



# Environmental management and open-air experiments in Brazilian Amazonia



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## ABSTRACT

In this article, I ethnographically examine “the biggest experiment in tropical conservation history,” an environmental management approach designed in Brazilian Amazonia. I focus on research conducted by scientists who support this approach using the results of their work at an open-air experiment. Drawing on this ethnographic study I critically revisit Bruno Latour’s deservedly influential ethnography of an open-air laboratory in Brazilian Amazonia. I also engage with his claim that open-air experiments constitute spaces in which scientists can avoid seeing the world as “Nature”—a gigantic collection of inert objects that experts sense they have to bring into order on their own. Latour shows that while working in their Amazonian open-air laboratory scientists perceived the forest as a network comprising human and non-human entities bearing creative capacities. He suggests that such experimentation enables humans to envision environmental management strategies based on human/non-human collaborations. In the open air, experts could thereby transcend the pervasive fatalism that plagues environmental policy circles and rekindle a more optimistic and enthusiastic stance toward environmental management. I argue that Latour’s is a visionary ethnography that anticipates contemporary trends in environmental management approaches. However, I also argue that his celebratory conclusions regarding open-air experimentation are misguided. I show that, while working in the open air, the scientists situated their work within capitalist experiments wherein humans and non-humans creatively collaborate in the construction of new, less inhabitable worlds.

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## Introduction

In recent years the notions of “open-air,” “*in vivo*,” and “real-world” experimentation have been used by scholars who study scientific and technological practices that transform spaces beyond laboratory walls (Krohn and Weyer, 1994; Gross and Krohn, 2004; Latour, 2011 [2001]; Callon, 2009). The terms are used to distinguish indoor from open-air experiments. While the former take place in carefully designed spaces under expert control, the latter are advanced in unpredictable worlds that are not of the experts’ making (Muniesa and Callon, 2007; Callon, 2009; Latour, 2004 [1999]; Clark, 2011). Scholars argue that open-air experiments could lead to profound political transformations as they may allow participants to forego the “desire for a false stability in the world” and embrace ever-new, shifting situations (Lorimer, 2012. See also: Gabrys and Yusoff, 2012; Latour, 2011; Stengers, 2010). For example, since the dawn of modern climate

science, environmental researchers have described global warming as a “geophysical experiment” unwittingly performed by humans through carbon-intensive modes of living (Revelle and Hans, 1957: 19).

While climate change is, no doubt, a dangerous experiment, some see in it political potential. Environmental disruptions destabilize taken-for-granted relations between humans and non-humans and offer proof that “another world is possible”—if not unavoidable (Stengers, 2009; Klein, 2014). From this latter perspective, persons and groups could respond to global environmental crises by advancing “wild experiments” whereby environmental management would be re-defined as “open-ended... political negotiations between people and wildlife” that would remake the worlds that humans and non-humans inhabit (Lorimer and Driessen, 2014; see also Johnson, 2014).

In this article, I examine an environmental management proposal that addresses climate change processes by taking an experimental approach. The policy approach I study here has been described as “the biggest experiment in tropical conservation history” (Tollerson, 2009) and is promoted by scientists whose

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ecological proposals draw on open-air scientific experiments in Amazonia. My study of science/policy experiments advances Bruno Latour's highly influential claim that open-air experimentation is an alternative to conventional environmental management schemes. Latour argues that conventional ecological policies lead to political inaction as their proposals leave populations feeling despondent, gloomy, and hopeless (Latour, 2007, 2008, 2011a). On the other hand, an experimental approach to ecological politics could rekindle "energy, optimism, ideals and forward-looking democratic spirit" (Latour, 2008: 2).<sup>1</sup> Such an approach elicits productive feelings and emotions, Latour argues, as experimental politics forego ideas of "Nature" (a word that, along with others, I capitalize throughout this article to underline its ontological specificity).

An Anglo-European ("Modern") idea, Latour sees "Nature" as a belief in the "unification of all existents" in a single realm bounded by invariable laws (Latour, 2013: 99; Latour, 1993 [1991]). Moderns believe in Nature as a sphere that, in its inertia and invariance, is opposed to Culture and Society (the latter being realms of creativity inhabited exclusively by humans) (Latour, 1999 [2004]). From Latour's perspective, the idea of Nature leads to self-defeating environmental management schemes. For example, experts who respond to climate change by trying to "save Nature" take on the impossible task of devising and implementing a single plan that could be accepted by billions of humans while organizing innumerable non-humans within a single order (Latour, 2011b). Moreover, such efforts to command the planet would have to rely entirely on our puny human strength given that non-human beings, existing exteriorly to Culture and Society, are seen as incapable of offering any meaningful help—they are objects of intervention rather than entities with which collaboration is possible (Latour, 2005). For Latour, the *hubris* that comes with this conception of Nature forecloses human/non-human collaborations and rapidly devolves into political hopelessness. This would explain the current eco-political impasse wherein persons and groups feel it is impossible to implement policies capable of avoiding human-driven climate crises.

Latour claims that these problems can be surmounted through a brand of politics that, by addressing climate change as an open-air experiment, undermines ideas of Nature as a single, invariant realm. In relation to climate change, he argues, "the laboratory has extended its walls to the whole planet" and therefore "the real experiment is happening on us, with us, through the action of each of us, on all of us, with all the oceans, the high atmosphere, and even the Gulf Stream... participating in it" (Latour, 2011 [2001]: 3–4). Latour suggests that as humans come to recognize the open-air experiment in which they have been unwittingly participating they may sense a larger "us" that includes non-humans with whom collaboration is possible (Latour, 2008, 2013). From this perspective, an experimental response to climate change would focus on multiple attachments between humans and non-humans, as we finally acknowledge the latter's agency (Latour, 2014). An experimental stance in environmental management would not aim at pre-determined outcomes but instead invest in collaborative, open-ended projects that would be advanced with non-humans and aim at re-composing the world (Latour, 2007, 2010). Laboratories "move the world," Latour claims, not by placing the boulder of Nature on human shoulders, but by showing politically oriented groups that the worlds humans inhabit can

be recomposed by the fiddling of heterogeneous collectives (Latour, 1983).

