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# Infrastructures of environmental governance

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In the early 1990s, an ad hoc alliance between field biologists and oil companies resulted in a massive increase in the ability of biologists to collect Amazonian plant specimens. This arrangement permanently impacted experts' treatment of biodiversity as a technical and political problem in the region. Anthropologists have studied community-level environmental politics intensively, including in the Ecuadorian Amazon (e.g. Sawyer 2004). But they have not typically approached the expert design and implementation of environmental interventions in a manner that might, for example, elucidate the motivations and consequences of an alliance between oil work and biological fieldwork in support of biodiversity conservation.

Scholarship on knowledge infrastructures provides a rich conceptual toolkit for understanding this technical work (Bowker & Star 1999; Star 2010). When combined with sensitivity to the character of power and knowledge in modern institutions (Foucault 2007), analyses of experts' 'infrastructure work' (Star & Bowker 2010) might help us to understand how the management of human-environment relations takes shape at the level of concrete practices.

In this article, I trace the development of scientific infrastructure in Ecuador from botanical research supporting biodiversity conservation to later ecological research in the Ecuadorian Amazon. Examining this trajectory demonstrates how an analytical emphasis on knowledge infrastructures can help anthropologists understand the technical conditions of environmental governance.

PETER TABER

**Fig. 1.** *Environmental governance meets the environment: a botanist scales a tree to collect specimens from the canopy during an environmental impact assessment.*

## Reaching Ecuador's Amazonian biodiversity

In the mid-1980s, a scientific programme conducted jointly by the St Louis-based Missouri Botanical Garden and the Ecuadorian forestry department began fieldwork in the Ecuadorian Amazon. Ostensibly focused on rational forestry, the programme was prompted by concerns about the rapid rate of conversion of forest to agricultural land as a consequence of informal settlement. One of its eventual goals was to create scientific infrastructure, especially specimen collections, that would allow Ecuador to implement a nationwide system of protected areas for biodiversity conservation on the basis of species-level botanical data.

Botanists' fieldwork in the Amazon coincided with a controversial round of oil drilling in the same region. The intersection of these two phenomena – botanical fieldwork and oil development – provides a striking illustration of what Bowker (1994) has referred to as 'infrastructural inversion'. The term refers to the fact that 'historical changes frequently ascribed to some spectacular product of an age are frequently more a feature of infrastructure permitting the development of that product' (Star & Bowker 2010: 238).

While rapid biodiversity loss resulting from economic development became a widespread focus of public and expert concern, I show here how biodiversity (one 'spectacular' concern emerging in the 1990s) became an actionable political problem in the Amazon as a consequence of the oil work that was later managed in its name.

The most basic infrastructure required by botanists for biodiversity conservation, and one that Ecuador lacked in the 1980s, was a collection of plant specimens that would allow them to characterize the flora of the region. While collecting plants in the Amazon for this purpose, two main problems confronted botanists. First, the Amazonian tree canopy from which specimens needed to be collected, loomed anywhere from 25-60 m above the forest floor. Fieldwork involved a laborious process of climbing trees in order to collect specimens. Second, much of the region remained relatively inaccessible, requiring botanists to focus their efforts on collecting in the limited areas that could be reached easily by car or truck and from which large bundles of specimens could be routinely transported back to Quito, Ecuador's capital city.

An encounter between botanists and petroleum field operations in the late 1980s initiated a series of agreements (first informal, later contractual) that alleviated both of these problems. As a US expatriate who headed the botanical field programme put it in one interview:

> We were driving along […] and stopped where they were drilling a well, and I sort of explained to them that we were interested […] in where they were cutting down trees, because then we don't have to climb them, we can get specimens from the trees, botanical specimens, much easier – including the epiphytes, and the trees if they're in flower or fruit, etc. So we became sort of camp followers of the petroleum industry […]. That had been sort of my *modus operandi* in Nicaragua and elsewhere and … that's generally the way botanists in the tropics have worked.

