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BOUNDARY OBJECTS AND BLINDING: THE CONTRADICTORY ROLE OF GIS IN THE PROTECTION OF THE AMAZON RAINFOREST

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Abstract

Based on detailed observations of how senior officials and forest rangers collaborate together using geographic information systems (GIS) this article examines the contradictory role of boundary objects in the enforcement of deforestation control policies in the Brazilian Amazon rainforest. Specifically, we unpack the mechanisms behind the way in which these artifacts have simultaneously facilitated joint work and fostered conflict between different groups working in the region. From these observations it emerged that the reification of work related the role of GIS as a boundary object contributed on the one hand the emergence of new forms of collaboration at a distance but on the other hand led to a process we call boundary-blinding, namely, the inability of managers to understand the practices and outcomes of the work of the groups across boundaries. From that the paper proposes a (re)conceptualization of the notion of boundary objects that pays particular attention to the process of reification and its contradictory outcomes in the context of joint work. The paper also concludes point out to some of the challenges involved in fostering inter-departmental collaboration through ICT in the public sector.

Keywords: boundary objects, collaboration, reification, environmental policy, Amazon rainforest

1   Introduction

Over recent decades the shape and nature of work has been transformed considerably in the public sector. Not only is work undertaken within governmental agency units, but it is now also undertaken with people working in different units and sometimes different agencies and regions. Such new forms of boundary crossing work have arisen in part from the emergence of new professions, increasing levels of specialization and broader trends such as pressure to reduce costs and integrate governmental services (Engestrom 2001; Blackler and Regan 2006). Central to such possibilities has been the ongoing development of information communication technologies (ICTs) that provide for the storage and transmission of data over great distances. Such changes have allowed for new forms of work to take place across occupational, cultural, geographical and time-zone boundaries. The opening up of these boundaries may involve people working with others who they may be unfamiliar with, who occupy very different roles and who hold very different assumptions about work (Engestrom et al., 1995; Suchman, 1994; Tsoukas, 1996). One important literature that has considered the role of ICTs and boundary crossing has been through the concept of boundary object (Barrett et al., 2010: 1200; Zeiss et al., 2009). This concept initially emerged from Star and Griesemer's (1989) study of the ways different professional groups collaborated with each other in the Museum of Vertebrate Zoology at the University of California in Berkley. They analyzed the interactions between philanthropists, administrators, hunters and scientists and found that shared practices (i.e. specimen preservation procedures, note-keeping standards) and artifacts (i.e. standard forms, repositories, general models, and maps) were crucial for the emergence of a fruitful collaboration between the different specialists. Star and Griesemer (1989: 393) referred to the artifacts as boundary objects, namely, objects that "are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites". Building on this initial contribution, subsequent studies have developed a view of boundary objects as being the basis for more engaged forms of social interaction. In particular, commentators have argued that the notion of boundary objects explain how certain objects may become "important means of achieving collaboration, promoting the sharing of knowledge between diverse groups" (Barrett et al., 2010: 1200; Zeiss et al., 2009).

More recently some in-depth studies of the role of boundary objects in particular settings have argued that boundary objects may hinder as well as aid collaboration (Briers et al., 2001; Carton et al., 2009; Levina, 2005; Levina et al., 2006). Notable here has been Barrett and Oborn's (2010: 1215) recent study of the work of a cross-cultural software development team. They found that initially software specifications facilitated collaboration by allowing Jamaican and Indian programmers to share their knowledge about the local context and technologies, respectively. However, following this initial phase, some Indian managers started to use software specifications to impose their authority over the Jamaican programmers in order to speed up the development process. As a result of these events the authors noticed that the software specifications stopped acting as a basis for knowledge sharing and contributed instead to growing frustrations and tensions between the two teams. Consequently Barrett and Oborn (2010: 1215) suggest that boundary objects are shaped by politics and are themselves subject to changing roles over time. Hence, they concluded that boundary objects should be conceptualized as "both pluralist, recognizing the potential for collaboration and conflict, as well as interactional" (Barrett and Oborn, 2010: 1215).

