METAPHORS WE SCAPE BY: THE POSSIBILITIES OF TERRAFORMING AS A NEW DESCRIPTOR OF LANDSCAPE

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1   ABSTRACT

Vocabulary has been a longstanding focus of landscape theorists, who have not only debated the various meanings of landscape and their consequences, but also offered a number of alternatives and specifications of place terminology. Drawing on arguments that language and metaphor have material impacts on the shape of the world around us, this paper explores what kinds of relationships and practices become imaginable through one emergent term—terraforming. Terraforming has its origins in science fiction, but has increasingly come to be used both by theorists in Science and Technology Studies and the Environmental Humanities as a critical descriptor, and by a wide array of other voices in disparate contexts. The paper explores how these terms extend or refine our understanding of environments and their formation, and the agencies they reveal. This is accomplished through a content analysis of dozens of these non-fiction references to earthbound terraforming.These linguistic possibilities are especially relevant in debates regarding the Anthropocene proposal and its underlying assumptions about humanity's capacity to manipulate the planet's systems. Critics of this proposal often employ a relational worldview that attempts to situate humans within environments, rather than maintaining a division between nature and culture. This project is shared by a number of landscape theorists, who have been developing alternative linguistic formations around landscape. Accordingly, terraforming can be seen as a term relevant to both conversations that has already demonstrated distinct metaphorical capacities in a variety of contexts.

1.1   Keywords
Terraforming, Relational Ontology, Anthropocene, Nonhuman Agency

2   INTRODUCTION

Noël van Dooren: Sorry … 'terraform'? Is this science fiction vocabulary?

*Fred Keijzer: Mm, I think it is more widely used. It simply means transforming
non-Earth environments in ways that make them liveable for organisms from Earth, including
humans.*

van Dooren: Ironic. Sounds like the essence of landscape architecture. (2015, 79)

What happens if we take seriously this observation by van Dooren, a Dutch landscape architect, which he made in an interview with Dutch philosopher Fred Keijzer in the *Journal of Landscape Architecture*, while discussing science fiction and otherworldly environments (Keijzer & van Dooren, 2015)? The idea of terraforming has its origins in science fiction of the mid-twentieth century, referring initially to the transformation of another celestial object for human habitation. But increasingly, the word is being used to describe a broad array of environmental modifications, in ways that touch upon what we typically think of as landscape architecture or environmental design.

Theoreticians in landscape architecture, geography, and other fields have engaged in a long dialogue about a key shared term, landscape, identifying both its strengths and its many weaknesses. They have also explored a range of other terms that qualify or respond to its identified challenges, such as scene; site and situation; and noun-like formations of ecology and the urban. More topological notions of systems, networks, and assemblages have gained increasing traction alongside models that emphasize relationships, emergence, and performativity. Each of these positions regarding (and alternatives to) landscape emerges in a specific context, which is formed by theoretical and practical interests within those disciplines, and the broader philosophical paradigm within which they travel. Moreover, each position within this diversity of conceptions opens up distinct possibilities for imagining and shaping what we commonly call landscapes.

As "the Anthropocene" has gained traction as both a scientific description of our current epoch and an element of the popular imagination, geological and atmospheric language has become increasingly prevalent. Ideas of atmosphere and world have received renewed interest, revealing still more possibilities. Humanity's status as a geological or environmental "force" and associated calls for geoengineering (Crutzen, 2002)—generally defined as the intentional modification of the Earth's atmospheric systems—have become a topic of ethical debate (Crist, 2013; D. Haraway et al., 2016; Malm & Hornborg, 2014). In this midst, terraforming has become increasingly used to refer to geoengineering activities proposed or already unfolding here on Earth at various scales and contexts, and especially to describe an array of activities that might otherwise be interpreted through more familiar landscape-derived metaphors and concepts.

