits for material recycling. State policy can set materials and energy taxes, and high effluent charges, to minimize pollution and encourage conservation. To discourage greater capital intensity, governments could increase taxation of new fixed capital, gradually higher for higher capital-per-worker ratios. This program sets a realistic goal. Yet while state policy is necessary to transition to the ecological synthesis, it will not be sufficient. Political and economic elites will resist both ecological limits to production and a more equitable social distribution of costs and benefits. Hard political conflict will be necessary to slow down and dismantle the treadmill of production. Treadmill scholars argue that coalition-building among social movements is "essential" to oppose these forces (Schnaiberg and Gould, 1994, p. 152). The environmental movement must broaden its demands to include citizen-workers' concerns for social welfare and equality. As Schnaiberg (1980, p. 420) said, high on the environmentalist movement agenda must be "to raise working-class consciousness of the social inefficiency of the growth coalition's expansion of production. Only when workers and the poor understand

for whom the environmental withdrawals are being made, and *for whom* alternative patterns of environmental usage might be more effective, only then will the movement broaden."

Treadmill scholars have been criticized for being pessimistic, as they present a bleak present and an insurmountable task. In my own experience teaching environmental sociology courses, I know students can feel hopeless and overwhelmed at the thought of where to begin to enact structural change. The socio-environmental program Schnaiberg proposes shows that we do not have to reinvent the wheel: we can use existing financial and legal mechanisms to enact change. He called it "a serious reformist, but not a revolutionary, suggestion" (Schnaiberg, 1980, p. 432). (It is also not a call for a socialist restructuring; see Schnaiberg, 1980, pp. 434–439.)

Schnaiberg urged us to think about possible environmental futures while we can. The social and ecological crisis of treadmill expansion is impending. If we are to avoid its worst impacts, we must have clear goals to act upon. When Schnaiberg wrote *The Environment*, he said that his generation had the "luxury" of time to envision options; yet warned that it was risky to wait (Schnaiberg, 1980, pp. 422, 428). In the 40 years since *The Environment* was published, the treadmill has vastly accelerated and globalized, increasing ecological degradation and social inequality locally and globally (Gould et al., 2008). The Intergovernmental Panel on Climate Change's Sixth Assessment Report on climate change tells us that we are running out of time (IPCC, 2022). Revitalizing Schnaiberg's proposal to slow the treadmill of production—a less known and utilized aspect of the treadmill theory—is of vital importance (Lewis, 2019). The following section shows how contemporary scholars apply and expand the treadmill theory, including exploring solutions to solving socio-environmental problems.

DIRECTIONS IN WHICH CONTEMPORARY SCHOLARS HAVE TAKEN THE TREADMILL THEORY

The treadmill of production—as a concept and as a theory—has generated many avenues of research. In this final section, I showcase the work of contemporary scholars that tests and expands the theoretical boundaries of the treadmill theory. I have organized this scholarship in subsections to better guide the reader, not because there are defined boundaries between these themes. On the contrary, as the reader will see, there are many overlaps and continuities; a sign of how fruitful and relevant the treadmill theory is.

Slowing Down the Treadmill of Production

As a consequence of the climate crisis, contemporary scholars consider solutions that restructure the treadmill to reduce social inequality and ecological degradation. Tammy Lewis (2016, 2019) revisits Schnaiberg's three syntheses for reconciling the socio-environmental dialectic and applies them to explain Ecuador's developmental trajectory. Lewis shows how Ecuador's economic development trajectory has shifted: from environmentally destructive, state-promoted, corporate-run petroleum extraction since the 1970s (economic synthesis), towards managed scarcity in the late 1990s, and finally, towards ecological synthesis from 2007 to 2017. In support of the treadmill theory, she identifies social movement activism as the key mechanism for this transition. In further elaborating the theory, Lewis highlights the

role of global actors and transnational funding in influencing local environmental movements and, consequently, state policy and local developmental trajectories.

As Lewis (2016, 2019) shows, Ecuador's shift towards ecological synthesis was marked by the nationalization of oil extraction under Rafael Correa's administration (2007–2017). With control over a larger share of oil extraction profits, the state sought to redistribute the economic gains of natural resource extraction by funding social welfare programs to address poverty, health, and education disparities, and to develop infrastructure. Environmental activists pressured Correa's administration to pass two key initiatives to fully shift towards the ecological synthesis: to grant constitutional rights to nature and *buen vivir* (translated in English as "good living" or "living well").

