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Environmental Geopolitics and Outer Space

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ABSTRACT

The cultural, legal, budgetary, infrastructural, and logistical processes through which the contemporary space race unfolds have measurable environmental footprints on Earth and in outer space. The question of where these footprints fall is arbitrated by larger questions of geopolitical power and vulnerability, which means that human engagement with outer space is also a question of environmental justice. On Earth, environmental (in)justice unfolds on multiple scales: local and stratospheric emissions from space launches, the placement of outer space related infrastructure in so-called peripheral places, and the role of power in determining whether the use of such infrastructure aids socio-environmentally constructive or destructive practices. Beyond Earth, the environmental geopolitics are likewise multiscalar, manifesting in contemporary pollution issues such as orbital debris and conservation debates such as planetary protection protocols. The environmental geopolitics of Earth and outer space are inextricably linked by the spatial politics of privilege and the imposition of sacrifice – among people, places, and institutions. This paper explores the concept of outer space environments through classical, critical, environmental, and feminist geopolitical theories.

Introduction

The contemporary space race has a measurable environmental footprint on the surface of the Earth, in the atmosphere, and beyond. Since the 1960s, over three hundred rocket launch sites have been built globally. Many were built by colonial or imperial powers in post-colonial states to take advantage of more desirable equatorial launch locations, where less fuel is required to escape Earth's gravitational pull. Among these, seventeen spaceports hosted ninety launches in 2017, each releasing between eighteen and twenty thousand tonnes of carbon dioxide into the atmosphere and discharging fuel wastes into the ocean. These launches ferried astronauts and satellites to an orbital space that is littered with a hundred million pieces of debris. Five of the largest active launch facilities – Kennedy, Baikonur, Jiuquan, Alcântara, and Guiana – cover a combined 11,000 square kilometers. The environmental impacts of these activities transform

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space among diverse communities, in our atmosphere, and on the celestial bodies reached by humans and human-made machines.

The environmental geopolitics of Earth and outer space are inextricably linked by the spatial politics of privilege and sacrifice – among people, places, and institutions. This paper unpacks several key terms – the environment, geopolitics, environmental geopolitics and environmental justice – and situates them within contemporary geographies of Earth and outer space to make the case for the immediacy of outer space to environmental concerns.

At a time when the enclosure and militarization of outer space is being normalized in US political and popular discourse, a critical environmental approach to outer space serves several purposes. Environmental geopolitics enables us to rethink outer space through concrete processes that transform environments on Earth, in space, and in the atmosphere, the latter of which we typically define as the boundary between "inner" and "outer" space (Olson and Messeri 2015). Transforming these environments involves territorial politics, which are always about power/knowledge (Foucault 1980; Ó Tuathail 1996). Power/knowledge is exercised through the territorial practices of states, firms, and individuals in the ongoing production of space on and off Earth (Beery 2016a; Dickens and Ormrod 2016). An environmental geopolitics approach to outer space renders seemingly far out ideas concrete by engaging the tangible processes through which the immensity of the cosmos is made political, differentiated, and contested. This not only facilitates more rigorous empirical social science research and theory development with respect to outer space, but also reveals the stakes of ongoing processes of privatization and militarization of the greatest global commons. These processes threaten to expropriate all but an extreme minority of a peaceful cosmos explored for the benefit of all humankind, as stipulated in the 1967 Outer Space Treaty (UN 1967), signed by all space-faring states.

This article proceeds as follows. Section one reviews geopolitical approaches to outer space environments in order to show how differentially empowered actors conceive of and relate to outer space. Section two describes outer space as an environment in order to establish it as a milieu in and through which environmental (in)justice can occur. Drawing on research from Brazil, the US, Russia, China, and Kazakhstan, the third section presents the environmental geopolitics of outer space on Earth. The fourth section discusses orbital debris and planetary protection protocols as empirical entry points into environmental geopolitics in outer space.

Geopolitical Approaches to Outer Space Environments

Power and vulnerability mediate the distribution of benefits and harms associated with human engagement with outer space. Because diverse actors with competing territorial agendas produce the *spaces* of outer space, questions of outer space are necessarily geopolitical. The manner in which we engage with outer space is environmental, insofar as we transform Earthly environments to get to and from outer space, we use space-based technologies to understand Earthly environments, and our engagement with outer space, whether orbits, moons, asteroids, or planets, has measurable environmental footprints. Although social scientists have brought outer space into concepts of the environment in recent years,[1] environmental geopolitics has not duly problematized outer space, despite its relevance to the field as well as the relevance of outer space environments to diverse domains of geopolitical inquiry. This section considers the characterization of outer space environments within several geopolitical schools of thought.

Classical Geopolitics

Classical geopolitical approaches foreground national interests and competition, often legitimizing extraterritorial empire-building (Haushofer 1925; Machiavelli 1961; MacKinder 1904), but perspectives vary with respect to outer space. Some maintain that whichever nation gains greatest control over outer space would gain the greatest strategic advantage through its conquest of the "ultimate high ground" (Dolman 2002). The effects of this view have been the steady militarization of space by major powers such as the US, China, India, and others (Burke 2018; Stares 1985). Other state-centric approaches observe that "those who can reap the benefits of space are much more likely to succeed in our interdependent and interconnected world" (Al-Rodhan 2016, 123), and so champion international space cooperation as a means of alliance-building to protect strategic interests (Johnson-Freese and Erickson 2006; Wang 2009), or to advance international agreements among partner states (Klinger 2018; Soares, Epiphânio, and Gilberto 2009). Both share a concern with how outer space should be used to enhance geopolitical power of nation states across terrestrial space. In this view, the environments of outer space are recast as strategic assets that must be instrumentalized to increase state power and authority.

Using outer space as a source of state or imperial power is nothing new. Elites have used the cosmos as a material and meaningful source of authority for millennia. Emperors and monarchs claimed that "divine mandates" installed them in their thrones (Marshall 2001; Monod 1999; Spence 1988). Religious figures backed these claims to territorial control by anthropomorphizing the evolution of the cosmos to claim privilege vested in them by a "God" or "gods" that "resided" in "the heavens" (Brown 2003; Crone and Hinds 1986; Gordis 2003; McAnany 2001; Stopler 2008). Religious figures aligned with state or imperial power positioned themselves as indispensible to appeasing heavenly powers in exchange for subordination and material wealth transfers from other people. Powerful actors past and present used claims of exclusive access to the ultimate high ground, even if only imagined, to organize regimes of territorial control on Earth, lending classical geopolitics a deep historical resonance with respect to outer space.