This new way of referring to what we might usually describe as landscape has cropped up in a range of places, from theoretical literature in the Environmental Humanities to popular narratives, and even as a metaphor that has been selected as relevant in unrelated scientific papers. In the Anthropocene (whether taken as a fact of geological history or a contested paradigm), how we see relationships that produce environments is clearly changing. Further, we have the opportunity, in choosing between various characterizations of sites and contexts, to materially influence not only discourses but the world around us through our use of certain frames. Feminist Science and Technology (STS) scholar Donna Haraway, one of metaphorical terraforming's biggest advocates argues that "it matters what thoughts think thoughts" (D. J. Haraway, 2016, p. 35). This paper takes that challenge seriously, and considers what becomes thinkable about the environments usually called landscapes when we think with terraforming instead. This exploration is conducted by drawing together references to terraforming in myriad contexts and comparing their descriptive potentials. Specifically, the paper identifies a number of dimensions—spatial and temporal scale, agency and intention, media, and environmental conditions—which terraforming extends as a description of landscape or environment formation.

These extensions offer an intriguing complement to recent efforts to imagine ever more relational and dynamic conceptions of landscape. The metaphorical potential of our descriptions of the places we encounter and inhabit is implied in these projects which aim to rethink that language. These efforts emerge in a context of ongoing attempts to theorize landscape's bridging or hybrid character between nature and culture. And they are desperately needed now as a counter-point to the problematic mode of thinking that underlies the Anthropocene proposal, namely that humans have finally overcome nature once and for all.

Because landscapes are where the evidence for the Anthropocene and its proponents' recommended solutions are situated, such theorizing is of critical importance.

3   THE PRODUCTIVE POWER OF METAPHOR

While theoretical notions of atmosphere and world might draw newfound potency from the material and scalar aspects of the Anthropocene imagination, and notions of situation, assemblage, and nexus highlight the relationality of landscapes, the gerund *terraforming* and its various conjugations—terraformed, terraformer, terraformation, and so on—render landscapes as constructed in a much more explicit way. Terraforming highlights the ongoing production of environments, and insists upon the clarification of subjects and objects. In doing so, it invites a richer articulation of the ways environments come to be, an important question in the so-called Anthropocene. As various authors use the word terraforming, they often draw attention to possibilities beyond human-focused conceptions of landscape as something made by or for humans, or at least framed by their vision. Instead, other agents come on to the stage, and other scales, media, and conditions become thinkable. For critics of the Anthropocene and modern-rationalist thinking in general—who often express a desire to overcome dichotomized thinking regarding nature and culture, and instead employ a relational model—terraforming offers a way of making such possibilities more apparent and explicit as ongoing and historical, rather than speculative processes. In doing so, it opens up the possibility for rethinking, and ultimately materially producing landscapes in this way.

This is possible because metaphors play such a powerful and foundational role in our thinking. Metaphors aren't simply linguistic references or comparisons, but fundamental to how we understand the world, capable of "highlighting and hiding" certain aspects of it (Lakoff & Johnson, 2008, p. 10). Landscape can be investigated through the metaphors that structure it. Landscape can be understood for instance as a revealing cross-section, as a culturally-produced text, or a way of seeing, each metaphor emphasizing distinct features (Demeritt, 1994). The ways that landscape is represented exist within a field of references that often have political implications, for instance landscape's association with the feminine within a dichotomized hierarchy (Meyer, 1994). Newer metaphors, such as Haraway's cyborg and Latour's networks can also provide opportunities to shift our perspective regarding those problematic nature-culture binaries (Demeritt, 1994).

We can also make material changes to the worlds that metaphors conceptually discursively reveal or mask. These processes are in fact intertwined, or co-produced. As STS theorist Sheila Jasanoff argues, "the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it" (Jasanoff, 2004, p. 2). These socially circulating ideas contribute to broader spatial imaginaries—"socially held stories, ways of representing and talking about places" (Watkins, 2015, p. 509). While earlier theorists of spatial imaginaries have focused on their linguistic or representational aspects, increasingly imaginaries are recognized as co-productive with material practices. We perform imaginaries in the world as we imagine it to be, and the world responds, in ways that in turn reshape our imaginaries and their constituent concepts.

