

From Jungle to Space: Cartography, Satellites, and the Environment

FELIPE FERNANDEZ CRUZ¹

Tulane University

Abstract: This article explores the history of how humans have come to map and conceptualize geographical space, and its eventual effects on the environment. Focusing on the history of mapping, aeronautics and space flight, the article explores how science and technology has been employed by the Brazilian state to conquer its frontiers, especially the Amazon. It then shifts the analysis to how this spatial conquest came to affect the environment in the region. The governments of Getulio Vargas (1930-1945) and then later the Brazilian military dictatorship (1964-1985) used mapping, airplanes and satellites to promote economic development in the region, and how development caused environmental degradation and conflicts with indigenous peoples. Finally, we see how satellite imagery reversed that trend when it was later deployed to enforce environmental laws, vastly reducing the rate of deforestation in the Amazon.

Resumo: Este artigo explora a história de como os homens tem mapeado e conceituado geograficamente o espaço, e seus eventuais efeitos sobre o meio ambiente. Focando a história do mapeamento, da aeronáutica e dos voos ao espaço, o artigo explora como a ciência e a tecnologia tem sido empregada pelo governo brasileiro na conquista das fronteiras, especialmente da Amazônia. Analisa como essa conquista espacial afetou o meio ambiente na região. Os governos de Getúlio Vargas (1930-1945) e da ditadura militar brasileira (1964-1985) usaram o mapeamento, aeronaves e satélites para promover economicamente o desenvolvimento da região, desenvolvimento que causou a degradação do meio ambiente e conflitos com os povos indígenas. Finalmente, analisamos como as imagens de satélites reverteram essa tendência quando passaram a ser usadas par reforçar as leis ambientais, reduzindo enormemente a taxa de desmatamento na Amazônia.

Recebido em 13/07/2018 e aceito em 04/12//2018.

1. Professor Assistente na Universidade de Tulane especializado em História da América Latina e História da Ciência e Tecnologia.

In 2007, the Google corporation announced its Lunar X-Prize, promising a prize of US\$20 million to the first private team to land a rover on the moon by the year 2015 – along with an extra US\$4 million if the robot navigated to and photographed one of the original moon landings. Over the years, the Lunar X-Prize has caused some controversy. Archaeologists and preservationists were enraged at the possibility of damaging the sites of original moon landings, claiming they are part of humanity’s historical heritage. Others questioned whether it was legal for a private corporation to land on the moon in the first place. After all, who owns space? Who gets to explore it?

As it turns out, there is a body of international law dealing with the rights to navigation in space and other celestial bodies.² Sputnik, the first satellite to orbit the earth, was its first precedent. While historians have focused on the great phobia the Soviet satellite spread among Americans, new research has shown that the administration of President Eisenhower saw a silver lining. As Sputnik flew over the United States, it established a *de facto* principle of free navigation of space, ensuring the Soviets could not protest when American satellites eventually reached orbit.³ In 1967, an international agreement called the Outer Space Treaty set the rules for the exploration and use of outer space.⁴

In 1943, thirteen years before Sputnik, a much smaller event took place that would also help define geographical space and its occupation. It

2. For more on the contemporary controversy surrounding moon landing rights, see the following news story: “Google’s Goal: Inspire First Privately Funded Moon Landing,” Interview, *Tell Me More* (National Public Radio, August 11, 2011), <http://www.npr.org/2011/08/11/139536084/googles-goal-inspire-first-privately-funded-moon-landing>.

3. Paul Dickson, *Sputnik : the shock of the century* (New York: Walker Pub., 2001).

4. Alex Young, “Diplomacy in Space: The Final Frontier of International Law,” *Harvard International Review* 35, no. 3 (2014): 6–7.

was in a remote region along the Araguaia River in central-western Brazil. An expedition had been sent there to explore and colonize the region: It was the Roncador-Xingú expedition, the vanguard of a much larger program of colonization of Brazil's frontiers: The *Marcha para o Oeste* (March to the West). Launched by President Getúlio Vargas, it sought to explore, map and colonize the region, which had been thus far relatively unknown and unreachable by the Brazilian state.

The expedition was building an outpost with a landing strip so that it could be supplied by airplanes. After clearing a stretch of the forest so that airplanes could land, the government sent a military officer specializing in celestial navigation to determine the precise coordinates of this new outpost – the leading edge of Brazil's exploration and conquest of its own territory. The officer spent three days making precise measurements. When he was done, he took them back to the then capital Rio de Janeiro so that this new locale could be added to the map of Brazil, making the conquest official. It was an act of defining a real location as an abstract geographical space.

Going back another 443 years in time, we find yet another moment in humanity's long history of defining places in space: this time, a seafaring expedition of the fledgling Portuguese empire. Even though they were bound for India, the ships turned west in the South Atlantic. They had to follow the winds and currents westward before turning back towards the southern tip of Africa. This time, however, they went just a bit further west and encountered an unknown landmass. It was April of 1500, and the Portuguese expedition led by Pedro Álvares Cabral had just happened upon Brazil. Soon after making a first landing, the master pilot responsible for navigation took celestial measurements with a sextant to determine their precise location. This information was so important that Cabral actually

sent one of the ships back to Portugal with a report of the discovery and its geographical coordinates – handicapping his flotilla for the much longer journey to India. In the Portuguese tradition, historian Patricia Seed has argued, the act of taking these measurements was in fact a way to lay claim to the land.⁵

At this point we might ask: what do these three moments, spread over five centuries, have in common? The answer to this question is the central theme of this article: the mapping and conceptualization of geographical space, particularly in frontiers, and its impact on the environment. The three events are certainly all encounters with new emerging frontiers. Yet they are also episodes on the history of humanity's conceptual understanding of space and its scientific formalization through navigational technologies. As many scholars have argued, geographical space is culturally and socially constructed.⁶ The abstraction of physical locations into conceptual spaces is ever-evolving, varying over places, cultures and time.