Whether from a military, royal, or religious standpoint, these classical views define the outer space environment as a source of natural, spiritual, or military threat (Olson 2012; Peoples 2008; Shariff and Norenzayan 2011). The invocation of these threats is politically and economically expedient for mobilizing capital and labor power in the form of tithes, tributes, or defense appropriations. By the same token, such discourses characterize outer space as replete with riches to be enjoyed only by the spiritually worthy (Schwaller 2006; Smart 1968) or capitalized on for strategic advantage by the most technologically advanced (Klinger 2017; Lewis 1996). In the latter case, outer space and its earthly infrastructures can be misconstrued as a "depoliticized environment" (Swyngedouw 2011), shaped by technological development policy instead of politics. This view naturalizes a state-centric *realpolitik* approach to the cosmos. This view strips the cosmos of any environmental significance beyond its potential to be instrumentalized to serve national strategic interests, and has been deployed with renewed vigor under the Trump administration in the United States.

Critical and Anti-Geopolitics

Critical geopolitics interrogates how hegemonic ideas of state and non-state power are (re)produced through discourses and practice, while anti-geopolitics positions politics outside and against state apparatuses (Ó Tuathail 1996). Critical geopolitics deconstructs the taken-for-granted ideas of outer space as organized according to state actors competing for control and hegemony (Dunnett 2016; Sage 2008, 2016). In this respect, Macdonald's (2007) anti-*astropolitik* critiques the classical geopolitical strain of thought that recasts outer space as populated with strategically valued "objects for which powerful states may compete" (Dolman 2002, 138). Although the "*anti-*" approach to geopolitics has been critiqued for reifying the divide between state and society (Sharp 2011), its challenge to the narrow definition of state interests provokes broader imaginings on the diverse possibilities of human engagement with power (Koopman 2011), and with outer space (Parks and Schwoch 2012).

These broader imaginings are not visible in classical geopolitical approaches to outer space. By contrast, the lens of critical geopolitics brings the neoliberalization of the state into focus (Dodds, Kuus, and Sharp 2013). Drawing on Foucault, this perspective treats the emergence of private space firms as consistent with neoliberal governance rather than as a break with the "tradition" of national space programs because the state is characterized as one of several assemblages of power that remake global geographies (Rowan 2017). Indeed, the rise of a private space sector must be accompanied "from start to finish" (Foucault 2010, 121) by people determined to facilitate the colonization of public institutions by the private sector, and who are in a position to marshal the power of the state to enforce this process.

Environmental Geopolitics

Environmental geopolitics grew up with critical geopolitics in the post-Cold War era in the Euro-American world. Environmental sciences were consolidating under the emergence of new satellite regimes, at the end of what Höhler (2015) described as the heyday of "Spaceship Earth" and the environmental age. The concept of spaceship earth was one of several popular global responses to the first photographs of Earth "from the outside," depicting our planet as a delicate sphere hanging in space (Cosgrove 1994, 2003; Jasanoff 2004; Litfin 1997; Maher 2017). These images intersected with the Cold War surveillance apparatuses that shifted with the fall of the Berlin wall from enemy reconnaissance to environmental monitoring. Global environmental problems could provide "a new ordering principle" for post-Cold War intergovernmental relations in which states would cede some power to international agreements and supranational organizations to manage global environmental problems (Castree 2008, 423).

Practice since then has been quite different, marking the persistence of classical geopolitical approaches to the environment even in the face of paradigm-shifting issues such as climate change (Dalby 2014). When environmental changes are framed as threats to which states must respond, and only powerful states respond to protect narrowly-defined national interests, environmental geopolitics are not at all synonymous with conservation or environmental justice. Summing up this state of affairs, Castree (2008) concluded: "currently dominant visions of the pattern of environmental geopolitics are a form of power-knowledge which help perpetuate global inequality and environmental degradation." As insufficient action to mitigate climate change has become the norm for international politics, the US intelligence community has reframed the environment as an adversary (Brown and Pensack 2018), feeding a growing fatalism in policy and popular culture that Earth's increasingly dangerous environments can no longer be managed, only eventually escaped (Zorthian 2017). Geographers critique this apocalyptic national security approach to anthropogenic environmental change for generating multiple forms of violence (Dalby 2002; Dodds and Pippard 2005; Peluso and Watts 2001). They contend that the environment is not merely something to which the security apparatus of the state must respond. Rather, the environment is actively remade by (in) action on the part of political and economic elites to reduce the environmental destruction and greenhouse gas emissions that are altering the planet (Dalby 2014).

Smith's (1990) thesis on the production of nature, from which environmental geopolitics drew insights, holds that nature is produced through human labor rather than pregiven. The use of outer space is enfolded in this dialectical relationship between geopolitics and the environment through power-laden practices that co-produce society and outer space (Beery 2011, 2016a; Dickens and Ormrod 2016; Dunnett et al. 2017). Indeed, the multi-billion dollar investments in satellite instrumentation intended to generate greater "certainty" about a changing climate have been critiqued by scholars positing that a comparable investment in developing alternatives to fossil fuels would do much more social and environmental good (Litfin 1997). A critical attention to state and imperial power, as exercised through and in relation to the environment, distinguishes environmental geopolitics from classical geopolitical concerns with the maintenance and expansion of national power.

Feminist Geopolitics

The production of space is always an environmental process, which entails geographical questions of justice, access, risk, and vulnerability. Feminist geopoliticians critique both conventional and critical geopolitics as disembodied, noting that "critical geopolitics decentres the nation-state, but in its quest to destabilize the normative, it rarely engages transformative or embodied ways of knowing and seeing" (Ó Tuathail et al. 2010, 317). The perception of outer space as unthinkably "big" has perhaps undermined greater geopolitical reasoning of outer space and the environment in relation to the putatively "little" things such as embodied experience in and in relation to human action in outer space.[2] This follows on a practice, long critiqued by ecofeminist scholars, of erasing the local in placeless formulations of the global (Haraway 1988; Litfin 1997; Tsing 2005). By challenging conventional scalar divisions (Christian, Dowler, and Cuomo 2016; Hyndman 2001; Sharp 2011), and connecting seemingly disparate people, places, and events, a feminist geopolitical approach reveals the connections across distance, difference, and various operations of power as they are materially manifested and lived (Dowler and Sharp 2001; Fluri 2009; Koopman 2011; Massaro and Williams 2013; Pain 2009; Secor 2001). In this configuration, the state is neither the unquestioned primary actor in global affairs nor "simply repressive and thus always and everywhere something to be resisted," (Sharp 2011, 273; see also: Smith 2011; Harker 2011). A feminist geopolitical analysis of human engagement with outer space thus does not aspire to the 'imperialist pretense' of supplanting all other forms of analysis (Dixon 2015), in this case through a dismissal of classical or critical geopolitics, rather it views different schools of thought as useful for illuminating how diverse actors and institutions think and act in relation to outer space.

Hyndman's (2001) formulation of feminist geopolitics provides analytical purchase on the environmental geopolitics of outer space because it is concerned with "examining politics at scales other than that of the nation-state; by challenging the public/private divide at a global scale; and by analyzing the politics of mobility," calling attention to the specific arrangements of capital, infrastructure, and raced and gendered vulnerability in the pursuit of greater engagement with outer space. Thus feminist geopolitics enables a "both/and" approach to the environment and outer space, by examining the actions of empowered actors in the production of outer space, while also interrogating the interests vested in the perpetuation of narrow, disembodied definitions of the environment in relation to outer space. The point is to identify structures and instances of injustice so that they can be remedied while shifting the paradigm from one characterized by conflict in the name of competitive national security regimes to one focused on peace-making and bodily security. Hence, this approach can account for the material, discursive, ideological, and lived spaces and practices that produce not only the environments of Earth and space but also our ongoing attempts to understand them.