Buen vivir or *vivir bien* (*sumak kawsay* in Quechua, *suma qamaña* in Aymara) is a concept that emerges from Andean indigenous cosmologies, proposing the right to living well for humans and nonhumans (Gudynas, 2011). As Lewis (2019, p. 227) argues, the concept of *buen vivir* "shifts the value of the environment from exchange value to use value, which Schnaiberg considered an important aspect of an ecological synthesis." The concept of *buen vivir* presents the opportunity to connect US-based environmental sociology to Latin American theories of development in order to pursue further avenues of research. Most significantly, it also offers a real-life example of a value system that challenges treadmill values, presenting an environmental future where society–ecosystem relations shift from domination and exploitation towards care and harmony of people and the environment (Leguizamón, 2023).

While *buen vivir* is shaping the environment–development debates in Latin America, in Europe and the United States degrowth is the main proposal for slowing down the treadmill of production. Like Schnaiberg's ecological synthesis, degrowth "challenges the hegemony of growth and calls for a democratically led redistributive downscaling of production and consumption in industrialized countries as a means to achieve environmental sustainability, social justice and wellbeing" (Demaria et al., 2013, p. 209). Ryan Gunderson, Diana Stuart, Brian Petersen, and Sun-Jin Yun (Gunderson et al., 2018) study how alternative, renewable energy may help reduce carbon emissions. They argue that degrowth and collective ownership are the most favorable social conditions to better realize the environmental gains of alternative energy. Alternative energy production and use respond to the treadmill's "imperative to utilize energy to increase economic growth (and, thus, energy throughput) and the use of energy production itself as a capital accumulation strategy" (Gunderson et al., 2018, p. 38). Thus, even though renewable energy is touted as a technological solution to environmental problems, alternative sources of energy supplies have created an "energy boomerang" effect, neither substituting nor reducing fossil fuel energy production and use, but instead increasing it. Following other treadmill theorists (Gould et al., 2008; Schnaiberg, 1980; Schnaiberg and Gould, 1994), Gunderson et al. (2018) also propose a more democratic control of technological trajectories to alter production organization to reduce society's pressure on the environment: that is, to "degrow."

There is statistical evidence supporting the claim that slowing down the treadmill of production reduces ecological disorganization. Michael Long, Michael Lynch, and Paul Stretesky (Long et al., 2018) examine the effect of the 2008–2009 Great Recession on pollution levels in the United States. These authors argue that the decline in real gross domestic product (GDP) resulting from the economic downturn offers a natural experiment to observe the environmental effects of a slowing treadmill. Analyzing quantitative data on pollution emissions, they show that the recession reduced toxic releases at the state level. The authors thus argue

that their results provide empirical evidence to support the treadmill theory: a reduction in production levels will reduce ecological disorganization and highlight the state's central role in this process.

However, an economic recession per se does not make an ecological synthesis. Sudden economic downturns such as the 2008 recession may reduce pollution levels, but also tend to create widespread social havoc: generally, increases in poverty rates, unemployment, and social inequality. We see a similar situation with the COVID-19 pandemic. State-mandated lockdowns shut down cities and economies overnight. As a result, energy and carbon emissions fell at the fastest rate since World War II (BP, 2021). Yet, not only did social inequality worsen during this time, but also markets expect that energy use and emissions will rise rapidly once economies reopen, surpassing pre-2019 levels (Clark, 2021). This situation renews Schnaiberg's plea to have a plan to restructure the treadmill. Otherwise, political and economic elites will use their power to return to a "normal" state of treadmill acceleration.

In addition, poor countries cannot be asked to "degrow" as they still need to "develop" (meaning, to promote sufficient economic growth to address basic needs). As treadmill theorists argue, to reduce the ongoing tension between production expansion and ecological limits it is necessary to shift the entire development paradigm. That is, to move away from economic growth (often measured as GDP) as an indicator of social wellbeing. *Buen vivir*, with its focus on living well within planetary boundaries, is such a proposal. So is the case of Bhutan. Anders Hayden (2015) shows how Bhutan's development strategy is shifting away from focusing on GDP growth towards gross national happiness (GNH). As Hayden (2015, p. 162) argues, "Bhutan thus represents a valuable case to examine current possibilities and challenges facing an ecological politics of sufficiency that questions infinite growth of production and consumption." As the author shows, local but particularly global forces continue to pressure the state to follow treadmill values, limiting state capacity to move towards a sufficient-growth, strong GNH model. This shows the transnational character of the treadmill of production and invites further theorizing about the impact of transnational private capital on national development trajectories (Gould et al., 2008, p. 72).