As some scholars have argued (Harman, 2009; Bennett, 2010), Latour's claims are substantiated by ethnographic data and in particular by his rightly celebrated study of scientific practice at an open-air laboratory in Brazilian Amazonia, originally entitled *The "Pedofile" of Boa Vista. A Photo-Philosophical Montage* (Latour, 1995 [1993]).<sup>2</sup> In this influential piece Latour argues that scientists working in the open air offer us an alternative to apocalyptic diagnoses of environmental problems in Amazonia. He convincingly shows that in the open air scientists came to see the forest as an ever-shifting composition created by entities with which collaborations are possible. The animals, soils, and vegetation that compose the Amazonian ecosystem are shown to exhibit creative capacities based on which they take part in building shifting environments. For example, Latour describes research that seemed to show that Amazonian earthworms actively re-make soils into a substrate over which trees could grow, thus *expanding* forest cover. From this perspective experts need not come with plans to save inert Nature but should instead learn to work alongside non-human entities whose creativity could help in accomplishing environmental goals. Scientific experimentation without laboratory walls is thus described as capable of instilling politically productive optimism.

In this paper I advance two arguments regarding Latour's Amazonian ethnography. First, I claim that his is a visionary study that anticipates contemporary trends in environmental management approaches in Amazonia. I then argue, however, that his own ethnographic evidence as well as subsequent research I carried out at an open-air experiment in the basin contradicts Latour's political conclusions.<sup>3</sup> Regarding my first claim, Latour's work anticipates a massive open-air experiment campaign that took place in Amazonia in the late 1990s and that transformed environmental politics in the region (Lahsen and Nobre, 2007; Walford, 2012). Open-air experimentation carried out after Latour's fieldwork informed environmental management proposals that are *not* designed to manage Amazonia as an object or Nature that could be ruled by expert plans. Their experimental work brings scientists into the open air: uncertain spaces in which the worlds humans inhabit appear as shifting compositions produced by collaborative relations among humans and non-humans.

Nevertheless, I also show that environmental management in the open air does *not* instill a sense of optimism that may result in a brand of politics that aims at composing more hospitable worlds. This is my second claim. Scientists who sense Amazonia as a shifting network of human/non-human collaborations also sense that some of the experimental entanglements are undermining the worlds that humans and non-humans inhabit. Although scientists perceive that the experimental re-composition of the world is possible, they also see that emerging worlds expose them to capitalist experiments that are driving profound socio-ecological crisis.

My argument is based on ethnographic research carried out over the course of two years with 86 scientists who are either from Brazil or have conducted research in Amazonia for decades. My

<sup>1</sup> This exact quote also appears in an article by Ulrich Beck's (2010). The reason why both Latour and Beck include this same line in two rather different articles may be that these pieces were written around the time they were Fellows at the Breakthrough Institute—a pro-growth, "post-environmental" think-tank that advocates for market-friendly environmental management approaches and is critical of left-wing ecological proposals.

<sup>2</sup> The article was first published by Latour in French in 1993 and translated into English under this title in 1995. It was subsequently republished as *Circulating Reference: Sampling the Soil in the Amazon Forest*, as chapter two of his book *Pandora's Box* (1999).

<sup>3</sup> Latour's oeuvre is vast and diverse and his thought has undergone very important shifts (Rodríguez-Giralt, 2012; Harman, 2009). His environmental concerns, for example, are relatively recent (Fortun, 2014). My argument here is *not* intended as a comment on Latour's theories. My intention is to advance an *ethnographic critique* of one of Latour's most important arguments involving experimental politics. That said, Latour's interest in experimentation is a constant through his work and an ethnographic reevaluation of his political claims in this regard could contribute to a broader re-assessment of his theoretical work.

interlocutors work in non-governmental environmental organizations (NGOs) and universities in Brazil and the United States. During my fieldwork, I interviewed them, followed them to scientific and environmental policy conferences, and on two occasions joined them on fieldtrips to an open-air laboratory in Amazonia in which they carried out policy-oriented environmental research.

My ethnographic study draws on not only Latour's work but also research that explores experiments as situations in which non-human entities—from instruments to chemicals to non-human animals—creatively interact with humans and with one another in ways that challenge conventional views of Nature as a passive domain (Hacking, 1983; Shapin and Schaffer, 1985; Knorr-Cetina, 1981; Rheinberger, 2010). My analysis of the vibrant worlds created by experimentation practices focuses on what Gail Davies calls “experimental spatialities”: spaces wherein experts *collaborate with*—rather than *work above*—non-experts and non-humans (Davies, 2010: 670, see also: Livingstone, 2003; Powell and Vasudevan, 2007; Powell, 2007; Krause, 2015). This emphasis on space makes it possible to explore environmental management in the open air as efforts that recompose the worlds that humans inhabit (Lorimer and Driessen, 2014). At the same time, however, geographers emphasize that “an experimental ecological politics could easily be understood as justification for the wildest geo-engineering experiments currently proposed by green capitalists, deepening current patterns of inequality and exploitation” (Lehman and Nelson in Johnson et al., 2014: 445; see also: Mitchell, 2011; Yusoff, 2013; Clark and Yusoff, 2014). Advancing the perspective suggested by this literature, I offer a precautionary note to temper Latour's celebration of open-air experimentation. A critical appraisal of Latour's work shows that while experimentation may be a necessary condition for composing more hospitable worlds, it is not sufficient as a political strategy.