By inserting themselves into petroleum work sites 'behind the chainsaws and ahead of the bulldozers', as their reports put it, botanists radically increased the efficiency of their plant collecting efforts. As the arrangement became routinized, they accompanied petroleum work crews by helicopter to increasingly far-flung sites. The coupling of botanical fieldwork to oil development transformed the spatial relationship between the body of the plant collector and the forest canopy by bringing the canopy within reach. It also collapsed the geographic distance between Quito and the lower Amazon by making helicopter transportation financed by oil companies routinely available. For a time, the scientific infrastructure work underpinning biodiversity conservation was itself supported by the infrastructure of oil work.



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**Fig. 2.** *A collection of specimens on a workbench in the National Herbarium's collection room awaits identification by a private consultant.*

The convergence of botany and oil development had two immediate scientific outcomes. First, botanical knowledge of new species accrued at an unprecedented rate on the basis of the sheer volume of specimens collected. Second, botanists discovered that lowland Amazonia exhibited much greater floristic variability than their discipline had anticipated. The avalanche of botanical knowledge confirmed the general importance of the region for conservation purposes. But it also threw into question the scales at which the lower Amazonian landscape functioned ecologically, and thus the scales at which it might be optimally managed. Botanists subsequently understood their biological exploration to be a first step toward studying the region's ecology in terms of differing spatial scales of diversity, work that converged with emergent debates in plant ecology.

More subtly, with a growing specimen collection that allowed botanists to identify a significant portion of the vascular plants they encountered, a new subjective orientation toward Ecuador's Amazon became available. It was no longer strictly a space for the discovery of new vascular plants, but one that could be evaluated on the basis of already existing botanical knowledge to avert damage in the context of the oil development in which botanists found themselves embedded. Botanical fieldwork took large steps toward supporting protected area planning. But in the process, scientific understandings of *what* the lowland Amazonian environment *was* were significantly complicated, new scientific problems came sharply into focus and the lower Amazon's character as an oil field formed a new point of specialized environmental intervention.

To borrow a term from Michel Foucault (1983), biodiversity conservation planning operated with its own distinctive 'political rationale' – a set of historically specific reasons in terms of which social reality was to be managed, in response to specific problems. Biodiversity conservation's political rationale emphasized the description of geographic space in terms of the ensembles of living things that inhabited it as a step toward designing protected areas. It required infrastructure work of botanists that was conceptually straightforward but logistically onerous: to get Amazonian plant specimens.

The infrastructure work involved in enacting biodiversity conservation did not operate within neat institutional lines. There was no official name, letterhead or organizational headquarters for the technological ensemble 'plant collectors-plus-oil work'. Botanists simply used the means available to them to collect plants, and petroleum operations enjoyed a degree of environmental legitimacy by helping environmentally-minded scientists. The height of the Amazonian canopy and that of human plant collectors, the bulldozers, chainsaws and helicopters of oil work, hastily drawn-up contracts, and a rapidly-accruing specimen collection, all entered into an unplanned but highly productive configuration that we could call an 'assemblage' (Li 2007; Rabinow 2003).

The arrangement lasted roughly half a decade as biologists and oil companies quickly acquired what they needed or found other ways to achieve their goals. Despite its evanescent character, this assemblage left behind a permanently altered relationship between basic biological science, environmental management and natural resource extraction in Ecuador's Amazon.

As scholars in science and technology studies (STS) have long observed, focusing on scientific practices like these helps us to think carefully about the nature of the boundaries and interactions between organizations and communities of specialists (Star 2010; Star & Ruhleder 1995). Whereas we might imagine environmental knowledge to be fed into a distinct arena of deliberative policymaking, no such arena existed in Ecuador in the early 1990s. Rather, field biology was interwoven directly with new forms of intervention, like protected area design and environmental impact assessment conducted by a complex field of organizations that coalesced around biodiversity conservation in the 1990s. These included non-govern-

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mental organizations (NGOs), bilateral aid agencies, scientific institutions and private contractors as well as the state agencies that evolved to work with them. With relatively weak state institutions and a heavy reliance on NGOs and private contractors, Ecuadorian biodiversity conservation was typical of what is now recognized as neoliberal environmental governance. Yet, because of its reliance on a shared set of scientific products and practices, much of this work was more tightly coordinated than an analytical preoccupation with 'decentralization' might lead us to believe (Taber 2016). A focus on the infrastructure work involved helps us to scrutinize our own assumptions about how environmental governance works.

