



Nuclear Weapons and the Treadmill of Destruction in the Making of the Anthropocene

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Abstract

This research analyzes the human dimensions of environmental degradation and injustice in the age of nuclear weapons. Human societies are fundamentally linked to global environmental systems and are transforming ecological conditions in dramatic ways, such that the current epoch has been termed the Anthropocene. This article highlights the human health consequences, ecological transformations, and threats to biodiversity imposed by military institutions in the Anthropocene; emphasizing how these outcomes can be traced to specific interrelated sets of processes and generative conditions. I advance the treadmill of destruction theory as one useful theoretical framework for examining these socio-ecological interrelationships. The investigation focuses on the institutional foundations of nuclear war strategy and preparations for nuclear war, and their interactions with ecosystems. I provide an analysis of the American nuclear weapons production process, revealing how a treadmill of destruction emerged after World War II. This analysis of how the developmental dynamics of nuclear weapons have changed over time brings greater clarity to the Anthropocene concept and the distinct role of military institutions in shaping the new era.

Keywords: treadmill of destruction, exterminism, nuclear weapons, mutant ecology, Anthropocene



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A critical interdisciplinary debate concerns how to define and measure the Anthropocene epoch. Much attention has been given to the anthropogenic transformations caused by economic activity. The “golden spike” in carbon dioxide emissions and the exponential growth of resource exploitation and chemical production after World War II has been at the center of the discussion over the economic forces at play (Brunnengraber and Gorg 2017; Steffen et al. 2015). But the radioactive fallout since the onset of nuclear weapons testing in 1945 has also been suggested as an ideal indicator (Waters et al. 2015). Nuclear activities other than weapons testing have been given little attention in this debate. Considering the impact of well-known disasters like Chernobyl and Fukushima, this is a significant gap in our understanding of the challenges of the new Anthropocene era.

This focus on the ecological transformation caused by human economic activity—a focus with political and ethical implications—has eschewed discussion of the global environmental impacts of the military and civilian use of nuclear power, particularly nuclear waste (Brunnengraber and Gorg 2017). I suggest that one way to further the debate over the Anthropocene is through a more careful analysis of the ways in which the developmental dynamics of nuclear weapons production have changed over time. The nuclear arms race provides an enlightening context to examine the interventions of social institutions into the relationship between humans and the environment. This article argues that in the Anthropocene, an era defined by the human-driven global impacts that have imposed a rapid and extensive change in the Earth’s geology (Crutzen 2002), the environmental consequences of the “treadmill of destruction” (Hooks, Lengefeld, and Smith 2020) are a definitive marker of socio-ecological transformation.

The production of a single nuclear weapon is a militarized technological-industrial-scientific process that generates a catalog of hazardous and radioactive wastes. A nuclear arms race is guided by an *expansionary logic* that results in qualitatively unique environmental outcomes. The first nuclear weapons created in 1945 mark a critical break with the past, where humans introduced the possibility of multigenerational genetic mutations into ecosystems (Masco 2004). However, the nuclear arms race that emerged during the 20th century Cold War took on an *inertia*¹ that has significant implications for understanding the impact of radiation on human health, ecosystem functioning, and biodiversity. To understand this dynamic, I focus on the institutional foundations of nuclear weapons production in the United States from the Manhattan Project to the present.

The institutional foundations of nuclear weapons production refer to the processes and logic guided by military institutions within the state. Hooks and McLauchlan (1992) describe these foundations as including the relations and interactions with geopolitics, technologies, ideologies, and political-economic arrangements that influence strategies of war and war preparation. The

¹ In general, inertia refers to the resistance of a physical object to changes in its trajectory and velocity. In the social sciences, inertia is often connected with the work of Bourdieu who argues that “The categories of perception of the social world...incline agents to accept the social world as it is, to take it for granted, rather than to rebel against it, to counterpose to it different, even antagonistic, possible...If objective power relations tend to reproduce themselves in views of the social world that contribute to the permanence of these relations, this is therefore because the structuring principles of a world view are rooted in the objective structures of the social world: power relations are also present in people's minds, in the form of the categories of perception of these relations” (1985:728-729).

present approach attempts to foreground the distinctiveness of the military's institutional power within the state while avoiding an overemphasis on the insularity of the military from the state's civilian institutions—the sources of ideological, economic, and political power (Mann 1984). The analysis, therefore, focuses on

centers of military planning and power, especially those that influence the extraction of resources from society and the wielding of infrastructural power by the state... The process of making war transforms society, including the institutional foundations of warmaking in subsequent historical periods (Hooks and McLauchlan 1992: 759).

The present examination is an individualizing comparison that permits the historical analysis of the changing forms of war and its environmental consequences in the Anthropocene. Attention to the outcomes generated by processes tied to nuclear weapons production reveals a template for future research into the impacts of organized violence on the environment.

The article proceeds in four steps. I begin by introducing the treadmill of destruction theory as a generative mechanism that produces and molds empirical outcomes, situating the present analysis by outlining the process of nuclear weapons production. Second, I spell out this article's basic argument, calling attention to the historical transformations in the institutional foundations of war strategy and war preparation in the Anthropocene. I argue that a fuller understanding of the Anthropocene requires a focus that goes beyond weapons testing to examine more closely the processes of nuclear war strategy and weapons development. The third step illustrates this argument by considering the case of American nuclear weapons development since the Manhattan Project and the human health and ecological consequences of the logic and processes of the treadmill of destruction. This case—the American nuclear arms race—is selected for theoretical salience in identifying an expansionary institutional logic and the environmental consequences of this logic. The final section discusses the implications of the American nuclear weapons experience in the 20th century for the escalation of nuclear competition underway in the 21st century.

The Treadmills of Production and Destruction

A key theoretical debate in environmental sociology centers on the conflict between ecological limits and the needs of capitalism and/or militarism. The treadmill theory describes a dynamic where a logic of accumulation drives harmful additions and withdrawals from the environment. The treadmill of production theory (Schnaiberg 1980) focuses on the growth imperative of capitalism and how capitalist economic organization systematically degrades the environment because of its insatiable appetite for profit. The treadmill of destruction theory builds on the logic of the production treadmill by arguing that military organizations drive the expansion of negative environmental practices and inequalities through the logic of arms races and geopolitics (Hooks and Smith 2004; 2005). This logic of accumulation is driven not by an economic growth imperative, but instead by competition among military organizations that procure dangerous raw materials, manufacture baroque weaponry, and generate wastes of unprecedented toxicity.