### Latour's ethnography in an open-air laboratory

In October 1991, Bruno Latour joined a group of scientists working at an open-air laboratory in a forest/savanna transition area in Amazonia (Latour, 1995 [1993]). His trip took place between two key events in the recent history of the region: the murder, in 1988, of environmental leader Chico Mendes, and the 1992 “Earth Summit” in Rio de Janeiro (a United Nations conference on “Sustainable Development”). These occurrences, each in its own way, brought Amazonia to the forefront of global political discussions in which Northern populations often framed the region as “Nature under threat” (see: Hecht, 2011). Such narratives foregrounded violence against social movements, widespread deforestation, increasing inequality, and dwindling biodiversity. Against this accretion of despair, Latour described the open-air laboratory he visited as a space of human/non-human collaborations in which scientists could cultivate a sense of optimism rather than a feeling of impending disaster.

Latour's expedition took place at a forest/savanna transition site in which Edileusa Sette-Silva—a botanist who was part of the research team—had carried out systematic interventions over several years: she divided the terrain based on a Cartesian grid, tagged trees, and collected vegetation samples. Through these actions, Sette-Silva discovered that, along a twenty-meter-wide strip of the forest/savannah border, vegetation from both ecosystems grew increasingly intermixed. The news reached French scientist Armand Chauvel, who then organized the expedition to determine whether the forest was advancing over the savanna or vice versa. Latour explained that Chauvel, as a soil scientist, thought that soil erosion was leading to the advance of the savanna. As a botanist, Sette-Silva thought that vegetation dynamics were expanding the forest.

Latour explains how the scientists were able to ask these questions and form opposing hypotheses thanks only to Sette-Silva's building of a laboratory as a space in which the creative capacities of non-human entities could be brought into view. For example, the experiment at the lab was neither designed nor carried out by the scientists. The shift in vegetation patterns was unplanned and found after the fact—as if Sette-Silva had built a laboratory only to realize that an experiment was already being carried out by unidentified entities following an inscrutable plan of action. Chauvel's expedition was intended not to impose a scientific plan at this site but instead to contribute to the ongoing experiment with a new set of tools, among which the “pedocomparator” was particularly important: a rather simple square box with an interior grid (ten rows by ten columns), it allowed scientists to make side-by-side comparisons of soil samples gathered at various depths.

The pedocomparator demanded that Latour and the others spend long hours digging holes, examining the color, texture, and composition of soil samples, and molding soil fragments so they could fit into the pedocomparator's compartments. The tool and associated practices established a chain of transmutations that transformed the forest's soils into samples, then into profiles, and latter into diagrams of transects that rendered perceptible subtle variations in the soil underneath the forest/savanna area. A piece of Amazonia, Latour argues, was materially remade into a “traveling referent”: a portable image that carried with it some of the forest's material attributes to distant places where scientists could work on unveiling elusive ecological processes.

While articulating this chain of transmutation, Sette-Silva and Chauvel found that, contrary to their expectations, the soil below the forest/savannah border was similar to the forest's underground—as if vegetation shifts were *preceded* by changes in the soil. The expedition's question was consequently reformulated: either the forest was creating its own soil and preparing conditions suitable for its expansion or, to the contrary, the savannah was degrading the forest's soils and pushing forest vegetation back. The scientists concluded that Amazonian earthworms were behind this riddle: living at the forest's borders, they ate sandy savannah soils and excreted material with higher clay content, thus transforming the savannas' underground into matter over which forests apparently could grow.

Latour ends his essay with a picture of Chauvel typing at his computer in front of a large map of the Amazon. The author invites us to see in this picture a scientist whose work did not represent an inert Natural world “out there” waiting to be mastered. Chauvel instead acted like the earthworms, taking the forest (in the form of traveling referents) to academic audiences across the world, thus intensifying relations between the forest and spaces of scientific practice. Moreover, the *Photo-Philosophical Montage* shows the open-air laboratory as a space that allows scientists to reveal more hospitable emergent worlds thanks to the actions of entities such as worms that facilitate forest expansion. Scientific knowledge in the open air, Latour concludes, “[speaks] of... a real interior world, the coherence and continuity of which it helps to ensure” (Latour, 1995 [1993]: 170).

Latour's conclusion that experiments in the open air would allow scientists to sense themselves in an “interior world” has important political implications. Consider, for example, the conclusions that scientists might have reached by studying Amazonia as Nature. They would have seen problems too large for any one group to tackle: high deforestation rates, destructive development projects, deadly violence against social movements, and inaction in international environmental law. In these terms Amazonia was too large an object, inaccessible to human action and therefore unavoidably doomed. In contrast, and as Graham Harman put it in his interpretation of Latour's fieldwork, the laboratory offers a vantage point from which it is possible to see that a coherent space

can be created by altering shifting webs of human/non-human relations (Harman, 2009: 76; Harman, 2014: 48, see also Bennett, 2010).

In what follows I will explain that Latour's argument anticipates important shifts in environmental management approaches in the basin that took place in relation to open-air experiments. I will then contend that Latour's ethnographic material and recent ethnographic evidence suggest that his political conclusions are unfounded.

