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Envisioning Amazonia: Geospatial technology, legality and the (dis) enchantments of infrastructure

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Abstract
The article discusses the sociotechnical infrastructures of deforestation detection in the Brazilian Amazon and the forms of visibility and legality these enact. It draws upon a long-term ethnographic study of how digital infrastructures impinge upon, and are enacted as, social relations. We focus upon the role of satellite images in these processes and on how the arrangements for their production and circulation become sites where knowledge and 'un-knowledge' are engendered and environmental politics waged.

Keywords
Deforestation, Amazon, politics of knowledge, data infrastructure, geospatial technology

Introduction

Among the many tragedies of the commons that afflict the contemporary world, the lingering death of the Amazonian rainforest is particularly emblematic. Forest-loss, argue Lövbrand and Stripple (2006),'re-territorialises' 'global' narratives of climate change, mapping them onto specific geographically bounded forests. Brazil's tropical forest remains the largest in the world and home to some of its richest ecosystems. The efforts to 'sustainably' manage this forest could therefore be seen as representative of the global 'sustainability' drive as a whole. Speaking at the turn of the century, US Vice-President Al Gore (1998) argued that information technologies such as 'high resolution satellite imagery of the planet,

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digital maps, and economic, social, and demographic information' cannot but bring about better 'decision-making for a sustainable future, land-use planning, agricultural, and crisis management'. Indeed, the new digital infrastructures centered around satellite imaging and Geographical Information Systems (GIS) are still thought to make possible what Annelise Riles (2000: 179) calls a 'governance by *fact*'. At the same time, anthropologists have highlighted what Harvey and Knox (2012) call 'the enchantments of infrastructure' noting that infrastructures rarely, if ever, fulfill the demands, promises and expectations projected onto them. Arguably, one common symptom of such 'enchantment' is the tendency, as Wendy Chun (2006: 9) puts it, to accept '[techno-]propaganda as technological reality, and [to conflate] possibility with probability'. We therefore need to focus on how digital infrastructures function in practice rather than merely on how they are supposed to function.

The satellite en-visioning of Amazonia is instructive in this respect. In many ways the 'jungle' appears to stand, literally as well as metaphorically, as the Other of order and organisation. It can be rendered manageable only insofar as its opacity is penetrated and is made known in particular ways. The article therefore sets out to address a number of interrelated questions: How do the new digital infrastructures of deforestation detection impinge upon, and are enacted as, social relations? What are the forms of visibility and legality they enact? Empirically, the paper is based upon an on-going 10-year 'multi-sited' (Marcus, 1995) ethnographic study of the practices and technologies for monitoring the forest. We have sought to understand the different ways that the systems (and the labours) of imaging and administering Amazonia are being performed in a broad range of empirical settings. These included the sites where digital infrastructures are operated and maintained – such as Brasília where the Ministry of the Environment and IBAMA the Federal, Environmental Agency are located and São José dos Campos where INPE (the Institute for Space Research) is based - to the forest clearings along the 'deforestation arc' (see Figure 1). To this end, the research utilised a number of methods ranging from interviews – with practitioners, INPE scientists, officials and relevant policy actors in Brasilia (over 143 formal interviews conducted plus many more informal conversations) – to the ethnographic observation of ranger patrols in deforestation hot spots (i.e. Alta Floresta, Juina and Sinop) as well as the analysis of satellite data, agency reports and other forms of institutional documentation. The themes of this article emerged from the data through an extended case analysis (Tavory and Timmermans, 2009).

The rest of the article is organised as follows. The first section outlines the sociopolitical developments, forces and discourses out of which the present digital infrastructures for envisioning Amazonia have historically emerged. We then shift our focus from the political and scientific 'centres of calculation' (Latour, 1987) to the farms and ranches along the still relentlessly advancing 'deforestation arc' where the mundane work of deforestation detection and law enforcement is (or fails to be) performed. The final sections of the paper consider some of the implications of the argument developed here for the understanding of geospatial technologies as sites where contests over notions of government, development, conservation and the public good are routinely waged.

The view from the top

In *Seeing Like a State*, Scott (1998) notes that states tend to develop distinctive ways of viewing their territories, ways that are constitutive of the manner wherein threats are framed, opportunities identified and schemes of improvement devised (Zukosky, 2007; Li,

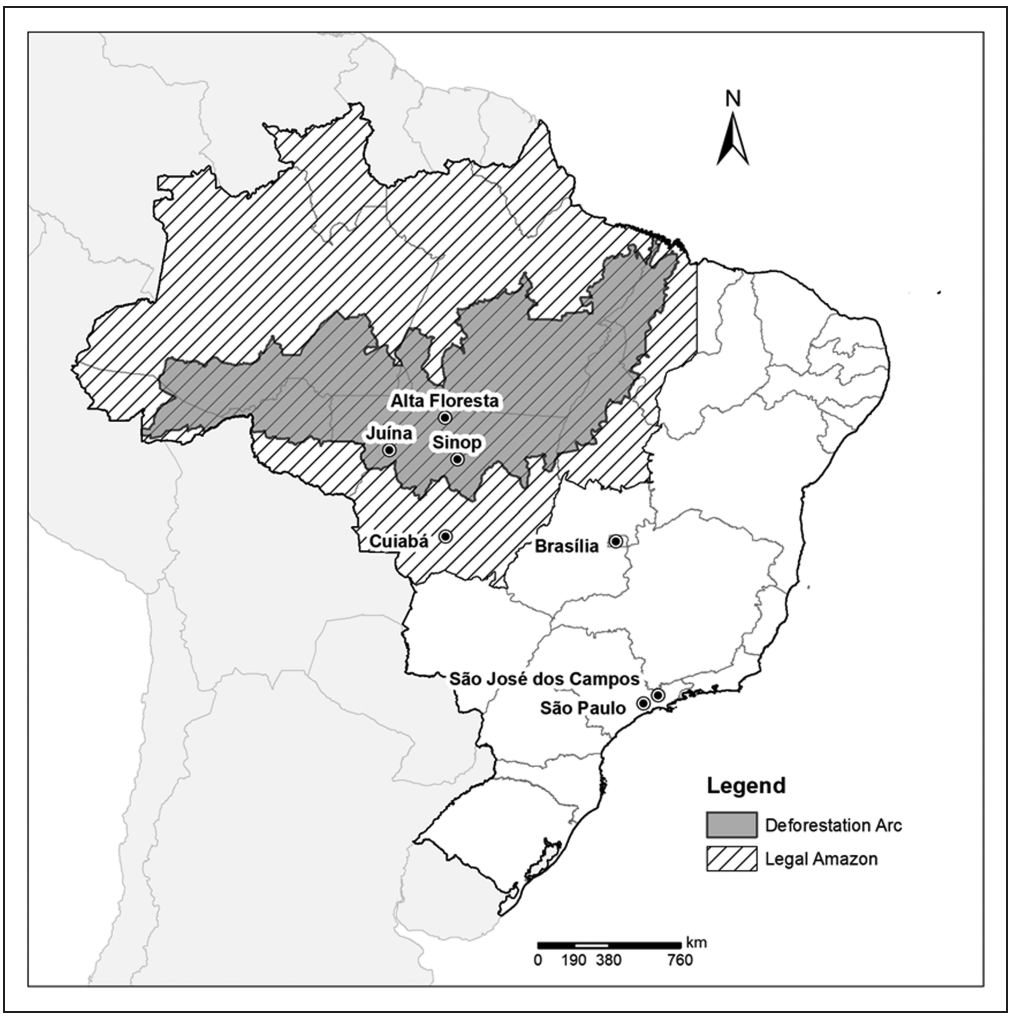

Figure 1. The research sites.

1999; Miller and Rose, 1990). Thus, data infrastructures could and should be understood as apparatuses of governmentality (Foucault, 2010) that reveal, *inter alia*, the 'forms of political rationality that underlie technological projects' (Larkin, 2013: 328; Collier, 2011). The envisioning of Amazonia reflects this pattern. No other major tropical forest in the world has been monitored so intensively, for so long and for such different reasons. For the military regime which – in the wake of the 1964 *coup* – initiated this monitoring, the Amazon presented urgent problems of *security* and *sovereignty*. The opacity of the rainforest, it was feared, prevented the state from knowing whether settlers from other countries might be infiltrating remote parts of the region. The regime's 'National Integration Plan' therefore highlighted the colonisation of the Amazon with small farmers from the overcrowded Northeast as a national priority in need of a reliable database. The newly created National Institute for Space Research (INPE, 2008), a powerful symbol of Brazil's modernity and technological prowess, was thus assigned with developing the remote monitoring

systems necessary *inter alia* for 'providing information to improve the process of occupation of the Amazon' (Novaes et al., 1980: 10). As an INPE scientist explained:

> The lack of knowledge was considerable as was the fear of international greed as indicated by the slogan 'integrate [the Amazon] to avoid losing it' .... [So] from the beginning, INPE had the mission to address this issue ... via remote sensing. (Interviewee/#35/2007)

As Amazonian colonisation gathered pace, it became increasingly important to be able to centrally monitor just how much of the forest was *in fact* being converted into farms and cattle ranches. To meet this need, INPE and the Brazilian Institute for Forestry Development (IBDF) generated a number of Amazon-wide deforestation assessments. Initial results were not encouraging for state planners. Alarmed by data indicating *low* deforestation rates (De Mello, 2006), they began to re-evaluate the conduct of the project. The focus on small settlers now appeared to have resulted in a scattershot approach to Amazonian colonisation and to be in urgent need of rationalisation. As a result, by the mid-1970s there was a change of emphasis away from small farmers and towards big corporations and private investors. A change that is also indicative of a shift in the way that Amazonian forest was problematised: as anxieties regarding foreign intrusion ebbed, concerns regarding *development* came to the fore.