Outer Space as an Environment

Defining the outer space environment can take on mind-bending complexity in the attempt to reconcile infinite distances with quotidian lived experience. It has proven challenging enough, as Hecht (2018, 112 emphasis original) noted, to "hold *the planet* and *a place on the planet* on the same analytic plane." But just as neither place nor planet make sense without the other, so it is with Earth and space.

We define the outer space environment relationally – in relation to Earth, to the *anthropos*, to our imagined absence, or in relation to human visions of possibility and peril. Relational definitions of the outer space environment invariably draw on relational geographies across Earthly environments, which, following the feminist geopolitical approach, reveals how the perhaps unexpected connections between people, places, and power produce outer space environments on Earth and in space.

Environmental justice shares this epistemological orientation. The premise of environmental justice is that the rights of those who suffer environmental harm "have been systematically usurped by more powerful social actors, and that 'justice' resides in the return of these rights" (Capek 1993, 7). For the environmental justice framework to help us make sense of outer space, we must not only understand outer space as an environment, but also think through how human engagement with outer space constitutes environments in which (in)justice can occur.

Outer space environments are mutually transformed with human society when we encounter them. Whether people and machines have altered a particular interplanetary landscape (Gorman 2005) or observed the far greater number of sites that are unlikely to be visited by humans or robots in the future (Vertesi 2015), coming to know new space environments ignites human imaginations with new possibilities. New imaginaries have material consequences, informing policy, practice, and investment choices (Kearnes and Thom 2017; Klinger 2017; Messeri 2016). Material consequences are mediated through the technological capacity to deal with dynamics of distance, temperature, radiation, and institutional capacity to orchestrate ongoing engagements with outer space.

In the broadest sense, the environment of outer space encompasses everything that was and ever will be (Hawking and Penrose 1996). Perhaps because of a certain epistemological agoraphobia that inhibits geographical engagements with questions of infinity, the political economic effects of the popularization of these theories over the course of the twentieth century has received limited attention (Giudice 2012; Riordan 2001), and this totalizing scale has been left outside of most studies of human-environment dynamics. Using environmental geopolitics, it is possible to build our epistemologies out to the totality without reproducing earlier religious-themed schemata that placed the heavens utterly and ineffably "beyond."

Put simply, outer space is a global environment insofar as it is the environment in which Earth resides. By thinking of outer space as Earth's environment, much as we might think of the space within our atmosphere as "our" environment, this "nested" approach replicates problematic conceptions of the environment as a separate thing outside of the self. Our planet is *of* the cosmos, an accretion of matter floating through space that consolidated over billions of years and now hosts its own diverse environments *of which we are.*

Outer space as a global environment is dynamic, as our planet spins on its axis at a constant speed while orbiting the sun at thirty kilometers per second along a trajectory that is nine hundred and forty six million kilometers in circumference. Anything that enters this trajectory at a given point in space and time can also enter the global environment. Large objects such as asteroids and space weather phenomena, such as solar flares, capture more popular attention because they may spectacularly damage orbital and terrestrial infrastructure. Less well known are the daily showers of microscopic space dust that nourishes the microbial life that regulates global oceanic and atmospheric environments (Baker 2002; Helmreich 2009).

Anthropocene and Outer Space

Even with the expansion of Anthropocene literature, efforts to think at the scale of the planetary (Spivak 2003) draw our attention "inward and downward" (Olson and Messeri 2015), to the regions of the cosmos where human activity is concentrated or to our own solar system (Dickens and Ormrod 2016; Praet and Salazar 2017; Salazar 2017a). Noting this tendency, Olson and Messeri (2015), building on Agrawal (2005), proposed a "heliosystemic environmentality" to describe how our concept of the environment centers on the sun and its crucial role in sustaining life on Earth. Thinking of the environment as something on the scale of our solar system amplifies the significance of environmental changes on Earth. As Salazar (2017a) has observed, the loss of Earth's polar ice caps is made even more dramatic when one considers that they are not only important to stabilizing Earth's orbit, they are also likely unique in our solar system.

Anthropocene concerns with global environments have, in practice, delineated inner and outer environments, where the "outer" environments consist of the spaces beyond the atmosphere and beneath the lithosphere. This brackets what tends to count as the human environment to the space between the surface of the Earth and the limits of our atmosphere (Olson and Messeri 2015), although indigenous concepts of the anthropocene have more nuanced conceptions of boundaries (Inoue, Aoki, and Moreira 2017). But much of climate change, everyday life, and localized environmental experience unfolds within this space, hence our anthropocentric "surface bias" (Bebbington and Bury 2013) when defining what, and where, constitutes the environment.

Life, Death, and Boundaries

The atmosphere serves as a boundary layer between life and death, the biosphere and the beyond. Most of life as we know it can only live within this layer between the ocean floor and the atmosphere, indicating that definitions of the environment tend to be synonymous with life, although the growing research on "extremophiles" living beneath glaciers or on hot ocean vents animates the search for similar sorts of life on other moons and planets (Hashimoto and Kunieda 2017; Helmreich 2009; Rothschild 2007; Salazar 2017b; Vaidyanathan 2017). As fears over the precarity of life on Earth become increasingly salient within the Anthropocene (Pain and Smith 2008; Swyngedouw 2013), the search not only for life but also for habitable exo-planets represents an extension of environmental sensibilities to other parts of our solar system and galaxy (Helmreich 2009; Olson 2018; Segura et al. 2005). This is driven by multiple motivations: from scientific curiosity, to the pursuit of profits, to an apocalyptic sensibility looking for an escape from an Earthly doomsday scenario (Dittmer and Sturm 2010; O'Neill 2000; Walker 2018).

Each of these approaches to the question of life in our cosmos informs different material practices in Earthly environments. The question of life in relation to outer space takes three primary forms: the search for new forms of life; experiments with living in outer space, and mitigating threats of an uncertain future on Earth. The latter compels humans to fantasize about colonizing the cosmos in order to survive. This abiding concern with the future informs a series of "anticipatory practices," intended to provide relief to some – not necessarily all – lives (Anderson 2010).

Building on this, environmental geopolitics of outer space are therefore about life and death. This is not simply a matter of "making live" and "letting die" but about rethinking environments in which life and death are both possible and predictable (Foucault 2003). The public declarations of Mars One activists' willingness to die in space are a display of human volition to approach a deadly environment in order to make it livable. Through their sacrifice, they hope to create extraterrestrial spaces where life and death are rendered more predictable (Greene 2014; Jamieson 2016). In the process of remaking environments in outer space, understandings of the human position shift in relation to Earthly environments. Most critically, the dominant trend seems to be rethinking Earth as something that can be "left behind" (Bianco 2018) in the relentless pursuit of a "somewhere else" that looks like Eden (Messeri 2017).