Jasanoff and Kim further articulate this thinking through the concept of "sociotechnical imaginaries," emphasizing the co-productive relationships between groups of people, technologies, ideologies, and the material world, and the political nature of these complexes (Jasanoff & Kim, 2015). A corollary to this line of argument is that there is an ethical dimension to the practices we use in the world: our technologies have the potential to make certain forms of life and the worlds they require more or less possible, creating winners and losers (Winner, 1986). Another STS theorist, Karen Barad, argues for thinking in terms of "ethico-onto-epistemologies," drawing together our modes of representation and ontological assumptions about what things are with our material practices and their outcomes as fundamentally inseparable (Barad, 2007). This through-line, from foundational assumptions and concepts to ethical outcomes, is precisely the one that Haraway traces when she says "It matters what thoughts think thoughts. It matters what knowledges know knowledges. It matters what relations relate relations. It matters what worlds world worlds." (D. J. Haraway, 2016)

The Anthropocene proposal is riddled with problematic tropes of geological agency and planetary stewardship that can be unpacked through this kind of critical attention to metaphors (Rickards, 2015). Its critics argue that the Anthropocene in fact bundles together a number of ideas, including descriptions of planetary change and an emphasis on certain technological interventions to address them (Crist, 2013). But if the Anthropocene's proponents highlight humanity's technological capabilities, whether for ill or for good, it hides both the differences between various groups of humans and economic systems, with distinct

capacities to exercise geological agency and experience harm (D. Haraway et al., 2016; J. W. Moore, 2017), and the role of nonhumans, both in the past and in the future, in shaping the world (D. J. Haraway, 2016).

For Haraway, it is terraforming, as an earthly, rather than other-worldly practice, that holds the promise of allowing us to act and think more responsibly as we co-productively engage with both our environments and our attitudes about them. The Anthropocene metaphor, with its overemphasis on human agency, is particularly problematic, in that it not only conceptually incapacitates nonhumans, but also limits our ability to imagine a more relational mode of environment-making. As will be shown below, this isn't simply an optimistic or idealistic hope that Haraway points to. Instead, terraforming, as a metaphor, seems to actually make such possibilities thinkable for many who use it.

4   THINKING SITES RELATIONALLY

Scholars of landscape have long been engaged in efforts to articulate relationships between humans and nature, and employed varying conceptions of landscape to that end (Wylie, 2007). As noted above, a significant goal of the metaphorical work of figures like Latour and Haraway has been to supplant those distinctions entirely (Demeritt, 1994), and facilitate a reimagining of what might be called naturecultures (D. J. Haraway, 2008). This revealing and moving beyond dualist conceptions of nature and culture, toward a more relational mode of thinking and acting, has been of significant interest for many theorists, including not only those in STS, but a broader philosophical lineage. Their tradition includes Deleuze and Guattari's rhizomatics (Deleuze & Guattari, 1987), Alfred North Whitehead's earlier process philosophy (Whitehead, 1929/1978) and John Dewey's Pragmatist notion of emergent publics (Dewey, 1927/2016), and is also reflected in systems thinking-influenced philosophies of assemblage (DeLanda, 2016) and posthumanism (Wolfe, 2010).The kinds of relational thinking these authors represent has been influential in contemporary literature in STS and the environmental humanities, and are reflected in a number of shifts, which highlight key features of this mode of argument, including the Nonhuman / Multispecies Turn (Grusin, 2015; Kirksey & Helmreich, 2010), and the Relational / Ontological Turn (Castree, 2003; Mol, 1999).