Whilst there was widespread conviction that Amazonia was rich in natural resources, noone could be sure what these resources were, where they were located, or how they might be extracted (Gonçalves, 2005). Remote sensing technologies, such as airborne radar and satellite images were therefore obvious solutions in this quest to 'separate myth from reality' (Pereira, 1971: 90). Technologically generated visualisations became central to the planning of new roads and to the siting of new logging, agricultural or mining projects. In spite of concerns voiced by anthropologists hired by the World Bank to evaluate the impact of development projects on indigenous populations (Price, 1989), substantial loans were provided by international institutions for the construction of roads and dams, the digging of mines and the clearing of forest for ranching (Hecht and Cockburn, 1989: 116). Enticed by subsidies and tax breaks, international investors flocked to the region. Amazonian 'development', however, remained plagued with anxieties that the large sums allocated to grandiose projects in remote locations might merely fuel corruption. Projects, it was feared, might 'remain on paper', as investors bribed officials to 'turn a blind eye'. Ways of seeing were therefore needed that were not reliant on the corruptible eyes of local officials. Geospatial technology appeared as the obvious technical fix in this quest for incorruptible vision (Rajão and Hayes, 2009). Thus, one of INPE's main tasks during the 1970s–1980s was to gather data on whether Amazonian development projects were indeed being carried out (Tardin et al., 1979). As a senior INPE scientist who had been involved in this enterprise put it: 'How else could the government inspect such remote areas if not with satellites?' (Interviewee/#72/2009)

It is worth reflecting at this point on the illegibilities that are created by such apparatuses of visibility. It should be clear by what has been said so far, that under the logics of 'sovereignty' and 'development', deforestation did not register as a problem – other than in terms of possible risks to future wood production and desertification. Officials were convinced that timberland conservation requirement of 50% of all private properties set in the new Brazilian Forestry Code compiled in 1965 would be more than enough to ensure a rational use of Amazonia's natural resources (Ahrens, 2007). Nonetheless, by the early 1970s the term 'tropical deforestation' was already emerging as an *environmental* issue with global consequences, and not simply as a matter of reliable timber supply.

A UN report (Matthews et al., 1971) initiated a series of papers exploring the rainforest's influence upon the global climate and its value as a 'genetic reservoir'. Work by anthropologists (Meggers, 1971; Price, 1989), ecologists (Richards, 1970) and geographers (Denevan, 1973) provided compelling evidence regarding the effects of deforestation on wildlife and on indigenous populations. The Amazonian rainforest was no longer an impenetrable jungle waiting to be tamed by human enterprise, but a fragile ecosystem in need of protection.

Initially, however, calls to protect the rainforest made little impact. Qualitative studies carried out by anthropologists were dismissed by government (natural) scientists and policy makers as ideologically antagonistic towards state-sponsored development (Schor, 2008; Rajão, 2011). There was a widespread view among INPE scientists that the only rigorous, and thus admissible, data on Amazonian deforestation was that obtainable by means of satellite technologies: only those with access to such technology were able to make credible statements about the subject. Until the 1980s, most agencies using GIS were broadly aligned with the Brazilian government agenda. Geospatial data was therefore mainly used to *undermine* claims that the rainforest was in danger. Officials could dismiss environmentalist concerns and anthropological and biological studies by arguing that deforestation was limited and ultimately harmless (Bourne, 1978). Similarly, the UN Food and Agriculture Foundation (FAO), one of few institutions with geospatial capabilities, was equally dismissive of environmentalist concerns (Emmelin, 1972: 136; FAO, 1976). FAO's (1981) assessment of tropical forests was thus presented as proof that deforestation was under control, and it was in any case a necessary step in the development of tropical countries. Thus officials argued that fears of forest loss were 'excessive and misdirected' and environmentalists were being far too 'speculative' in their assessments of the relation between deforestation and global weather (Clayton, 1982). It is evident then that technological apparatuses of visibility played a key role not only in facilitating the implementation of a developmentalist agenda but also in de-legitimating environmental(ist) concerns about the Amazon.

The restoration of democracy in the 1980s brought in its wake an increased sensitivity to international criticism of the accumulating environmental damage of the development agenda. Study after study showed that deforestation had been systematically underestimated (Fearnside, 1982; Malingreau and Crompton, 1988). Scientific critics, we might say, began to use the official developmentalist apparatuses of data generation in order to make the fate of the Amazon visible in a different way. They were thus most successful when they used geospatial data to create their own mathematical projections of Amazonia's future. Fearnside (1982) used INPE's deforestation data for the years 1975 and 1978 to argue that deforestation was growing exponentially and that the Amazon rainforest could well disappear by the end of the century. Using the last Amazon-wide deforestation assessment then available (for the year 1978) together with some extensive but incomplete assessments for the years 1980 and 1983, World Bank economist Dennis Mahar (1989) argued that the growth of deforestation was in fact, exponential:

> Landsat images were cited as proof [by the Brazilian government] that the environmentalists – some of whom had predicted the demise of the Amazonian forest by the end of the century – had greatly exaggerated their case (Denevan, 1973). More recent data, however, make it clear that there was no cause for complacency. [...] The 1988 figure is equivalent to 12 percent of Amazonia and is larger than France. (Mahar, 1989:7)

Such predictions therefore 'collide[d] with one of the Amazon's great illusions: the illusion of infinite size' (Fearnside, 1982: 82).

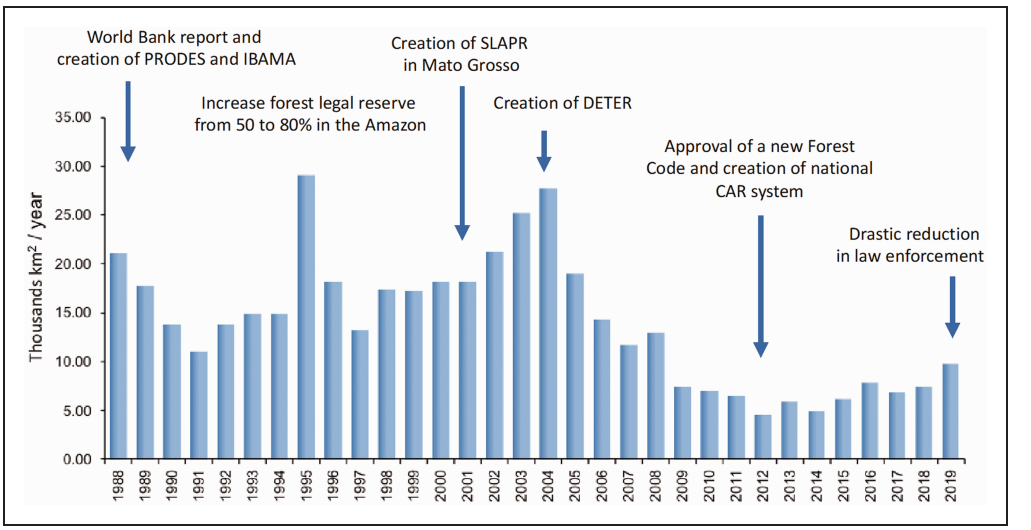

Figure 2. Annual deforestation rates estimated by PRODES/INPE and the year of creation of key policies and technologies.

Following Mahar's study, international banks suspended the disbursement of loans the Brazilian government forcing a U-Turn on its policies towards the Amazon (Hecht and Cockburn, 1989). Furthermore, Grass-roots movements, such as that led by the rubber tapper Chico Mendes, were attracting increasing attention in the international media. The 1988 assassination of Mendes and the publication of Space Shuttle pictures showing large areas of the Amazon on fire precipitated a political crisis (Gonçalves, 2005). Amidst the mounting international crisis, the government asked INPE to create PRODES, a new system based on orbital remote sensing with which to more accurately measure yearly deforestation rates (Figure 2). The aim of PRODES was two-fold. First, the government wanted to 'demonstrate to the international community our [Brazil's] concern with the environment', as a senior politician who was one of the protagonists in these events explained (Interviewee/#7/2007). By creating a technological apparatus that would regularly monitor deforestation (instead of sporadically), the government would establish its credentials as a competent manager of the rainforest. The system was therefore expected to provide (what officials termed) 'objective' (quantitative) data to challenge Mahar's projections (Tardin et al., 1989: 3). A senior INPE scientist involved in the development of the system summarised the political motivation thus: 'Back then it was clear that PRODES was only about generating a number before an adventurer [i.e. critic] does so' – Interviewee/#35/2009).

In addition to creating PRODES, the Brazilian government also made a number of constitutional and policy changes, inaugurating environmental education, establishing new national parks and, importantly, abolishing subsidies for cattle ranching, a key driver of Amazonian deforestation (Browder, 1988). The environmental law enforcement agency (IBAMA) was created to control deforestation in the region (Brasil, 1989: Art.44).