Treadmills—production and destruction—are distinct phenomena that can co-exist in a synergistically destructive way (Smith, Hooks, and Lengefeld 2014) and operate at a global scale (Jorgenson and Clark 2009; Jorgenson, Clark, and Givens 2011).

A recent recasting of the treadmill theory lays the ground for the investigation of a treadmill as a mechanism. Hooks, Smith, and Lengefeld (2020) theorize that the treadmill mechanism: (1) involves organizations and institutions that are highly centralized and often vertically integrated distributional instruments which unevenly disperse power and resources; (2) competition between organizations is tied to irresponsible environmental additions and withdrawals; (3) these entities accumulate power and capital by strategically controlling the flow of energy and resources. A treadmill mechanism exists as a dynamic force that has the transformative potential to alter the relationships between human societies and built environments.

A treadmill mechanism is infused with the social context from which it emerges. The present research emphasizes the social context of the Cold War nuclear arms race. Although the concept of a socially and environmentally damaging arms race is not a novel historical phenomenon, the lethality of an arms race in the nuclear era is unprecedented. E.P Thompson (1982) coined the term “exterminism” to explain the logic of the nuclear arms race, a logic based in irrationality and having an inertia.² The concept builds upon C. Wright Mills’ conception of the absurdity of the “drift and thrust towards World War III” which was “a defining characteristic of our epoch” (1958: 1). Former President and 5-star General Dwight Eisenhower (1961) also saw this convergence of military bureaucracy and the arms industry as a major threat to the American public. For Thompson (1982), the ferocity of the nuclear arms race was propelled by exterminism:

While the “thrust” towards exterminism was ultimately irrational, it contained its own logic of continuing escalation and an inertial force. As the scope of the mobilization for war—the number of laboratories, strategists, civilians, supporting organizations, weapons, and the amount of money in play—increased, the prospects of shutting down or redirecting the military-industrial complex became more remote. Thompson was describing the logic of nuclear war as the logic of exterminism (Lindseth 2012: 166).

Exterminism permeated American society. Because it was infused with an exterminist logic, the treadmill of destruction focused on the manic creation of nuclear weapons. This enormous commitment to national security goals harmed the national economy by directing scarce capital and scientific resources towards the development of “baroque” weaponry with little civilian application (Kaldor 1981; Melman 1985).

This article will demonstrate that the treadmill of destruction mechanism in the United States harms public health, creates mutant ecologies, and threatens biodiversity. Military organizations promoted a doctrine of ideological confrontation in which the path of victory was realized by

² Exterminism in the United States was derived from the normal dynamics of capitalism (Thompson 1982). The American path to state-building was secured through a dynamic of capitalized-coercion (Tilly 1990) in which generous accommodations were granted to a powerful capitalist class in exchange for the social resources needed to wage a nuclear arms race (Hooks and McLauchlan 1992; McLauchlan 1997). In contrast, Soviet exterminism was derived from a coercive-bureaucratic path of state-building (Thompson 1982).

exercising “military hegemony on the cheap through reliance on science-intensive strategic weapons” (Hooks and McLauchlan 1992: 775). The bureaucratic calculus of American political and military organizations emphasized maximizing production and prioritizing the national security state’s goals over the protection of the environment. Nuclear modernization efforts by the rival nation (real or perceived) seemed to sanctify the national nuclear security strategy and the environmental sacrifices that resulted. And because the prior aggressiveness of the national strategy appeared to provide the advantage in this existential arms race, the weapons modernization logic was expanded and accelerated, which led to a negative ecological outcome for the nation (and the world). The central point is that a nation that pursues nuclear weaponry does so in a unique social context and through a strategic and organizational arrangement that guides the selection and amplification of specific processes. The treadmill of destruction mechanism channeled the flow of resources—natural, techno-scientific, and industrial—towards the creation, maintenance, and “modernization” of nuclear weaponry. The next section draws attention to the harmful effects generated by the treadmill of destruction mechanism in terms of human health, mutant ecologies, and threats to biodiversity in the Anthropocene.

The Anthropocene

A nuclear weapon is a complex weapon-system that has over five thousand parts (Caldicott 2002). Different weapon designs require unique components, generate unique waste streams, and can impose unique risks. Civilian and military nuclear technologies both require uranium ore which must be mined, milled, converted, and enriched. Plutonium, which is reprocessed from spent nuclear fuel, is a military product used in most modern nuclear weapons. Depending on the weapon design, the military production process can include: plutonium production; plutonium separation and reprocessing; manufacture of plutonium components; fabrication of other radioactive and non-radioactive hazardous weapons components; weapons assembly; research, development, and design and associated experimental labs; and inactive weapons production and radioactive waste dumping or storage sites (Makhijani and Saleska 1995; U.S. Department of Energy 1997a).

Nuclear weapons development introduced the potential for genetic mutation into the biosphere, yet it is an overlooked aspect of the Anthropocene. The distinct change in geological processes that define the Anthropocene from the previous Holocene epoch involve:

marked acceleration of rates of erosion and sedimentation; large-scale chemical perturbations to the cycles of carbon, nitrogen, phosphorus and other elements; the inception of significant change in global climate and sea level; and biotic changes including unprecedented levels of species invasions across the Earth (Zalasiewicz et al. 2017: 56).

One of the most compelling markers of the Anthropocene’s beginning is the fallout from nuclear weapons testing (Waters et al. 2015; Zalasiewicz et al. 2015, Zalasiewicz et al. 2017). However, nuclear testing is only one aspect of nuclear weapons development that generates toxic and radioactive wastes. Fallout as an absolute marker of the Anthropocene, therefore, provides an incomplete picture of the consequences of nuclear technologies. The riddle of dealing with nuclear

waste remains unresolved (Schrader-Frechette 1993); the challenges include coming to terms with unpredictably long timescales and enormous geological, technological, and social uncertainty (Brunnengräber and Görg 2017). Examining the treadmill of destruction mechanism is critical for a more contoured understanding of the Anthropocene.

My key argument is that a treadmill of destruction mechanism uniquely endangers human health, generates mutant ecologies, and poses a threat to biodiversity.³ Radiation experiments on vulnerable citizens without informed consent, unintentional widespread contamination of food and water sources, the disproportionate exposure of nuclear workers and armed forces personnel, and physical and psychosocial trauma from living in a radioactive environment are examples of the human health threats (Makhijani et al. 1995; Stawkowski 2016; U.S. Congress 1986). Mutant ecologies are reproductive and biosocial outcomes of genetic mutation that spreads through the ecosystem (Masco 2004; 2006).⁴ Biodiversity loss is a significant problem in the Anthropocene (Rockström et al. 2009), and many human activities toxify the environment to the detriment of biodiversity (Jinnah et al. 2017). Nuclear weapons development leaves more than the physical scars where weapons have been tested. Radionuclides are dangerous for biological life because they can cause genetic mutation in living cells, impact the reproductive capacity of future generations, and decrease the overall fitness of populations of species. Chronic radiation exposure can alter the genetic structure of populations (Lawrence et al. 2015). For example, in addition to radiation sickness and death among residents and workers, wildlife in the Chernobyl exclusion zone⁵ has undergone genetic mutation (Beresford and Copplestone 2011).