Theorists of landscape as both an interpretive and practical tool have pursued a number of agendas that resonate broadly with the concerns of many relational thinkers. For instance, Elizabeth Meyer has explicitly challenged binary thinking about landscape through a feminist lens that references Haraway's cyborg trope (Meyer, 1994). And Kenneth Olwig's exploration of the "substantive nature of landscape" through investigation of landscapes as emergent from situated politics in Western and Northern Europe (Olwig, 1996) provides a historiographic grounding for what Latour describes as a thing-politics better suited to addressing the relational assemblages of humans and nonhumans he describes than our conventional framings of environmental politics (Latour, 2005). And John Wylie meanwhile proposes a relational and material phenomenology of landscape, rereading the landscape gaze through the work of Deleuze and Merleau-Ponty, as well as Latourian Actor-Network Theory (Wylie, 2006). More broadly, there has been a turn toward ideas of performativity and emergence in landscape practice, which is especially evident in the work and writing of many landscape urbanists (Barnett, 2013). While that project proceeds broadly from a systems sensibility, there are also arguments for a return to landscape "gardening" as a historical description of, or metaphor for, ecological landscape practice, which has newfound relevance for thinking performatively (Raxworthy, 2003; Weilacher, 2016).

The theorization of other terms for landscape is significant in this context. Sites can be understood in terms of its "upstream" and "downstream" affective registers, moving beyond received notions of bounded space (Burns & Kahn, 2005). Situation can emphasize the possibilities of emergence among an array of actors present (Barnett, 2013). Assemblage, well-worn at this point, emphasizes the contingent relationships among those various actors, near and far. Notions of atmosphere emerge both in an attention to the specific conditions, materiality, and productive technologies of space (Gissen, 2014), and in more philosophical attention to affect (B. Anderson, 2009). Worlds and worldmaking, likewise, have become a common refrain for many in recent multispecies writers, who employ the term to emphasize the emergent and ongoing processes (Ogden, Hall, & Tanita, 2013). This language has also been picked up in a few instances regarding design, with worldmaking offering a way to account for design's ability to imagine forms of life, which structures facilitate (S. Anderson, 1987). Worlds can be understood, like assemblages, in terms of topological density, more connected to themselves than to other places (Bryant, 2014). And it is from this point that Haraway's use of the term most directly extends, qualifying the world metaphor by turning to a neologism that makes explicit both the earthly materiality and constructedness of worlds, while implying actors that produce them at the same time.

Moving forward, this paper argues that Haraway's evocative use of terraforming is not merely a clever if ultimately marginal trope, but rather one with greater potential and resonance, used by authors writing both before and after her recent book and the essays it is culled from, many of whom are likely unaware of her work. Terraforming is in fact an emergent term, and one whose metaphorical potentials speak specifically to the concerns that many of these landscape theorists have called attention to in their exploration of expanded vocabularies of place.

5   (RE)DEFINING TERRAFORMING

Terraforming has its origins in science fiction of the mid-twentieth century, referring initially to the transformation of another celestial object to be habitable for Earth-originating organisms. It can be considered a form of planetary engineering, and is typically differentiated from geoengineering by the target of the activities—elsewhere or Earth respectively (Fogg, 1995). It was initially coined in "Collision Orbit," a short story by Jack Williamson (writing as Will Stewart), where he described the transformation of a range of celestial objects, from small asteroids to planets, into breathable worlds with familiar levels of gravity, by spatial engineers, trained in professional college programs and working for interplanetary engineering firms (Stewart, 1942). Since then, the term has proliferated, and its varied usages can be synthesized into three related planetary activities: modify other worlds to support life from Earth, modifying Earth to support alien life, and modifying Earth generally (Prucher, 2006).

Chris Pak, a literary scholar writing on terraforming's use in fiction, highlights ways the term has been used over time to reflect upon and respond to changing attitudes about the environment in policy and the general public, revealing fictional terraforming accounts' political or critical dimensions. But he notes that the third and most recent definition (circa 1997), reflects "a shift in awareness of humankind's ability to alter planets through climate change and other global effects" (Pak, 2016; 2). Pak also links terraforming to "landscaping," which he defines as the conversion on nonhuman environments into ones that support and are imbued with meaning by humans. Terraforming, as an environmental literary trope, thus becomes a venue by which to reflect on these activities, especially and most recently, as this third definition brings these ideas home to Earth. "The ability to alter the landscape and the ethical dilemmas this poses direct attention towards the future," Pak writes. "The fundamental question asked is how we want to live, and it emerges from the concern over whether we can continue living in ways that threaten the integrity of our environments" (Pak, 2016, 17). It is this moment that this paper enters into, expanding on Pak's statement to explore instances of this third definition in nonfiction texts, trying to understand how, in the last twenty years, this term has begun to infiltrate our conceptual terrain, providing opportunities to reframe descriptions of landscape in the Anthropocene.