A central feature of our argument is that issues of reification and boundary objects are fundamental in understanding the contradictory effects of boundary objects. Reification refers to the transformation of entities into things or objects and thus is implicit in the notion of boundary objects. Indeed, reification has been central to the establishment of boundary objects. For examples in Star and Griesemer's (1989) study that the state of California, animals and habitats were reified into maps, stuffed specimens and inscriptions in field notes, which was fundamental for these artifacts to function as boundary objects. Despite the importance of reification for understanding the functioning and

consequences of boundary objects, so far no study has addressed this issue empirically and theoretically. For instance, Star (2010) in her last paper dedicated to the notion of boundary objects complained that while the relation between interpretive flexibility and boundary objects has been extensively studied, other aspects of boundary objects hinted in the 1989 paper such as its informatic structure (i.e. the way information is reified) and the relation between ill and well-structured uses (i.e. local and shared aspects) of boundary objects have been largely ignored (see also (Star, 2010; Trompette et al., 2009).

Having this underdeveloped area in mind, this paper will draw on the understandings of boundary objects and reification mentioned above in order to explore the ways in which GIS in the Amazon facilitated or hindered collaboration between different occupational groups. In particular, it aims at showing: 1) how the reification of locations into latitude and longitude and of complex territories into the GIS allowed groups operating at different scales to work together while still being able to refer to each other's work unambiguously; and 2) how the visibility and invisibility the GIS afforded was implicated in the nature and possibilities for collaboration between the different occupational groups as well as vast spatial boundaries. From this the present study intends to contribute to this debate by showing empirically how boundary objects may afford contradictory outcomes and how an explicit understanding of the process of reification illuminates some open questions concerning the functioning of boundary objects. We will consider this theme in relation to an interpretive case study of the use of role geographic information systems (GIS) in the Brazilian Amazon rainforest (Walsham 1995). We will draw on the concept on boundary objects to help make sense of detailed observations and 85 semi-structured interviews and observations collected between 2007 and 2009. In order to obtain a broad perspective of the different groups involved in the case study, the informants for this research ranged from an ex-president and three ex-ministers of environment, to forest rangers and local farmers. The empirical data here mainly concerned IBAMA, the Ministry of the Environment and INPE (Brazilian Institute for Space Research), with a smaller role played by informants from SEMA-MT (Mato Grosso's environmental agency) and other parts of the government as well as local producers and environmental non-governmental organizations. We will attend to the following research questions: How does boundary crossing emerge in practice? Under which conditions does ICT help or hinder this process? How does the process of reification promoted by ICT influence collaboration? Overall we will argue that the overreliance on ICT may prevent groups from understanding the work done by others to an extent that the use of ICT hinders organizational effectiveness. We will refer to this as boundary-blinding. This short paper is organized as follows. The next section presents analyzes the contradictory role of GIS in the environmental protection of the Amazon. In the third and final section we draw implications to the understanding of the role of ICT in the provision of complex and geographically distributed governmental services.

2   GIS and joint work in the Amazon

The Brazilian government has been increasingly using GIS for a wide variety of roles in the last three decades. In particular, PRODES (the program for the calculation of deforestation) has provided yearly deforestation rates which have guided the policies towards the region since 1989, while DETER (deforestation detection in real-time), which was created in 2004, has been extensively used by IBAMA and state-level environmental agencies to enforce the country's environmental policy at ground level. In this way, the use of GIS has become diffused not only in policy-making but also in law enforcement practices in the region. This section discusses how forest rangers in Mato Grosso, scientists in São Paulo and senior officials in the Federal District collaborate using this family of geographic information systems, from now on indicated "the GIS" for brevity. At first it is going to be highlighted how the process of reification promoted by the joint use of the GIS as a boundary object facilitated cross boundary work. Then it is going to show the other side of this process and discuss how boundary objects and reification fostered tensions and contradictions.