Thinking concretely about specific elements of our biosphere dissolves the boundary between life and "the environment" on Earth contrasted to the deathliness of outer space. For example, microbial and chemical processes such as photosynthesis illustrate the elegant links between the cosmos and life on Earth. The plants that sustain a breathable atmosphere and an abundant food supply are "communicating and mediating between the cosmic and the mineral, the sky and the ground, taking up and transforming energies and materials through their processes" (Gabrys 2016, 13). Although the solar radiation that nourishes life on Earth has extreme origins in a ball of plasma over a hundred times larger than Earth, with a surface temperature of over five thousand degrees Celsius, its interactions with the biosphere in many parts of our world are celebrated as life giving, nourishing, and pleasant. Life and environment, Earth and outer space, are linked in a long series of chemical reactions and flows of electromagnetic radiation.

This moves us away from "environment as container" and toward a milieu from which life is inseparable (Canguilhelm 2001). Indeed, transporting humans beyond the atmosphere requires engineering living milieus within closely contained spaces (Aronowsky 2017; Battaglia 2017). Similarly, dreams of interplanetary civilization involve creating Earthly milieus on other worlds (Kearnes and Thom 2017). In contrast to most human-environment relations on Earth, in outer space great lengths are taken to close the human body off from the outer space environment within the world of the space suit, ship, and station. While this closure may be possible down to the molecular scale, it is not possible at the atomic level, as cosmic radiation penetrates space station and space suit walls to alter the DNA of astronauts taken outside of the protective membrane of our atmosphere (Dietz et al. 2013).

The "extreme" serves as a uniting principle for social science research in outer space and in analog environments on Earth, such as the deep ocean or Antarctica (Olson 2018; Praet and Salazar 2017). This concept "shapes an analytic of limits and ever-opening horizons – epistemological and physical – provoking new understandings of humanness, environment, temporality, and of inter-species life as we think we understand it, here on Earth" (Battaglia, Valentine, and Olson 2015, 252). If geopolitics is about how power is situated across "a spectrum of scales of social life" (Hyndman 2009), then environmental geopolitics is about how life and living are mediated by power relations exercised through our physical environment. An environmental geopolitics of outer space simply ceases to take for granted the spaces beyond our atmosphere as we consider the complexity of human-environment relations.

Like global environments, outer space is perhaps not so much extremely distant as it is startlingly immediate. Outer space is big but it is also always experienced locally. Local experiences of the outer space environment take a variety of forms beyond those astronauts who have stepped out of the airlock (Jones 2006): from the sixty tonnes of cosmic dust that showers Earth daily (Gardner et al. 2014), accumulating in stratospheric clouds and coating rooftops and sidewalks (Genge et al. 2017), to the mediated experience of exploring different other-worldly environs through robot proxies (Vertesi 2015), to the individualized 'uplinking and downlinking' (Thrift 2005) that connects people and machines to satellites in Earth's orbits for a multitude of purposes. It is from this 'yoking' (Abbott 1995; Moore 2008) of locality-and-totality that we can discern the environmental geopolitics of outer space on Earth and in space.

Environmental Geopolitics of Outer Space on Earth

On Earth, the environmental geopolitics of outer space are inseparable from questions of environmental justice. Environmental (in)justice unfolds across multiple scales through concrete processes: localized and stratospheric emissions from space launches (Carlsen, Kenesova, and Batyrbekova 2007; Jones, Bekki, and Pyle 1995), the placement of outer space related infrastructure in national and global peripheries (Gorman 2007; Mitchell 2017; Redfield 2001), and the use of such infrastructure to advance or thwart environmental destruction (Da Costa 2001; Guzmán 2013; Parks 2012).

Human engagement with outer space enlists industrial economies, global networks of infrastructure and expertise, and the generation and control of information. All of these activities take place in specific sites and are subject to ongoing transformations in territorial governance practices. By locating infrastructures that are securitized, dangerous, and environmentally toxic in remote areas, the state or empire accomplishes two things. It consolidates power in far-flung territories while mitigating against liabilities and security threats that might arise from placing launch infrastructures closer to the metropole. In order to reduce environmental impacts, adequate resources, personnel, and expertise need to be assigned to the task of monitoring and mitigating the regional fallout of rocket launches (Hall et al. 2014). This may not be the case if the site in question has been deemed sacrificable by those with territorial control.

Launches and Their Infrastructures

Reaching outer space requires Earthly infrastructure, which means that space launches have concrete footprints that change according to developments in launch technologies. The placement of outer space related infrastructure on Earth is a question of environmental (in)justice. Which sites are chosen, who is expropriated, and which environments are impacted is subject to strategic geopolitical calculations, which, more often than not, employ classical geopolitical reasoning (Hickman and Dolman 2002; Ingold 2006; Meira Filho, Guimarães Fortes, and Barcelos 2014; NDRI 2006). Launch sites are tightly controlled to reduce the risk of interference or failure, therefore situating launch sites in remote areas is often explained in terms of safety and security (Zapata and Murray 2008). No doubt this is important: rockets are composed of many tonnes of material and combustive fuel, so they must be launched in places where damage from routine as well as potentially catastrophic explosions can be contained. For humans to reach “the final frontier,” they must first find a frontier space on Earth that can be made into an empty space in which controlled explosions can be routine.

Frontiers are seldom as empty as those aiming to conquer them would claim. Where they are not populated by people, they are filled with other sorts of meanings and life forms (Klinger 2017; Tsing 2005). Potential launch sites and testing ranges deemed by government authorities to be simultaneously remote, safe, and suitable to contain the risks of rocket launch must first be *made empty* of people, with prior land use regimes or territorial claims pushed beyond designated buffer zones (Gorman 2007; Mitchell 2017). Hence the placement of space infrastructure follows colonial geographies of extraction, sacrifice, and risk (Mitchell 2017; Redfield 2001). As Gorman (2007) put it: “because of their distance from the metropole, these places lend themselves to hosting prisons, detention camps, military installations, nuclear weapons, and nuclear waste. All of these establishments, including rocket ranges, have inspired reactions of protest.” These so-called 'peripheral' spaces are nevertheless central to their inhabitants and their neighbors, who question the logic of extraglobal conquest in the face of unresolved Earthly injustices.

Consider, for example, the case of the launch site in Alcântara, Brazil, which has been well documented by Araújo and Filho (2006) and Mitchell (2017). Through a close examination of local, national, and international politics, these authors document how the government's racialized approach to the subsistence communities displaced by space infrastructure deepened structural inequalities. Grassroots opposition to the launch site grew not out of an *a priori* ideological opposition of poor people to national progress in outer space, as some officials alleged, but rather resulted from the failure to account for the food insecurity generated by state resettlement projects. The resettlement schemes were themselves misinformed by impoverished notions of local livelihoods. Local claims against the deprivations caused by state-sponsored space practices have deepened schisms between the military and civilian space programs at the federal government level.