Subsequent crises that took place in the 1990s and 2000s would also prompt similar reactions. In the wake of a spike in deforestation rates (1995), the Forest Code was revised with the 'legal reserve' increased from 50% to 80% for the rainforest biome. Thus, owners of properties located in the rainforest must retain 80% of the original forest (in addition to

any 'Areas of Special Preservation' such as riparian zones, slopes and mountain tops) with only the remaining 20% available for farming or ranching. In 2003, Environment Minister Marina Silva (herself the daughter of Amazonian rubber tappers) made PRODES satellite images and deforestation maps (formerly classified as matters of state security) available on the Internet. The same period saw the inauguration of a number of new systems, notably DETER which provides IBAMA agents with fortnightly reports of new deforestation. Satellite data thus became important for all those, whether within or outside the state apparatus (including NGOs) seeking to advance sustainability agendas. INPE's monitoring systems, which for much of their history had been held under suspicion by NGOs and members of the scientific community (Fearnside, 1993) have therefore come to be regarded as the 'envy of the world' (Kintisch, 2007: 536). INPE has become one of the most cited sources of deforestation data, featuring in many academic articles and NGO reports (Fearnside, 2005; Greenpeace, 2008). Many of the former critics of INPE now defend the institution against government attempts to outsource monitoring activities to private companies (Stokstad, 2017) or the interference of the current Bolsonaro Administration (e.g. BBC, 2019; Spring and Eisenhammer, 2019).

The emerging emphasis on 'conservation' and the associated redefinition of (unauthorised) forest clearing as an environmental crime ('deforestation') does not however *displace* developmentalist agendas (e.g. Simmons et al., 2019). As we shall see, both these 'rationalities' (Miller and Rose, 1990) *and* their associated modes of knowing and ordering (Law, 1994) still co-inhabit the infrastructures of administration and continue to mediate the Amazon qua *both* a fragile ecosystem in need of conservation *and* a perennial resource frontier.

The view from the ground

'An infrastructure occurs', argue Star and Ruhleder (1996:114), 'when the tension between local and global is resolved'. What are then the tensions between global and local, how are they problematised, and how do they get (or fail to be) resolved? In his classic study of the work practices of 'street-level bureaucrats' (such as police officers or social workers), Lipsky (1980: xiii) argued that 'the routines they establish, and the devices they invent to cope with uncertainties and work pressures effectively *become* the public policies they carry out' (emphasis in original). Modern administration, Weber (1978) notes, typically operates by displacing the events it seeks to manage from their original social contexts to the secluded physical space of 'the Office' where they can be (impartially) processed in line with the rules of the institution (Becker and Clark, 2001). The *local* actor-networkings of street-level bureaucrats appear to short-circuit this process. The *de facto* 'de-coupling' (Meyer and Rowan, 1977) of local practices from formal policies is highly problematic for managers who find it difficult to rein in their agents' discretion and to direct it in line with institutional goals (Prottas, 1978). In the case of, what we might call, 'jungle bureaucrats' – those agents tasked with enforcing the law and implementing environmental policies in Amazonia – this problem is, if anything, more acute.

The profile of the forest rangers recruited by IBAMA following its creation in 1989, was a world away from that of the well-educated, well-paid officials in Brasília. The majority had only an elementary or technical education and had been recruited from the local population. Pay was low and resources few. Rangers were suspected to be much closer to the values and views of the farmers they had to inspect than to those of the distant bureaucrats managing them. Many of those rangers had formerly worked for IBDF, an agency that had been created to facilitate the *exploitation* of the forest. As a senior official put it, 'asking IBDF

rangers to enforce deforestation control laws was like asking pyromaniacs to control forest fires' (Interviewee/#23/2009). It is therefore hardly surprising that for much of its history IBAMA has been afflicted by a succession of corruption scandals with, for instance, rangers bribed to ignore (unauthorised) deforestation or being involved in the illegal sale of logging and forest-clearance authorisations. Consequently, IBAMA acquired the reputation of an inefficient and corruption-ridden organisation, a notoriety that it has found difficult to shake.

There is a by now extensive body of research that attempts to document how the discretional powers of street-level bureaucrats are (or are not) being eroded by the introduction of digital technologies (e.g. Bovens and Zouridis, 2002; Jorna and Wagenaar, 2007). Indeed more and more of the work formerly carried out by 'human actors' comes to be 'delegated', as Latour (1992) would put it, to technological systems (Ribes et al., 2013). When we seek to trace how exactly the various labours of deforestation-detection are, as it were, 'passed around' between different categories of actor, a complex picture emerges. In the days before the current generation of geospatial technology, fines would have been administered in the course of site inspections with the ranger in the role of eye-witness to the act (similar to a traffic warden issuing a ticket). The infraction document would identify the property using locally recognised reference points (e.g. 'near the tall nut tree'; 'by the river bend') and calculate the deforested area again in approximate terms using the '*olhometro*' – a colloquialism derived from *olho* (eye) and *metro* (meter). Such documents, however, were often unable to successfully bridge the geographical and cultural distance between, for instance, forest and courtroom. Their labours of detection would often unravel when challenged by landlords' attorneys and their hired experts. For example, landscape references often lacked sufficient specificity and could be fitted to many other forest locations. In addition, the rangers' impartiality as witnesses was always in question given the agency's reputation for corruption. With the development of the new geospatial technologies, however, GPS coordinates have replaced local references and '*olhometric*' calculations. Since the introduction of DETER, a satellite-based monitoring system able to detect clearings almost on a daily basis, all fines for deforestation and the accompanying technical reports include satellite images.

Accordingly, IBAMA has refocused its recruitment to computer-literate graduates. The number of rangers with higher degrees ('analysts' in agency terminology) has therefore grown substantially while the number of 'technicians' (those with 'merely' local/practical knowledge) has declined (IBAMA, 2008; Jackson, 2015). IBAMA HQ now offers GIS upskilling sessions and advice via Skype to those working in the Amazon. Agency officials would often describe the period before remote sensing as a time when IBAMA had been 'blind'. Enforcement was entirely dependent on 'luck' and the technicians 'forestry instincts', i.e. practice-acquired intuition. Rangers would patrol particular areas where illegal deforestation was known to take place but, given the size of the areas in question, it was more in hope than expectation. As a ranger put it: 'Before GIS technology it was much more difficult to do our work. [W]e would go to a certain region . . . door-to-door and hope to get some information that *might* lead us to the place of a crime' (Interviewee/#16/2008).

While IBAMA maintains a toll-free 'greenline' for anonymous tip-offs, such information is frequently misleading or insufficiently detailed. In addition, since regional managers lack detailed knowledge of the municipality where they operate, they would often be unable to position their agents effectively. Satellite-based *yearly* rates may have provided reliable indicators of deforestation, but this data was not *timely* enough to be of much practical use. In pre-DETER times, a senior official explained, 'INPE's monitoring systems used to take almost two years to release deforestation data, when it was too late to plan anything'

(Interviewee/#11/2008). The introduction of the new technologies at local level, and the frequent updating of deforestation data, argued a senior official, was an 'eye opener'. IBAMA, 'started being able to see deforestation *while* it was happening, and not [merely] the final result of deforestation' (Interviewee/#48/2009).

Officials interviewed in the course of this research stressed that the availability of new geospatial technologies has not only facilitated the increase in the number of fines administered but also, and crucially, they have brought about an improvement in their 'legal quality'. In other words, an improvement in the ability to document the evidence, so as to better establish deforestation as a *legal* fact (environmental crime) in distant offices and courthouses. As an IBAMA agent stated:

> in most cases the old processes failed to [properly] identify either the person responsible [for the deforestation] or the site . . . Since we started to clearly identify [in the notices of infraction] . . . [both] *the exact location and the authorship of the crimes* . . . the situation has improved a lot. (Interviewee/#02tv/2018)

This enhancement of the 'legal quality' of the documents renders them, according to our interlocutors, better able to function as 'boundary objects. In Star's and Griesemer's (1989) sense of the term, between *inter alia* field and office, courtroom and forest clearing.

The improvement in the infraction reports' 'legal' – or to borrow from Latour (1987) 'mediating' – qualities is *more* than a question of an improved ability to accurately represent the facts of the case. Figure 3 shows two infraction reports from SEMA-MT, the environmental agency of the State of Mato Grosso with responsibilities similar (at state level) to that of IBAMA. The document on the left uses GPS coordinates (and *not* the ranger's *olhometro)* to calculate the deforested area. The 'new style' report on the right uses satellite images and GIS. If, as Weber (1978: 975) once argued, bureaucracy works 'more perfectly' the more it succeeds in 'dehumanizing' itself, then the handwritten document on the left has been less than successful in this regard. When compared with the one on the right it appears still enmired in human subjectivity and (corruptible) personal judgment. The former document may well contain exactly the same data but lacks, to borrow from Riles (2000: 10), the latter's 'persuasiveness of form'.