Terraforming's transition from fiction to speculative science is marked by a small but compelling discourse about precisely what constitutes terraforming, and its relation to other candidate terms, among them planetary engineering, ecopoiesis (Haynes, 1990), and planetary ecosynthesis (Averner, 1976). The transformation of a planet into a lively environment can be conceived of as a transition through ecological succession, from early bacteria and lichens through the introduction progressively more complex forms of life (Graham, 2004). Ecopoiesis has come to be used to refer to the earliest phases of such a succession (Haynes & McKay, 1992). But ecopoiesis is a term that in its initial conception was much more open-ended, suggesting the establishment of an environment or ecosystem in ways that might not be directly oriented toward human benefit (Haynes, 1990). This emergent, rather than directed conception of planet-making is one that Haraway's exploration of terraforming resonates with. She writes, "from the start, the greatest planetary terraformers (and reformers) of all have been and still are bacteria and their kin," but also gives recognition to "the spread of seed-dispersing plants millions of years before human agriculture" as a "planet-changing development" (D. J. Haraway, 2016, p. 99). This provocation situates humans' planetary agency not as something newfound or unique, but in fact an old and well-established aspect of life generally. As will be shown below, this more-than-human sense of the word is one that many of its users intuitively recognize and emphasize in their usage of it.

6   TERRAFORMING AS A RELATIONAL CONCEPT

Haraway's imaginative calls are compelling in their own right—the idea of a world made and remade in messy but fulfilling ways by assemblages of humans and nonhumans provides a powerful counterpoint to the technocratic solutions to contemporary challenges of climate recommended by Anthropocene advocates. The term provides a way to situate arguments that multispecies practices of soil carbon

sequestration through regenerative agriculture and similar practices can make a significant contribution to carbon drawdown (Leu, 2017; Rhodes, 2017). But perhaps even more compelling than the theoretical articulation of terraforming is the thin, if already widely spread use of the term to describe practices of environmental modification by humans and nonhumans alike.

To document this pattern, references to earthbound terraforming were gathered from dozens of non-fiction sources. The examples of terraforming on which this discussion is built do not represent every usage of the term, but in their variedness, provide a representative sampling of how the term is being used. They emerged through a slow gathering process incidental to a broader research effort, and were supplemented by online, content-aware searches of books, journal articles, websites, and periodicals, as well as word of mouth contributions from colleagues. The rigor of the sources ranges from well-known books by established Environmental Humanities scholars and academic papers to journalistic blog posts and student projects. Rather than limiting this analysis to only those instances published in academic contexts, the analysis tends toward breadth, seeking to capture the emerging senses of the term, which might be more exploratory in less-established or edited uses. The success of this broader casting of the net also reinforces the argument that this term is entering into and circulating within the environmental imagination in many different ways, beyond the confines of critical environmental discourse.

Terraforming is a concept with utility across a broad range of disciplines and discourses, as evidenced by the wide range of authors, from various fields, who chose to describe their objects of study in this way. Among these fields are environmental policy, criticism, and design, but surprisingly also medicine, biology, and history. The deployment of terraforming in historical and critical environmental writing in particular is quite often an ironic provocation, a purposeful choice that reveals some deficit in our conventional mode of thinking about relationships between agents and environments. Clearly, these authors all recognize in their own ways that words have significant power to shape what we imagine is possible. The sections that follow discuss at a finer grain the results of a comprehensive content analysis of these varied uses. They are explored across six interrelated dimensions: agency and intention, spatial and temporal scale, and media and condition. In each case, these authors have contributed to a sometimes dramatic and sometimes subtle stretching of our conception of just what environments are and how they come to be, making new metaphorical links and opening possibilities for rethinking how we manipulate landscapes in less anthropocentric terms.