2.1 Reification and collaboration across boundaries: the role of scaling and informatic structures

It was observed in many instances that the transformation of complex phenomena (i.e. the Amazon as lived by its inhabitants) into data objects such as georeferenced polygons, lines and points indicating the location and size of recent deforestation, played a key role in enabling collaboration across boundaries. From our analysis it was possible to identify two main ways in which the reification of processes enabled the functioning of the GIS as a boundary object. Firstly, it was possible to observe that the process of reification contributed to render the GIS flexible enough to fit the local needs of the different groups involved, and in this way facilitating joint work across occupational boundaries. Central was the ways in which the GIS allowed for the broad aggregation of data at a macro level, and then for the disaggregation of data at meso and at a micro levels. At a macro level, senior officials working for Federal government require broad and aggregated data of Basil's Amazon region in order to formulate and revise the region's environmental policy. However, at a meso level the same data is disaggregated by regional managers to create state-level deforestation control strategies and by local managers to negotiate financial and human resources with senior government officials. IBAMA local managers also disaggregate, manipulate and superimpose other geospatial data from the GIS-based maps in order to create maps covering the area under their jurisdiction. Finally at a micro level, forest rangers further disaggregate these maps *in situ* so as to show single areas of deforestation. Here they use their handheld GPS to identify the specific coordinates of deforestation, and the boundary of a particular farm so as to assess whether the extent of the deforestation within a particular farm is permissible by law. This detailed map can then be used to issue fines to specific landowners for breaching the law relating to deforestation. From this sequence of operations it is possible to observe how reifications provided by the GIS were aggregated and disaggregated, and consequently acquired different meanings for different occupational groups depending on their specific practices (see *Figure 1*).
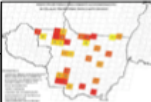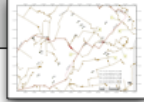

Community/GIS	Deforestation rate	Amazon deforestation map	State deforestation map	Logistics map	Map-image in fine/license
Scientists					
Policy-makers	�			
Senior officials		�│			
Local managers			▮		
Forest rangers/bureaucrats				▮	
Farmers					▮

Figure 1 The (dis)aggregation of deforestation across occupational boundaries at IBAMA

In other words, the ways that the data could be provided at a macro, meso and micro scale provided the interpretive flexibility required to the tailoring of boundary objects to the needs of local practices (Henderson 1991; Star 2010). However just as senior officials were not concerned with disaggregated data that identified specific areas of deforestation, IBAMA rangers were not concerned with data that was aggregated policy level data as this would not assist in identifying or issuing fines. This meant that they were primarily only aware of and interested in the data that was relevant to their particular

practices. More recently Star (2010) mentioned the importance of the shift between ill and well-structured use of boundary objects. In particular she pointed out that it is this process that allows boundary objects (e.g. a maps), to have a shared meaning across groups (e.g. a map of the state of California) and specific usages within a given group (e.g. touristic map showing camping locations). In highlighting the relation between scales and reification it would seem that not only interpretive flexibility but also specific types of reification may play an important role in allowing the shift between ill and well-structured uses suggested by Star (2010). This suggest that the reifications provided by GIS afforded a level of flexibility that allowed for the *coexistence* of both a wide range of local uses tailored to fit the requirements of each group as well as a shared use across occupational boundaries – a characteristic that is one of the hallmarks of boundary objects (Barrett and Oborn 2010; Star 2010).

Figure 2 *Location of some of the groups formulating and enforcing the environmental policy in the Amazon: 1) scientists in São Paulo; 2) senior officials in the Federal District; and 3) forest rangers in the Amazon region*

A second key way in which the process of reification is closely related to the role of the GIS as a boundary object relates to the ways in which it facilitated joint work across spatial boundaries by allowing for the disembedding between time and space (Giddens 1990; Barrett, Sahay et al. 2001). One of the most striking aspects of the case study (and one of the main difficulties in researching it) are the spatial boundaries, namely the vast geographical distances that separate the different groups involved in the formulation and enforcement of the policy within the Brazilian Amazon region. Even though the actual enforcement of the environmental law takes place in the Amazon rainforest, the forest rangers that perform this work rely on the work done thousands of miles from their locations. In particular, it is mostly in Brasília that politicians and ministry officials devise policies and strategies to reduce deforestation and attorneys analyze legal appeals from the farmers (see **Figure 2**). Prior to the introduction of the GIS, there were paper-based documents created to record clearings that were then transferred via post between the different occupational groups working across such vast distances.