Characterising deforestation

Satellite-imaging and GIS-generated data have become central to the agency's resource allocation practices and to the planning of missions. Data on deforestation rates and the number of fines and the area of embargoed properties, allow senior officials to evaluate the work of local offices and to assess the performance of local managers. Similarly, geospatial technology is utilised by local managers to coordinate the work of their forest rangers, and by the rangers themselves to facilitate cooperation with the agency's attorneys in regional and central offices. It is worth emphasising, however, that by itself, a satellite image is not sufficient proof that an environmental crime has indeed been committed. In order to establish deforestation as a legal fact, rangers need to visit the site identified and establish, among other things, 'ownership of the act'. For example, that it was a *deliberate* (not accidental fire) on the land of *this particular* landlord (not in a neighbouring estate, nor in 'no man's land' – land ownership remains nebulous in Amazonia).

In stark contrast with the past, rangers today rarely leave their local offices without specific instructions as to where they are to go. For short missions with few targets, local managers will enter only a set of geographical coordinates into the GPS devices used by

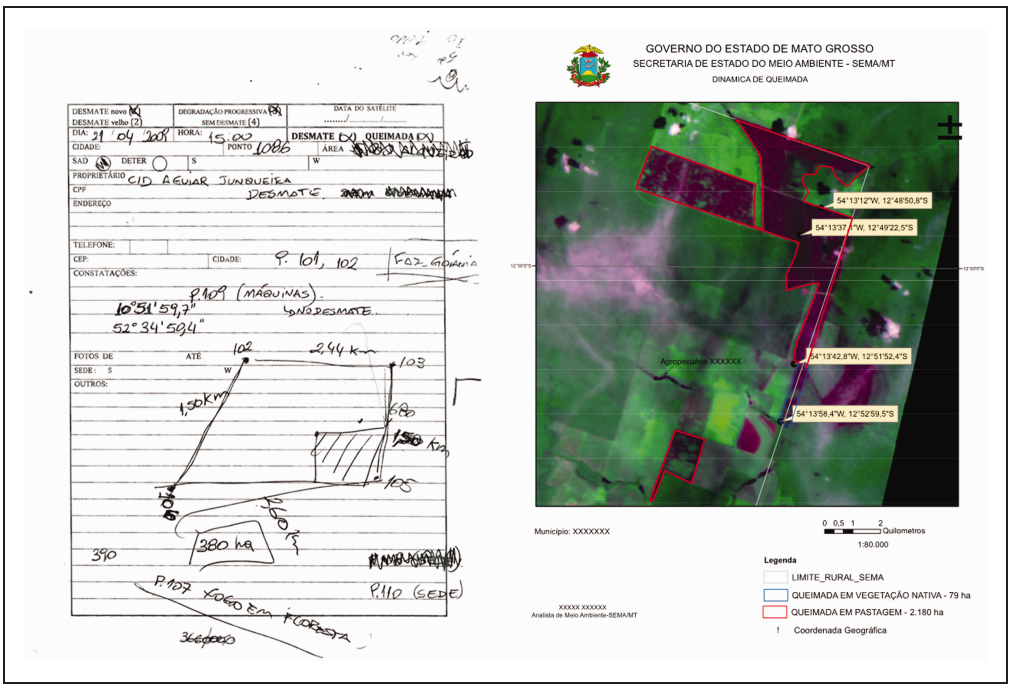

Figure 3. Examples of an infraction notice which manually records GPS coordinates to calculate the deforested area (left) and (right) a contemporary notice which utilises satellite images and GIS.

Figure 4. On the left, a group of rangers and soldiers approach the landlord's agent (far left). On the right, an IBAMA agent writes a notification to the landlord – the first step towards the imposition of a deforestation fine.

rangers. For more complex missions, however, a ranger with expertise in geospatial technologies (an 'analyst') will generate a 'logistic map' under the supervision of the local manager to guide the rangers in the field. A typical week-long patrol begins with the allocation of a set of 'points' to be checked by a team of rangers who, together with a military

escort, will then set off in a group of two or three off-road vehicles. It is the job of the rangers to physically locate and 'characterise' the *specific* deforestation indicated in the satellite image (see Figure 4). Physically accessing the particular deforestation 'point' shown in the data is not an easy task in spite of all the technological gadgetry. It requires considerable local knowledge and ability to interpret the terrain and identify clues to potential access routes. Once the *right* deforestation has been 'located' its characterisation can commence. The labour of 'characterisation' begins with the recording of the location and extent of the deforested area using GPS. Rangers also compile a detailed photographic record of the state of the terrain on the date of the inspection. These photographs enable the characterisation of a particular deforestation as an *intentional* act (rather than say, the result of an accidental fire) by documenting *inter alia* the scars left by the tractor-dragged chains used to break the burnt vegetation and the planting of seeds. A key part of 'characterisation' is the identification of the landlord, the presumed agent of deforestation. This can be tricky in an area where lands are often occupied illegally and land titles forged. The following research diary excerpt describes such an inspection:

> At about 08:30 the caravan leaves the road in order to follow an unpaved path across the soybean fields. Valeria is in the first car leading the pack. Guiding her is a hand-drawn childlike map sent by an anonymous denouncer. After going back and forth, and asking a not-very-collaborative farmer for guidance, we arrive at a small house by the river. A couple of old farmers are sitting at a table in the veranda trimming a pile of beans. Valeria approaches one of the farmers while the rest of our group starts taking pictures of the area by the riverside which shows clear evidence of a degraded Area of Permanent Preservation. The old farmer protests that he is only an employee and the *patrão* (boss) is not here. While this is going on, a middle-aged man arrives in a SUV. The old farmer tells us that the new arrival is the landlord's brother. 'Who has reported me?' the man shouts at us. The rangers look at him but no-one replies. He looks nervous and starts talking to a ranger. After he has understood that he (or his brother) have illegally deforested an Area of Permanent Preservation he protests: 'But that was 'opened' more than 6 years ago!' 'That maybe so; replies the ranger curtly, 'however, the law dates back to 1965'. After that, the man becomes uncooperative. When asked to confirm that he is the owner's brother, he replies: 'Uhm, ehm, I'm just a relative.
>
> Later, Valeria was able to obtain some further information, check his documents and write a notification requesting that the owner of the property should attend at the IBAMA offices in Sinop to show any licenses and the title of the property within 7 days.

Following a mission, IBAMA agents will focus on producing the documentation and to pass it on to the landlords and their lawyers, as well as to IBAMA attorneys and senior officials located in Cuiabá, Brasília or some other faraway location. The task, however, must be performed using geospatial technologies in such a way as to display clear signs of 'proper procedure' (Zimmerman, 1969, i.e. objective assessment of the evidence as opposed to personal bias or malicious prosecution). Herein lies the official answer to the 'relative's' question 'who has reported me?': there was no need for a denunciation. It is the 'eye in the sky' that sees everything. But, of course, as we already know, he *had* been reported. Nevertheless, when the file is compiled – to paraphrase Latour's (1987: 175) Janus – the satellite image 'will appear as the driving force' behind the inspection.

The function of satellite data is twofold: to account for the detection of deforestation and, also, to make visible its 'dynamic' by reference to satellite images of that same locality obtained in previous years. As Ricoeur (1990) has noted, effective sense-making presupposes

and requires a plot in which each the different elements (e.g. satellite images, photographs taken *in situ*, documents, testimonies) is allocated an explanatory function in a causal narrative. Causal narratives, however, are at the same time attributions of agency. Not only the agency of the 'author' of the environmental crime, but also the agency of the 'sociotechnical assemblage' (Amin, 2014) responsible for the detection of the crime. In these plots, rangers typically figure as but the human components *cum* Derrida (1976) 'supplements' of an authoritative techno-logical system. Their corruptible eyes are increasingly displaced by new machineries of vision seemingly able to capture the data devoid of subjective interference. As we have seen, the often painstaking, forensic and detective work performed by rangers in order to establish both the 'nature' and 'authorship' of the crime remains key to the effective operation of all technological systems. At the same time this dependence tends to be, so to speak, placed 'under erasure' (Derrida, 1976) in official accountings of the process. This is assumed to release the 'facts of the matter' from their continuing indebtedness to individual agents and local knowledge, thus rendering them better able to survive any forthcoming 'trials of strength' (Latour, 1987) in the, often drawn out, legal process.

Systems, delegations and management control

In the new information ecology enacted by means of the new geospatial technologies, rangers are the objects, as well as the agents, of surveillance. As will be recalled, corruption – and accusations of corruption – have blighted the work of IBAMA ever since the agency's creation. Officials do worry about the possibility that their rangers might be involved in corrupt dealings. Whilst in the past, individual rangers had considerable discretion to follow 'gut feelings. Local managers using GIS are now able to specify which sites are to be inspected and to review the fines administered. Rangers are thus increasingly denied the discretion to 'negotiate' with farmers or to ask for bribes. Unsurprisingly, local IBAMA managers were rather guarded regarding such uses of the system. It is understandably difficult for managers to explicitly state that they distrust their subordinates. It was only in the course of more informal conversations with agency officials that corruption anxieties would come to the surface. In the words of a former manager:

> In Brazil you should never send an agent to the field for whatever reason if you do not have a way to control his actions. . . . The System gives me the size for each individual piece of deforestation. I would then tell the agent: 'I want you to go in these five farms shown in the map and bring me back the fine. If you find other deforestation, you can do it, but I want you to bring me at least these five'. In this way, we have taken away from the agent's hand the decision about whether to fine someone or not, because it was already decided by the System. (Interviewee/#03tv/2018)

The satellite image thus serves to both initiate and legitimate the rangers' actions in the field.