Through the lens of classical geopolitics, these structural inequalities scarcely register, with the result that the 'crawling' progress of Brazil's space program is pathologized as poor management practices symptomatic of an inadequately implemented national development vision (Amaral 2010). Critical geopolitics helps deconstruct the nationalist performativity of such endeavors by considering the political and economic value placed on the spectacle of spaceflight (Boczkowska 2017; Macdonald 2008, 2010; Sage 2016). Feminist geopolitics draws our attention to the racialized and gendered dispossession advanced by the state, through the construction of space infrastructure and exercised through access to land. The fact that environmental and public health impacts were only considered by the authorities after years of mobilization by Black social movements, religious communities, and scholars highlights the ways in which inattention to the local in the pursuit of space power perpetuates environmental injustice, which in turn interrupts national plans for space progress.

Rocket launches affect local and global environments through the construction of infrastructure, the exposure of local environments to toxic residues, and the dispersal of pollutants in land, air, and sea. Rockets are the only source of direct anthropogenic emissions sources in the stratosphere. Ozone-depleting substances (ODS) such as nitrous oxide, hydrogen chlorine, and aluminum oxide are emitted by rockets, and can destroy 10^5 ozone molecules before degrading (Voigt et al. 2013). The ozone layer prevents cancer and cataract-causing ultraviolet-b waves from reaching the Earth. As of 2013, rocket launches accounted for less than 1% of ODS emissions. As other ODS are phased out under the Montreal Protocol and the frequency of lower cost space launches increases, the proportion and quantity is likely to increase (Durrieu and Nelson 2013; Ross et al. 2009).

Although affluent economies in the northern hemisphere are responsible for most ODS emissions (Polvani 2011; Rousseaux et al. 1999), the geography of exposure disproportionately affects an overall higher population in remote regions and in the southern hemisphere (Norval et al. 2011; Robinson and Erickson 2015; Thompson et al. 2011) because ozone depletion is most serious in regions where high altitude stratospheric clouds are most likely to form: above the polar regions and major mountain ranges (Carslaw et al. 1998; Perlwitz et al. 2008). This is an example of environmental injustice on a global scale, where the global south bears the environmental burden of actions predominately taken in the global north, rocket launches included. In the process, global power relations are reinscribed through the uneven distribution of harm to peripheral and southern bodies, mediated in this case through the redistribution of gases in the stratosphere that increase exposure to solar radiation.

Coming closer to Earth, environmental geopolitics of outer space are manifest in the dispersal of particulate matter into ecosystems surrounding active launch sites. This is more than a strictly local environmental concern, because which spaces are subject to the hazards of launch sites involves careful calculations weighing financial cost, state power, and multifarious territorial interests. With each launch, surrounding areas are showered with toxins, heavy metals, and acids over a distance that varies widely with wind, weather, and precipitation patterns at the moment of lift-off.[3] The most researched of these pollutants are hydrogen chloride, aluminum oxide, and various aerosolized heavy metals. Release of these pollutants from rocket launches results in localized regional acid rain (Madsen 1981), plant death, fish kills, and failed seed germination of native plants in launch sites (Marion, Black, and Zedler 1989; Schmalzer et al. 1992).

These effects, and research on them, are mostly concentrated within one kilometer of the launch site. But they have been recorded several kilometers away under certain weather conditions (Schmalzer et al. 1998). Recent studies on the concentration of trace elements in wildlife in areas near NASA launch activities in Florida, USA, found that more than half of the adults and juvenile alligators had “greater than toxic levels” of trace elements in their liver (Horai et al. 2014). Both the subject, and the vague statement of findings, highlights the lack of research into the impacts on downstream human and non-human communities. In contrast to the precautions taken to protect workers in buildings adjacent to facilities where these technologies are developed (Bolch et al. 1990; Chrostowski, Gan, and Campbell 2010), much less consideration is given to communities within the dynamic pollutant shadow of rocket launches.

In Kazakhstan, Russia, and China, researchers have begun examining the effects of the highly toxic liquid propellant, unsymmetrical dimethylhydrazine

(UDMH), which has been in use since the dawn of the space age. It has noted carcinogenic, mutagenic, convulsant, teratogenic, and embryotoxic effects (Carlsen, Kenesova, and Batyrbekova 2007), and it has been found to cause DNA damage and chromosomal aberrations in rodents living near the Baikonur cosmodrome in Kazakhstan (Kolumbayeva et al. 2014). Despite these known hazards, methods to detect UDMH at the trace concentrations at which toxic effects begin to manifest in humans do not yet exist (Kenessov, Bakaikina, and Ormanbekovna 2015), meaning that there is no knowledge of how this circulates in the environment, bioaccumulates up the food chain, or could potentially be sequestered through soil or plant filtration. The lack of technology or methodology to adequately track the dispersal of hazardous pollutants that have been used for decades in the surrounding environment illustrates another aspect of environmental injustice: the preference on the part of political and economic elites to create spaces of waste rather than allocate adequate resources to maintain safe and non-toxic environments.[4]

The hyper-local politics of basic livelihood security shape long-term access to outer space and space geopolitics at multiple scales. Attending to the local matters is important, not just because it sheds light on broader geopolitical processes, but because failing to do so leaves the substantive matters of human engagement with outer space entirely overlooked, at best. At worst, ignoring local environmental conditions recasts them as places to be "left behind," casualties in a Darwinian race to the cosmos in which the poor have no place. Attending to the environmental geopolitics of outer space on Earth shows the co-production of Earth and space. Earthly environments and social relations are remade in our evolving relationship with outer space and reconceived alongside evolving deliberations on the prospects for human survival.

Technologies and Local Practices

Much of what is thought of as the actual operations of geopolitics – from firing missiles to tracking natural disasters to following pollutant dispersal – are mediated through technological arrangements that relay data "about and through environments as they watch over Earthly spaces and even transform the planet into a digital Earth" (Gabrys 2016, 3). Access to these technologies is deeply uneven within and across countries, reflecting and retrenching existing geopolitical arrangements of power through the differential capacity to sense, monitor, and access information generated by space-based and space-linked technologies.

Military and surveillance uses of satellite technology are well-theorized (Bruno and Lins 2007; Dolman 2002; Gregory 2006; Harris 2006; Hasian 2016; Paglen 2008; Parks and Schwoch 2012; Weizmann 2007); yet, the way in which satellites are enlisted in competing territorial logics exercised through land use practices that seemingly bear no relationship to outer space is much less theorized. Because of the importance of land use practices to the chemical composition of our atmosphere, coupled with the effectiveness of doomsday scenarios at generating investment and policy changes in favor of formulating an "exit strategy" for humans from a climate-ravaged Earth (Autry 2011; Valentine 2012), certain hyper-local practices in remote places take on an iconic significance. Consider, for example, the international political significance attached to halting mining, cattle ranching, and agriculture in the name of rainforest conservation.