Developments in the science and technologies behind the mapping of geographical space are often born out of a necessity, especially when different societies seek to explore and exploit new frontiers. This push onto new frontiers, on the other hand, is often driven by the desire for new economic development, which in turn means the extraction of natural resources. In this article I will analyze the exploration and conquest of Brazil's Amazonian frontiers and its impact on the environment, focusing on the role of mapping, aviation and satellite monitoring on the region's environment in the twentieth century. In doing so, this article delves into

5. Patricia Seed, *Ceremonies of Possession in Europe's Conquest of the New World, 1492-1640* (Cambridge: Cambridge University Press, 1995), 100–106.

6. Henri Lefebvre, *The Production of Space*, trans. Donald Nicholson-Smith (Malden MA: Blackwell, 2007).

how geographical space is created, or in other words, territorialized.

Historian Hal Langfur has offered a good working definition for territorialization which I use here, arguing that “maps, historical geographies, official pronouncements and state policies” are developed in the process of territorializing regions, or rather, exerting “command over space.”⁷ The process of territorialization, however, is also an exercise in the abstraction and simplification of physical environments – an exercise necessary for states to efficiently harvest natural resources, as well as to exploit human labor. In considering how the complexities of different environments and their peoples are simplified for the benefit of states, I turn to the work of James Scott in his seminal book *Seeing Like a State*. Scott, through a variety of case studies, describes this phenomenon as the process by which states make their territories and people “legible,” creating a synoptic view that allows for more control and extraction of resources – or in his words:

“The premodern state was, in many crucial respects, partially blind; it knew precious little about its subjects, their wealth, their landholdings and yields, their location, their very identity. It lacked anything like a detailed “map” of its terrain and its people. [...] How did the state gradually get a handle on its subjects and their environment? [...] In each case, officials took exceptionally complex, illegible, and local social practices, such as land tenure customs or naming customs, and created a standard grid whereby it could be centrally recorded and monitored.”⁸

7. Hal Langfur, *The Forbidden Lands: Colonial Identity, Frontier Violence, and the Persistence of Brazil's Eastern Indians, 1750-1830* (Stanford: Stanford University Press, 2006), 89.

8. James Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1998), 2.

From this perspective, we can think of how the territorialization of space makes previously unknown lands into “legible” maps – environments ready to be exploited. In this article, I will take the concept of territorialization upward, tracing how the conquest of airspace, and even outer space, has helped shape the environment in Brazil’s Amazon and center-west region. Tracing the development of aviation, and eventually the use of satellites, I will argue that the creation and conquest of airspace sharply increased Brazilians’ ability to exploit natural resources in the country’s frontiers, dramatically shaping the environment of these regions. But first, we must understand how humans came to territorialize airspace.

Inventing a three-dimensional world

The long history of how space is conceptualized had to undergo a major paradigm shift in the early twentieth century. The advent of aviation, and with it the newfound ability to fly, forced people to rethink of space as three-dimensional. Topographic maps had done that to some extent, but the ability to navigate through the air, and look down on the earth necessitated a whole new way to think of space. How can one map airspace? Who owns different areas of it? Who can navigate through distinct regions in the atmosphere? How can meteorologists map the currents of air through the atmosphere like nautical charts had mapped oceanic currents? These might seem like settled questions today, but they were critical in the early twentieth century.

The problem of who has the right to fly where was first addressed in the 1910 Paris Aviation Conference. One argument adapted a nautical concept to the atmosphere, proposing that the sky should be like the oceans: international territories with the right to free navigation. Another

line of thought was that airspace should be territorial, with each country controlling access to the space above its territory. In that conference, the German and the French held a position of granting some free access, while the British, concerned about the end of their secure isolation as an island, opposed the idea and defended a proposal for full territorial control. World War I, by demonstrating the potential power of airplanes in warfare, led to a more restrictive agreement, with national airspace being considered sovereign territory.⁹

The evolving science of meteorology also dealt with the problem of envisioning a three-dimensional world. Before the twentieth century most meteorological observations were done at a local scale and were unable to see the broader patterns that could enable long distance flight through the atmosphere. Vilhelm Bjerknes, a Norwegian meteorologist, used data from weather stations spread over large areas that, using principles from applied physics, enabled the understanding of large air masses and fronts – thus understanding movement in the atmosphere from a three-dimensional perspective.¹⁰ It is also worth noting that meteorologists also borrowed from nautical traditions in the terminology used for their science, using the term “aerial ocean” to describe the atmosphere.¹¹

Processes of mapping and territorialization throughout human history have been heavily shaped by culture, science, and technology. That is, we must abstract away from the idea that maps are objective representations of

9. David Courtwright, *Sky as Frontier: Adventure, Aviation, and Empire*, 1st ed. (College Station: Texas A & M University Press, 2005), 43.