There is typically a hiatus that arises between, what we might call, the 'ideal logic' of technological systems (a key source of their enchantment) and the manner in which they are operated in practice. Indeed, there was an evident gap between how rangers used the technology and scientists' and senior officials' expectations of how the technology *should* be used. In discussions, Space Agency scientists would commonly assume that the supply of 'real time' deforestation data (DETER) meant that forest rangers would inspect the areas identified as soon as the data became available in the System in order to catch perpetrators 'chainsaw in hand'. This (panoptic) view was also shared by many senior officials in both

IBAMA HQ and the Ministry of the Environment in Brasília. For instance, an IBAMA official responsible for strategy argued that:

> [Before DETER] we could not interrupt *on-going* deforestation. This was the problem at the beginning of the use of satellite images. With DETER there was a great improvement. We started receiving pointers from DETER every 15 days. It says 'something is going on here, it is changing here' and INPE gives this information to IBAMA. It was a jump, a paradigm change. After that we started to work with very short time strategies. And then people could go to the field and interrupt on-going deforestation. (Interviewee/#48/2009).

To enable local managers to plan their missions in line with the (presumed) 'real-time' logic of the system, scientists in Brasília have devised the 'priorities map'. Every 15 days, scientists (re)calculate the ranking of priorities for law enforcement drawing upon DETER data and other system information. 'Priorities maps' are then sent to IBAMA offices in the Amazon where, it is expected will be used by local managers to 'interrupt deforestation' as it happens.

Observation of work practices in the field, however, reveals a rather different picture. From a local manager's viewpoint, it is not feasible to inspect deforestation points as soon as these have made their appearance on DETER. IBAMA funding has always been low, so local managers have usually large areas to oversee with only one or two teams of rangers at their disposal. They therefore plan missions in ways that allow the inspection of as many deforestation points as possible in the course of a single patrol. Deforestation reports are typically left to 'accumulate' for a few months before it is worthwhile despatching a team to an area. As a forest ranger explained in the course of an informal conversation,

> In Brasília they have this utopia that we should be able to get the guy with the chainsaw in hand thanks to real-time monitoring systems, but in reality it is very far from it. (Fieldnote/#19/2008).

Limited resources mean that local offices are unable to inspect *all* the deforestation pointed out by DETER. Instead of being in urgent need of yet more deforestation data in order to improve their work, the system is already creating a backlog that far exceeds IBAMA's local capabilities. Furthermore, and in contrast to the centrally held view that the most efficient strategy is to visit the most recently detected deforestation sites, local managers reported that they plan missions so as to 'show the presence of the state' throughout the territory under their jurisdiction. They explained that they aim to visit every municipality at least once every six months in order to underscore to the local community that the state is 'watching them' even when the municipality does not show a particularly high deforestation rate. In contrast to popular images of Foucault's Panopticon, visibility *to* the state is, in other words, only credible if the state itself is visible.

In addition, the work of inspection involves the juggling of scarce resources in the light of the contingencies of unfolding missions. Managers would explain that it is not uncommon to start a mission with one aim and then change it in response to events unfolding and incoming demands from other agencies. For example:

> I sent a team to check some properties in Colniza, but that I also received a request from FUNAI [National Indian Foundation]. Since ... indigenous lands have priority, I asked [the rangers] to check that first. After two days, we were not able to find the issues pointed out by FUNAI. However, we did find 70 logs in the region. Today we have just found another lot with more than 300 logs .... [W]e always have to take decisions on the spur of the moment.(Personal communication#2/2009).

The disenchantments of technology

Rangers would often voice their scepticism regarding the relevance of geospatial techhnologies designed in distant 'centres of calculation' to their own work needs:

> [T]he problem in Brasília is that often they develop technologies that nobody asked for, like this electronic fine, while the technologies that we *really* need they don't develop. The guys in Brasília don't know our reality and don't like coming here because they think it's the end of the world. (Fieldnote #19/2008)

The target of the ranger's discontent was, what we might call, a class of GIS-based monitoring and registry systems exemplified at local level by Mato Grosso's Environmental Licensing System for Rural Properties (*Sistema de Licenciamento Ambiental de Propriedades Rurais* or SLAPR) and, more recently, at a national level, by the Environmental Rural Registry (*Cadastro Ambiental Rural* or CAR). The central problem that these seek to address is that even though advanced satellite-based systems such as DETER have been tracking Amazonian deforestation, what they cannot 'show' is the *legal responsibility* for the land where 'environmental crimes' have appeared. 'If you have a speed trap', argues *The Economist* (2013), 'but the cars have no numbers, that's useless'. The objective is, as a senior Ministry of Environment official put it, to give 'a name and surname' to deforestation. Giving 'a name and surname' to deforestation is, as we have seen, the job of the forest rangers. As will be recalled, however, resources allow only a relatively small number of the sites identified to be physically inspected. Furthermore, as we have argued, much of the actual work of detection, that the rangers do perform tends – to use Derrida's (1976) term – to be placed 'under erasure' in order to uphold particular idea(l)s of 'proper procedure' (Zimmerman, 1969). As a result, those back in the 'centres of calculation' (including senior officials) tend to have a rather limited understanding of the rangers' actual practices and, consequently, unrealistic expectations of the instrumental efficacy of particular digital infrastructures. The record of SLAPR is a case in point.

Created in the late 1990s and funded by the G7 (PPG7) and the United Nations Development Program (UNDP) SLAPR was conceived as a three-stage system. In the *licensing* stage, the georeferenced borders and land-use of each individual property are registered in the system. In this process, those who have deforested more than the percentage allowed or to have done so in Areas of Permanent Preservation (*may*) have to pay a fine and sign an agreement to restore forest cover. In the *monitoring* stage, each property is monitored using satellite and GIS technology in order to identify any changes in forest cover. Finally, in the *enforcement* stage, those detected to be deforesting illegally would, not unlike *The Economist's* (2013) drivers caught in a speed trap, receive their fine by post. Such artefacts then enact an orderly vision of the Amazon where clearly demarcated properties have stable boundaries and legal owners. Let us note at this point that although they theoretically dispense with the need of *in situ* inspections allowing deforestation control to be carried out 'at a distance, this ambition was dismissed by rangers as unrealistic. Such systems, they pointed out, cannot assign legal responsibility since the owner is not necessarily the agent of the act in a land where squatting and conflicting claims are common. For example, as an IBAMA agent put it:

> The novelty of last year was the use of police reports by farmers to protect themselves from us. The guy sets fire to his property to clear the land for the cattle, and then goes to the police to say it was arson [by persons unknown].

It is only in *in situ* inspections, it was noted, that tractor tracks and grass seeds can be found and the true identity of the crime (and the criminal) exposed.

Even though, as one of the system's creators put it in an interview, they only ever issued 'a few [electronic] fines as a test', SLAPR was widely proclaimed by researchers, funding agencies and policy-makers alike as the future of deforestation control (e.g. Wertz-Kanounnikoff, 2005). Fearnside (2003) described SLAPR as demonstrating, for the first time, how governments *could* control deforestation. Similarly, and in addition to providing non-refundable loans, the World Bank presented SLAPR to other tropical countries as an exemplar of 'best practice'. PPG7, another funder of SLAPR, described it as its main 'success story' (MMA, 2002: 28).

Reasons to doubt the efficacy of SLAPR become evident when we examine more closely how 'objectivity and transparency' were *actually* accomplished within the system. One example: Mato Grosso state officials tended to allow experts in geospatial technologies hired by landowners to interpret images of their property. While senior officials tend to refer to satellite images as mirrors of reality, such images do not 'speak for themselves' but require considerable interpretive labour. Indeed, as we found out in the course of this research, satellite images typically provide considerable room for differing interpretations of what is, or is not, 'forest'. Consider for instance the map-image of a SLAPR environmental license shown in Figure 5. The hired expert has drawn a line (in white) separating forested from de-forested areas. There are at least three areas, however, which are here classified as forest (circled) but where the prevalence of darker tones on the satellite image suggests that the area is severely degraded, possibly as a result of selective logging. Current and former officials confirmed the prevalence of such practices. For instance, a senior manager at SEMA argued that the blurriness of the satellite images in relation to degraded or small-forested areas, such as the ones adjacent to rivers, allowed hired experts to generate the representations they favoured (Interviewee/#28/2008). When questioned directly, a SEMA official (while clearly uncomfortable with the question) responded that they rarely tended to challenge such interpretations of satellite images.

Clearly, the ways in which these lines are drawn on the images *also index networks of socio-economic privilege*: it is the larger landowners that can afford to employ their own experts. Furthermore, to paraphrase Garfinkel (1984: 186), there are, arguably, 'good *organizational* reasons' for such 'looking but not seeing'. The key performance indicator for SLAPR was the number of properties registered, *not* the deforestation levels on these properties. Indeed, as a number of studies have shown, more deforestation was taking place inside than outside the SLAPR (Rajão et al., 2012).