### Experimental politics in Amazonia

Since Latour's trip to Amazonia the region has been the site of the most important open-air experiment in the history of the basin: the *Large-Scale Biosphere–Atmosphere Experiment in Amazonia*, or LBA. The experiment's objectives were to study the functioning of the basin as a “regional entity” and, crucially, to explore how “changes in land use and climate affect the biological, chemical and physical functions of Amazonia” (Nobre et al., 1996). During LBA's more international phase (1998–2006) the experiment brought together more than 1700 scientists and 200 institutions from Brazil, Europe, and the United States (Artaxo, 2012; Nobre et al., 1996). Although LBA projects varied widely, they all focused on human impacts on macro-ecological processes and their results made two things clear: first, that Amazonia was not a Natural space exterior to human impacts, and second, that the basin's highly heterogeneous ecology is undergoing disruptive transformations. Under titles such as *Amazonia and Global Change* (Keller et al., 2009) and *The Amazon Basin in Transition* (Davidson and de Araujo et al., 2012), LBA publications describe the region as advancing toward a “disturbance-dominated regime” in which environmental approaches should be designed to “manage both biophysical and socio-economic transitions” (*idem*: 327; see also A. Nobre, 2014). As Myanna Lahsen and Antonia Walford have shown, LBA campaigns have been particularly influential by establishing data flows linking shifting ecologies to political forums (Lahsen, 2004; Lahsen and Nobre, 2007; Walford, 2012).

The late Bertha Becker argued (Becker, 2004) that the LBA contributed to a profound shift in environmental management. Since the 1990s ecological proposals for Amazonia gradually rejected ideas presupposing the basin as a Natural space that experts could protect or improve based on pre-determined plans (Hochstetler and Keck, 2007). LBA scientists played a role in this shift through policy proposals they designed, such as REDD+ (or Reducing Emissions from Deforestation and forest Degradation, the “+” was for improving carbon stocks). As I have mentioned, REDD+ is a forest management scheme characterized by supporters as “a fundamental test case” for new conservation strategies and “the biggest experiment in tropical conservation history” (Tollerson, 2009). The main idea behind REDD+ is that, rather than excluding humans from Amazonia in order to save Nature, environmentalists should offer local populations monetary payments in exchange for leaving forests standing. These payments would be made in proportion to the amount of carbon that forest conservation efforts prevented from being released into the atmosphere. Central to this approach is the idea that humans (together with the pastures and farmlands they build) are an intrinsic part of the basin's ecology and that environmental management schemes should recruit local populations and agricultural and ranching operations to their cause.

Critics describe REDD+ as “the world's largest experiment” in payments for environmental services (Corbera, 2012) and argue that it operates within conventional environmental frameworks that are intended to control Nature by placing tropical spaces under expert control (Boyd, 2010; Löwbrand, 2009; Gupta et al.,

2012; Beymer-Farris and Bassett, 2012; Lohmann, 2008; Mentore, 2011; Lansing, 2010). However, other scholars show that some REDD+ efforts could promote experimental approaches to environmental management (Agrawal et al., 2011). That is, REDD+ could offer Amazonian peoples a platform for undertaking open-ended negotiations wherein they could advocate for environmental management efforts that would promote traditional land rights, impose a moratorium on macro-development projects and further non-Western modes of living (Wallbott, 2014). Susanna Hecht, for example, attributes to REDD+ the potential to promote expert/non-expert collaborations that could create “socio-natures,” open-ended compositions made of human livelihoods and biophysical dynamics that are co-produced over time (Hecht, 2012; see also Hecht, 2010; Hecht, 2014; Schwartzman et al., 2010).

Developing Latour's Actor Network Theory (ANT), Michel Callon suggested that schemes such as REDD+ could be seen as part of an *in vivo* experiment in climate politics that breaks the colossal issue of climate change into manageable questions such as “how can we scientifically evaluate, and thereby economically value, the effects in terms of greenhouse gas abatement of replanting a forest in a rural area of Brazil?” (Callon, 2009: 544). The smaller questions posed by environmental management schemes such as REDD+, Callon claims, could inspire scientists, economists, and non-experts to collaborate as “researchers in the wild” (*ibid.*: 545; Callon and Rabeharisoa, 2003). Moreover, policies like REDD+ could help environmental scientists and policymakers overcome a sense of despondency as they make “this protean issue of climate change manipulable and manageable. . . Instead of a shock, trauma or complex issue, a dense network of problems appears” (Callon, 2009: 544, emphasis added).

### A critique of Latour's ideas on experimental politics

Recent science/policy developments in Amazonia offer an ideal test case for Latour's ANT arguments on the politics of open-air experimentation. Open-air experiments in Amazonia undermined ideas of the forest as Nature and informed post-natural environmental approaches that were intended to alter shifting networks of problems (Rojas, 2015). Latour deserves credit for anticipating these developments. And yet, recent ethnographic evidence contradicts his assumption that the post-Natural sight of networked ecologies would energize environmental management approaches with a sense of optimism. Take Carlos, for example, a senior LBA scientist who collaborates with scientists who designed the original REDD+ proposal. When I asked him whether his climate/policy work elicited in him optimism about the future of Amazonia he offered a candid, telling rebuke:

I think that is not the way. I think that your rationalizing does not make a lot of sense. I do not think about [environmental crises in Amazonia in terms of] pessimism or optimism—as if it was a two-sided game. The game has millions of sides. This is the main game. To understand the complex dynamics of a region like the Amazon with several socioeconomic aspects—each pushing in its own direction. And then several political aspects, several biophysical aspects—related to the behavior and dynamics of forest–atmosphere interactions. Right? To reduce *that complex network* of mechanisms to just a matter of pessimism or optimism is not possible. It is wrong. It is ridiculous reductionism. I think even infantile.

[emphasis added]

Carlos tells us that his scientific work in the open air unveils networks that carry sinister undertones. Drawing on decades of work in Amazonia's open air he describes climate politics as a “game” with “millions” of “sides,” “aspects,” “dynamics,” and



“interactions.” Carlos sees such a complex situation, unlike Nature’s static framework, as open to world-making collaborations between scientists, politicians, forests, and the atmosphere. Nevertheless, he saw the new worlds that would emerge from these shifting relations as less than hospitable. “Life will be much harder on our planet 50–100 years from now,” Carlos told me, due to “a decision taken by our generation and three generations before us—to increase greenhouse gas concentrations in the atmosphere *in order to achieve economic growth*” (emphasis added). Carlos here made reference to his research on the entanglements of human modes of living in Amazonia (and elsewhere) with the construction of macro-infrastructure projects, the burning of forests, the expansion and intensification of industrial production, and the capitalist idea of endless economic growth.