10. For a history of the Bergen School of Meteorology, as this paradigm came to be known, see Robert Friedman, *Appropriating the Weather: Vilhelm Bjerknes and the Construction of a Modern Meteorology* (Ithaca: Cornell University Press, 1989).

11. In Brazil, you can see the term used in this text by Brazilian meteorologist Joaquim Sampaio Ferraz. see Joaquim Sampaio Ferraz, *Meteorologia Brasileira (Esboço Elementar de Seus Principaes Problemas)* (São Paulo: Companhia Editora Nacional, 1934).

territories, but rather human projections about what they *imagine* a territory to be, or even what they *want* it to be.¹² Mark Monmonier, in his book *How to Lie with Maps*, explores maps as tools that go much beyond their usage as navigational aids, demonstrating by countless examples how they can be tools used for purposeful deception.¹³ This social and cultural construction of geographical space is a foundation for understanding how the Brazilian state conceived of, mapped, territorialize and came to use both the physical and geographical space of its frontiers.

Aeronautics Advancing the Ranching Frontier

The territorialization of airspace enabled safe long-distance flying, which in turn accelerated incursions into Brazil's frontiers. The Amazon and the country's center-west region are notoriously difficult to access. The terrain made the building of highways and railways very difficult, and there are not many east-west rivers other than the Amazon river itself.

For these reasons, the advent of aviation was celebrated as a panacea for the country's spatial problem. Leaders who decried Brazil's lack of interiorization imagined airplanes crisscrossing the airspace of the nation, helping settle territories and flying back to the coast with the natural resources they hoped to extract from Brazil's untapped bounty. *Aeroclubes*, non-profit organizations dedicated to the promotion of aviation as well as the training of pilots, started appearing in the country's capitals. By the 1920s there was a movement dedicated to the promotion of aviation.

12. D. Graham Burnett, *Masters of All They Surveyed: Exploration, Geography, and a British El Dorado* (Chicago: University of Chicago Press, 2000).

13. Mark Monmonier, *How to Lie With Maps*, 2. ed. (Chicago: Univ. of Chicago Press, 1996).

These evangelizers of the air age saw the new technology both as a path to modernization of the mostly crop export economy as well as a means by which to conquer the vast distances that hindered the territorialization of Brazil's frontiers.

One enthusiastic proponent of the aerial conquest of the frontiers declared in 1915 that “the airplane is a means of locomotion that does not require roads. [...] The network of air roads is varied and infinite; any two points on the surface of the earth's □ surface are always connected by an air route, □ which is the fastest [route], the best conserved and for which the placement and □ maintenance costs nothing□.”¹⁴ While the excitement for the coming air age was ebullient, the statement shows a large dose of naïveté about the realities of air routes. Aviation was still in an era of pioneers flying off in small and precarious airplanes. The new technology was seen through romantic eyes: the lone pilot, in leather jacket, silk scarf and goggles taking off for an adventure into the big blue sky.

But practical air routes certainly do not “cost nothing” – and require much more than a daring pilot – things like landing fields, stockpiles of fuel, radio communication networks and technical expertise. The viability of employing this new technology as a form of transportation also depended on developments in the still incipient atmospheric sciences, in particular the ability to accurately predict the weather. In Brazil's case, another important requirement for the practical use of aviation was also largely absent: accurate maps. As we will see, maps of Brazil's interior were wildly inaccurate, making flying through those regions a dangerous proposition.

There were also challenges of a bureaucratic nature. Brazil's First Republic (1889-1930) was a relatively weak federalist state in which

14. “Aviação - Considerações Gerais,” *Aerophilo*, September 1915.

provincial governments held the most power. This presented a problem for creating a national network of air routes, which required coordination and standards at the federal level. In the First Republic, states often set their own standards and legislation surrounding aviation, and even more troublesome, had their own individual weather bureaus which could not coordinate to provide proper large-scale forecasts with the methods of the Bergen school of meteorology.

This would start changing drastically when Getúlio Vargas came to power through a coup in October 1930. A strong proponent of national unity and centralized power, he reorganized the national framework of agencies administering aviation, eventually centralizing them under a Ministry of Aeronautics in 1941. Vargas believed strongly in the aviation's potential for uniting the fractured nation-state and worked to develop Brazil's aeronautical infrastructure. During the 1930s, he also incentivized the development of air routes by foreign airlines, in particular the American PanAm and the German Lufthansa, which created extensive routes throughout Brazil. The airlines, however, serviced the most economically viable routes along the populated Brazilian coast. The state would have to lead the aerial conquest of the frontiers, and at close of the 1930s it still lacked the technical and human resources to undertake such a project.

That last piece of the puzzle would fall into place with the outbreak of World War II. Brazil held strategic natural resources for the war effort, like rubber, which made it a critical partner for the Allies.¹⁵ It also had another important resource that few historians have discussed – its

15. For more on rubber extraction in Brazil during World War II, see Seth Garfield, *In Search of the Amazon: Brazil, the United States, and the Nature of a Region* (Durham: Duke University Press, 2013).

airspace.¹⁶ Brazil's northeastern city of Natal is the closest point to Africa in the South Atlantic, making it an ideal launching pad for supply routes to the war in Europe and North Africa.¹⁷ This led the United States to make a large investment in the development of Brazil's aeronautical infrastructure, including the construction of large airports and a large supply of aircraft. At the same time, the Vargas regime was leading a large-scale campaign to develop national aviation, training over a thousand new pilots in the first few years of the war. The policies, infrastructure, equipment and human resources were now in place for Vargas to realize his ultimate aeronautical goal – to employ aviation in the exploration, conquest and settlement of Brazil's frontiers.