Nevertheless, the Ministry of the Environment officially adopted SLAPR as the desired standard for the Amazon. It supported the development of a series of similar infrastructures culminating in the creation of the nation-wide Environmental Rural Registry (CAR). CAR is said to herald a new era of data-driven development and environmental governance by facilitating 'control, monitoring, environmental and economic planning and the fight against deforestation' (Art.29, Lei 12651/12; *Decreto* 7830/2012). CAR requires the registration of all rural properties (and of the ways the land is being used) into its database. Once 'who owns what' has been registered, *then* satellite monitoring in conjunction with the georeferencing of property boundaries will, it is expected, reveal the compliance of each property with the requirements of the Forest Code and hold property owners properly accountable for any illegal deforestation detected on their land. The emphasis then was on the system's technical 'potential' which, it was assumed, will be seamlessly translated into practice.

In the Amazon, as we have seen, it is always difficult to know who is responsible for any particular act of deforestation as rural properties are often unregistered or subject to

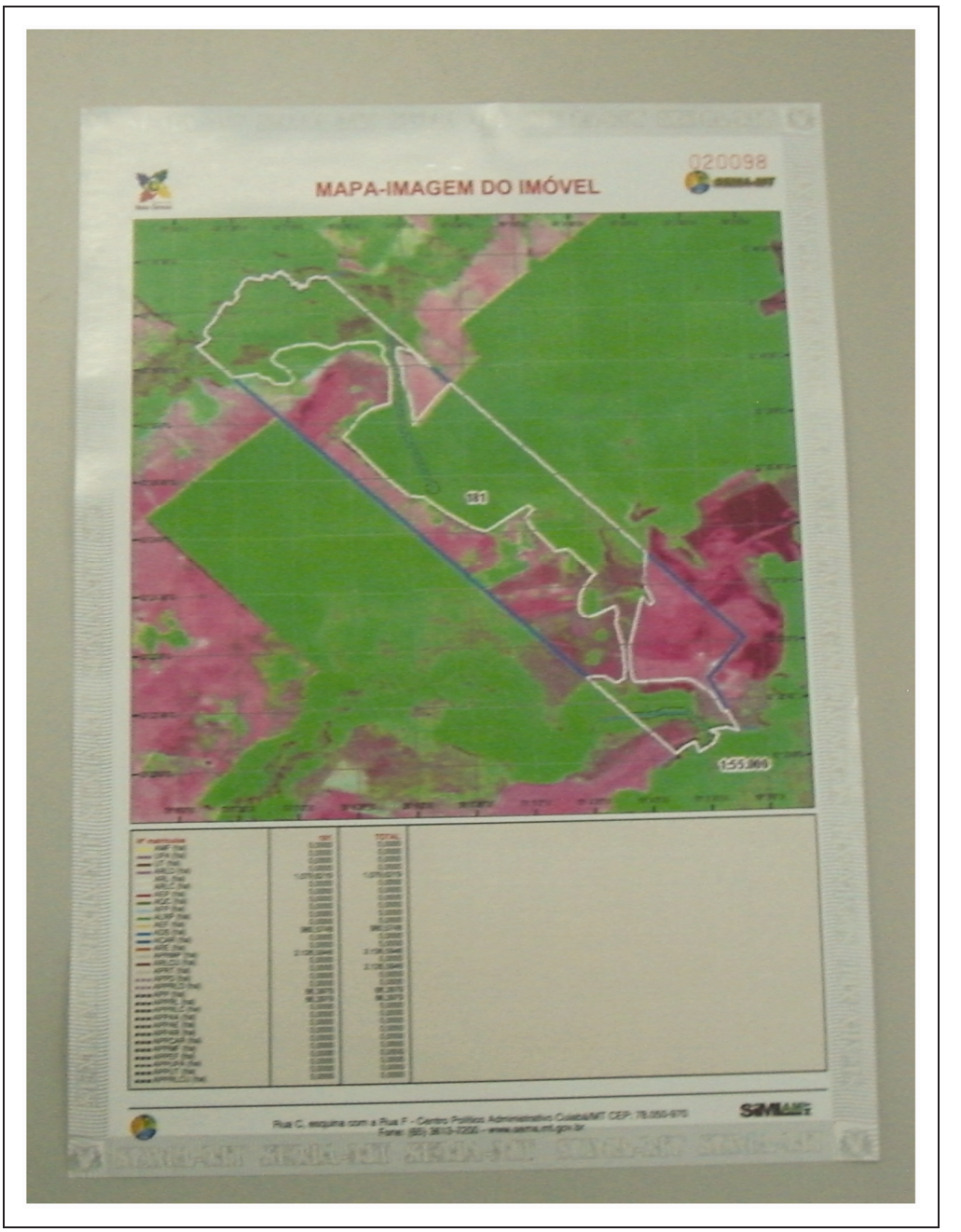

Figure 5. Forest–deforestation classification of a Mato Grosso farm.

multiple, contradictory (and forged) claims (Holston, 1991; Campbell, 2015a, 2015b). Such claims are colloquially known as '*grilagem*' (from *grilo* = cricket), a reference to the use of crickets to artificially age counterfeit documents. These practices are, so to speak, but the bureaucratic refractions of an oft-violent world, where lands are squatted and re-possessed, property boundaries drawn and re-drawn, and rivals chased away. (On the dynamics of land

disputes, see Simmons (2002, 2004, 2005.)) Against this backdrop, it is perhaps premature to evaluate CAR's ambition to 'fix a singular vision of territory in a standardised database of knowledge' (Campbell, 2015b: 158). Nevertheless, there are already indications that at least some of the practices of 'looking but not seeing' (as our interlocutors would put it) that afflicted SLAPR may now be in the process of colonising CAR.

The evolution of technological infrastructures, Star and Ruhleder (1996) remind us, is typically beset by various 'double binds'. As had been the case with SLAPR, CAR evaluation practices by the Federal Government and donor agencies have also focused on the number of properties registered, rather than on any effects on deforestation. There is evidence that managers were purposefully *not* fining the farmers joining the system precisely in order to facilitate enrollment, thus perpetuating practices of 'looking but not seeing'. An NGO representative reported to us the following comment, allegedly made by a senior manager in the State of Pará when questioned by the Minister of the Environment (on the basis of a 2014 study by one of the authors): 'You have to decide what you want us to do. *Either* we attract the farmers to join CAR *or* we start issuing fines to them'. As an IBAMA ranger summed up this institutional double bind:

> The problem today is that the state only has the stick [to curb deforestation] and no real carrot. Because if the state *had* a carrot the farmer would have joined CAR independently of the presence of a stick. Therefore, the carrot dangled by the state today is the *absence* of a stick. (Interviewee/#01tv/2014)

Discussion

Technological infrastructures, anthropologists caution, 'refract rather than merely translate' political projects (Dalakoglou, 2012; Harvey and Knox, 2012; Reeves, 2017:717). Perhaps ironically – given the widespread currency of 'transparency' discourses – images, and the material infrastructures for their production and circulation are often central to how such 'refractory' effects are engendered (e.g. Strathern, 2000; Styhre 2010). Hull (2012: Ch5), for instance, in his ethnography of urban planning in Islamabad describes how the circulation of maps showing where planners intend to build particular (sect-specific) mosques incite squatters from other sects to preemptively occupy those very sites. A political scheme to combat sectarianism ends up having the opposite effect.

The use of geospatial technologies for environmental protection is, as we have seen, not immune to such 'refractions'. For example, whilst there is some evidence that small farmers registered with CAR in Pará and Mato Grosso had initially reduced their 'land-clearing' activities once it became apparent that the system was not being used to fine transgressors, the rate of deforestation on such properties rapidly increased (Azevedo et al., 2017). So while CAR's *enrolment* strategy has been a major success with over 6 million farms registered (representing most of the target area), lax enforcement has meant that by 2016 over half of all Amazonian deforestation was taking place *inside* the registry (Watanabe, 2017). In 2016, in response to rises in deforestation, senior officials from Pará, Mato Grosso and IBAMA mentioned that they had now started to use CAR to issue fines remotely. Even though this was a pilot with only about 500 fines issued by each of these agencies, it immediately ran into political opposition. A Mato Grosso official reported that in mid-2016, under a new secretary, the team that issued CAR-based fines was disbanded. Thus, in order to safeguard IBAMA's CAR-based enforcement operation, internally known as 'Remote Control', a senior official reported to us that the Environment Minister had

instructed that the operation be kept secret. Reports of its existence were bound to incite the wrath of the increasingly powerful (in a stagnant economy) *ruralistas* in Congress. Furthermore, an informal conversation an IBAMA official revealed that the (then) current Minister of Environment, Ricardo Salles, ordered the suspension of the use of CAR to remotely issue fines. This and the suspension of various key policies informed by geospatial data led to a drastic reduction in both remote and *in situ* law enforcement activities, leading to a 30% leap in deforestation rates between 2018 and 2019 (see Figure 2).

Plagued by conflicting demands and riven by contradictory imperatives, information infrastructures, however technologically sophisticated, always ran the danger of becoming instruments not of 'factual' governance but of official '*un*knowledge' (Mathews, 2011). 'Looking but not seeing' facilitates the documentation of unregistered property therefore achieving one objective of the system at the expense of another combating deforestation.