I should clarify here that Carlos did not believe in Capital. This is to say, for him disruptive economic operations were not an automatic process driven by a single logic. His research revealed something resembling William Connolly’s depiction of capitalist dynamics as a decentralized configuration of human and non-human forces (Connolly, 2013). Carlos’s work revealed complex socio-natural networks whose ecological outcomes would always be open-ended and highly unpredictable—but would invariably lead to potentially catastrophic ecological crises. Such prognosis offered no reasons for either pessimism or optimism.

Carlos’s views were shared by other LBA scientists and also, quite crucially, resonated with Armand Chauvel’s *published* work on Amazonian earthworms. Chauvel never published the results of the brief expedition to which Latour contributed—and which suggested *forest expansion* occurred thanks to Amazonian earthworms. Contrary to Latour’s interpretation, however, Chauvel’s subsequent work offers a bleak interpretation of the collaborations that earthworms established with humans in Amazonia. For example, his most important peer-reviewed publication on the subject, based on decades-long multi-sited research that linked various experimental sites, offered a radically dismal view of the earthworm known as *P. Corethrus*. In this piece, published in *Nature* in 1999, Chauvel described the earthworm as an “aggressive exotic colonist” unwittingly introduced by humans into agricultural lands in which they proliferated thanks to their capacity to survive in low-nutrient, degraded soils and displace native soil fauna. In such places the earthworm could add up to more than 90% of the soil’s fauna, and its excretions—as much as one hundred tons of highly compact clay per year per hectare—saturated the soil’s upper levels with a solid crust that disrupted water and chemical exchanges between soils and the atmosphere (Chauvel et al., 1999).

Chauvel writes that earthworms thus *hampered forest growth* rather than encouraging it and behaved as a soil degradation agent that he describes as “more insidious” than bulldozers or cattle (*ibid.*). As it emerged in the published results of Chauvel’s open-air experiments, the worm is portrayed as a truly “monstrous” entity (not quite animal, not quite human, not quite machine) that echoes and amplifies human impacts as it collaborates to disrupt environmental processes at regional and global scales (*ibid.*, see also other publications to which Chauvel contributed: Barros et al., 2001, 2004). The creative potential of human/non-human collaborations in the open air does not necessarily lead to the construction of a coherent interior space. Chauvel and Carlos describe the open air as a spatiality wherein human/non-human collaborations may reinforce the destructiveness of agricultural operations that appear in their scientific work as what I call “capitalist experiments”: a decentralized and shifting network of landholders, foreign vegetation species, soils, scientific knowledge, and fossil-fuel-intensive technologies that come together in ecological configurations driving macro-ecological disruptions.

I use the expression “capitalist experiment” as an alternative to perspectives that depict contemporary macro-ecological crises as

resulting from the destructiveness of capitalist logics. Such depictions focus on humans who, in order to expand economic operations, replace diverse socio-natural spaces with pre-designed ecologies capable of delivering commodities to global economic circuits. In contrast, a study of capitalist experiments zeroes in on trial and error strategies advanced by land speculators whose capitalistic goals (framed by the drive for endless accumulation of wealth) are pursued by creating ever-shifting socio-natural configurations. In the areas in which scientists such as Carlos and Chauvel work, ranching and agro-industrial ecologies are built by humans who embrace extreme risks and sometimes use violent means to establish novel relations with non-human animals, machines, cash, and fossil fuels (Baletti, 2014; Rojas, forthcoming). In forest/savanna transition areas in Amazonia those who excel in implementing pre-defined economic projects that require tightly controlled environments are likely to find nothing but bankruptcy. Commodities production requires endless experimentation. Only those who are willing to navigate deeply unpredictable situations and build permanently shifting socio-natural configurations are likely to succeed in capitalistic economic competition; a point resonating with Lippert (2015). I will now elaborate on these points by shifting my attention to scientific practices that link open-air science/policy experiments with unfolding capitalist experiments in Amazonia.

### Open-air experiments in contemporary Amazonia

In 2012 I visited an open-air laboratory in a forest/savanna transition area in Amazonia built by a science team that had collaborated with Carlos in LBA projects. The laboratory comprised three land-cover types: undisturbed forest, degraded forests, and monocrop farmlands. At monocrop sites it was farmers—not scientists—who intervened in the landscape by transforming native ecosystems into hundreds of thousands of acres in which they constantly tried novel agro-industrial methods. Meanwhile, in nearby forests pathways in the native vegetation were opened, creating a Cartesian grid of trails that made it possible to carefully follow vegetation dynamics. Distributed throughout the grid were several 10-meter-deep pits containing instruments that monitored underground humidity. Similarly, dozens of sensors placed across the area measured aboveground temperature, humidity, rainfall, and solar radiation. A large set of strategically placed nets captured litterfall (dead leaves and branches) while measuring belts that were permanently fixed to dozens of trees monitored biomass growth. At various spots traps monitored the growth of micro-roots while dozens of tubes protruding from the ground allowed my interlocutors to plug in equipment to measure “soil respiration.”