In the 1980s, when the first reports using satellite imagery to measure the extent of rainforest clear-cutting over the preceding decade were published, the international outcry was immediate (Hecht and Cockburn 1990; Skole and Tucker 1993). Ahead of the 1992 Rio Earth Summit, international environmental and indigenous rights communities organized around a unifying concept to take on activities as diverse as state-promoted cattle ranching, World Bank-funded highway projects, indigenous land demarcation, and biodiversity protection. The multifarious grassroots and global demands to "Save the Rainforest!" provoked domestic policy changes in Brazil and redirected global capital flows to a host of organizations working toward those ends. With growing knowledge of the role of Amazon rainforests in climate and weather regulation, preserving the Amazon became a key matter in international climate negotiations. These combined efforts slowed the rate of deforestation in the late 2000s and led to the creation of the *Fundo Amazonia* to collect payments from developed countries in exchange for satellite-verified reductions in the rate of deforestation provided by Brazil's National Space Research Institute (*INPE: Instituto Nacional de Pesquisas Espaciais)*. Remote sensing data gathered by INPE supported environmental policies, reducing the rate of deforestation by 72% between 2004 and 2016 in Brazil (Seymour and Busch 2016). Progress toward reducing deforestation in Brazil is intermittent, primarily because of ongoing struggles between multiple interest groups seeking to control land use on the Amazonian frontier. Donors, activists, government officials, international institutions, military personnel, indigenous groups, mining and agribusiness companies, and others leverage satellite imagery – or disparage it as a foreign-funded conspiracy – to advance their particular vision of land use in the Amazon region. Conflicting visions of power and prosperity vie for policy prominence and access to capital flows in order to advance one set of seemingly mundane practices over another. Whether digging holes, raising cattle, or leading groups of backpackers on eco-adventures, these local, unglamorous practices have been retranslated into pressing matters of global importance via the politically consequential dissemination of satellite imagery (Rothe and Shim 2018). The use of satellite technology shapes Earth environments for specific people in concrete ways, with effects measurable in everything from the assassination of environmental activists (Global Witness

2017) to the transnational displacement of deforestation (Thaler 2018), to the changing composition of the atmosphere (Costa and Foley 2000).

Referencing the intensifying climate crisis, prominent actors in the contemporary space race have yoked their advocacy for privatizing and colonizing outer space to predictions of environmental apocalypse (Dittmer and Sturm 2010; Haynes and McKay 1992; Pelton 2016; Westing 2013). These actors view societal collapse in the face of political and environmental disaster as unavoidable (Burrows 2006; Highfield 2001; Morgan 2006). Therefore the only salvation for "those most capably endowed" of the human species lies in "off-loading humans from the planet" (Dolman 2002). A partial reading of scientific data coupled with a refusal to work toward (or even imagine) more just and sustainable futures on Earth has led some to the conclusion that Earth must eventually be left behind.

Yet, the international scientific community has been unequivocal in its consensus that climate-induced disasters can be avoided if we implement appropriate policies supported by ongoing scientific research (IPCC 2014). Space-based technologies are crucial in this effort, but they can be selectively ignored if the data undermines the interests of power (Kreutzer et al. 2016). The 2017 decision by the White House to order NASA to stop collecting climate change and Earth observation data undermines the capacity of the US to formulate and implement science-based policy (Milman 2016; Thompson 2017). This complements a series of decisions by the same administration to accelerate greenhouse gas emissions through expanding fossil-based energy production while cutting public programs that maintain social resilience (Greshko, Parker, and Howard 2018). Implementing these policies undermines strategies for human survival, granting eschatological predictions a greater degree of likelihood (Latour 2015; Plumer and Popovich 2017; Sengupta 2018). This creates greater investment opportunities for those private space enterprises promising to provide an 'exit strategy' to paying customers with the means to escape a violent and ruined planet. Even if they never achieve lift-off, there are tremendous sums to be raised simply by allowing people to reserve a seat on a hypothetical voyage (Collard 1989; Farwell 2017; Harris 2009).

Examining the use of outer space-based technologies from the perspective of environmental geopolitics troubles simplistic characterizations of these technologies as either constructive or destructive. Setting aside the debate on the military uses of satellite technologies, it is possible to see this dual character of space-based and space-linked technologies with respect to Earthly environments and climate change. This preliminary survey of environmental geopolitics of outer space on Earth illustrates three primary valences of the concept. First, the territorial politics of space launch infrastructure construction – which share important characteristics with the creation of other sorts of sacrifice zones to construct prisons, military bases, and missile ranges – reinscribe existing spatial inequalities. Second, the differentially distributed environmental (in)justices that result from space launch emissions – whether through ozone depletion a hemisphere away, or soil and water contamination within a few kilometers of the launch site – ground even the most top-down efforts to achieve spaceflight in local struggles for livelihood security. Third, the selective use of space-based and space-linked technology to generate data can lead to the creation of policies and institutions that alter land use regimes for or against the survival of certain groups of humans. These three valences of environmental geopolitics of space on Earth are linked to outer space through multiscalar processes unfolding within and across our atmosphere.

Environmental Geopolitics in Outer Space

Beyond Earth, environmental geopolitics in outer space manifest in diverse forms. To provide an entry point into this complex issue, this section focuses on contemporary multiscalar pollution issues such as orbital debris and regulatory efforts to control interplanetary contamination. Examining these concrete examples within and beyond our atmosphere from the perspective of environmental geopolitics brings several questions to the fore: what is the nature of human activity in outer space, which humans are conducting these activities, and how are these activities transforming outer space environments? How are the consequences of these actions differentiated among different groups of people, and how do these consequences affect mobility for different actors? How are different groups held accountable (or not) for the environmental consequences of their actions on Earth and in outer space?

Most approaches to outer space environments contain some element of risk, a fear of hazard, or mandates by diverse actors and institutions to assess and mitigate risk. How risk is assessed, and which risks are left unexamined reflects the interests of power in managing the affective politics of human engagement with outer space. As Ormrod (2013, 740) puts it: "NASA's Environmental Impact Assessments…are known to be fabrications but are still preferred to uncertainty, [are] engineered and selected to function in the interests of those in power [and] provide scenarios that legitimate State acquiescence to capital."

As geopolitical practices in (and in relation to) outer space generate environmental hazards and uncertainties, (in)action on the part of state, capital, scientific, and civil society interest groups deepens inequalities and environmental injustices. Contrary to the notion that environmental pollution in outer space is inconsequential, ethically sound, or benign (Amah et al. 2012; Ehricke 1972; Lamb 2010), human actions in outer space directly shape politics on Earth. For example, cluttering launch trajectories with orbital debris or prohibiting shared use of off-Earth spaces through the assertion property rights forecloses access to outer space environments by future space-faring groups, particularly those in developing countries.