Images and inscriptions are often, even routinely, 'mobilised' (Latour, 1987) for purposes that flatly contradict the rationales of the systems that had generated them. This becomes evident in the ways in which landowners frequently seek to utilise the agency granted to documents in administrative infrastructures in order to divert the process of documentation to their own purposes. As already mentioned, property relations in Amazonia are often 'founded on fraud, informal debts, violence, and opportunism' (Campbell, 2015a: 159). Against this backdrop, CAR was explicitly set up as a system of environmental protection and *not* a vehicle for the 'regularisation' of land ownership. It therefore tolerates the registration of overlapping property claims: in a study of 150,000 CAR registrations in the state of Pará, 108,000 were found to overlap (48,000 by 100%) with other properties. The extent of such 'overlaps' amounted to more than 14 million hectares (the size of England). In spite of the stated intention to, so to speak, 'bypass' the messiness of conflicting land claims, CAR remains deeply entangled in them. A range of actors from land-grabbers (*grileiros*), to various municipalities (purveyors of the popular slogan 'join CAR so that the Government will guarantee your land') have re-framed the registration process in exactly these terms. For farmers, CAR registration officially inscribes their claim to a given piece of land making it possible, in due course, for *grilagem* documents to become genuine land titles. As might be expected, large landowners ('*grandes*') are the most adept in the performance of these labours of manipulation. They are able, for instance, to 'launder' estates over 2500 hectares (the upper legal limit that can be recorded) via the registration of multiple properties, ostensibly owned by small farmers (*pequenos*) that are often expelled from their lands under death threats and violence. Seen in this light, the artefactual agency of systems like CAR (Passoth et al., 2012) appears to recede in practice revealing the various 'operators and the manoeuvres that lie behind' it (Perez, 2016: 218).

Conclusions and afterthoughts

The Amazonian rainforest remains the most closely observed in the world. Over many decades, the Brazilian state has assembled a complex sociotechnical apparatus in order to monitor forest loss. Such information infrastructures operate, however, at the intersection of mutually interfering political demands, incommensurable goals, and competing organisational logics. The ways in which SLAPR and CAR function in practice resemble not so much the workings of the enchanted technological infrastructures envisaged, and still rhetorically invoked, by their sponsors, but rather shifting and unstable network formations.

It is worth recalling here the notion of 'looking without seeing' which our interlocutors would often use to name the pathologies of ostensibly 'panoptic' (Foucault, 1979) systems. If, as Comaroff and Comaroff (2003:288) argue, it is now all but axiomatic that 'to see is to

know', then knowing what *not* to see and thus what *not* to know, becomes indispensable social knowledge. Anthropologists sometimes use the term '*un*knowledge' (Mathews, 2011) for those forms of knowledge which are, as it were, to be in-attended to in order to facilitate the smooth running of particular political-administrative projects and systematisations. Research in legal studies and in the sociology of government have highlighted the role of active non-knowing and non-enforcement as a technique of governance – when laws and regulations 'are officially present' but remain unenforced (Gilbert, 2015; Huisman, 2019: 172). These can range from immigration laws in US 'sanctuary cities' (Martínez et al., 2017) to rental housing regulations in the Netherlands (Huisman, 2019). Seen in this light, the sociomaterial apparatuses of deforestation detection constitute particular sorts of 'boundary objects' (Star and Griesemer, 1989): conduits through which legality and illegality are allowed to leak into one another. We have seen how the various 'orderings' (Law, 1994) of development and conservation, neoliberalism and ecology, uneasily cohabit and parasitise one another. While precarious, incomplete and riven by contradictions, such infrastructures 'hold together, as it were, by systematically 'disattending' to the logic of the other order' (Brown and Reavey, 2017). Thus, the recently elected (2018) Bolsonaro administration with its 'neoliberal' emphasis on economic 'development' in Amazonia, is encouraging, as *The Economist* (2019: 15) notes, 'a large amount of deforestation, by not enforcing the laws that prohibit it'. To this effect, the new environment minister Ricardo Salles, has removed 21 of IBAMA's 27 state heads in a 'clear out' of the agency. At the same time, the head of INPE was forced to resign for producing data that showed rapid rises in deforestation: for looking *and* seeing 'like an NGO' (e.g. BBC, 2019; Spring and Eisenhammer, 2019).

By tracking the labours of attention and in-attention and the associated practices of knowing and unknowing, we can begin to understand the moments when, and the processes by means of which, one form of order(ing) transits into, or is usurped by, another. Such an understanding, we propose, is key to making sense of the current predicament of the Amazon now feared to be near a tipping point at which it will be longer able to generate its own rainfall (see Salazar et al 2007; Walker et al, 2009; *The Economist*, 2019) and of the vicissitudes of the infrastructures that had once been invested with its protection.

Highlights

- The information infrastructures by means of which the Amazon is currently made visible operate at the intersection of mutually interfering political demands, incommensurable goals, and competing organisational logics
- The ways in which geospatial technologies function in practice resemble not so much the workings of the 'enchanted' infrastructures envisaged, and often rhetorically invoked, by their sponsors, but rather shifting and unstable network formations.
- By attending to the labours of attention and un-attention and the associated practices of knowing and unknowing, we can begin to understand the moments when, and the processes by means of which, one form of order(ing) transits into, or is usurped by, another.
- Such a focus helps us make sense of the ways in which not-knowing and non-enforcement can function as techniques of governance.

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References

Ahrens S (2007) 'Sobre a reserva legal' Paper presented at the *11° Congresso Internacional de Direito Ambiental*, São Paulo, 1–5 June.

Amin A (2014) 'Lively infrastructure'. *Theory, Culture & Society* 31(7/8): 137–161.

Azevedo AA, Rajão R, Costa MA, et al. (2017) 'Limits of Brazil's Forest Code as a means to end illegal deforestation. *Proceedings of the National Academy of Sciences* 114(29): 7653–7658.

BBC (2019) 'Amazon deforestation: Brazil's Bolsonaro dismisses data as 'lies''. Available at: https://www.bbc.co.uk/news/world-latin-america-49052360

Becker P and Clark W (2001) *Little Tools of Knowledge*. Ann Arbor, MI: University of Michigan Press.

Bourne R (1978) *Assault on the Amazon*. London: Gollancz.

Bovens M and Zouridis S (2002) From street-level to system-level bureaucracies. *Public Administration Review* 62(2): 174–84.

Browder J (1988) Public policy and deforestation in the Brazilian Amazon. In: Repetto RC and Gillis M (eds) *Public policies and the misuse of forest resources*. Washington, DC: WRI, pp.247–297.

Brown S and Reavey P (2017) Dark organization theory. *Journal of Cultural Economy* 10(3): 280–295.

Campbell JM (2015a) The land question in Amazonia. *Political and Legal Anthropology Review* 38(1): 147–167.

Campbell JM (2015b) *Conjuring property*. Seattle, Washington, DC: University of Washington Press.

Chun WHK (2006) *Control and Freedom: Power and Paranoia in the Age of Fiber Optics*. Cambridge, MA: MIT Press.

Clayton H (1982) Fears for tropical forest 'excessive'. *The Times*, 15 June, 2.

Collier SJ (2011) *Post-Soviet Social: Neoliberalism, Social Modernity, Biopolitics*. Princeton, NJ: Princeton Univiversity Press.

Comaroff J and Comaroff J (2003) Transparent fictions or the conspiracies of a liberal imagination. In: West H and Sanders T (eds) *Transparency and conspiracy: ethnographies of suspicion in the New World Order*. Durham: Duke University Press, pp.287–300.

Dalakoglou D (2012) The road from capitalism to capitalism: infrastructures of (post)socialism in Albania. *Mobilities* 7(4): 571–586.

De Mello NA (2006) *Políticas territoriais na Amazônia*. Annablume.

Denevan W (1973) Development and the imminent demise of the Amazon rainforest. *Professional Geographer* 25(2): 130–135.

Derrida J (1976) *Of Grammatology*, Baltimore, John Hopkins.

Emmelin L (1972) The Stockholm conferences. *Ambio* 1(4): 135–140.

FAO (1976) Management and utilization of the tropical moist forest. *Unasylva* 28: 112–113.

FAO (1981) *Projecto de evaluacion de los recursos forestales tropicales: los recursos forestales de la America Tropical* (No. UN 32/6.1301-78-04). Rome: Food and Agriculture Organization.

Fearnside P (1982) Deforestation in the Brazilian Amazon: how fast is it occurring? *Interciencia* 7(2): 82–85.

Fearnside P (1993) Desmatamento na Amazônia: quem tem razão nos cálculos – o INPE ou a NASA? *Ciência Hoje* 16(96): 6–8.