Sustainability and Ecological Modernization

The treadmill of production theory explains the causes, consequences, and solutions to the most pressing problem of our lifetimes: is capitalism socially and environmentally sustainable? Ecological modernization theory is most often contrasted with the treadmill theory on this urgent question (Barboza, 2014). While treadmill theorists argue that the logic of growth institutionalized in the world system is incompatible with social and ecological sustainability, ecological modernization theorists claim that the logic of capitalism can be separated (decoupled) from its toxic, industrial technologies. Thus, ecological modernization theorists argue that corporations should invest in developing greener, cleaner technologies, as there are profits in ecological sustainability (Spaargaren and Mol, 1992). This is the prospect of a "green" or "sustainable" capitalism, the most widely accepted solution to solving environmental problems in contemporary society.

A substantial body of research sets to out empirically test the treadmill of production and ecological modernization in a comparative perspective. These studies consider cross-national, longitudinal data on economic growth, pollution, and resource depletion to determine whether the global economy is decoupling or not; meaning whether economies grow but emissions do

not (Givens and Jorgenson, 2011; Jorgenson and Burns, 2007; Jorgenson and Clark, 2011, 2012; Thombs, 2018; York and McGee, 2017). Cross-national investigations are necessary because they account for the transnational and integrated character of global production. As nations can externalize costs, it is possible to see a reduction in the ecological footprint of a particular country, but a growing impact overall. This body of research expands the treadmill theory by providing complex analytical tools to measure the anthropogenic impacts on the environment (Rosa et al., 2015; York et al., 2003a, 2003b), and by engaging in conversation with the theory of ecologically uneven exchange (Bunker, 2005; Jorgenson, 2016; see also Chapter 4 in this *Handbook*).

Scholars have applied the treadmill theory to assess the sustainability claims raised by proponents of specific technological innovations. These include alternative-fueled vehicles (McGee, 2017), genetically modified crops (Leguizamón, 2014, 2016, 2020), information and communication technologies (Simpson et al., 2019), irrigation technologies (Sanderson and Hughes, 2019), and nanotechnology (Gould, 2015). These authors show how their examples of technological modernization, all of them alleged solutions for problems as diverse as global hunger, resource scarcity, and climate change, in fact speed up social and ecological disorganization in the specific contexts in which these technologies are deployed. For sustainability to occur, rather than focusing on the technologies per se, treadmill scholars suggest instead investigating the social basis of technological trajectories. Sustainable solutions thus require restructuring the organization of production by promoting impactful science and public awareness (Gould, 2015), and prioritizing care and precaution over profitability (Leguizamón, 2020). Treadmill theorists ultimately consider ecological modernization "a form of re-engineering to reduce the environmental disruption generated by treadmill production" (Schnaiberg, 1997, pp. 74–75).

In addition to studying specific "green" technologies, treadmill scholars have also engaged with the sustainable development paradigm. The World Commission on Environment and Development first defined "sustainable development" in its 1987 report, *Our Common Future*, as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The three main goals of sustainable development are economic growth, environmental protection, and social equity; also referred to as "the three E's": economy, environment, and equity (Weinberg et al., 2000). Treadmill scholars have tested real-world examples proposed to achieve sustainable development, including urban recycling (Gould et al., 1996; Schnaiberg, 1997; Weinberg et al., 2000), ecotourism (Gould, 1999, 2017; Weinberg et al., 2002), and organic agriculture (Obach, 2007, 2015).

For example, Adam Weinberg, Allan Schnaiberg, and David Pellow (Weinberg et al., 2000) engage in a longitudinal, comparative analysis of a few rich case studies of urban recycling in the Chicago area. They show how, despite advocates' goals and expectations, recycling has turned into a profit-based enterprise. Economic gains are modest, and captured by large private firms; firms that also benefit from public funds. Ecological gains are modest too. Only a small percentage of total urban waste is diverted from landfills and incinerators. Equity gains are poor, as the quality of the jobs recycling creates are low. The authors conclude that while recycling has the potential to achieve the three E's of sustainable development, in practice the current, capitalist political-economic structure limits, resists, or defeats existing and proposed efforts for sustainable development. Brian Obach (2007, 2015), in his analysis of organic agriculture in the United States, reaches a similar conclusion: while the rise of organic agriculture

has achieved some slowing down of the treadmill of production, the market limits future steps toward a more sustainable food system.