'Biodiversity' was an available way of conceptualizing the variability of living forms for specialists working in Ecuador's Amazon prior to this botanical field programme. Yet it only became an actionable problem there – subject to expert practices that were deemed feasible – as a *consequence* of petroleum development. Oil development made the actual management of biodiversity in the Ecuadorian Amazon possible. And botanists' reliance on oil work to implement conservation's political rationality incurred a subtle change in the focus of environmental governance in the region, from the deforestation produced by informal settlement to the environmental mitigation of petroleum development. As a political and technical problem, biodiversity in the Ecuadorian Amazon – its spatial distribution, the various scales at which it aggregated, its rates of regeneration, how it might be protected amidst extractive development – acquired new concreteness, complexity and urgency as the oil field became legible to botanists' expertise.

## From biodiversity inventory to forest dynamics

Biodiversity conservation and the sciences that supported it benefited from widespread public interest throughout the 1990s, as concerns about the loss of tropical rainforest became mainstream. This interest encouraged the scientific study of 'diversity' itself. Ecologists interested in figuring out why tropical forests exhibit such high levels of species diversity needed a knowledge base – and corresponding infrastructure – that could help them address the question systematically. The findings of forest ecology have yet to be linked back to programmes of governance in much of Ecuador. And since the turn of the millennium, climate change has usurped biodiversity loss as the pre-eminent global environmental problem in public discourse, basic science and institutional intervention. I now consider the infrastructure that was produced for ecological research in Ecuador in the 1990s and 2000s, and how this infrastructure may be taken up by programmes of environmental management in the future.

As intended, the research in floristics accomplished by the aforementioned botany field programme served as the basis for ecological research in Ecuador in the mid and late 1990s. Extensive knowledge of local floristics produced by botanists was a pre-requisite for field ecology in the region. Plant ecology required its own infrastructure in the form of permanent forest parcels – plots of land in which scientifically described vascular plants could be studied on a minute spatial scale, over long periods of time and with minimal anthropogenic interference (Losos & Leigh 2004; Malhi et al. 2002). Ecuador saw a wave of such parcel construction throughout the 1990s. Consequently, lowland Amazonian forest itself is now an infrastructure for basic science, policy and management. Whereas the rationale of biodiversity conservation encouraged a focus on the distribution of taxa across space, permanent forest plots allow for in-depth study of the growth and development of vascular plant communities in specific spatial locations 'indefinitely or until there is no more money or no more forest', as one field manual put it (Mågard & Svenning 1995). Such exhaustively studied spaces are important for attempts at linking the quantitative indicators often used by ecologists, resource managers or others interested in environmental monitoring (Gabrys 2016) with the findings of decades of taxonomically based field biology.

Over roughly the same period as the boom in parcel construction, the database has taken a place alongside academic articles as an esteemed scientific product (Bowker et al. 2010). Databases resulting from Amazonian plots can now be linked, allowing ecologists to make comparisons across space, examine long-term trends and make arguments on the basis of the statistical power enabled by large sample sizes.

One finding of ecological research in forest dynamics has been that the spatial and temporal scales at which forests maintain species diversity do not coincide neatly with those at which human polities have historically been organized and governed (e.g. Ter Steege et al. 2013). Results derived from the forest dynamics paradigm lend themselves to sophisticated evolutionary theory-building, but do not translate easily into managerial prescriptions.