The organs and tissues of every American born after 1951 have been exposed to radiation from nuclear weapons testing (U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, and the National Cancer Institute 2001). Yet the environmental causes of illnesses and risks to the public from weapons activities have often been contested by the forces driving military production (Cable, Shriver, and Mix 2008). The Hanford “Green Run” is an instructive example of how the treadmill of destruction drove the irresponsible and intentional

³ Bickham et al. define biodiversity “...as the number, variety, and variability of living organisms within a temporal and spatial scale. It exists as a continuum, including higher taxa (genera, families, etc.), species, populations, subpopulations, individuals, and genes. Disruption of genetic equilibria at any of these levels has a direct bearing on the decline of diversity, subsequent enhancement of vulnerability to environmental stress, and extinction of species” (2000:34).

⁴ The reproductive and biological outcomes that constitute mutant ecologies can be understood in three forms: “(1) injury, as in cancer or congenital deformity, (2) improvement, as in adaptation to a given environment, and (3) noise, as in an uncertain effect” (Stawkowski 2016:146). Injury can be understood as the harmful radiation-induced genetic and chromosomal changes that genetic toxicologists refer to as “environmental mutagenesis” (Frickel 2004; Wassom et al 2010). Improvement via adaptive response to radiation is not supported or demonstrated by any evidence under field conditions (Møller and Mousseau 2016). Noise and uncertainty are significant because of the complex physical and chemical reactions that radionuclides undergo when released in the environment. As radioecologists note, the process of radionuclide “speciation” alters the physico-chemical form of radionuclides over time and can intensify their biological uptake, bioaccumulation, and bioconcentration (Salbu 2009).

⁵ The Chernobyl nuclear reactor exploded in 1986 in the Ukraine, releasing significant levels of radionuclides into the environment. An “exclusion zone” was created and the area is now uninhabited by humans.

experimental release of radioactivity that risked direct exposures to the public through the air and indirect exposures as radionuclides entered the food chain.⁶ The purpose of the radioactive iodine-131 experiment was for American scientists to learn how to evaluate Soviet plutonium production, but inadequate planning and unfavorable weather conditions resulted in its deposition along the eastern and central parts of Washington and Oregon (Whiteley 1999; Brown 2013). The Green Run demonstrates that internal exposures to iodine-131 pose a unique threat in the development of thyroid cancer. While several assessments of thyroid disease near Hanford have found negative results, it is important to note that the National Academy of Sciences concludes that:

given the imprecision in the exposure estimates and the effect of other statistical issues, the absence of any observable radiation effect is not proof that there is none. It does mean that the iodine-131 exposure did not have large effects. However, until estimates are given with appropriate confidence limits, we do not know how much risk to the thyroid is compatible with the data (National Academy of Sciences 2002).

The incident was only one of hundreds of routine radioactive releases across the U.S. nuclear complex.

A mutant ecology represents a transformative break with the ecological history of a place; this transformation can challenge the structural integrity of all biological life including plants, animals, and humans (Masco 2004). It can transform entire populations of species into “environmental sentinels” that are used to track radioactive materials through the biosphere (Masco 2004; Shaw 2005; Stone 2002). Human-made radionuclides undergo complex physico-chemical transformations in the environment, they can bioaccumulate in the food chain, and they introduce genetic instability into biological systems (Salbu 2009). The production of a single nuclear weapon can generate this genetic instability; the production of a nuclear arsenal radically accelerates and compounds the risks of genetic mutations among a globally interconnected web of species. Every former U.S. weapons production site is a Superfund⁷ site. Thus, it is critical to attend to how historical patterns of institutional growth and development generate this outcome.

The industrial revolution led to the greatly enhanced lethality of warfare, but from 1945 onward this lethality grew by several orders of magnitude, fundamentally altering the historical process of warring and the international security context (Hooks 1990; Hooks and McLaughlan 1992). Following the bombing of Japan and the end of World War II, the United States continued manufacturing nuclear bombs, conducted advanced thermonuclear weapons research, and tested thermonuclear devices in the Marshall Islands (O’Neill 1998). The Soviet Union reacted to the

⁶ The U.S. General Accounting Office (1994) documents that “Some routine Hanford radiation safety procedures were intentionally relaxed for test purposes...during 1945-47, when routine Hanford iodine releases were conducted that totaled up to several dozen times more than the Green run release, doses exceeding present limits may have been recurred downward [in] infants through the air-pasture-cow-milk thyroid pathway”.

⁷ “Superfund” is the informal term for the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). This 1980 Congressional legislation gave the Environmental Protection Agency the authority to manage abandoned or uncontrolled hazardous waste sites (U.S. Environmental Protection Agency 2020).

American bombing of Japan by mobilizing its coercive bureaucratic apparatus to rapidly develop its own bomb. A dynamic of reactive arms races followed the first Soviet weapon test, with both nations racing to amass the largest nuclear arsenal. When the Soviet Union reached strategic parity, the United States emphasized the “modernization” of its nuclear capabilities with the intent of making them “more reliable, deadlier and more destructive” (Roberts 2016: 182). The Soviet Union reacted in kind by refocusing efforts on the production and testing of thermonuclear weaponry.

This section introduced some of the human health, mutant ecology, and biodiversity consequences of nuclear weapons production in the Anthropocene. The treadmill of destruction posed a threat to the health of local, regional, and global ecosystems:

if each nuclear test advanced the potential of the bomb as a military machine, it also increased the global burden of radioactive elements in the biosphere, overturning the “national security” logics supporting the nuclear arsenal by introducing the possibility of cellular mutations in plants, animals, and people on a planetary scale. (Masco 2004: 519)

The treadmill of destruction has harmed and continues to impose risks on human health, while its mutant ecologies introduce genetic instability into populations, and have deleterious effects on biodiversity. These outcomes broadly threaten the integrity of biological life and ecosystem health and functioning.