In the early 1940s, the Vargas government launched the *Marcha Para o Oeste*, a program focused on exploring, settling and connecting with transportation routes the frontiers of central-west Brazil and the southern Amazon. One of the central pieces to this effort was the *Roncador-Xingú* expedition, which started advancing into the region during World War II. Their method was to spearhead colonization by building several airstrips along the route of the expedition. As a result of the Brazilian-American alliance during the war, as well as the National Campaign for Aviation (in which the government and wealthy citizens donated airplanes to aeroclubes to train more pilots), the country became home to a vastly larger fleet

16. These two works discuss the importance of aviation in Brazil during World War II, but from the perspective of diplomacy and physical infrastructure and equipment. William Burden, *The Struggle for Airways in Latin America* (New York: Council on Foreign Relations, 1943); Frank D. McCann, "Aviation Diplomacy: The United States and Brazil, 1939-1941," *Inter-American Economic Affairs* 21, no. 4 (Spring 1968): 35–50.

17. The only historian to discuss this resource at any length is Frank D. McCann. See chapter 8 of Frank D. McCann, *The Brazilian-American Alliance, 1937-1945* (Princeton, N.J.: Princeton University Press, 1974); McCann, "Aviation Diplomacy: The United States and Brazil, 1939-1941."

of airplanes, aviation personnel and infrastructure after WWII. The past dreams of an aeronautical frontier had become feasible.¹⁸

While the state used airplanes to advance into the center-west region of the country, one group of affluent Brazilians was taking advantage of it: farmers and ranchers. Their use of aeronautics to expand farming and ranching operations would have a great impact on the environment of the region. In the settled agricultural frontiers of Mato Grosso, ranch owners were making extensive use of airplanes to manage their properties. Alice Rogers Hager, an American journalist, made extensive observations of their practices while traveling in Brazil. She was sent to Brazil as part of the many cultural programs of the Office of the Coordinator of Inter-American Affairs designed to culturally approximate the Brazilians and Americans as part of the war effort.¹⁹

Hager travelled across Brazil by air as a guest of the Brazilian government, to document how the progress of aviation was changing the country. Her travels resulted in a book titled “Frontier by Air: Brazil Takes the Sky Road.”²⁰ During the trip, she took particular notice of how many ranchers were becoming pilots in order to manage their lands and check their herds.²¹

In Mato Grosso do Sul, where torrential rains often made roads impassable, the advantages were quite clear, and ranchers set about making landing strips across the state – in addition to the ones built by the local

18. Raquel França dos Santos Ferreira, “Uma História Da Campanha Nacional Da Aviação (1940-1949): O Brasil Em Busca Do Seu ‘Brevê’,” *Cantareira* 17 (December 2012): 75–86.

19. For more on the many cultural programs designed for this purpose, see Antônio Pedro Tota, *The Seduction of Brazil: The Americanization of Brazil during World War II*, trans. Lorena B. Ellis (Austin: University of Texas Press, Teresa Lozano Long Institute of Latin American Studies, 2009).

20. Alice Hager, *Frontier By Air: Brazil Takes the Sky Road* (New York: Macmillan, 1942).

21. Hager, 40–41.

aeroclubes. Hager experienced this herself when she was invited by a rancher to a barbecue at his property. She flew one hour south of Campo Grande, the capital of Mato Grosso do Sul, to the ranch of her host: a man she called Colonel Pereira. One of the first things she noticed was that the name of the ranch was painted in big letters on a roof – providing a navigational aid for pilots.²² This was a widely used method in early aviation – the United States air mail, for one, prepared its transcontinental route in a similar way.²³ The state of Minas Gerais had officially adopted the practice as well, ordering all municipalities to create signage for passing pilots, and the FAB (*Força Aérea Brasileira*, the Brazilian Air Force) had also mandated such markings in several other cities.²⁴

Colonel Pereira had pioneered the practice in the region, flying between five other ranches he owned and his home in São Paulo – but others soon followed and at least twenty other ranches in the area built these airstrips, in essence creating a network of potential emergency landing sites and increasing flight safety with navigational markers on their roofs. These airstrips had an added benefit: the animals grazed on the special grass laid on the runway, making for very firm, safe landing strips – a practice that was adopted even in military air mail fields, some of which had in-house donkeys for the purpose. The wealthy ranchers even used their aerial network for social visits. Colonel Pereira often held lavish barbecues for many guests and reminisced that at some of these events he would have as many as twenty-eight airplanes land at his farm for a meal.²⁵ This phenomenon was not limited to these frontier regions. In 1940, ranchers

22. Hager, 54.

23. Courtwright, *Sky as Frontier*, 61.

24. “Minas e a Sinalização de Suas Cidades,” *Aviação*, November 1941; Nélson Freire Lavenère-Wanderley, *História Da Força Aérea Brasileira*, 1975, 141.