At the same time, the avalanche of ecological data produced by forest plot networks is available to be translated from the concerns of forest ecology to those of measuring climate change and managing its impacts (e.g. Fauset et al. 2015). Forests constitute irreplaceable repositories of species diversity that are forecasted to 'die back' as a consequence of anthropogenic climate change; and they are sinks that actively draw in and store enormous volumes of carbon. In addition to its planned role in scientific research on tropical biodiversity, the formatting of lowland Amazonian forest as an infrastructure of data-intensive plant ecology may lead to new framings of the forest in relation to carbon budgeting and climate change – for example, by enabling the conversion of existing tree measurements into approximations of above-ground carbon stocks.

Lowland forest is thus poised to be an active node within national and regional carbon economies. Claims made in either climate or petroleum politics will increasingly be based on what specialists and non-specialists can do with the data that have accrued over the last two decades of concern for environmental crises. The interface between biodiversity and climate informatics may thus be one more domain in which environmental politics plays out (Edwards 2010; Fortun 2004; Waterton et al. 2013).

It is worth emphasizing that this 'informaticization' of ecology is unlikely to extricate science, policy or management from the messy local-level environmental politics that anthropologists have had so much success studying. Understanding these dynamics will likely require careful attention to specialists' 'boundary work' as they negotiate the lines between formal organizations and communities, as well as those between policy and science (Ascher et al. 2010), between disciplines like biology and ecology and appreciation of the 'digital divide' that often separates Northern and Southern institutions.

Yet, we might anticipate that if forest ecology and carbon budgeting become common governmental forms, communities living in close proximity to these forests will find themselves amidst a complex 'infrastructural ecology' (Star & Ruhleder 1995) that encourages their political concerns to be formatted to reflect the terms of climate politics. Similarly, environmental management remains interwoven with the political economy of oil, but the relationship between the two is again being reconfigured. Carbon increasingly figures as a currency with which the oil flowing out of the Amazon and the biodiversity living atop oil deposits might be commensurated.


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**Fig. 3.** *An intern mounts a plant specimen and attaches the label. Producing specimens that follow botany's complex conventions is a time-consuming and labour-intensive process. Moreover, acceptable herbarium specimens must be mounted on acid-free paper, which is not produced in Ecuador and must be imported.*

Informaticization and the carbon economy add layers of complexity, creating new criteria in terms of which environmental politics will be cast at various levels. They participate, in other words, in the ongoing problematization of the environment (Foucault 1994).

## Conclusion

Much as Foucault's (2007, 2008) genealogies of liberalism help us to understand how contemporary ways of reasoning about human conduct became thinkable, attention to the infrastructure work undergirding environmental governance clarifies how particular rationalities of environmental governance become actionable. Bowker's 'infrastructural inversion', for example, refers to historical phenomena like the collaboration between biologists and petroleum field operations as a means for producing knowledge about biodiversity that would later be used to regulate Amazonian development. Simultaneously, the term also labels a strategy for analyzing those processes to understand how they facilitate the emergence of new environmental problematics – for example, by looking empirically at the practical work involved in producing knowledge about biodiversity as a starting point for understanding how it becomes a domain of expert intervention.

Conceptual resources from STS approaches to infrastructure encourage a nuanced, granular anthropological approach to the technical dimensions of environmental politics. Moreover, as the examples above show, there is no direct route from political rationale to intervention in environmental governance. The work involved in producing the knowledge that specialists believe is required at time $t_0$ is likely to contribute to transforming their understandings of what the relevant environmental problems are, the institutions they inhabit and the contexts in which they operate by time $t_1$. Tracing these reflexive processes of institutional reconfiguration is an important potential contribution of the analytical strategy proposed here (Karasti et al. 2016).