Blue–Green Coalitions

Treadmill theorists argue that political conflict is necessary to slow down the treadmill of production. For that purpose, movements need to make coalitions in order to expand their base. Treadmill theorists highlight the potential of cross-movement alliances between workers and environmentalists, also referred to as "blue–green" coalitions.

Despite the strong connections between labor and environmentalist agendas, coalitions between these movements in the United States have been sporadic, when not fraught (Gould et al., 2005; Obach, 2004). So, what has kept these movements apart? On one side, labor has mostly supported treadmill values, at least for as long as production expansion promised to increase workers' wages and benefits. Obach (2004) shows how the labor movement in the United States has advanced the treadmill of production through collective bargaining, political advocacy, and as an ideological force. On the other side, the mainstream environmental movement has not directly engaged with labor concerns (Gould et al., 2005).

When have there been moments of convergence between these movements? The labor movement in the United States has long been concerned about public health concerns, demanding cleaner forms of production to improve working conditions (Gould et al., 2005; Mayer, 2011; Obach, 2004). As Mayer (2011) shows, health-related issues are the main common ground for building blue–green coalitions. Tomassetti (2020) reaches a similar conclusion in his study of the labor movement in Italy. He shows how the Italian unions allied with environmentalists to fight for a decent and healthier working environment. These alliances have been instrumental in slowing down the treadmill of production and leading a "just transition" (Obach, 2004; Tomassetti, 2020).

Protests against neoliberalism and corporate-led globalization, particularly during the 1999 protests against the World Trade Organization in Seattle, were an opportunity for the labor–environmentalist agenda to coalesce (Gould et al., 2005). The transnationalization of the treadmill has undermined labor security as corporations outsource production, and increased ecological disruption at global levels. However, rising hostility against local dissent post-9/11 took away the momentum of the anti-corporate globalization movement in the United States, diluting the links between labor and environmentalists (Gould et al., 2005).

The Trump administration created new barriers for coalitions, pitting economic growth and job creation (particularly in the energy sector) against environmental protection, mainly climate change. The "jobs versus environment" debate promoted by the Republican Party is so entrenched that even those most vulnerable to extreme climate events, such as many Louisianans, defend the oil and gas industry and deny climate change (Hochschild, 2018). In the aftermath of Trump's presidency, it is pressing to build on this scholarship to understand the factors that foster (or impede) the formation of blue–green coalitions.

A key lies in the work of grassroots groups engaged in environmental justice work, a movement that brings together actors who share the same structural position in the political economy, and similar tactics and demands (Gould et al., 2005; Gould et al., 1996; Pellow, 2002). Further alliances are being created by youth climate justice movements, such as the Sunrise Movement. They are demanding a Green New Deal that tackles both climate change and social justice demands.

The Treadmill Theory and Environmental Justice

Treadmill analysis predated and provided key theoretical contributions to environmental justice studies (Gould et al., 2008, p. 67ff.). Most significantly, the treadmill theory offers an explanation for how and why environmental problems and solutions are not shared equally in society. Much environmental justice (EJ) scholarship has narrowly focused on methodological issues and environmental racism; that is, on the role of racial inequalities in explaining why communities of color often bear the burden of production practices. The "race versus class" debate in EJ studies has produced significant methodological advances, but has missed the larger picture: environmental injustice is always about both race and class (Pellow and Brulle, 2005). The treadmill theory has provided a theoretical framework to EJ studies that explain environmental inequality by class within communities populated by people of color and immigrants (Pellow, 2002; Pellow and Park, 2002).

Further theoretical elaborations on EJ studies build on the treadmill theory. The treadmill theory provides an analytical framework to study how environmental racism and class inequalities affect populations. However, the treadmill theory, like other political-economic perspectives, does not pay enough attention to racism, sexism, colonialism, and other drivers of social inequality beyond capitalism in the division of social and environmental harms and privileges (Pellow and Nyseth Brehm, 2013). David Pellow (2018) has called for a critical environmental justice program (CEJ) to address this gap (see also Chapter 6 in this *Handbook*). Recent work, including by Pellow and Ian Carrillo, and myself, builds on these links between the treadmill theory and CEJ (Carrillo, 2020; Carrillo and Pellow, 2021; Leguizamón, 2020).