25. Hager, *Frontier by Air*, 55.

in the southern state of Rio Grande do Sul started a campaign to train one thousand pilots in the region, which would also help the development of their estates.²⁶

It seems that the animals themselves adapted to the air age. At first, cattle scattered startled by the sound of the airplane – but eventually grew accustomed to it and just kept on calmly grazing. Some early pilots, flying airliners before the wide availability of radio navigation towers, even used the behavior of cattle as a navigational aid. A young pilot apprentice learned this trick from his commanding officer while flying for VARIG airline in Rio Grande do Sul. They were flying above a low cloud layer and were uncertain of their position. The veteran pilot dipped the aircraft below the clouds and quickly rose again, affirming they were on the correct route – despite the lack of any obvious visual references. He explained to the confused young apprentice that those cows were used to them flying on this regular route, and if they had been off the route, the cattle would have scattered in fear.²⁷ Historians have found a similar issue in the early history of US automobiles, when farmers complained that the loud engines of the first cars often caused distress among their livestock.²⁸

But the use of airplanes in ranching went beyond the convenience of wealthy owners. The shipping of produce by air is relatively common today. Pineapples, for instance, are flown from Hawaii to the continental United States. Sheep are regularly shipped by air from New Zealand and Australia.

26. “A Campanha Dos Mil Aviadores Gaúchos,” *Aviação*, December 1940.

27. Lili Lucas Souza Pinto, *Assim e Voava Antigamente* (Porto Alegre: Livraria e Editora Magister, 1990).

28. Ronald Kline and Trevor Pinch, “Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States,” *Technology and Culture* 37, no. 4 (1996): 768–69.

Fresh seafood is also often found in the cargo holds of airliners.²⁹ It is a common enough practice that it is protested by environmentally conscious consumers concerned with the carbon footprint of flying – enough that one British chain of sandwich shops even proudly advertises that they have stopped the practice.³⁰

Yet one would assume that in the 1940s and 50s, when travelling by airplane was a privilege for the wealthy, that only very expensive cargo would be shipped by air. That does not seem to be the case. While it is hard to collect hard data on what kind of cargo was shipped (as far as I know, the PanAm archives, for example, have no such records) there is enough anecdotal evidence to indicate all sorts of less valuable cargo, including produce, was flown in these early days.

One PanAm mechanic flying from British Guyana to Brazil in 1952 to investigate an accident in the Amazon, noted this fact when he noticed a strange odor in the plane. Fearing some mechanical mishap, he inquired with the flight attendant who simply pointed out that on that leg of the trip they usually carry cabbages being exported to Brazil. Once in Brazil, where his duty was to investigate the crash of an airliner in the Amazon, he noticed the same pattern. They were using the airstrip of a rancher to get closer access to the site of the accident, and he learned that the owner used the airstrip to ship his beef to market in Belém, some 400 miles away – a feat that would be impossible by river navigation.³¹ In fact, the Brazilian Air

29. Stacey Vanek Smith, “Tired Of Paying For Checked Baggage? You’re Actually Getting A Good Deal,” *All Things Considered* (National Public Radio, January 21, 2015), <http://www.npr.org/2015/01/21/378905601/tired-of-paying-for-checked-baggage-youre-actually-getting-a-good-deal>.

30. One German colleague of mine, an aviation historian, in order to reduce her carbon footprint, refuses to fly unless crossing the Atlantic for this very reason.

31. “Accident: Brazil, Amazon Jungle Boeing 377 StratoCruiser NX1039V Flight 202” (1952), Series I, Box 120B, Folder 130, PanAmerican World Airways Collection, University

Force also resupplied frontier bases the same way, with regular flights for meat and produce, and some small regional airlines even existed for the sole purpose of transporting beef from frontier regions.³²

In fact, the scenes described by air mail pilots aboard their aircraft suggest that local populations started to forego their riverine navigation altogether for the free flights (any Brazilian citizen could board an air mail flight for free). Passengers on the FAB air mail planes often included an assortment of Indians and local peasants, along with their cargo: chickens, parrots, crops, monkeys, cattle, sacks of flour, jerked meats and bundles of clothes. One pilot remembers a man who brought an enormous live turtle and loaded it with much difficulty – he refused to use one of the bench seats, and so he sat on his turtle during the entire journey.³³ The famed anthropologist Claude Levi-Strauss also noticed this phenomenon when flying in Brazil's frontier regions, saying that in local flights he would often share the space with the hens and ducks of farmers, along with crates of their produce, too heavy to haul through the forest.³⁴

An article in the aviation magazine *Asas* prompted readers to consider air cargo for their commercial needs, arguing that it was not exclusively for the priciest of merchandise. “Certainly, you would not want to ship a 5kg bag of beans from Rio de Janeiro to Recife,” as those circumstances would

of Miami Libraries.

32. Ary Barbosa, “Paraense Transportes Aéreos,” *Catalineiros*, May 30, 2011, http://www.catalineiros.com.br/index.php?option=com_content&view=article&id=93%3Aparaense-transportes-aereos&catid=10%3Anossas-origens&Itemid=10; Siudmar Machado de Carvalho, “Missão de Evacuação Aero-Médica (EVAM),” *Catalineiros*, February 11, 2013, http://www.catalineiros.com.br/index.php?option=com_content&view=article&id=242%3Amissaoevam1953&catid=3%3Aamazonia-nossa-vida-nosso-mundo&Itemid=3.