However the accuracy of such documents was often highly contested. One crucial aspect of enforcing fines within the Amazon is the agreement between the farmer, attorney and ranger that the legal documents and the information contained in them all refer to a particular farm. Prior to the GIS, the accuracy of the paper-based documents was often questioned. Farmers and their attorneys would say that the local references used in such documents to locate the boundaries of deforestation, and then to correlate it with the boundaries of a particular farm such as the name of the municipalities (which in many cases may be as large as Belgium), roads and other local names (e.g. "near the river bend" or "after the rubber tree") were inaccurate or insufficient. In other words, forest rangers used relational references of space which depended on the knowledge of particular contours and features of the landscape as seen by someone living in the region. Similarly, prior to the introduction of the GIS, the size of deforestation in the fines was usually calculated using the *olhometro*, that is, the measuring of size in an approximate way based only on sight and experience. This again was readily open to question by the farmers attorney. An IBAMA attorney illustrated this issue by saying that:

> [T]he infraction notices did not have the geographical coordinates and in some cases not even the [detailed] address. So, in most cases these old process finished like that: without finding the person responsible [for the deforestation] or the area. In the end the affectivity [of IBAMA's work] was really low. When we started to indicate clearly these infractions, by indicating the author of the crimes and its exact location [with the GPS] that the notices of infraction has started to have as well, the situation has improved allot. Now at least we know the area where it happened even though we may not be sure who did it" [the illegal act]."

The GIS overcame some of these problems by being able to map individual farms and clearings in the forest and relate them to particular geographical coordinates. This then allowed for others far removed from the actual location of the farm to undertake their work based on a type of reified evidence that is considered to be independent from the person and the local knowledge based on which it was created. In this way the introduction of the GIS as a boundary object reduced the possibilities for contestation over the details of the legal documents. This suggests that the GIS enabled the different groups to create reifications which in practice act as "immutable mobiles", entities that are believed to be independent from the knowledge of the local context being represented, and consequently can even be read at great distances while maintaining the identity of the location (Star and Griesemer 1989; Latour 1990).

In relation to the notion of boundary objects more in general, our study confirms the well established claim that when they are indeed plastic enough to be interpreted according to the local needs of multiple specific groupings, then they offer important opportunities for boundary crossing (Star and Griesemer, 1989). However, further to this, by highlighting the process of reification in the functioning of boundary objects we suggest that two further points that have been largely neglected by existing empirical studies that have drawn on the concept of boundary object. First, the reification of complex territories into combinable data elements (i.e. polygons, lines and points) allowed groups working with different scales (macro, meso and micro) to work together while still being able to refer to each other's work and maintain single identity. This ability of the GIS to afford the scaling up/down has undoubtedly been crucial for the coexistence of local and shared uses of this artifact, which is one of the crucial aspects of joint work across occupational and spatial boundaries. Second and closely related to the above, the scaling up/down in the case of the GIS can only happen due to the presence of a common *informatic structure* (i.e. longitude/latitude) that help to stabilize the meaning of geographical locations across spatial and occupational boundaries. Both points taken together suggest that in some cases the dynamic between local (i.e. well-structured) and shared (i.e. ill-structured) uses of boundary objects is closely linked to the way information is structured within these artifacts and the way this information is transformed (or not) as it crosses boundaries (Star 2010). Further, the ways in which the reified data took on scientific truth, and thus was able to not only be shared and worked upon by different occupational groups, but also accepted as accurate by the farmers, attorneys and judges, is also an aspect of boundary objects that has thus far not been discussed extensively.

2.2   Reification and boundary-blinding: losing the practices for the GIS artefact

The previous section has argued that by reifying particular dimensions of the Brazilian Amazon such as forest clearings and land ownership into digital data, the GIS has acted as a boundary object, so providing opportunities for collaboration between groups operating across occupational and spatial boundaries in the Amazon. However, there were some circumstances in which the process of reification promoted by the GIS was undermining the very practices this artifact was supposed to improve. This section will argue that the overemphasis on reifications may hinder joint work by aggravating a process we refer to as "boundary-blinding", that is, the inability of the some groups (usually senior officials) to understand the practices taking place across boundaries (usually low rank officials). In particular our analysis has identified two dynamics that have led to boundary-blinding: the belief that the GIS deterministically reduces deforestation and the view that the GIS offers a mirror of the Amazon and of the work of the rangers.