The Treadmill of Crime

A significant body of research extends the treadmill theory into the study of environmental crime. Michael Lynch coined the term "green criminology" in the 1990s to draw attention to environmental harms within criminology (Stretesky et al., 2013a). Green criminology advances criminology studies by providing a theoretical framework to understand how and why severe ecological damage may be left unaddressed by the state: both allowed under the law, and encouraged by corporate profitability. Lynch and his coauthors, Paul Stretesky and Michael Long, have developed an extensive body of work that applies the treadmill theory to explain how political-economic relations shape the law in cases of environmental harm (Long et al., 2012; Lynch et al., 2013, 2020; Stretesky et al., 2013a).

Green criminologists have applied the treadmill theory to explain why some crimes of ecological withdrawals and additions, such as the British Petroleum (BP) oil spill in the Gulf of Mexico, are defined as crimes while others are not (Stretesky et al., 2013a). Green criminology thus expands the treadmill theory by analyzing how environmental law legitimates extractive activities. In this sense, ecological disorganization is permitted under the law when it benefits treadmill expansion and the corporate and state actors who benefit from this expansion.

Green criminologists have thus studied how corporate power may influence environmental law, for example through lobbying and donations (Long et al., 2012), for their benefit at the expense of the rest, as with the privatization of freshwater sources (Johnson et al., 2016). Green criminologists have reached an important empirical finding that supports the treadmill theory: companies that violate environmental laws do not experience many (if any) negative collateral consequences (Greife and Maume, 2020; Stretesky et al., 2013a, 2013b). This schol-

arship shows that state enforcement of environmental laws through monetary penalties does not slow down the treadmill, because fines are not large or consistent enough; fines are taken as the costs of doing business. In addition, green criminologists have studied the links between crimes against nature and violence against Indigenous peoples (Crook et al., 2018; Lynch et al., 2018).

The Treadmill of Destruction

Lastly, scholars have expanded the treadmill theory to study ecological degradation driven by militarism and geopolitics, recasting the treadmill of production as the "treadmill of destruction" (Clark and Jorgenson, 2012; Gould, 2007; Hooks et al., 2021; Hooks and Smith, 2004, 2005).

The 20th century, as Schnaiberg observed, was a period of massive industrialization. It was also the bloodiest in human history, seeing two World Wars in addition to a dozen other wars around the world (Hooks and Smith, 2005). At the turn of the 21st century, wars, invasions, and occupations are a constant, from the United States over Afghanistan and Iraq, to Israel over the West Bank, Russia over Ukraine, in addition to conflicts across India, Pakistan, and North Korea, among other places. Mass industrial warfare is resource-intensive, particularly the use of fossil fuels to feed, clothe, and transport troops. It is also heavily toxic, leaving behind traces of chemical pollution and metal debris that can last for generations. As Greg Hooks and Chad Smith (2005, p. 20) argue, chemical weapons, from atomic bombs to "weapons of mass destruction," make the environmental damage of war-making and militarism qualitatively more dangerous. That is because its inputs (nuclear, chemical, biological) are selected on their potential to make the enemy's environment inhospitable. In addition to being extremely dangerous and damaging when deployed, these weapons also leave a deep environmental footprint in the extraction and processing stages. The "treadmill of destruction" thus builds on the treadmill of production theory by exploring the expansionary dynamics that create ecological withdrawals and additions, focusing in particular on "expansionary dynamics associated with war and militarism: geopolitical competition and arms races" (Hooks and Smith, 2005, p. 21).

Scholars have applied the "treadmill of destruction" framework to analyze US militarism over Native lands and peoples (Hooks and Smith, 2004), the war on drugs in Colombia (Smith et al., 2014), and environmental injustice on Latinx environmental health vulnerability in urban areas (Alvarez, 2020), among other cases.

CONCLUSION

This chapter has reviewed the treadmill of production theory. I first explained its theoretical structure, regarding its analysis of the negative environmental and social impacts of capitalist production. Then, I discussed the solutions that treadmill theorists propose to address the environmental crises. I highlighted Schnaiberg's call for an ecological synthesis to reduce the ongoing tension between production expansion and ecological limits. Finally, I summarized the work of contemporary scholars that test empirically and expand the theoretical boundaries of the treadmill of production. Their scholarship is impressive in size and scope; a sign of how influential the theory has been since the turn of the 21st century, and its continued theoretical relevance to analyze and address ongoing socio-environmental problems.

NOTE

1. For scholarship on how power elites use culture, discourse, and ideology to legitimate treadmill expansion and prevent collective action, despite negative consequences, see Adams et al. (2020), Bell and York (2010), Gould (1993), Gunderson (2017), Leguizamón (2020), and Shriver et al. (2020).

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