33. Newton Marcos Leone Porto, “O Correio Aéreo Nacional,” *O Popular*, February 23, 2002.

34. Claude Levi-Strauss, *Tristes Tropiques*, trans. John Weightman and Doreen Weightman (New York: Penguin Classics, 2012), 31.

make it prohibitively expensive. But under the right ratios of distance and weight, all sorts of merchandise might be economically transported by air. Many hotels in Rio regularly flew in higher quality lettuce from São Paulo, which would have wilted on the train – without being much more expensive than the train trip. The examples abounded: fledgling chicks from Rio to a farm in the Amazon, fresh shrimp from Florianópolis to Rio, orchids from the south of the country all the way to the amazon, and even prize cattle for breeding.³⁵

The use of aviation in the countryside was not limited to cattle ranching and transportation, but also involved other early agricultural uses. Another author in the *Asas* magazine also proposed to replace the old practice of lighting tar filled cans to generate smoke in advance of a frost. It could easily be substituted by more efficient smoke generating airplanes – which were being used in World War II to conceal troop movements.³⁶ Also of note, one of the first airplanes designed by EMBRAER, the Brazilian aircraft manufacturer, was the *EMB Ipanema*, a crop-duster. In that sense, aviation for farming also facilitated the spread of pesticides, causing yet another environmental impact in these regions.

While the benefits of aeronautics were obvious in the settled agricultural frontier of Mato Grosso do Sul, some private enterprises wanted to press on, further into the hinterlands. With a mind towards pushing into more isolated areas, three airline executives formed a real estate company, the *Colonizadora Imobiliária do Vale do Araguaia* (Colonizing Real Estate of the Araguaia Valley). In 1955, the company bought a substantial amount of land on the banks of the Araguaia river. Their idea was to use a large barge to transport supplies up the lengthy river, where they would build a

35. “O Que Se Pode Transportar Por Via Aérea,” *Asas*, April 1944.

36. “Defesa Aérea Contra As Geadas,” *Asas*, March 1945.

landing strip. The large runway would then be used in conjunction with the river to transport construction materials and build a town that would be primarily reached by air – the village of Santa Teresa. Their effort to build an aeronautical town in a faraway location was praised by the aviation press.³⁷

The expansion of farming and ranching into Brazil's western frontiers, along with other economic activities like mining, has had an enormous environmental impact in the region. The use of airplanes did much to extend the reach of these commercial operations into Amazon and center-west regions of the country, and with this vast expansion also came an increase in deforestation and conflicts with indigenous peoples. But the process of territorializing space, and its impact on the Amazon, did not end with the development of aviation. The push into outer space and the advent of satellite imaging would eventually accelerate, and then later help halt, deforestation in the region.

Reaching new heights: seeing the Amazon from space

As described above, one of the biggest challenges encountered in the exploration and settlement of Brazil's frontiers was the lack of reliable cartography. But starting in the 1970s, the use of new forms of radar mapping and satellite imagery would drastically change the Brazilian state's ability to map these remote regions and exploit their resources. This was also a time when the Brazilian military dictatorship (1964-1985) sought to aggressively assert state control of the amazon and promote economic development in the region. Project RADAM (*Projeto Radar da Amazônia*,

37. "Gente de Aviação Funda Cidade No Oeste," *Aviação*, April 1955.

Amazon Radar Project), which first started in 1968 but came to fruition in the early 70s, was the first major step in taking the colonization of the Amazon into outer space.

The project began after several Brazilian experts worked with NASA (National Aeronautics and Space Administration in the United States) to get training on new advances of a technology called SLAR (Side Looking Airborne Radar), which was a vast improvement on traditional photographic aerial mapping.³⁸ Mapping by aerial photography is particularly ineffective in tropical regions because these rainy environments almost always have some form of cloud cover blocking the view. SLAR, on the other hand, does not rely on direct visual observation but rather on sensing radio waves bouncing back from the ground – and while clouds or rain may affect the radio signals, they are still very efficient at sensing the ground underneath.³⁹ By equipping high altitude aircraft with SLAR equipment, scientists were able to map 32 kilometer wide area under the flight paths of these aircraft. The technology can go beyond simply mapping topography. SLAR, later combined with satellite imagery and sensing data, could measure a variety of data items such as types of soil, vegetation type and density, water pollution and mineral deposits.⁴⁰

RADAM was a cooperation between several government agencies. It was first spearheaded by INPE (*Instituto Nacional de Pesquisas Espaciais*, the National Institute for Space Research). But another major player was the Ministry of Mines and Energy, which was focused on the direct development of natural resources in the Amazon. A wide variety of experts

38. Claudio Rolando Sonnenburg, “Overview of Brazilian Remote Sensing Activities. [Amazon Region]” (São José dos Campos, SP: Instituto Nacional de Pesquisas Espaciais, August 1, 1978), <https://ntrs.nasa.gov/search.jsp?R=19790005263>.