6.1   Agency and Intention

One of the most important challenges these texts raise is the question of agency—who is acknowledged as having the ability to manipulate environments? The agents identified range broadly in size and cognitive capacity, extending well beyond human engineers and planners, to nonhumans and even nonliving entities, as well as technological systems in which those actors are embedded. Despite its futuristic origins, many authors have found terraforming a useful way by which to interpret earlier societies. These include early hunter-gathers (Lovett & Poudyal, 2006), indigenous groups in North and South America (Giordano, 2009; Mann, 2011), and early colonial efforts (Barton, 2004; Wilkinson, 2004). Such descriptions resonate with contemporary notions of cultural landscapes, but highlight the uniquely productive dimensions of these places, and don't depend heavily on distinctions between designed or vernacular landscapes. Instead, the interrelationship of cultures, production, and ecologies becomes expressed as integral. It also recasts these practices as contemporary, even futuristic, perhaps even surpassing our own understanding of the possibilities of transformative landscape management. Such a move provides a counterpoint to longstanding associations of indigenous groups with nature.

Landscapes are typically thought of as the product of a dialogue with human subjects, whether through their active manipulation, their drawing upon the landscape as resource, or through their gaze. But subjectivity and the acknowledgement of agency that coincides with that status are extended in several of these references to terraforming. Some of these references simply extend agency to charismatic nonhumans, but others more provocatively blur the sense of individuality associated with terraforming entities altogether, muddling affect and intention in ways that resonate with Jane Bennett's calls for anthropomorphization as a materialist tool, and her notion of distributed agency (Bennett, 2010). One scientific paper with a much less philosophical agenda uses terraforming to describe the activities of Antarctic springtails, small arthropods whose molted skin binds together small mineral particles in ways that create a beneficial sheltered environment (Hawes, 2016). Likewise, cancer cells are described as terraformers in a couple of instances, suggesting that our body's tissue is an environment that can be

transformed (Perone & Magnani, 2016; Yang et al., 2014). This reference provides a fascinating extension of Haraway's calls for kinship with other earthly terraformers—not only are we related, we and our cancer cells are one flesh, so to speak, battling over the appropriate reconfiguration of our material structure, with distinct takes on what parameters facilitate flourishing.

At the farthest end of this spectrum, glaciers and climate systems are also described as terraforming landscapes, in ways that differentially impact various ecological communities and the hominid species that inhabit them, for instance favoring our own species over our Neanderthal cousins (Lee, 2009), or changing ecosystems and their constituent species composition more broadly (DeWalt et al., 2016). Some authors in the Environmental Humanities pose the possibility of terraforming as an emergent phenomenon, arising not from humans as intending individuals, but as collectives integrated with their technological systems (Luke, 1997; Luke, 2015; Woods, 2014). Even a sociotechnical assemblage such as an airport could be considered a terraformer (Fuller & Harley, 2004). Collectively, these instances suggest that a lack of intention we associate with thinking individuals need not be a disqualification to being a terraformer, nor is biological life as such a requirement. Habitat formation for oneself, while a significant function for many, is also not essential—impacting the habitat of someone else can be terraforming, if one is a glacier, for instance. This point also applies to humans: there are always winners and losers in environmental modification. This expanded sense of agency touches upon the relational ideas of site outlined above, extending the zone of action and affect upstream and downstream from immediate environments.

A final theme that complicates definitions of agency are ideas of emergence and intention as factors within terraforming acts. Does terraforming emerge from the accrued effects of non-coordinated entities or the behaviors of systems that are more than their individual actors, or is it a directed activity, that, guided by an individual organism or coordinated group, results in niche construction or environmental modification? The authors employing these terms take different approaches, even as they describe the activities of similar agents. Those describing geo-engineering schemes imagine directed human activities, whether in rogue experiments or coordinated international policy; some environmental writers, however, anticipate a more complex set of relationships between humans and their systems that doesn't flow from any particular intention, yet still has global effects (Luke, 1997; Morton, 2016). And Haraway takes an emergent view that entangles the active agencies of humans and nonhumans—terraforming simply can't be a one-species show, regardless of the level of intentionality attributed to any particular organism (D. J. Haraway, 2016).