However, the most important intervention carried out in the forest involved periodic disturbances through which the science team created ecological conditions similar to those anticipated for Amazonian futures. Scientists believed that climate change—in the form of changes in atmospheric temperatures—combined with regional deforestation (driven by agricultural expansion) was creating a dryer regional climate in which droughts were becoming more frequent and severe. Dryer forests were prone to fires that created inroads that could make it easier for savanna vegetation to advance—thus driving macro-ecological disruptions. The experiment I visited was designed to shed light on these ecological shifts by placing various forest sites under varying levels of environmental stress. Scientists could then closely follow processes such as agricultural expansion that altered a complex web of relations in ways that could remake swaths of the basin. As a young scientist working in the laboratory stated:

Climate change, land use change, biodiversity loss, food production, and expansion of agricultural areas, these are all inter-

linked factors. *So it is a web.* Whatever you do you will affect all [other] processes. [Environmental issues] have to be tackled in a very broad way in order to imagine these processes together. [emphasis added]

The experiment made explicit unstable webs wherein the active role of non-human entities amplified, echoed and shaped macro-ecological shifts. As we walked around the lab my interlocutors constantly compared their efforts with those of previous research projects from which they borrowed strategies to unveil the creative actions of non-humans. In one such occasion, the most senior researcher at the laboratory during my trip, a scientist I will call Margaret, told us the story of a scientist who, over the course of several months, tried to “kill a tree” in a pioneer rain-exclusion experiment. The experiment she described diverted rainfall from a plot in the middle of which a large tree stood in order to trace the tree’s physiological changes under water stress. The experiment, however, ran into trouble when the tree continued to live seemingly unaffected—possibly thanks to its root system’s expanding beyond the rain-exclusion area. In response to the tree’s unexpected response the scientist expanded the rainfall exclusion area and dug a trench all around the site in order to limit underground water infiltration. And yet, after all that, Margaret told us in laughter, the tree survived, forcing the scientist to abandon the experiment.

The scientist’s failure to “kill the tree” was particularly fascinating for my interlocutors as it proved a point that was extremely dear to them: plants respond in creative and unanticipated ways to human actions and to each other’s behavior. Rather than facing a passive Nature, they engaged unruly entities and shifting socio-natural landscapes (Beisel, 2015; Rodríguez-Giralt, 2015). When scientists explained this point to me (which they often did) they repeatedly referred to a previous LBA experiment that simulated a four-year drought by deploying plastic-foil panels that excluded up to 60% of total rainfall over one hectare of Amazonian forests. Some months into the experiment, a scientist involved in the project recounted, “some trees started to [pause]... Let’s say they went crazy.” By which he meant that unanticipated plant behavior was observed. For example, some trees transformed their root systems by growing larger capillary roots close to the surface where they captured moisture from the air and redirected humidity downwards, from the surface and toward drier, lower soils. Over the short term, the site’s vegetation showed “resilience” to hydric stress as plants exhibited a wide repertoire of responses to the scientists’ actions. Crucially, in the fourth year of the simulated drought, large-tree mortality spiked beyond anticipation, suggesting that a threshold (or tipping point) had been crossed. As large trees began to die they left under-canopy vegetation exposed to direct solar radiation, further undermining the living conditions for smaller plants. At this point the plastic panels were removed, and the study focused on how degraded forest recuperated with the return of rainfall. The experiment I visited was similarly designed. My interlocutors saw human-driven ecological crises as an opportunity to examine creative non-human actions.

### Capitalist experiments

As they worked in open-air laboratory scientists labored to make explicit the ways in which human and non-human collaborations composed local ecosystems. For example, Margaret often busied herself taking soil samples through actions reminiscent of Chauvel’s engagements—although she had no pedocomparator and her operations were unsystematic and improvised. On one occasion, Margaret took drilling tools to a site at which forests

bordered monocrop plantations that extended over tens of thousands of acres. She dug vertically, extracting soil samples as large as baseballs and laid them on the ground in order of extraction—thus building a crude profile that showed a sandy composition at the top and a clay-like consistency at the lower levels. As she did this, Margaret taught those who accompanied her that to facilitate studying the samples we could add a little water and press the mud between our fingers. She encouraged us to smell the earth, compare the colors of samples and even persuaded some of us—those whose enthusiasm overcame concerns about agrochemical concentrations—to taste tiny bits of the underground in order to verify the presence of saline elements. As we manipulated the soil, my companions discussed the probable history of “soil disturbance” that was made explicit in this profile. A more rigorous study, Margaret speculated, would find a deep layer with traces of a once-existing forest. Then, the observer would find a succession of rapid shifts: the forest was burned down, a ranching site and cattle ground had been established, and some years later mechanized agriculture had arrived. The top layers would contain biomass from genetically modified harvests, the remnants of recent commodity shipments to China and Europe.

Margaret’s contribution to the experiment consisted in a set of instruments that would amplify the capacity to sense Amazonia as a space in which human and non-human entities mixed in shifting configurations. She was helping to equip the laboratory with a set of eddy flux towers like dozens of others her institution had helped to build across the world. The towers were loaded with instruments that generated real-time “data streams”: tens of measurements per minute on land–atmosphere exchanges (water, carbon and other trace gases) as well as data on climate (temperature, solar radiation, etc.). The laboratory would soon be brought within a “vast machine” of global environmental observations (Edwards, 2010) wherein streams of information would cut across Amazonian sites and research centers across the globe—a more powerful version of Latour’s “circulating referents.”

Margaret explained that the flow of data established by the towers made it possible to explore whether there was “some critical threshold that you [might] reach,” a point at which large-scale agricultural disturbances will lead to a “feedback loop” wherein the loss of some forests would lead to “losing the rest of your forest.” Tellingly, for Margaret the scientific and political challenge in tracing the possibility of such macro-ecological collapse was *not* to understand human threats to Nature. Her efforts were oriented toward contemporary modes of human living in wealthy parts of the world that were permanently “catching up” with science in the sense of altering the Earth System that scientists like Margaret studied. “The world is catching up on us,” Margaret claimed,

People won’t stop messing with stuff [and] now many things are changing. Climate is changing, CO<sub>2</sub> levels are changing. You know? Air pollution is increasing, particles in the atmosphere are increasing. . . we are dumping more nitrogen on ecosystems. . . You name it! All is different. And in a big way. So the hard part is not observing change, but trying to attribute it, to, to locate it. . .