Fearnside P (2003) Deforestation control in Mato Grosso. *Ambio* 32(5): 343–345.
Fearnside P (2005) Deforestation in Brazilian Amazonia. *Conservation Biology* 9(3): 680–688.
Foucault M (1979) *Discipline and Punish*. London: Allen Lane.
Foucault M (2010) *The Birth of Biopolitics: Lectures at the College de France: 1978–1979*. New York, NY: Picador.
Garfinkel H (1984) *Studies in Ethnomethodology*. Englewood Cliffs, NJ: Prentice Hall.
Gilbert M (2015) Insincere Rules. *Virginia Law Review* 101(8): 2185–223.
Gonçalves C (2005) *Amazônia, Amazônias*. São Paulo: Contexto.
Greenpeace (2008) *Desmatamento na Amazônia: o leão acordou*. Available at: http://www.bibliotecadigital.abong.org.br/handle/11465/1330
Harvey P and Knox H (2012) The enchantments of infrastructure. *Mobilities* 7(4): 521–36.
Hecht S and Cockburn A (1989) *The Fate of the Forest*. London, Verso.
Holston J (1991) The misrule of law: land and usurpation in Brazil. *Comparative Studies in Society and History* 33(4): 695–725.
Huisman CJ (2019) Non-enforcement as a technique of governance: the case of rental housing in the Netherlands. *European Journal of Cultural and Political Sociology* 2(6): 172–200.
INPE (2008) *Avaliação do INPE sobre o relatório: 'Inspeção de pontos e áreas do DETER' da secretaria de estado do meio ambiente-SEMA do governo do estado do Mato Grosso*. São José dos Campos: INPE.
Jackson R (2015) *A Credible Commitment: Reducing Deforestation in the Brazilian Amazon 2002-2012*. Innovations for Successful Societies Report, Princeton University, http://successfulsocieties.princeton.edu/
Jorna F and Wagenaar P (2007) The iron cage strengthened? *Public Administration* 85(1): 189–214.
Kintisch E (2007) Carbon emissions: improved monitoring of rainforests helps pierce haze of deforestation. *Science* 316(5824): 536–537.
Larkin B (2013) The politics and poetics of infrastructure. *Annual Review of Anthropology* 42: 327–343.
Latour B (1987) *Science in Action*. Milton Keynes: Open University Press.
Latour B (1992) Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts. In Bijker WE and Law J (Eds.) *Shaping technology/building society*. Cambridge, MA. MIT Press, pp. 225–258.
Law J (1994) *Organizing Modernity*. Oxford: Blackwell.
Li T (1999) Compromising power: development, culture and rule in Indonesia. *Cultural Anthropology* 14(3): 295–322.
Lipsky M (1980) *Street-Level Bureaucracy*. New York: Sage.
Lövbrand E and Stripple J (2006) The climate as political space: on the territorialisation of the global carbon cycle. *Review of International Studies* 32(2): 217–235.
Mahar D (1989) *Government Policies and Deforestation in Brazil's Amazon Region*. Washington, DC: World Bank.
Malingreau JP and Crompton JT (1988) Large-scale deforestation in the Southeastern Amazon basin. *Ambio* 17(1): 49–55.
Marcus G (1995) Ethnography in/of the World System: the emergence of multi-sited ethnography. *Annual Review of Anthropology* 24: 95–117.
Martínez DE, Martínez-Schuldt RD and Cantor G (2017) Providing sanctuary or fostering crime? A review of the research on 'sanctuary cities' and crime. *Sociology Compass* 12(1). Available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/soc4.12547
Mathews, A. (2011) *Instituting Nature*, MIT Press.
Matthews W, Kellogg W and Robinson G (eds) (1971) *Man's Impact on the Climate*. Cambridge, MA: MIT Press.
Meggers B (1971) *Amazonia*. Chicago: Aldine.
Meyer JW and Rowan B (1977) Institutionalized organizations: Formal structure as myth and ceremony. *American Journal of Sociology* 83: 340–363.
Miller P and Rose N (1990) Governing economic life. *Economy and Society* 19(1): 1–31.

MMA (2002) *Experiences of the Pilot Program to Conserve the Amazon and Atlantic Forests of Brazil*. Brasília: Ministério do Meio Ambiente.

MMA (2014) The Environmental Rural Register (CAR), Ministério do Meio Ambiente. Available at:: http://www.mma.gov.br/redd/index.php/en/legal-framework/national/the-environmental-rural-register-car

Novaes RA, Martini PR, Tardin AT, et al. (1980) *Relatório de atividades do ano de 1979: Departamento de sensoriamento remoto e programas da area*. São José dos Campos: INPE.

Passoth JH, Peuker B and Schillmeier M (eds) (2012) *Agency without Actors? New Approaches to Collective Action*. London: Routledge.

Pereira O (1971) *A Transamazônica: prós e contras*. Rio de Janeiro: Editora Civilização Brasileira.

Price D (1989) *Before the bulldozer: the Nambiquara Indians and the World Bank*. Cabin John, MD: Seven Locks Press.

Prottas J (1978) The power of the street-level bureaucrat in public service bureaucracies. *Urban Affairs Quarterly* 13: 285–312.

Rajão R (2011) *Objects, boundaries and joint work: the role of geographic information systems in the formulation and enforcement of deforestation control policies in Amazonia*. PhD Thesis, Lancaster University.

Rajão R, Azevedo A and Stabile MC (2012) Institutional subversion and deforestation: Learning lessons from the system for the environmental licencing of rural properties in Mato Grosso. *Public Administration and Development* 32(3): 229–244.

Rajão R and Hayes N (2009) Conceptions of control and IT artefacts: an institutional account of the Amazon rainforest monitoring system. *Journal of Information Technology* 24(4): 320–331.

Reeves M (2017) Infrastructural hope: anticipating 'independent roads' and territorial integrity in Southern Kyrgyzstan. *Ethnos* 82(4): 711–737.

Ribes D, Jackson S, Geiger S, et al. (2013) Artifacts that organize: delegation in the distributed organization. *Information & Organization* 23(1): 1–14.

Richards P (1970) *The Life of the Jungle*. New York: McGraw-Hill.

Ricoeur P (1990) *Time and Narrative 1*. Chicago IL: University of Chicago Press.

Riles A (2000) *The Network Inside Out*. University of Michigan Press, Ann Arbor.

Salazar LF, Nobre CA and Oyama MD (2007) Climate change consequences on the biome distribution in tropical South America. *Geophysical Research Letters* 34: L09708.

Sant'Anna L (2008) Maggi diz que INPE mente sobre devastação. *Estado de São Paulo*, 27th January.

Schor T (2008) *Ciência e tecnologia: o caso do experimento de grande escala da biosfera-atmosfera na Amazônia*. São Paulo: Annablume.

Scott JC (1998) *Seeing Like a State*. New Haven, CT: Yale University Press.

Simmons CS (2002) Development spaces: the local articulation of conflicting development, amerindian rights, and environmental policy in Eastern Amazonia. *Professional Geographer* 54(2): 241–258.

Simmons CS (2004) The political economy of land conflict in the Eastern Brazilian Amazon. *Annals of the Association of American Geographers* 94(1): 183–206.

Simmons CS (2005) Territorializing land conflict: Space, place, and contentious politics in the Brazilian Amazon. *GeoJournal* 64: 307–317.

Simmons CS, Walker R and Aldrich S, et al. (2019) Discipline and Develop: Destruction of the Brazil Nut Forest in the Lower Amazon Basin. *Annals of the American Association of Geographers* 109(1): 242–265.

Spring J and Eisenhammer (2019) Brazil space research chief to leave job after Bolsonaro deforestation spat, Reuters, 2 August 2019. Available at: https://www.reuters.com/article/us-brazil-environment-job/brazil-space-research-chief-to-leave-job-after-bolsonaro-deforestation-spat-idUSKCN1US20H

Star SL and Griesemer J (1989) Institutional ecology, translations and boundary objects. *Social Studies of Science* 19(3): 387–420.

Star SL and Ruhleder K (1996) Steps toward an ecology of infrastructure. *Information Systems Research* 7(1): 111–134.

Strathern M (2000) The tyranny of transparency. *British Educational Research Journal* 26(3): 309–321.

Stokstad E (2017) In controversial move, Brazil may outsource Amazon deforestation monitoring. *Science*. Available at: https://www.sciencemag.org/news/2017/05/controversial-move-brazil-may-outsource-amazon-deforestation-monitoring

Tardin A, dos Santos A, Lee D, et al. (1979) *Levantamento de areas de desmatamento na Amazônia legal atraves de imagens do satelite Landsat*. São José dos Campos: INPE.

Tardin A and da Cunha PE (1989) *Avaliação da alteração da cobertura florestal na Amazônia Legal utilizando sensoriamento remoto orbital* (No. INPE-5010-RPE/607). São José dos Campos: INPE.

Tavory I and Timmermans S (2009) Two cases of ethnography: Grounded theory and the extended case method. *Ethnography* 10(3): 243–263.

The Economist (2013) Trees of knowledge: How Brazil is using education, technology and politics to save its rainforest. Available at: http://www.economist.com/news/special-report/21585096-how-brazil-using-education-technology-and-politics-save-its-rainforest-trees

The Economist (2019) On the brink: The Amazon is approaching an irreversible tipping point, *Economist*, August 3–9: 14–16.

Walker R, Moorea NJ, Arima E, et al. (2009) Protecting the Amazon with protected areas. *PNAS* 106: 10582–10586.

Watanabe P (2017) Cadastro Ambiental Rural não impede desmate nem incentiva restauro. Available at: https://www1.folha.uol.com.br/ambiente/2017/07/1898079-cadastro-de-propriedade-rural-nao-impede-desmate-nem-incentiva-restauro.shtml

Weber M (1978) *Economy and Society*. Berkeley: University of California Press.

Wertz-Kanounnikoff SA (2005) *Forest Policy Enforcement at the Amazon Frontier: the Case of Mato Grosso*. Heidelberg, Universität Heidelberg.

Zimmerman D (1969) Record-keeping and the intake process in a public welfare agency. In Wheeler S (ed.) *On Record: Files and Dossiers in American life*. New York, NY: Sage, pp.319–345.

Zukosky M (2007) Making pastoral settlement visible in China. *Nomadic Peoples* 11(2): 107–33.