6.2   Spatial and Temporal Scale

The range of sites and scales that these terraformers engage with is equally broad, from the tissues of the human body to regional ecosystems and the global atmosphere. In the middle ground, terraforming refers to more familiar and localized scales of site design and microclimate manipulation (Agency Architecture, 2014; Wei, 2015), land disturbance (Dance, 2016; Jackson & della Dora, 2016; L. J. Moore, 2014) and ecosystem modification (Barton, 2004; Wilkinson, 2004). For many, it is a regional process, playing out at the scale of a continent or biome (Cathcart, 1995; Lovett & Poudyal, 2006; Mann, 2011). This breadth suggests a very elastic definition of the scale of what constitutes a site or an environment. But this elasticity of scale shouldn't be read as a muddying of terraforming's typical planetary conception: after all, the original use of the term referred to the terraformation of an asteroid only two kilometers across (Stewart, 1942). Instead, this original use, which describes the creation of favorable gravitational, thermal, and atmospheric conditions, implies that site emerges in relationship to the environmental conditions desired, and the systems that produce those conditions. Absolute scale, it seems, is secondary to more relative notions of site and system for these authors.

Time provides an additional dimension, ranging from terraforming gestures imagined as a directed act unfolding at familiar construction schedules to the slow emergence of changing conditions over many generations, and even geologic periods. While long-range planning activities may occasionally work with the possibility of multi-generational development in mind, and historical analysis of some cultural landscapes recognizes their development over hundreds or thousands of years, much of typical design action is focused on short-term transformations. Only recently have more process-oriented unfoldings become a part of design inquiry and practice. Conditions produced through undirected and collaborative actions, where designers become one among many in a long relay, significantly challenge that identity. In these instances, design and its notion of bounded, targeted intervention or object production no longer apply. Sites and effects are no longer coterminous in time and space, or nested hierarchically in clear units. Instead "flat ontologies" that can trace these connections wherever and whenever they lead are required.

6.3   Media and Conditions

Related to this sense of scale are question of medium and conditions—what do terraformers manipulate directly, and how is this connected to desired environmental outcomes? With its reference to previously lifeless worlds like Mars, terraforming implies that no environmental variable, whether atmosphere, temperature, gravity or magnetic field, is taken for granted; each emerges as some action or effect, through some material intermediary, which must be accounted for. There is no longer a passive external container called nature which supplies these conditions.

In many references to terraforming, there is a familiar focus on management of the vegetal components of ecosystems, but also a greater attention to the production of underlying environmental needs, such as soil and irrigation. There is also a greater acknowledgement of their ability to frame certain forms of social life and interdependent plant and animal communities, especially in the case of historical references (Giordano, 2009; Mann, 2011). In more speculative descriptions of earthbound practices, these conditions become variables that are explicitly identified, as in a call to irrigate and plant the Sahara, with increased rainfall implicated as a byproduct of such actions (Bushnell, 2006).

There is also recognition of direct and indirect atmospheric impacts from a variety of organisms' respiration. Cyanobacteria, for instance (D. J. Haraway, 2016), manipulated the global atmospheric composition through increases in waste oxygen, triggering the Great Oxygenation Event, a global extinction, conditions to which life eventually responded, leading to oxygen-breathing species like ours. Bacteria are also proposed as a tool—manipulated through genetic engineering—by which increase carbon sequestration (Solé, Montañez, & Duran-Nebreda, 2015). At the historic end of the technological spectrum, grazing animals and fire are used to maintain a savannah landscape at a regional scale (Lovett & Poudyal, 2006).