Technological determinism was evident in our case in a number of ways. The Brazilian government has spent (and continues to) considerable sums in the acquisition of satellite images with higher spatial (i.e. more quality) and temporal resolutions (i.e. more frequent snapshots) so as to try to provide data that is as near to being "real-time" as is possible. Interviews with different scientists and senior officials suggested that behind these heavy investments is a belief that the availability of more detailed and timely data is crucial for reducing deforestation in the Amazon. When it comes to the description of the way these systems are used in law enforcement, senior officials and scientists again provide accounts that are more focused on the capabilities of the GIS than on the actual practices undertaken by the forest rangers. In particular, scientists and senior officials often assume that forest rangers work on the same "real-time" basis as the GIS, expecting rangers to launch operations that are able to interrupt ongoing deforestation and arrest the perpetrators in the act as soon as new deforestation data appears on the computer screen. This was evident in the way a senior official who was actively involved in the development of the GIS described the practices of forest rangers:

> 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 there" and INPE gives this information to IBAMA. It was a jump, a change of paradigm. After that we started to work with very short time strategies. And then people could go to the field and interrupt ongoing deforestation. Look, here, lots of deforestation points and fires, and then the people [rangers] would go there and find lots of people trying to do deforestation.

However, despite the prevalence of the view that law enforcement takes place in real-time as a consequence of the GIS, a closer look at the actual practices of forest rangers reveals a very different situation. The rangers have to face significant challenges in order to leave their bases and get to the locations pin-pointed by the GIS. It is not uncommon for forest rangers to take two days or more to reach a given location within their jurisdiction. Further issuing fines was very time consuming as it was important that detailed records of coordinate and pictures were taken as evidence in case the farmer challenged the fine that the rangers imposed. In addition to that, IBAMA and other environmental agencies have difficulties in recruiting and retaining forest rangers in the Amazon, leading to a chronic issue in relation to the lack of qualified personnel. Consequently it is often impossible for the rangers to be able to respond to specific deforestation points as soon as they are detected by officials in Brasília or São Paulo by using the latest GIS technology. Instead, local managers usually have to wait until the number of deforestation points detected cumulate into a sufficient amount for them to consider it worthwhile to send a team of forest rangers to the region. Therefore, typically deforestation is only investigated and potentially prosecuted several months after being detected by officials using the GIS. Further to the delay in investigations, many areas of the

Amazon rainforest are not even investigated. This was evident in only 17%[1] of the deforestation detected by INPE between 2004 and 2008 actually lead to IBAMA issuing a fine. Therefore not only deforestation control in "real-time" is infeasible in practice but also that forest rangers cannot cope with the volume of deforestation data currently provided by the GIS. The above suggest the presence of a view that a technology with certain characteristics is able to determine a specific practice independently of the context in which this technology is introduced. A perspective that views deforestation control as a set of canonical practices reified in the technical capabilities of the GIS, and are blinded of the complex non canonical practices involved in the actual enforcement of the environmental policy in the Amazon taking place across occupational and spatial boundaries (Brown and Duguid 1991). The following account from a local manager about an ongoing mission provides an illustration of the complex and emergent character of law enforcement activities:

> I sent a team to check some properties in Colniza, but that I also received a request from FUNAI [Foundation for the Indigenous Populations]. Since it was on the way to Colniza, and indigenous lands have priority, I asked them [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. [...] Ultimately, I spent 10 workdays on an issue that I thought would take only a couple of days. For this reason I can say that we always have to take decisions on the spur of the moment.

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[1] Percentage calculated by dividing the sum of the areas fined for illegal deforestation by IBAMA by the total deforestation detected by INPE in the same period.

Figure 3 *Forest rangers collecting evidence related to a potential illegal deforestation in a farm in the Amazon.*

In some cases the emphasis on the technical capabilities of the GIS as being the best approach to reduce deforestation has been so intense that some scientists and government officials believe that one day the detection of deforestation and the issuing of fines will be able to be automated, done solely by machine, and without any human operator on the ground. Indeed, one of the main justifications behind the development of SLAPR, a GIS developed by SEMA (the environmental agency of the state of Mato Grosso), is the ability of this technology to capture the full name of the owner and the location of a farm in the Amazon. In particular, some senior officials reported that with the help of the GIS the government aims to exert remote control over farmers by monitoring and issuing fines from a distance. In this way they suggested that the detection of deforestation solely through the GIS would dispense of the need for forest rangers. However, such a view was dismissed by many forest rangers as being fanciful, as the detection of new deforestation and its enforcement within SLAPR and other GIS involves not only scientists detecting the deforestation, but also forest rangers who have to go to the specific location indicated by the GIS in order to find the perpetrator of the crime who might not necessarily be the land owner (see Figure 3). Consequently senior officials often wrongly conflate deforestation as detected and reified on the GIS with deforestation being under control. This suggests a degree of boundary-blinding whereby the very existence of professionals working across boundaries is denied (Star and Strauss, 1999).