Scrutinizing experts' infrastructure work – often piecemeal and ad hoc, with enduring effects that may only be recognized retrospectively – leaves little room for either progressivist histories of science or righteous denunciations of the machinations of technocrats. Nor would it be especially insightful to argue that infrastructure work 'fails' when it does not result in omniscient institutional 'vision' or control. Environmental infrastructure work addresses problems of sufficient complexity that they will never be tidily solved, only ameliorated or gradually transformed. Furthermore, the normative sensibilities with which we, as anthropologists, tend to view actors in environmental politics (Conservation, good! Oil, bad!) are unlikely to be helpful guides for empirically unpacking the infrastructural entanglements whereby environmental knowledge is actually produced. Understanding the infrastructures of environmental governance requires a readiness to honestly trace assemblages cutting across institutional boundaries, an appreciation for bricolage and contingency and an analytical lens that can accommodate the creeping pace at which large-scale sociotechnical systems take shape – what some have called 'infrastructure time' (Karasti et al. 2010).

For people living in regions of Ecuador that have attracted conservationist interest over the last three decades, 'biodiversity' is now one readily available orientation to local life forms. It exists amidst other, more traditional relationships to resources and offers a point of articulation between diverse local discourses and practices and the agendas of the institutions of environmental governance. It seems likely that environmental governance will continue to produce new ways of understanding and acting toward the environment – including, perhaps, the formal objects of carbon budgeting and climate change mitigation – that will achieve a similar ubiquity. Incorporating within our analyses the infrastructure work that underlies shifting paradigms of environmental governance will aid us in understanding the shape of environmental politics to come. ●

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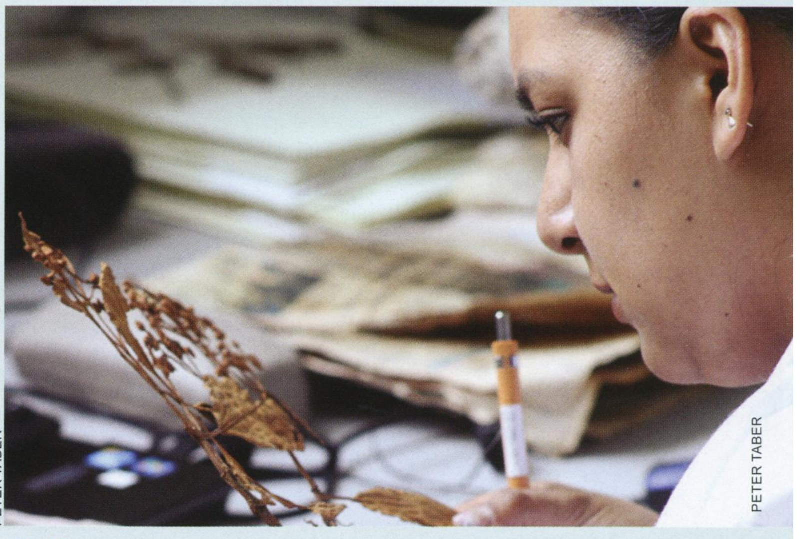


**(From left to right, above to below)**

**Fig. 4.** *A curator updates the identifications of a number of specimens. In lieu of curation, the physical organization and labeling of a specimen collection will rapidly cease to reflect scientifically accepted taxonomies. Scientific infrastructure relies on complex chains of such ongoing and socially dispersed 'infrastructure work' in order to function.*

**Fig. 5.** *After a long day of fieldwork, students prepare the samples collected from an inventory parcel for drying in gas-powered dryers.*

**Fig. 6.** *Mounted specimens waiting to be accessioned into a herbarium collection.*

**Fig. 7.** *A curator checks the identification of plants in the collection at Ecuador's National Herbarium.*

**Fig. 8.** *Students receive direction from a professor while setting up and inventorying a permanent forest parcel at a research station operated by the Amazonian State University, near the city of Puyo.*

**Fig. 9.** *Specimens collected in an environmental impact study that have been preserved in alcohol, dried, frozen (to kill insects and fungi), and which are now awaiting identification.*

**Fig. 10.** *Identifying plant specimens from a petroleum environmental impact assessment with the aid of a comparative collection. Whereas traditional botanical plant collecting results in specimens that can be incorporated into an herbarium collection, environmental impact assessment generates large volumes of low-quality specimens, like this one, that are of little scientific value over the long term. When most botanists are employed in such studies, finding sources of viable specimens becomes a problem.*

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