Orbital Debris

Because of the growing body of scholarship and public discourse on orbital debris (Pai 2018; Radtke and Stoll 2016; Smirnov et al. 2015; Strauss 2018), it provides a useful entry point to environmental geopolitics in outer space. Orbital debris refers to the material circulating in Earth's orbits. Practically speaking, "Earth's orbits" are the spaces ranging between one hundred sixty kilometers and forty thousand kilometers above sea level, where human-made satellites are located.[5] Within these areas, over a hundred million pieces of debris circulate, ranging from the size of a grain of sand to decommissioned satellites. Because of their high velocities (10 km/second), "even sub-millimeter debris pose a realistic threat to human spaceflight and robotic missions," (Liou 2018). The greater the quantity of space debris, the more limited safe exit trajectories and orbital pathways become.

Earth's orbits are a "vertical public space," (Parks 2013), which by treaty belong to all humankind. They mark a global environment that begins in the disputed zone above where sovereign airspace ends and outer space begins (Beery 2016b). The definition of this boundary remains unsettled because developed countries refused to recognize sovereign claims of equatorial states to the areas directly above their airspace, which extend into the geostationary orbit between thirty-five and forty-thousand kilometers above Earth's equator. Most people interact daily with orbital space, directly through communications or navigation technology, or indirectly within state and corporate regimes of surveillance. The question of how this space is organized is scarcely subject to public debate, with a few notable exceptions (Delegations 1976). This is exacerbated by the fact that, as Lisa Parks (2013) notes, orbital maps are proprietary, despite the billions paid by the taxpaying public to subsidize satellite development.

The spatiality of Earth's orbits further invites us to consider the verticality of territorial politics and how this verticality is understood by diverse geopolitical schools of thought (Adey 2008; Beery 2016a; Braun 2000; Bridge 2013; Bruun 2018; Elden 2013; Steinberg and Peters 2015; Valentine 2016). From the standpoint of classical geopolitics, orbital space is a strategic high ground, the enclosure of which would serve hegemonic interests by establishing a monopoly on surveillance and communications infrastructure. Indeed, international contests for global hegemony between China, the US, and the EU are fought in part through satellite and signal contracts (Wang 2013). A more vivid illustration is the development and testing of anti-satellite missiles. Currently, Russia, the US, China, and India have developed various types of weapons designed to destroy satellites in orbit (Grego 2012). While the capacity to disable a hostile powers' satellite seems a reasonable defense capability to develop, it is not simply a matter of "shooting down" a satellite in the manner in which a combat jet or drone might be shot "out" of the sky (Hansel 2010). Destroying a satellite generates thousands of pieces of orbital debris that take on unpredictable orbital pathways. This jeopardizes all other existing space infrastructure, and could lead to cascading collisions in which all manner of satellites are disabled (Gunasekara 2012; Hebert 2014).

Access to orbital space is critical to national development and sovereignty (Al-Rodhan 2012). Orbital debris further constrains the already limited launch pathways for potential space-faring states (ESOC 2017). This limits the data collection and communications capabilities of emerging space powers that must either purchase data packages and transmission services from private firms or rely on data services selectively provided for free by other national space agencies. Furthermore, actions to develop technologies to actively reduce orbital debris receive intense scrutiny because of their potential dual use: if a laser can eliminate space garbage, it could eliminate a working satellite (Phipps et al. 2012). The environmental practices of early space powers in Earth's orbits have generated a geopolitics characterized by entrenched power differences and inequalities manifest through limited access for developing countries and limited accountability for developed space powers. In this case, practices by more powerful actors degrade the environments of Earth's orbits, which leads to the exclusion of less powerful actors. Environmental degradation has been used as a territorial strategy to consolidate geopolitical advantage in other places (Peluso and Watts 2001; Renner 2006; Shaw 2016). This may partially explain the lack of substantive action to reduce orbital debris on the part of those bearing historical responsibility. Debates around regimes of accountability, or lack thereof, mirror debates on historical responsibility for greenhouse gas emissions (Newell and Mulvaney 2013).

Critical and feminist geopolitics investigates the way in which satellite technology is used, for whose benefit, and at whose expense. Satellites are, among other things, an "eye in the sky" that is capable of monitoring movements across the surface of the Earth. Whom is subject to this surveillance, and who has access to such data, is politically and economically contested (Paglen 2008; Parks and Schwoch 2012). Indeed, one of the challenges of satellite technology is precisely its strength: that by allowing us to understand the Earth as a "system," (Schellnhuber 1999) it can also give us the misconception that the whole Earth can be managed remotely or through computing networks, which are not programmed to understand, much less attend to, the basic needs of the majority of Earth's citizens (Gaard 2017; Gabrys 2016; Jasanoff 2004; Litfin 1997). Focusing on "national" access to orbital space elides these inequalities between those who benefit from the construction and maintenance of satellite infrastructures and those who do not.

To be clear, critiquing current practices of satellite data generation is not to dismiss its importance. Satellite technology has been critical for advancing climate science, coordinating disaster responses, and democratizing – to a point – global communication. Equal access to orbital space by new space powers and democratic access to satellite-based data is important for reducing a variety of global inequalities. While NASA images showing Earth crowded by orbital debris have stimulated commentaries on "human" pollution in outer space (Skinner 2017; Taylor 2007), the fact remains that very few countries are responsible for the vast majority of orbital pollution. This is a form of environmental injustice insofar as the polluting activity of one subset of users reduces accessibility for subsequent parties.

Planetary Protection Protocols

The fifty-year-old planetary protection protocols provide the second entry point to the environmental geopolitics in outer space. These are concerned with protecting environments on Earth and in space from unknown biohazards that might "hitch hike" among celestial bodies on both robotic and crewed vehicles (Nicholson, Schuerger, and Race 2009), and therefore provide a biological control to space exploration (Kminek et al. 2017). Although these principles are generally agreed-upon, practices have been uneven (Frick et al. 2014). As the search for life and potentially habitable worlds intensifies, questions of planetary protection have increased in importance. Each space agency has developed internal protocols to protect Earth environments from "micronauts" (Nicholson 2009) or "alien invaders" (Helmreich 2009), while a growing body of research aims to protect the scientific search for life on other Moons and planets from the unknown effects of human contamination (e.g. Macauley 2007).

The concerns of planetary protection operate on two different temporal scales: the immediate and the extremely long term, which points to the multiple time horizons in environmental geopolitics in (and in relation to) outer space. Immediate concerns are those that have primarily to do with the "back-contamination" of samples brought back to Earth (Takano et al. 2014) as well as the protection of life on Earth from a potential plague from space (Meltzer 2012). Longer-term concerns reflect an ethics informed by a sense of the contingency through which life on Earth evolved. Humans emerged after several billion years of chemical and biological evolution: to allow for the possibility of life to evolve elsewhere, it is imperative that our exploration of other planets does not jeopardize "processes of pre-biotic organic syntheses under natural conditions" (Kminek et al. 2017, 15).