Margaret’s skills—and those of her colleagues—were needed to step out of environments under control and into the open air—a space of never-ending experimentation in which they could “watch” unsettling worlds in the making. My interlocutors worked diligently to make explicit how, *because of* ecological disruptions driven by capitalist operations and lifestyles, animated worlds emerged offering abundant data about uncertain futures. Such a perspective informed the policy efforts derived from their research.

## Experimental politics in the open air

Scientists expected that experimental research on Amazonia's "complex network" could inform future REDD+ initiatives or similar programs. The idea was to determine carbon emissions generated by various agro-industrial practices and thus show which farming procedures were less carbon-intensive. Such information could be used to certify landholders who, having adopted "good agricultural practices" (low-emissions methods), could be rewarded with carbon payments through a REDD+ program. This approach required experimental collaboration between farmers and scientists who would use towers, machinery, agrochemicals, and engineered plants over successions of harvests to collectively determine the diverging ecological impacts of various agro-industrial methods. The effort did *not* place agricultural operations under the command of environmental scientists. To the contrary, the idea was that scientists would learn to make environmental management projects compatible with the experimental intensification of agro-industrial operations. Scientists were firmly placing themselves in an open air that, as Margaret had shown, was created by humans and non-humans who collectively composed spaces suitable for capitalist ecologies that were built in order to permanently increase yields and profits.

The experimental spatialities thus created are reminiscent of Fabian Muniesa and Michel Callon's analysis of *in vivo* political/scientific experimentation. Callon and Muniesa argue that experiments represent more than a way of generating knowledge about the world; they "provoke" new worlds whose characteristics will vary depending on the space in which the provocation takes place (2007). They describe three ideal types of experimental spaces (and therefore three kinds of provocations): the "laboratory," the "platform," and the "*in vivo* experiment." "Laboratories," Muniesa and Callon argue, presuppose a clear-cut separation between an "interior" and an "exterior": in the interior of the laboratory experts find solutions to predefined problems which are then sent outside for implementation (*ibid.*: 170–173). A good example of "laboratory" initiatives can be found in expert plans to "save" Amazonia by creating natural parks designed by experts to keep non-experts outside pristine environments.

The "platform," on the other hand, is a space for experimentation that questions the distinction between the "inside" and "outside" of the lab. Platforms also favor "research in the wild" (Callon and Rabeharisoa, 2003) wherein broad publics have a say in the problems and objectives that define science/policy experiments (Muniesa and Callon, 2007: 173–174). A few years before my visit, the Amazonian experiment had functioned as a "platform" housing a greenhouse in which environmentalists grew native tree species that were distributed to nearby landholders who requested stalks to be used in reforestation projects.

Finally, the "*in vivo* experiment" as defined by Muniesa and Callon opens the platform and entirely abolishes the distinction between the "inside" and the "outside" (thus creating what I call the "open air"). The list of *in vivo* experiment participants is not defined in anticipation—one of an *in vivo* experiment's objectives is to render explicit new participants and bring them within the experimentation collective (*ibid.*: 178–179). The REDD+ approach to which scientists hoped to contribute was one such project as it did not prescribe what producers should do but offered environmental data and economic incentives so agricultural entrepreneurs could innovate—creating new procedures and investing in novel economic undertakings. Scientists hoped a certification approach would attract an undetermined pool of participants who would join an unstable and open-ended chain of market transactions. The scientific/agro-industrial experiment would quite literally pro-

voke new worlds through novel modes of farming, unprecedented alliances and associations, new commodity shipments, and altered levels of atmospheric pollution and nutrient runoffs. This *in vivo* approach was *not* intended to "save Nature," preserve Amazonian human/non-human associations in their current form, or even avoid potentially catastrophic futures. A young scientist assigned to work with data from Margaret's towers made this clear when I asked whether the environmental policies his team supported could avert future ecological crises. He offered a negative response:

Even if we stop [agro-industrial operations] we would have, in the long term, the effects of [the environmental disruptions] we have already caused. So to think we can avoid [ecological crises] is utopian. We cannot. I think we cannot. [pause] We have provisions that there are some actions that seem to be more effective, that seem to have a certain effect, a reasonable effect, in reducing some aspects of such crises. Therefore, these tools should be prioritized and have continuity in order to secure this process.

Without exception, the members of the science team explained that experimental approaches to environmental management were analogous to their scientific projects in that they led them into the unruly open air. The policy goals they sensed could be attained in the open air were modest, to lay the least: "to have a *certain* effect, a *reasonable* effect in reducing *some aspects* of such crises." My interlocutors did not command but rather fiddled within capitalist networks working alongside non-human entities under the premise that agro-industrial intensification could not be halted. I asked Carlos if the subordinate position of environmental scientists and ecological goals within experimental forest management strategies was a cause of frustration. He offered a negative response.

No! It is not depressing nor frustrating [laughing out loud]. It is simply the way society works! [laughs]. When you say it is frustrating, it is because you want to ignore the sociopolitical and social functioning of our planet. Our planet is not driven by science. This is the mistake in your thinking. Because science does not command the planet, science does not drive the planet and it should not do so. Science is just one of the aspects, and not the most important one. People need to eat, they need to move, they need to have a minimum living standard.