IV. Case Study: American Nuclear Weapons Production

In the United States, a vast network of military-funded facilities concentrates the skills of scientific, industrial, and technical professionals towards the manufacture of nuclear weapons. There are seventeen major American nuclear weapons production facilities and dozens of smaller facilities that supported this effort dating back to the Manhattan Project. I limit the discussion to the American military’s plutonium reprocessing at the Hanford Reservation and plutonium pit manufacturing at the Rocky Flats Nuclear Arsenal. These sites were selected because they highlight the inertia of American nuclear weapons production, and these case studies shed light on the emergence of a treadmill of destruction centered on nuclear weapons. Although the current research is focused on the American treadmill of destruction, it is important to note the theoretical and geopolitical significance of the Soviet Union in this process. Establishing this case provides a foundation for future variation-finding comparisons with the treadmill of destruction that emerged in the Soviet Union.

Militarized nuclear production and manufacturing during the Cold War linked important organizations in the state, the scientific enterprise, and the national economy. The modern national security state emerged as a novel framework for controlling the manufacture and deployment of nuclear weapons (McLauchlan 1997; Raskin 1982). A bureaucratic inertia from within the nuclear security state drew energy from conflicting ideological visions of the post-war world and a hegemonic competition marked by a nuclear arms race. The autarkic planning exercised by the Pentagon after World War II was decisive in the pursuit of specific technologies of warfare. The

military directly and intentionally increased its political power; it had first call on the raw materials, economic resources, and future industrial capacity of American society (Hooks 1990; McLaughlan 1997; Raskin 1982). During World War II, the Manhattan Project created the first nuclear weapons: an enormous secret military bureaucracy commanded a network of corporations, scientific researchers, projects, and subcontractors; it merged a system of indeterminate command structure with rigid vertically integrated organizational style (Hales 1997).

The pursuit of a nuclear weapon design is a military, technical, and political decision.⁸ During the Cold War rivalry, these decisions were made by insulated military bureaucracies. The following case studies focus on decisions surrounding the processing and use of plutonium in the fabrication of nuclear weapons. It is a radioactive element that remains fatally hazardous for half a million years. The physician Helen Caldicott explains that plutonium

is the most carcinogenic substance known to humans—hypothetically *one pound*, if uniformly distributed, could induce lung cancer in every person on earth... also causes mutations in the genes of reproductive cells—the eggs and sperm—posing a genetic risk to all future generations, a kind of random compulsory genetic engineering (2002: 62, emphasis added).

In metal form, it can spontaneously ignite when it touches air, and the presence of water can induce inadvertent criticality.⁹

Plutonium reprocessing occurred at Hanford Nuclear Reservation, one of the oldest and largest facilities in the American nuclear complex. Hanford primarily produced and reprocessed plutonium from its on-site reactors. Between 1953 and 1989, the Rocky Flats Nuclear Arsenal produced all of the approximately 70,000 plutonium pits¹⁰ in the American nuclear arsenal. As decisions surrounding nuclear weapons development and fabrication were made in the context of a treadmill of destruction, the institutional growth and technopolitical decisions placed a priority on creating evermore intimidating weapons, and the attendant impacts on human health, environmental harms, and risks of an ecological catastrophe were a secondary concern (or dismissed altogether).

Hanford Nuclear Reservation: PUREX

The Manhattan Project directed the construction of the Hanford Nuclear Reservation in Washington State, where it generated, separated, and reprocessed plutonium. At the onset of the Manhattan Project, Hanford emerged as an “atomic boomtown” constructed by tens of thousands of people at the remote sites in Washington State (Gerber 1992; 1996; Gosling 2010). Hanford

⁸ Caldicott (2002) notes that the U.S. has built 70,302 nuclear weapons using 65 designs.

⁹ “An inadvertent criticality event occurs when too much fissile material is brought together unintentionally to form a critical mass, thereby creating a runaway nuclear chain reaction. Since the assembly of the material into a critical mass is unintentional, the release of energy is extremely small compared to that released by a nuclear weapon or a nuclear power reactor; nevertheless, it can be lethal to those in the immediate vicinity” (Cochran 1993: 27).

¹⁰ Pits, also known as cores, are spheres of plutonium-239 that are used to initiate a chain reaction in advanced thermonuclear weapon designs (Makhijani et al. 1995).

underwent enormous expansion during the Cold War and produced critical innovations in the separation and reprocessing of plutonium. The key priority of Manhattan Project commander General Groves was secrecy and control of information (Hales 1997). This emphasis on secrecy permeated decision-making regarding site selection, labor relations, and environmental consequences of military activities at Hanford during World War II and the Cold War.

Dangerous and uniquely toxic materials and methods were deemed acceptable because of national security and military plutonium demand. Consider this simple example:

Once the war was over, [Manhattan] District officials approved a simple procedural change, known all along, that cut iodine emissions considerably—the slugs [fuel rods] were allowed to stay in storage while the short half-life of iodine decayed to a far safer level. But until war's end, District officials refused to add that extra few days to the production cycle (Hales 1997: 149).

The expediency demanded of the WWII nuclear weapons program meant officials resisted any procedural change that might slow production. This disregard for dangers to human health and environmental degradation led to intentional and large-scale dumping of radioactive wastes and byproducts, enormous leaking waste tanks, migration of wastes into the water table, and widespread contamination of the semidesert Hanford area. In 2000, a wildfire swept across several radioactive waste burial sites, making it still more difficult to contain and mitigate hazardous wastes stored there. Hanford is widely believed to be the most contaminated site in the US nuclear weapons complex (Makhijani et al. 1995).

Technological innovations at Hanford were geared towards production goals, environmental concerns were typically ignored. While great care was taken to filter the Columbia River water before use in the reactors, no such attention was given to filtering wastewater, as Hales observes:

virtually all the District's [Manhattan Project's] attention lay with the stages from river to pile [reactor]—where, in other words, the quality of the water reflected on the industrial output of the “product”....In that half of the circuit, thirteen stages moved the water from the river, held it in reservoirs, filtered, demineralized, deaerated, cooled, and refined the water so that it might enter the pile. Afterward, however, it was simply pumped into a 7,200,000-gallon retention basin, where it sat while the radioactive materials with the shortest half-lives emitted their radiation until the District determined it was practicable to pump it back into the Columbia (1997:134-35).

The Atomic Energy Commission managed its unprecedented volumes of radioactive waste as cheaply as possible by dumping it into different surface groundwater holding tanks, and by 1959 the site discharged 20,000 curies directly into the Columbia River daily (Brown 2013). Between 1944 and 1970 no less than 140 million curies were released directly into the atmosphere or the Columbia River as water flowed through single-pass reactors and was returned (Gephart 2003).