The second way boundary-blinding is hindering joint work in the Amazon relates to the over reliance on the abstract indicators provided by the GIS. In particular our analysis suggests that this trend has prevented senior officials from adequately understanding the social reality of the Amazon and the outcomes of the work of forest ranger. Following the establishment of INPE's GIS in the 1990s, the total deforestation figures released by the institute largely became the main basis for the creation of new policies, and in many cases were also used to evaluate the efficiency of these policies. For example, it was the growing deforestation rates detected by PRODES in 2002 and 2003 that has led the government to create PPCDAm, a new plan to control deforestation. Five years later, the reduction in subsequent deforestation rate as detected by the same GIS led to senior officials from the Ministry of the Environment concluding that PPCDAm was a success. Furthermore senior officials are keen to highlight the total number of fines and environmental licenses produced in a given period while discussing the effectiveness of their agencies in the environmental protection of the Amazon. This suggests that senior officials increasingly relied on the abstract indicators provided by the GIS as the main (and in some cases the only) way to evaluate the outcomes of law enforcement activities and policies in the Amazon.

As seen above, the reification of work with the help of GIS enabled the coordination of different joint work practices. However, it is important to note that these reifications constitute a very selective image of the Amazon and of the work of the rangers (Taylor and Johnston 1995). Thus the reifications provided by the GIS are often restricted to aspects of the Amazon that are quantifiable, spatially located in a precise way and observable from outer space and those aspects of the Amazonian reality that are immeasurable and complex often remain invisible to policy-makers. For example, the amount of work necessary to produce a single fine can vary considerably depending on the distance of the deforestation from the local office, the degree of danger involved in undertaking the operation, the willingness of the farmer to help to establish ownership as well as the complexity of individual cases. Additionally, not all forest rangers are able to issue fines and licenses with the same level of proficiency. This can led to some fines for illegal deforestation being withdrawn or overturned when they are challenged by lawyers and attorneys. Despite these differences the data provided by the GIS does not distinguish between the issuing of well-formed fines and faulty documents, and instead provides an aggregated figure of the total number of documents issued in a given period. This meant that senior officials were often unable to identify the relationship between these indicators and the actual punishment for illegal deforestation. Moreover, the emphasis on the quantity rather than the quality of fines means that senior officials tend to disregard the need for an improved legal and GIS

training for the rangers. Hence, by relying exclusively on these figures, senior officials often remain blind to the outcome of the rangers' practices and their actual implication for the environmental protection of the Amazon (Lipsky 1980; Blackler 2006).

So what does our case suggest in terms of the idea of boundary-blinding? Should not some form of boundary-blinding practices be expected in any geographically distributed organization? Commentators have already noted that organizations continuously adopt strategies that enable distributed and complex organizations to be manageable from afar (Law 1987; Cooper 1992). Strategies such as black-boxing (i.e. ignoring the details of the work done within a given group) and interfaces (i.e. reduce the communication between groups to a set of inputs/outputs) are often used as ways to reduce complexity (Kallinikos 2006; Spinuzzi 2008). Furthermore, the relation between the GIS and the blinding of outcomes in the Amazon should not come as a surprise. Studies exploring the implications of GIS and other technologies have already explored at length the inability of abstract symbols and related positivist epistemologies to capture the richness of social life (Pickles 1995; Taylor and Johnston 1995; Scott 1998). More specific to the public sector, these findings also confirm the problems generated by a growing emphasis on targets and indicators (Lipsky 1980; Miller 2003; Chapman 2004; Blackler 2006). However, what is particularly significant here is that boundary-blinding is preventing the different groups working in the protection of the Amazon from understanding each other's demands and therefore is preventing the creation of more effective polices, technologies and law enforcement strategies.