39. John Noble Wilford, *The Mapmakers* (New York: Vintage Books, 1982), 243–46.

40. Sonnenburg, “Overview of Brazilian Remote Sensing Activities. [Amazon Region],” 8.

were employed in analyzing data from the project, with scientists working the fields of “geology, geography, oceanography, agronomy, forestry, hydrology, pollution and image processing.”⁴¹

Despite the eventual use of satellite data, the project was not a complete departure from the previous methods of aeronautical colonization. In fact, it depended on the network of airstrips built during the earlier period of frontier expansion with efforts by the Vargas regime, local ranchers and later the FAB’ frontier territories. The planes carrying SLAR equipment have to navigate with a high degree of precision, flying for thousands of kilometers on a perfectly straight line. To do so in the 1970s, before the advent of GPS (Global Positioning System) which requires a network of satellites, the RADAM surveyors used SHORAN (Short Radio Navigation). This consists of setting up ground stations with antennas that communicate with the aircraft via radio signals – the time it takes for the signals to travel is measured and sent back, which allows for the calculation of the distance between the ground station and the airplane. The deployment of these ground stations presented a big challenge, but one that was ameliorated by the availability of airstrips into which equipment and personnel could be flown in – airstrips built in the earlier period described above.⁴² This was also a two-way street: the development of precise maps resulting from RADAM also did much to improve safe flying conditions in the region, enabling wider use of jungle airstrips. The project did not depend on airplanes alone. By the mid-70s, with a new satellite receiving station built in Brazil, a lot of the data started being gathered by satellites, transitioning the process of territorialization of airspace and Brazil’s frontiers into outer space.⁴³

41. Sonnenburg, “Overview of Brazilian Remote Sensing Activities. [Amazon Region].”

42. Wilford, *The Mapmakers*, 249.

43. Sonnenburg, “Overview of Brazilian Remote Sensing Activities. [Amazon Region].”

RADAM's goals were twofold: to help map potential natural resources but also provide accurate geographical and topographical data to support the construction of a massive infrastructure project: the building the Trans-Amazon Highway, a road of over 4,000 km through the heart of the Amazon.⁴⁴ A report produced by INPE about the early results of RADAM shows that the project yielded great results for the Ministry of Mines and Energy, identifying a wealth of natural mineral resources to be exploited in the Amazon. Among its findings were a manganese deposit estimated at 500,000 tons, gold, phosphate, cassiterite and a variety of other rare minerals. The resulting data also identified areas that had rich soils for farming, and well as identifying areas of great hydrologic potential for hydroelectric dams.⁴⁵ In fact, the Brazilian government found RADAM to be so successful that the project was extended to cover the entire national territory, being renamed as RADAMBRASIL.⁴⁶

It is hard to understate the massive environmental impact of this process of mapping and territorializing Brazil's frontiers – which itself was enabled by the human conquest of the atmosphere and outer space. The expansion of farming and ranching has caused massive deforestation since the 1970s. The mining of gold and other minerals has caused both deforestation but also contamination of air and water with mercury and cyanide.⁴⁷ The building of hydroelectric dams also enabled further commercial

3–5.

44. Wilford, *The Mapmakers*, 243.

45. Sonnenburg, "Overview of Brazilian Remote Sensing Activities. [Amazon Region]," 17.

46. Sonnenburg, 2.

47. Marjo de Theije and Ton Salman, "Conflicts in Marginal Locations: Small-Scale Gold-Mining in the Amazon," in *Between the Plough and the Pick*, ed. KUNTALA LAHIRI-DUTT, Informal, Artisanal and Small-Scale Mining in the Contemporary World (ANU Press, 2018), 261–74, <https://www.jstor.org/stable/j.ctt22h6r60.17>; Gregory P. Asner et

expansion in the region, while also having a great impact on the hydrology and biodiversity of the region. With 140 dams built and under construction in the Amazon by 2017 and projections for a potential total 428 potential dams, disruptions to the water flow have affected the biome of floodplains as well as causing further conflicts over encroachment into indigenous territory. Hydroelectric dams in the Amazon affect the environment far beyond the rainforest itself. The reduction of the Amazon river's flow into the Atlantic affects coral reefs and can even alter the trajectories of Atlantic storms, which can affect the Caribbean, Central America and the United States.⁴⁸ All of these have caused other problems beyond environmental impacts, with the expansion of commercial operations frequently causing further conflicts with indigenous groups.⁴⁹

While these technologies and projects like RADAM were employed to expand economic activity beginning the early 1970s, especially under the military dictatorship's promotion of economic activity in the region, they would later be employed to help contain environmental damage in the region. A later report on the RADAM published by INPE in 1978 already showed a marked transition in its primary concerns, with an increased focus on environmental monitoring. The report had a somber tone and focused on the environmental changes and their negative impacts, saying that the increased economic activity in the region would lead to, "in a not so distant future" where "life in large urban centers would become untenable."⁵⁰

al., "Elevated Rates of Gold Mining in the Amazon Revealed Through High-Resolution Monitoring," *Proceedings of the National Academy of Sciences of the United States of America* 110, no. 46 (2013): 18454–59.

48. Edgardo M. Latrubesse et al., "Damming the Rivers of the Amazon Basin," *Nature* 546, no. 7658 (June 2017): 363–69, <https://doi.org/10.1038/nature22333>.

49. de Theije and Salman, "Conflicts in Marginal Locations."

50. Carlos Rolando Sonnenburg, "INPE Remote Sensing Program. [Brazil]" (São José dos Campos, SP: Instituto Nacional de Pesquisas Espaciais, August 1, 1978), 2, <https://ntrs>.