The PUREX (Plutonium URanium EXtraction) initiative, created in the context of the Cold War arms race, displays the hallmarks of the treadmill of destruction. This initiative focused on the enhancement of nuclear weapons; it downplayed or ignored altogether the demonstrable and

enduring harm to the environment. Military leaders selected new nuclear technologies that supported novel weapons designs and materials based on efficiency and expediency. The PUREX separation and reprocessing technology revolutionized the reprocessing of plutonium (Gerber 1993; Makhijani et al. 1995). As anticipated, PUREX made possible significant efficiency gains in the extraction of plutonium and other radioactive materials used in weapons production.¹¹ The PUREX plant initially reprocessed plutonium into a liquid form, but liquid plutonium transport poses a substantial risk during transportation. As a consequence, Hanford built facilities to convert the liquid extractions to solids before transport (Makhijani et al. 1995). PUREX, although more efficient in terms of production capacity, uses lye to neutralize the waste prior to storage, and the resulting sludge is difficult to transport and yields a dramatic increase in the overall volume of waste (Makhijani et al. 1995).

The enormous volume and variation of low-level and high-level waste streams generated by reprocessing transformed the local hydrology around Hanford. Even before PUREX emerged in 1956, low-level waste discharges into “cribs” and holding ponds were showing catastrophic potential. Gerber writes that

Mounds had developed in the groundwater...as a result of the cooling water discharges from B, T, REDOX, and U Plant...The mounds shifted natural hydraulic gradients and drainage patterns, sometimes intersecting with underground plumes of contaminated liquids and routing them towards areas of high permeability and transmissibility...the pressure and weight of the mounds themselves increased the hydrostatic head, forcing all nearby or affected underground liquids to travel faster toward the Colombia River (1993: 23).

These hydrological dynamics were not fully understood at the time, but it was clear that the low-level waste being discharged into holding ponds and swamps was inducing changes, and Hanford hydrologists were concerned.

PUREX exacerbated the problem, tripling the amount of low-level waste released into the swamp and raising the groundwater mound to a record high of 418 feet. The first groundwater contamination was discovered from samples beneath a waste crib that showed over three months the radioactivity had increased by several orders of magnitude (Gerber 1993). Many changes and solutions were attempted, such as a diversion project that tried to route the groundwater through more desirable pathways. Yet the arms race imperative accelerated the reprocessing efforts, rather than slowing them to address the waste problem:

Wastes from the PUREX cribs continued to reach groundwater, intersect with the mound southeast of the plant, and travel into permeable zones. The effects of PUREX discharges on the groundwater beneath HW [Hanford Works] ranged from areas as far away as the pre-Hanford townsite to points of intersection with the

¹¹ Gerber reports “The first year of PUREX operations demonstrated such an overwhelming production capacity, along with economic efficiency as compared to the other separations plants, that the 4X Program was abandoned....The late 1950's and early 1960's witnessed even more spectacular production leaps at the PUREX facility. For short periods of time, PUREX demonstrated the capacity to operate at 3.6 times its design capacity” (1993: 12-13).

Colombia River....The effects continued and grew throughout the production leaps of the 1950s and 1960s...the period 1960 to 1965 was marked by the construction of other cribs and the discharge of the largest amounts of low-level waste at HW [Hanford Works] prior to the PUREX shutdown in 1972. Of the slightly more than 32 billion gallons released, 64 percent came from PUREX (Gerber 1993:v23-24).

These low-level radioactive and hazardous wastes changed the local hydrology and spread throughout the environment as a consequence of the hydrological transformation.

High-level liquid wastes were managed through a system of “tank farms” and enormous expansions of waste areas were tied to the increased rate of production from PUREX operations (Gerber 1993). Waste-tank explosions and leaks were a major concern. They represent catastrophic risks that can occur due to several problems, including radiolytic hydrogen, cooling system failure, the generation of explosive gases, and chemical explosions (Makhijani and Saleska 1995). The approximately 40 million gallons of liquid wastes generated by plutonium reprocessing required 149 single-shell tanks, which were constructed between 1944 and 1964; from 1968 to 1986, there was an addition of twenty-eight double-shelled tanks that hold over 24 million gallons of waste, both liquid, and sludge (Whiteley 1999). Between 30-40% of these high-level waste tanks contain volatile chemicals that can interact with each other and produce flammable products, and these dynamics are altered in the presence of radiation (Makhijani et al. 1995). The Hanford site is considered to be at the highest risk of catastrophic tank explosions, making it one of the most contaminated places in the U.S. weapons complex and possibly the planet (Makhijani et al. 1995).

The environmental consequences of the Hanford site were extensive and grew in tandem with Hanford’s production goals. As early as 1944, studies of the ecological and health impacts of Hanford conducted by the medical research division had already been documented (Brown 2013). Releases of iodine-131 from the chemical separation plants, found near the center of the 1,460-square kilometer site, were detected at distances of 84 miles from the boundary of Hanford (Hales 1997). From 1944 to 1972, radioactive iodine-131 releases occurred in the range of 630,000—980,000 curies (Whiteley 1999; Hanford Health Information Network 1997). As of the 1990s, Hanford contains the largest volume of liquid waste in the American nuclear weapons complex, with over 374 million curies of radiation (Makhijani et al. 1995). The Hanford complex is home to 1900 waste sites (Physicians for Social Responsibility 2017). It currently stores two-thirds of the high-level nuclear waste legacy in holding tanks; one-third of these tanks have leaked. In total, over one million gallons of liquid waste has leaked into the environment and contaminated 200 square miles of groundwater in dangerous proximity to the Columbia River.

Federal agencies overseeing Hanford consistently offered reassurances that no human health or environmental impacts occurred as a result of Hanford’s activities; these reassurances were demonstrably false (Office of Technology Assessment 1991; Whiteley 1999). Local and regional ecosystems were extensively contaminated by the vast quantities of chemical and radioactive by-products produced at Hanford (Gerber 1992). These releases—some unintentional and some purposeful—contaminated the air, river, and groundwater supplies (Dalton et al. 1999). Whether the releases were unintentional and intentional, they were justified in the name of national security.