These and other terraforming references point to a greater willingness to grant agency to or manipulate animals as part of terraforming schemes, recognizing their niche-constructing and ecosystem engineering capabilities. But biopolitical engagements with the animal kingdom aren't often considered in landscape theory and descriptions of practice. More often animals are seen as passive beneficiaries of habitat production schemes by those concerned with landscape—conceptually separate wildlife. Recent interest in oyster restoration and the beneficial filtering side-effect of their respiration-like approach to feeding hints is one of a few compelling exceptions (Orff & SCAPE, 2016), illustrating a thematic extension of design practice terraforming might speak to better than vegetal and pastoral notions of landscape.

If the core of environmental modification by humans has been vegetation management and infrastructural interventions, the attention to more mobile and diffuse nonhumans such as animals and bacteria is a provocative extension, and one that insists upon an extension of agency at the same time, challenging our ideas of media at the same time that it is expanded. While the misbehavior of plants or technology can be written off more easily as a design flaw, animals' opinions and agendas are much harder to ignore. For instance, an analysis of dairy cows reveals that they are collaborative workers in the milking operation whose lack of cooperation would make the task almost impossible (Porcher, 2017). Whether for the historic maintenance of a savannah or contemporary regenerative grazing schemes for carbon sequestration, animals are our terraforming collaborators, and we are theirs, each embedded in a broader complex, and structuring our respective behaviors in response to our position in a broader complex. In this light, plants should also be seen as lively, rather than simply material (Elkin, 2017).

And so, we should also turn this reflection on media toward ourselves—humans become media not only when our tissues are terraformed by metastasized tissues, but as we modify own practices. Without treading too far toward environmental determinism, it is worth noting again that environmental and social forms of life are co-productively connected, in ways that blur medium and condition.

7   CONCLUSIONS

This paper makes two major claims: first, that terraforming is an emergent description of landscape practice across an array of literatures, and second, that it opens up certain metaphorical possibilities for rethinking landscape formation relevant to contemporary theoretical challenges, namely an increasingly relational mode of operation. This isn't simply an ambition, but as the references collected to produce the study show, a demonstrated change in thinking, and in a few cases, in practice. The authors that explicitly invoke terraforming as a different or novel from of spatial practice, whether for good or for ill, but one that

regardless invites reflection on our relationships to the world around us, and the understandings that structure those relationships.

The uses of terraforming drawn upon in this analysis include design and activist artworks that stretch our notions of sculpture and architecture, landscape and habitat. From collaborative artworks that engage with other species or narrate possible worlds to structures that leverage plants to recover volcano-devastated ashfields and sea-level impacted beaches, these projects don't just shape or create spaces—they realize processes in ways that blur notions of agent and scale, medium and condition. In these works, and in historic landscape, forestry, and agricultural practices now described as terraforming, we see patterns and forms that are familiar, but also different, and richer. The unsettling character of these projects and descriptions is important to grapple with, not so much because it is new, but because it has always been there, embedded in the practices we call landscape and architecture. But now, with a different metaphor, previously hidden dimensions have been highlighted.

This project began with an attempt to understand how and why a seemingly inapplicable word—terraforming—was being used to describe environmental manipulations at familiar scales and with familiar tools. As Haraway argues, the concepts we use to frame lines of analysis permit certain possibilities and not others. The authors who mobilize the terms highlighted—worlds, atmospheres, terraforming—select these terms over more familiar ones, such as landscape, site, or environment, precisely because of the possibilities that become open to being thought through their usage. Following in the footsteps of the dozens of authors evaluated through this work, perhaps landscape architects should consider what this expanded vocabulary of environmental design offers, in terms of new modes of imagining and practicing. Such an effort will reward those who do so with new ways of describing environments, new media to engage with, and the possibility of imagining new forms of life. This engagement also presents the opportunity to contribute something significant to conversations about the future of the planetary environment—specifically by raising the aesthetic, cultural, and experiential possibilities that are emerging, or might be lost, as we continue to terraform the Earth in the Anthropocene. Terraforming, as a practice that attends to other actors and other outcomes, invites reflection on alternative ethics and principles for practice (Raghavan, 2013). Landscape architecture, reread through this metaphorical lens, can consciously become a world-making enterprise, one that is perhaps better equipped to world for multispecies flourishing, in an ethical and equitable manner.

8   REFERENCES

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