Boundary-blinding has been detrimental in a number of ways. Firstly by ignoring those that enforce the law and the ways in which it is carried out, senior officials are more likely to create policies that are infeasible in practice and technologies that do not fit with local needs. The example of the problems associated with the technologically deterministic view that the control of deforestation can take place in real-time and at a distance are clear illustrations of this issue, and these were by no means isolated cases. Different forest rangers complained that policy-makers often approve new regulations which cannot be implemented in practice owing to their complexity and resource demands. Consequently, they are often blamed for not fully implementing the law, even though the government does not provide the conditions required for this to take place. This has led to tensions in the relations between the different groups that have to work together in order to protect the Amazon. This was captured by a ranger who when referring to senior officials and scientists explained:

> [T]he problem in Brasília is that many times they develop technologies that nobody asked for, like this electronic fine, while the technologies that we really need they don't develop. The guys from Brasília do not know our reality and do not like coming here because they think that here is the end of the world.

A second negative effect arising from boundary-blinding hinted in the excerpt above relates to the marginalization of the rangers relative to the status the GIS in law enforcement. While the emphasis on GIS technology is leading the government to invest large sums in the construction of advanced and often underutilized GIS, the occupational groups that actually enforce the law are largely neglected and undervalued. Specifically, even though over recent years IBAMA has improved the provision of vehicles that rangers use to undertake missions and increased the rangers daily allowances for the period that they were away on missions, forest rangers still complain about their low salaries as well as their lack of training in GIS and relevant environmental laws. In addition, forest rangers frequently lament the fact that while they are often blamed by government officials for not enforcing the law 'correctly' when farmers' fines and convictions are overturned, they are seldom allowed the opportunity to brief attorneys directly and thus provide important evidence in a legitimate way in order to bring about more convictions. The attorneys thus privilege the apparent scientific "truth" that they believe the GIS affords and not the subjective interpretations of the rangers. The marginalization of the rangers highlights how the forest rangers are increasingly treated as nonpersons: actors with illegitimate voices whose views and opinions are not valued or identified as being significant in the enforcement of deforestation. This lack of legitimacy is akin to the invisibility of work and workers as discussed by Star and Strauss (1999) and is a central aspect of boundary-blinding. However our case has also highlighted that boundary-blinding is not only fostered by the lack of legitimacy of certain

groups, but also by the technological determinism among scientists and senior officials who value the development of new technologies and reified indicators at the expense of local voices (Grint and Woolgar 1997; Nardi and O'Day 1999; Brown and Duguid 2000).

3   Conclusion

By acknowledging the important ways in which reification is implicated in the functioning of boundary objects and especially with regard to the process of boundary-blinding we are able to offer some observations on some of the recent debates on the potentially contradictory character of boundary objects. As mentioned above, some authors have already noticed that depending on the circumstances boundary objects may change their role from facilitators to hinders of collaboration (Carlile 2002; Levina and Vaast 2005; Barrett, Orlikowski et al. 2007; Barrett and Oborn 2010). In the case of the Amazon as in the case study proposed by Barrett and Oborn (2010) these negative effects are related to differences in power and status between the different groups involved. So in the case of the Amazon as in the case of Indian programmers we could observe how the use of boundary objects (e.g. GIS, software specifications) became a way for a more powerful group (e.g. managers) to control other groups (e.g. rangers, Jamaican programmers). Yet, the accounts provided by the current literature suggest that boundary objects either help or hinder collaboration at a given time and context, precluding the possibility of hybrids or more fuzzy situations. Furthermore, the social dynamics indicated as elements hindering collaboration (e.g. politics, stereotyping) seem to be unrelated to the dynamics providing opportunities for collaboration across boundaries (e.g. flexibility, single identities, shared practice). However, in this paper we argued that the same process of reification which helps joint work by providing mobility and scalability also creates tensions through fostering boundary-blinding. In particular, on the one hand our case showed that reification is crucial for enabling the tailoring of GIS to the work needs (i.e. scale) of specific groups, and to the disembedding between time and space required for the overcoming of spatial and occupational boundaries. On the other hand, however, the reification promoted by the use of GIS as a boundary object has also promoted the invisibility of work practices and outcomes - a phenomenon that is hindering the ability of the Brazilian government to effectively tackle deforestation in the Amazon. From this analysis it is possible to conclude that in some cases the role of a boundary object as both an aid and an obstacle to joint work cannot be separated from each other. From this it emerges that the introduction of ICT in the public sector as an aid to inter-departmental collaboration should be analyzed as a potentially contradictory endeavor, whereby the same forces that enable collaboration may on the long run also hinder it.

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