Adverse human health effects from radiation exposure are a function of the dose rate, the type of radiation, and the sensitivity of the tissue exposed to radiation. “Cancer can occur at any level of dose received. The probability of cancer can be proportionate to the level of exposure” (Agency for Toxic Substances and Disease Registry 2006: 144). Studies of the Columbia River show that “levels of Hanford-derived contaminants in the Columbia River pose a current threat to humans who might be exposed to them” (Stewart 1999; U.S. Department of Energy 1997b). Those living “downwind” from Hanford have reported elevated rates of thyroid cancer related to iodine releases (Hanford Downwinders Litigation Information Resources Website 2020), while the Department of Energy now openly recognizes the occupational health threats experienced by nuclear weapons workers during the Cold War (U.S. Department of Energy 2019).

Hanford provides a stark example of mutant ecology. The Russian thistle plant, whose deep roots absorb strontium-90 and cesium, releases its head during development and creates windblown radioactive tumbleweeds (Masco 2004; Athas 2001). The Hanford Reach on the Columbia River is a critical spawning ground for Chinook salmon on the Columbia River, and the area has been impacted by contaminated radioactive and chemical wastes that have migrated upwards from the groundwater (Columbia River Keeper 2011; Washington State Department of Ecology 2020). Independent examinations of the impacts on salmon and trout populations in the Columbia River near Hanford show high rates of radiation-induced genetic mutations in offspring of all species, and the metabolism of plutonium in animal cohort studies points to the same conclusion: the bioaccumulation of radioactive isotopes within the food chain resulting from nuclear development posed a threat to the entire web of ecological systems (Brown 2013).

The impacts of this radioactive bioaccumulation and biomagnification vary significantly by species and these differences in turn impact biodiversity. Wildlife exposure to stored radioactive wastes can have both direct and indirect effects on an ecosystem that include the loss or disintegration of habitat and decreased biodiversity. Elevated levels of contaminants have been found in soil, tumbleweeds, yarrow, mulberries, and mice at Hanford (Agency for Toxic Substances and Disease Registry 2006). A study of predatory bird waste at Hanford revealed the presence of several radionuclides, and the authors conclude that “The concentrations...in the onsite samples indicate that residual radionuclides remain in the environment from retired plutonium production facilities” (Fitzner et al. 1981: 56). The predatory birds studied were transformed by the radiation exposure in their food sources, but also into “environmental sentinels” used to track radioactivity through the environment.

Hanford’s grim history highlights the dynamics of the treadmill of destruction. National security and military secrecy superseded environmental protection at the site and in the surrounding region. During the Manhattan Project and the ensuing Cold War, the Pentagon expanded its power by establishing a treadmill of destruction mechanism. The imperatives of the nuclear arms race led to maximizing the efficiency of production, such as the PUREX process. The larger waste burden of PUREX, special conversion facilities, and increased risk of consequences from catastrophe were frequently treated as technical problems that hindered the manufacturing velocity of plutonium for the arms race. The manifest, spectacular, and widespread

environmental threats and impacts were systematically ignored and suppressed. Risks to human health, the generation of mutant ecologies, and threats to biodiversity remain on an unprecedented scale at Hanford.

Rocky Flats Nuclear Arsenal: Sealed-Pit Weapons

In 1951 the Atomic Energy Commission built the Rocky Flats Nuclear Arsenal at a “remote” site only 16 miles from the boomtown environment of the Denver area, and as the largest local industrial plant in operation, it was an important job provider (Draper 2014). Makhijani et al. note that “Rocky flats did for the fabrication of plutonium parts what Hanford, Oak Ridge, and Savannah River had done for materials production. It greatly expanded the capacity for building nuclear weapons” (Makhijani et al. 1995: 240). The facility was constructed to accommodate the expansion of the nuclear weapons complex (especially Hanford and Los Alamos), in hand with the technopolitical pursuit of more dangerous sealed-pit weaponry. For every nuclear warhead in the US arsenal, Rocky Flats supplied the plutonium pits—the component that triggers a chain reaction in thermonuclear weapons. The Rocky Flats Plant provided well-paying and secure jobs. But workers were neither informed of nor were they protected from the catastrophic risks. For this reason, Cohen asserts that Rocky Flats is “one of the most disgraceful episodes in the annals of America’s interaction with the atom” (Cohen 2012: 1).

The Rocky Flats’ location was unique because of its proximity to a major metropolitan area, and a miscalculation in wind patterns almost guaranteed the contamination of the Denver area (Abas 1989). During the Manhattan Project, plutonium processing facilities were required to be at least twenty miles from cities with 1,000 people or more (Groves 1983). But as the Cold War arms race gained steam, the mandate of secrecy and national security resulted in relaxed standards for site selection (Abas 1989). Rocky Flats was an essential expansion because it was the only facility that could manufacture plutonium pits and unique weapon components on a large scale (Ackland 1999).

The United States transitioned to an arsenal of sealed-pit weapons while dismissing the risks of unintentional detonation (National Archives, Records of the JCS, Group 218, box 16, 5 March 1958). The imperative was to maintain technological superiority in the arms race. The Joint Chiefs of Staff argued that “the probability of an inadvertent nuclear detonation of a sealed-pit weapon with proper safety controls is extremely remote—in fact it approaches zero” (Dwight D. Eisenhower Library, DoD Series, box 1, Vol. II [9], 29 August 1958). These sweeping assurances obscured a dangerous trend. Sealed-pit weapons were involved in dozens of incidents, including major environmental catastrophes between 1961-1968: Jonesboro, North Carolina; Palomares, Spain; and Thule, Greenland (Miller 1985; National Security Archive 2014). Pits are particularly dangerous because they contain a concentrated mass of plutonium which must be machined for use in weaponry.

Plutonium is combustible and highly unstable, particularly in the high concentrations necessary for weaponization. At Rocky Flats, the risk of fire was high due to the large amount of

combustible waste generated during the plutonium machining process.¹² Once plutonium is on fire, exposure to water can set in motion criticality events (chain reactions). Plutonium processing buildings were not outfitted with sprinkler systems, but plant managers often made unapproved changes intended to improve worker safety (Ackland 1999). Hundreds of unintentional fires burned at Rocky Flats during its operation. Between 1966 and 1969, the plant fire department responded to 164 fires, 31 of which were plutonium fires, and dozens of others which were considered routine and not reported to the fire department (Cochran 1993).

Major plutonium fires at Rocky Flats in 1957 and 1969 released immense levels of plutonium into the air and soil (Makhijani et al. 1995), and both started from the spontaneous combustion of plutonium. The secrets of the 1957 fire were uncovered during the discovery proceedings in a court case involving a nearby landowner. The plutonium filters in the facility, saturated with plutonium dust due to improper maintenance, were destroyed by the fire and allowed the plutonium to escape directly into the environment (Moore 2012). Operators resumed production before restoring filters or monitors; no efforts were made to survey the radioactive contamination downwind from the facility. Between 40 and 500 grams of plutonium escaped into the environment during the incident (Colorado Department of Public Health and Environment 1999). Safety reviews of the 1957 fire made several recommendations to the operator Dow Chemical Company such as installing and maintaining adequate fire detection equipment and fire breaks between working areas. But efficiency was a higher priority than protecting workers or the environment. “Many of the actions were not taken for reasons of cost and perceived production requirements” (Cochran 1996:23).