Viewed another way, planetary protection protocols represent environmental justice on an interplanetary scale. This international code of conduct is designed to protect otherwise uninvolved populations of humans and other organisms from the activities of an extreme minority. By the same token, protocols of containment and control for the purposes of environmental protection on Earth and in outer space generate a particular environmental geopolitics that redouble the rationale of placing space-based infrastructure on Earth in “peripheral” areas, illustrated, for example, by the proposal to process biotic specimens from outer space aboard ships in international waters (Takano et al. 2014). The idea is that international waters provide a legally and environmentally “open” space in which specimens can be processed with minimal risk of contamination. The fact that international waters are teeming with organisms that circulate globally (Helmreich 2009; Steinberg 2013) problematizes this containment rationale.

The planetary protection protocols, nevertheless, reflect a broad recognition that outer space is much more than the open frontier beckoning to astro-imperialists. Rather, it requires careful consideration over what we put into and bring back from outer space (Reisinger 2018), and outlines a “leave no trace” framework to guide the manner in which humans and robot surrogates move back and forth across our atmosphere (Brueck 2018). The acknowledgement that there may be other sensitive biological systems with the prerogative to exist constrains the territorial ambitions of space exploration and shifts the strategy to one of careful exploration rather than the frontier ideologies of “terraforming” alien worlds for colonization or “a new gold rush” (Pelton 2016; Sparrow 1999).

Policy decisions going forward will determine the extent to which environments on Earth and in space are protected by the planetary protection protocols. These are subject to change with the successes and failures of competing interest groups. As private sector interest in “colonizing” space has grown in recent years, planetary protection protocols have been assailed for “inhibiting a more ambitious agenda,” to colonize Mars in particular (Fairen and Schulze-Makuch 2013). In cases where colonial boosters have not discarded planetary protection protocols wholesale, they have advocated for a looser ethics of “preservation” rather than “protection” (Cockell 2005). Transferring the logic of Earthly conservation regimes to other planets, this approach would instead carve up unexplored worlds into spaces of acceptable and unacceptable contamination, much in the same way that certain fractions of national territory on Earth are designated as “preserves” set aside from the planetary project of expulsion, pollution, and the creation of waste under capitalism (Moore 2015).

This approach equates exploration with contamination, which extends to outer space the colonial-capitalist processes that have devastated landscapes and lives on Earth. The upshot is if we insist that contamination is inevitable, then we will likely cease to invest in measures to prevent contamination, and so it will become a self-fulfilling prophecy. The danger here is a coupling between the religious zeal driving space colonization (Bjørnvig 2013; Sage 2016; Schwartz 2017; Slobodian 2015) and the assumption that exploration inevitably equals contamination will slide into logics of contamination as a "good" thing, in the chauvinist sense of Earthly "seed" impregnating "virgin" worlds (McKay 1990). Reconceptualizing the cosmos according to a binary framework of masculine agency[6] that is compelled to act on the (imagined and violently enforced) passivity of all other things has a clear environmental geopolitics. It is a rather facile extension of the narrow understanding of human life – only property-owning white men count as human (NAF 1789) – and the environment – created by God for man to enslave (cf. Bacon 1834, 224) – that underwrote the European colonial project and the rise of the Western world order with its genocides, mass extinctions, and anthropogenic climate change (Collard 1989; Federici 2004; Fox Keller 1985; Merchant 1990, 2003).

Conclusion

The stakes of engaging outer space as a domain of inquiry within environmental geopolitics are indeed about life and death as we reshape environments on Earth and in space: who is allowed to live, what is valued as life (or protected as the pre-biotic conditions for life), and what is considered acceptable death in our movements beneath, across, and beyond Earth's atmosphere. Diverse schools of geopolitical thought are useful for interrogating how outer space is conceived and engaged by differentially empowered actors.

A classical geopolitical framework concerned with competition among nations not only elides the inequalities and environmental injustices that can characterize diverse use of outer space, it reinforces them. Classical geopolitics rely on fixed hierarchizations between "big" and the "little," and this too has been critiqued by critical and feminist geopoliticians for obscuring how the banality of everyday life comprises part of an intertwined complex with the exercise of power at multiple scales. The lens of critical environmental geopolitics enables us to examine how multiple competing space aspirations transform physical and lived spaces by placing biospheres and the biotic at the center of political analysis. This dialectical relationship between the Earth and space environments, first elaborated by Dickens and Ormrod (2007) and Beery (2011) who were building on Harvey (1982) and Smith (1990), respectively, reminds us that nature and society are co-produced; therefore, how we produce outer space is inextricably intertwined with the production of socionatures on Earth. This is a question of horizontal and vertical territory, and territorial questions are always also environmental questions. Environmental questions concern people, which from a feminist standpoint are questions about justice mediated through unequal power relations. The manners in which different interest groups (fail to) attend to questions of justice in specific places determine broader environmental outcomes on Earth and in space. These struggles shape geopolitics in diverse ways that are – like the cosmos we have come to know – at once immense and immediate.

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Notes

1. Outer space scholars have utilized the lenses of anthropology (Battaglia 2017; Messeri 2016; Olson 2018; Valentine 2012) the anthropocene (Bertoni 2016; Boes 2014; Latour 2015; Olson and Messeri 2015; Salazar 2017a), environmental humanities (Aronowsky 2017; Helmreich 2017; Messeri 2017; Praet and Salazar 2017; Salazar 2017b), the production of nature (Beery 2016b), science and technology studies (Gabrys 2016; Jasanoff 2004), and cultural landscape approaches to outer space (Gorman 2005).
2. This mirrors moves in other domains of feminist geopolitical inquiry to examine domestic violence and contemporary international warfare in relation to each other, challenging the "big"/"little" distinction as it plays out between "big" domains of warfare and "little" spaces of intimate partner violence (Pain 2014; Pain and Staeheli 2014).
3. There is some interest in developing Green propellants (Bombelli et al. 2003; Gohardani et al. 2014).
4. Environmental justice literature is replete with illustrative cases (Auyero and Swistun 2009; Brown et al. 2003; Bullard 1996). As for noise pollution, there is currently no standard environmental assessment methodology to evaluate the impact of launch vehicles and sites (Sizov 2017), despite abundant research on the social and environmental impacts of aircraft noise pollution on humans and other animals (Ellis, Ellis, and Mindell 1991; Richardson et al. 1995; Yankaskas 2013).
5. The Moon is approximately four hundred thousand kilometers away from Earth. Although it is also in Earth's orbits, its influence on satellites and launch trajectories is less immediate than the material between lower Earth and Geostationary orbits.
6. For race and gender analyses of human engagement with outer space, see, *inter alia*: Bell and Parker (2009), Bryld and Lykke (2000), Dick and Launius (2007), Dickens and Ormrod (2016), Horner et al. (2015), Jennings and Baker (2000), Kilgore and Douglas (2003), Lathers (2012), Litfin (1997), Llinares (2011), Messeri (2017), McQuaid (2007), Penley (1997), Pesterfield (2016), Sage (2009), Shetterly (2016), Valentine (2012), and Weitekamp (2004).

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