For Carlos the subordinate political position of environmental scientists did not mean that the monolithic forces of Nature or Capital determined the outcomes of policy/science efforts. Like his colleagues, he argued that scientists should take part in a vast experiment while learning to collaborate with non-experts and remaining open to novel, emerging worlds. These worlds in the making were composed by networks that, however agile and unstable, could *not* be altered in certain significant ways. Ongoing capitalist experiments were unlikely to end any time soon and they were expected to intensify in a non-linear and decentralized fashion marked by cycles of boom and bust. Scientists anticipated that agro-chemicals, machinery, guns, and engineered organisms would continue to combine in unsteady, complex networks that allowed a tiny number of capitalists to take control of most of the land and profitably exploit hundreds of thousands of acres (Rojas, 2015). These agro-industrial experiments resulted in Brazilian agro-industrial corporations that offered vast financial support to political campaigns, lobbying firms, and pro-corporate NGOs. This combination of experimental forest management strategies and capitalist agro-industrial experiments would create new worlds indeed, but scientists expected these worlds to be less than hospitable.



## Conclusion: The open air as experimental spatiality

Latour's essential contribution to the study of experiments that are carried out beyond laboratory walls underlines how, by stepping into the open air, environmentally concerned populations can overcome despondency and take radical action in response to problems like climate change. From this perspective, conventional environmental management strategies that aim at saving Nature are self-defeating as they offer “nothing but a gloomy asceticism, a terror of trespassing Nature, and a diffidence toward industry, innovation, technology, and science” (Latour, 2011b). As a consequence, conventional environmentalism remains politically marginal, a conservative proposal unable to excite the imagination of persons and groups who are immobilized by the sense that issues such as climate change are too large for humans who feel forced to act on their own (*ibid.*). Open-air experimentation offers an antidote to this political debacle. It allows environmental managers like Carlos to place themselves in the open air, in a space in which they can address problems such as climate change as a “complex network.” Unlike Nature, this network can be re-composed by humans in collaboration with non-humans that range from forests and their denizens to the atmosphere and agro-industrial infrastructures. In the open air, environmentally concerned populations see opportunities for political collaboration multiply and, instead of trying to save pre-determined orders, join optimistic projects that leave “nothing... off the table” (Latour, 2004: 455; Latour, 2005).

As I have shown, the recent history of Amazonia confirms Latour's ethnographic insights into the political significance of open-air experiments. His rightly celebrated Amazonian ethnography demonstrates that, in the open air, scientists study something other than Nature—they study a network of relations undergoing transformations driven by the creative actions of entities that include non-humans such as earthworms. After his fieldwork in 1991 parts of Amazonia became experimental spaces in which environmental managers learned from their scientific work and moved away from efforts to save Nature. Policies such as REDD+ represent climate politics “after Nature,” demanding that experts and non-experts collaborate in environmental, economic, and political experiments. Placing themselves in the open air, environmentalists contribute to REDD+ in ways that, as MacKenzie et al. point out in relation to economic experiments, “multiply possible worlds” (MacKenzie et al., 2007: 15; Callon, 2009).

And yet, despite their experimental tenor, policies like REDD+ have *not* succeeded in rekindling “energy, optimism, ideals and forward-looking democratic spirit” (Latour, 2008: 2). My point here is *not* that, as I mentioned, important groups criticize REDD+ proposals on very solid grounds or that this policy is fraught with severe problems and contradictions. Rather, my point is that *even among REDD+ supporters this experimental policy does not rekindle a sense of optimism*. Although REDD+ does indeed lead to political actions, these are driven by a singular experimental fatalism. The scientists with whom I worked experienced the multiplication of possible worlds, recognized the creativity of non-human entities, and multiplied expert/non-expert and human/non-human collaborations. They did so while sensing that the open air in which they placed themselves was becoming less and less inhabitable. Ethnographic evidence thus shows that Latour's all-inclusive experimental “table” is ample enough to provide room for capitalistic experiments that are likely to intensify socio-natural disruptions.

My ethnographic critique complements theoretical critiques of Latour's claims about experimental politics. As Graham Harman has pointed out, Latour's political proposals are based on the idea that the worlds that humans should aim at re-composing are not made of invariable, self-contained *totalities*—but of *relations* that can be tinkered with (Harman, 2009, 2014). Latour's Amazonia,

for example, is not Nature under threat by Society or Capital, but a network open to re-composition. And yet we learn from scientists working in the open air that the networks they study, while shifting and open to intervention, bear qualities that are extremely hard for *them* to shift. Yes, scientists can alter the use of agrochemicals in Amazonia's expanding monocrop landscapes and thus contribute to multiplying possible worlds. But no, scientists do not see these efforts as capable of composing more inhabitable worlds. REDD+ experiments are carried out with the understanding that attachments between humans and agro-industrial technologies, soils, forests, and the atmosphere can be profoundly restricting. More attachments and collaborations do not necessarily lead to desirable outcomes. Scientists sense that the “increasing attachments between things and people at an ever-expanding scale” for which Latour (2011b) advocates brings them deeper into potentially catastrophic futures.

“Love your monsters,” Latour advises when writing about fossil fuels and industrial technologies (Latour, 2011). Chauvel's depiction of a monstrous soil-degrading earthworm that can be compared to bulldozers and cattle remind us that such advice may be all too simple in spaces like Amazonia. It ignores the monstrosity of human/non-human attachments that are powerful enough to recruit even environmental scientists into contributing to the expansion of environmentally-destructive landscapes shaped by colonial and capitalist experiments (Watts, 2011; Mitchell, 2011; Tilley, 2011; Fortun, 2014). A critical ethnographic appraisal of Latour's visionary work in Amazonia is highly valuable, I contend, insofar as it clarifies that endless multiplication of possible worlds and an ever-growing catalog of human/non-human relations need not lead to the “coherence and continuity” of a more hospitable “interior world.” By itself experimentation does not answer key questions such as how to detach ourselves from, for example, ecologically disruptive agro-industrial machineries. Failing to recognize such matters entails ignoring that even radical eco-political experimentation may lead to environmental management approaches that compose an open air in which only a minuscule minority of humans can thrive.

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