The 1969 fire started like many of the plutonium fires—with plutonium flecks in rags that spontaneously ignited. While it started in the same manner as so many others, this fire escalated into a near-disaster, contaminating over 400 workers and smoldering and reigniting several times (Ackland 1999). At \$70.7 million, the record-breaking industrial accident was the worst in U.S. history at the time. The Atomic Energy Commission estimated that \$22.3 million worth of plutonium was lost, with damages to the production facility estimated at \$48.4 million (Ackland 1999). Firefighters used water to quell the fire, and a catastrophe was barely averted:

The plutonium oxide “ash” from the burned metal became sticky like dough when it was drenched with water...if the fireman had been able to push the plutonium together, he probably would have triggered a chain reaction (Ackland 1999: 155-56).

Such a chain reaction would not have the destructive force of a weapon, but it would have released an even larger amount of long-lived high-level radiation into the environment.

¹² Ackland describes that “The lathes, milling machines, and other machine tools left fine metal chips as well as larger pieces, all of which were to be recycled....Before being pressed into briquettes, the plutonium chips were supposed to be dipped in successive baths of carbon tetrachloride cleaning solvent in order to remove the machining oil still sticking to the surfaces. Such degreasing was dangerous, however, since the chips spontaneously ignited so easily—the cause of many ‘routine’ fires” (1999: 151-152).

After investigating the fire, the Atomic Energy Commission blamed plant managers for failing to implement or follow fire safety procedures (U.S. Atomic Energy Commission 1969; Cochran 1996). These findings were kept secret because they demonstrated ignorance and negligence on the part of both the Atomic Energy Commission and its contractor Dow. Furthermore, the investigation into the 1969 fire concluded that the Atomic Energy Commission had utterly neglected the conclusions of the investigation into the 1957 fire at Rocky Flats:

The fire investigators' conclusion that the fire originally started in oily rags laced with plutonium did not appear in the investigation report...The agency preferred to imply that the fire's origin was a mystery...If the fire had burned through Building 776-777's already softening roof, thousands of pounds of deadly plutonium in the form of powdery ash would have exposed hundreds of thousands...Secrecy's thick walls prevented full disclosure about the Rocky Flats fire (Ackland 1999: 158-159).

Atomic Energy Commission officials wrote that Dow managers did not take the near-disaster seriously. They went on to praise the work of firefighters but neglected to share the potential implications of the accident with the public.

The United States continuously improved nuclear pits throughout the Cold War. The focus was single-minded: improve their effectiveness. There was little to no concern for the health of workers who made them or protecting the environment near the facilities manufacturing them. As the weapons technologies advanced, the risk of accidental detonation and nuclear scattering at Rocky Flats increased. "Many of these risks were due to the rapid growth of bomb technology, and the inadequacy of safety measures to address the new problems that arose from this technology" (National Security Archive 2014).¹³ Most important, it was more likely that the enhanced nuclear pits would accidentally generate an explosion (possibly triggering a nuclear explosion) and the scattering of radioactive materials across a broad area (Brodie 1987: 9).

The secrecy surrounding these complex engineering challenges was an exercise of technopolitical power, in which the political and environmental risks of accidental detonation were weighed against the risks of a technological disadvantage in the nuclear arms race. For military planners, the national security imperative ultimately outweighed the risk of nuclear explosions or incidents that scattered radioactive materials. By the mid-1950s, there had been no fewer than 34 accidents, with 5 of these resulting in the detonation of the primary high-explosives in these devices (Sandia Corporation 1959). A declassified review of nuclear weapons safety concluded that warhead design and storage limited the dangerousness of these early-Cold War accidents:

Until the mid-1950s, there really were no unresolved nuclear safety issues. Nuclear safety was achieved in a visible and almost absolute manner by ensuring that the fissile material was kept physically separate from the HE [High Explosive] and that gun types devices remained unassembled (Brodie 1987: 14).

¹³ see also Sandia Corporation (1959).

To deploy more advanced thermonuclear weapons (i.e., sealed pit technology), these safety features were abandoned, heightening risks across the US nuclear arsenal. In at least two cases, an incident in North Carolina and another in Texas, an accidental nuclear detonation was averted “by the slightest margin of chance, literally the failure of two wires to cross” (de Montmollin and Hoagland 1961).

Research on the human health impacts of Rocky Flats on both nuclear weapons workers and the public have been mired in controversy.¹⁴ A major comprehensive study found that airborne exposure to plutonium and carbon tetrachloride was the major contributor to the risk of cancer for both nuclear workers and the public, and these releases came from both routine operations and discrete events such as fires (Till et al. 2002). By 1989, there was evidence that corporate contractor Rockwell Industries had been illegally incinerating and storing hazardous and radioactive wastes, and the Federal Bureau of Investigation and the Environmental Protection Agency raided the Rocky Flats plant and prosecuted Rockwell for criminal violations of the Resource Conservation and Recovery Act and the Federal Water Pollution Control Act, resulting in the end of Rockwell’s management of the facility (U.S. Department of Energy 2003). After the closure of Rocky Flats, the legacy waste management program focused exclusively on an abbreviated cleanup effort at the site where the plant manufactured pits – while the surrounding buffer zone was transferred to the U.S. Fish and Wildlife Service and opened for public use in 2018 (Rocky Flats Right to Know 2020).

The concept of mutant ecologies informs the ongoing controversy over the post-Cold War conversion of the Rocky Flats buffer zone into a wildlife refuge with public access. Nuclear state secrecy continues to mask the environmental crimes of the past and obscure the ecological implications for the future. The U.S. Justice Department’s scandalous coverup of Rockwell’s activities at Rocky Flats was an outright denial of first-hand evidence that threatened to raise public awareness about the dangers of nuclear weapons facilities (McKinley and Balkany 2004). This denial set the stage for its flawed cleanup plan, which focused exclusively on cleaning up the plant site while ignoring the cleanup of radionuclides that traveled offsite into the buffer zone and beyond. Remediation standards for the site were based on studies which claimed that radionuclides left by Rocky Flats were “relatively immobile in the soil and groundwater;” this conclusion is in direct contrast to identified off-site migrations of plutonium into Walnut Creek at the downstream boundary of Rocky Flats and to studies of plutonium migration at the Yucca Mountain nuclear waste repository (Moore 2005; 2018). The 2003 Rocky Flats Cleanup Agreement—which was outright rejected by 86% of individuals and organizations who commented—set soil contamination limits based on this “immobility” claim. Adopting a risk-based end state approach, the Department of Energy cut cleanup costs by setting separate standards for soil and subsoil: 50 picocuries per gram the surface to a depth of 3 feet; up to 7,000 picocuries between 3 and 6 feet; no limits on the

¹⁴ Malin and Alexis-Martin (2017) note that “It is challenging to design statistically significant epidemiological studies of the health effects of long-term, low-level toxic exposure to local communities due to confounding lifestyle factors, a neoliberalized, privatized healthcare system that cannot provide answers, and the economic migration of populations away from the plant after its closure”.

concentrations of plutonium and other radionuclides below a depth of 6 feet (Moore 2005; 2018). Accepting the presence of radioactive contamination in the soil is part and parcel of a mutant ecology.¹⁵

There is a lack of research on the impacts of radiation on biological diversity at Rocky Flats. The studies that do exist indicate that radiation is spreading through the food chain and the environment, to the detriment of biodiversity. Contaminants in the soil are taken up in plants that are consumed by animals, and certain animals redistribute contaminants that remain in the soil. One study at Rocky Flats identified low levels of plutonium and other radionuclides in deer tissues (Todd and Sattelberg 2002). Another group of researchers identified 18 separate species of burrowing creatures which disturb surface soil as they dig into the ground—some burrowing as deep as 16 feet—and these creatures were estimated to disturb 11-12% of the surface soil at Rocky Flats annually (Smallwood, Morrison, and Beyea 1998). The soil brought to the surface by these creatures—potentially contaminated with radionuclides—can more easily be redistributed in the environment by wind, rain, and other events. While no research at Rocky Flats has fully examined the genetic effects of wildlife exposure to radiation, Moore (2013) reasonably suggests that the genetic impact of radiation exposure may not manifest for several generations.¹⁶ Additionally, there is evidence that grasses available for animal consumption have roots that can translocate radioactive materials from soil depths upward towards the surface (Kaplan et al. 2010). It is logical to conclude that a similar process may be occurring at Rocky Flats, where the prairie grassland roots penetrate deeper into the soil (Moore 2018).

The expansion of the arms race through the pursuit of more dangerous sealed-pit weapon designs distinctly accelerated the direct damage to the environment. It did so through the expansion of plutonium core manufacturing at Rocky Flats, but it also indirectly introduced substantial risks from unintentional weapons accidents. In the context of a treadmill of production focused on nuclear weapons and an accelerating nuclear arms race, the high-risk manufacture and use of high-risk sealed-pit weaponry were all but inevitable. Plutonium introduced into the environment from core manufacturing or sealed-pit weapons accidents has a half-life of 500,000 years. Recall that one pound of plutonium, evenly distributed, could induce lung cancer in every human on earth. At Rocky Flats “1100 pounds of plutonium [were] ‘lost’ in the ducts of the plant, drum, and glove boxes (used to machine plutonium)” (Caldicott 2002: 63).

Conclusion

With a focus on the United States, this article has examined the treadmill of destruction set in motion and sustained by the Cold War era nuclear arms race. This treadmill was infused with an exterminist logic that prioritized nuclear competition above all else—this logic is both irrational and has inertia. The United States aggressively pursued the development and fabrication of more effective nuclear weapons—and readily accepted the generation of larger volumes of waste that

¹⁵ The Soil Science Society of America (2020) notes that “soil is the foundation of basic ecosystem function”.

¹⁶ Moore (2005) bases this assertion on the work of geneticist Diethard Tautz, who argues that the delayed generational effects of radiation exposure create a “genetic uncertainty problem”.

were at the same time more radioactive, more toxic, and more volatile. At Hanford and Rocky Flats, environmental damage was widespread and obvious. The risks of still greater damage to the environment and human health (workers and community residents) grew dramatically. This increase in risks was justified under the banner of national security. Hiding these dangers from workers and community members was likewise justified on national security grounds. “Nuclear weapons that supposedly protect our democracy destroy it, because, to exist, they require secrecy and centralized decision-making which in turn allow deceit, damage, and denial” (Moore 2012: 91). As the United States was prepared to sacrifice democracy and the survival of humanity, it comes as no surprise that it was prepared to sacrifice the environment as well.

These findings enrich our understanding of the Anthropocene epoch. Humans are impacting the planet in several ways, including strategies of war and preparations for war. With the development and testing of nuclear weaponry, “nature entered a new kind of nuclear regime in 1945” (Masco 2004: 520). American nuclear weapons development was a state project embedded within a global geopolitical struggle that produced environmental atrocities. Analysis of the treadmill of destruction mechanism revealed wide-ranging human and ecological impacts. Workers and communities were exposed to toxic and radioactive materials as a part of routine operations and as a consequence of discrete events like the Green Run at Hanford and the plutonium fires at Rocky Flats, but the environmental causes of these illnesses were regularly contested by officials. The generation of mutant ecologies at Hanford resulted in genetic threats to an interconnected web of species, some with significant environmental, cultural, and economic value, such as Chinook salmon. The cleanup of Rocky Flats was based on a controversial standard for cleanup that ignored contamination that migrated into the surrounding buffer zone and set no limit on radioactive contamination at a depth below six feet at the plant site, well within the range of the many burrowing creatures that inhabit the prairie grassland. The bioaccumulation and biomagnification of radionuclides (such as plutonium, with a half-life of 500,000 years) has been identified in a wide range of flora and fauna at both the Hanford and Rocky Flats facilities and in the surrounding regions, posing risks to the genetic stability of local populations of species and the broader ecological resilience of these areas.

The focus of this case study was nuclear weapons development in the United States. But the lessons are stark and can be generalized. In the Anthropocene epoch humans have the potential to develop and deploy weapons—nuclear, biological, and chemical—that threaten the survival of the human species and to degrade the environment more broadly. If these weapons are developed and deployed in the context of a treadmill of destruction, insulated military elites will operate behind the veil of national security. The environmental threats will be obscured even as the frenzied competition to prevail in an arms race leads to evermore risky and irresponsible choices. The emergence of a 21st century nuclear arms race (Cortright 2020; Sanger 2020) underscores the importance of comparative historical research that articulates the treadmill of destruction mechanism.

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