While construction of hydroelectric dams in the Amazon has accelerated in recent years, satellites and remote sensing technologies like the ones used in RADAM have been deployed to drastically reduce deforestation. By using satellites and remote sensing, the Brazilian government has created a deforestation monitoring system that has enabled effective enforcement of environmental laws. With the use of these technologies, the rate of deforestation in the Brazilian Amazon was reduced by 77% between 2004 and 2011.⁵¹

Historians have traditionally studied environmental change largely through socio-economic, demographic and cultural lenses. More recently, however, historians of technology have turned their focus to the multifaceted relationship between the environment and technological developments. The Society for the History of Technology, the main organization on the subject in the United States, now has a thriving community of historians working on the subject, organized as a group they named “envirotech.”⁵² Scholars of Latin America have also turned their attention to the subject, with recent publications focusing on histories of water management and droughts.⁵³ In the past decades, Brazilian historians have also showed a renewed interest in environmental history, as seen by the publication of

nasa.gov/search.jsp?R=19790005297.

51. Javier Godar et al., “Actor-Specific Contributions to the Deforestation Slowdown in the Brazilian Amazon,” *Proceedings of the National Academy of Sciences of the United States of America* 111, no. 43 (2014): 15591–96.

52. “Envirotech — Bridging the Histories of Environment and Technology,” accessed December 18, 2018, <http://www.envirotechweb.org/>.

53. Here are two books dealing with these issues in Mexico and Brazil. Eve E Buckley, *Technocrats and the Politics of Drought and Development in Twentieth-Century Brazil*, 2018, <http://dx.doi.org/10.5149/northcarolina/9781469634302.001.0001>; Vera Candiani, *Dreaming of Dry Land: Environmental Transformation in Colonial Mexico City* (Stanford, California: Stanford University Press, 2014).

some anthologies on the subject in the past decade.⁵⁴ This article adds to this historiographical trend by focusing on aeronautical and space history and its impact back on the ground. As historians, we should diversify our studies of technology and environment by looking at how previously unstudied technologies and histories shape the environment over time. New studies, by expanding our understanding of diverse technological mechanisms and their environmental impacts will help better understand the bigger picture, and to analyze the history of technology and the environment as broader, interconnected systems.

BIBLIOGRAPHY

“A Campanha Dos Mil Aviadores Gaúchos.” *Aviação*, December 1940.

“Accident: Brazil, Amazon Jungle Boeing 377 StratoCruiser NX1039V Flight 202,” 1952. Series I, Box 120B, Folder 130. PanAmerican World Airways Collection, University of Miami Libraries.

Asner, Gregory P., William Llactayo, Raul Tupayachi, and Ernesto Ráez Luna. “Elevated Rates of Gold Mining in the Amazon Revealed Through High-Resolution Monitoring.” *Proceedings of the National Academy of Sciences of the United States of America* 110, no. 46 (2013): 18454–59.

“Aviação - Considerações Gerais.” *Aerophilo*, September 1915.

Barbosa, Ary. “Paraense Transportes Aéreos.” *Catalineiros*, May 30, 2011.

54. Jó Klanovicz et al., *História Ambiental No Sul Do Brasil: Apropriações Do Mundo Natural* (São Paulo: Alameda Casa Editorial, 2012); Paulo Henrique Martinez, *História Ambiental Paulista: Temas, Fontes E Métodos* (São Paulo, SP: Editora Senac São Paulo, 2007).

http://www.catalineiros.com.br/index.php?option=com_content&view=article&id=93%3Aparaense-transportes-aereos&catid=10%3Anossas-origens&Itemid=10.

Buckley, Eve E. *Technocrats and the Politics of Drought and Development in Twentieth-Century Brazil*, 2018. <http://dx.doi.org/10.5149/northcarolina/9781469634302.001.0001>.

Burden, William. *The Struggle for Airways in Latin America*. New York: Council on Foreign Relations, 1943.

Burnett, D. Graham. *Masters of All They Surveyed: Exploration, Geography, and a British El Dorado*. Chicago: University of Chicago Press, 2000.

Candiani, Vera. *Dreaming of Dry Land: Environmental Transformation in Colonial Mexico City*. Stanford, California: Stanford University Press, 2014.

Carvalho, Siudmar Machado de. “Missão de Evacuação Aero-Médica (EVAM).” *Catalineiros*, February 11, 2013. http://www.catalineiros.com.br/index.php?option=com_content&view=article&id=242%3Amissaoevam1953&catid=3%3Aamazonia-nossa-vida-nosso-mundo&Itemid=3.

Courtwright, David. *Sky as Frontier: Adventure, Aviation, and Empire*. 1st ed. College Station: Texas A & M University Press, 2005.

“Defesa Aérea Contra Às Geadas.” *Asas*, March 1945.

“Envirotech — Bridging the Histories of Environment and Technology.” Accessed December 18, 2018. <http://www.envirotechweb.org/>.

Ferraz, Joaquim Sampaio. *Meteorologia Brasileira (Esboço Elementar de Seus Principais Problemas)*. São Paulo: Companhia Editora Nacional, 1934.

Ferreira, Raquel França dos Santos. “Uma História Da Campanha Nacional Da Aviação (1940-1949): O Brasil Em Busca Do Seu ‘Brevê.’” *Cantareira* 17 (December 2012): 75–86.

Friedman, Robert. *Appropriating the Weather: Vilhelm Bjerknes and the Construction of a Modern Meteorology*. Ithaca: Cornell University Press, 1989.

Garfield, Seth. *In Search of the Amazon: Brazil, the United States, and the Nature of a Region*. Durham: Duke University Press, 2013.

“Gente de Aviação Funda Cidade No Oeste.” *Aviação*, April 1955.

Godar, Javier, Toby A. Gardner, E. Jorge Tizado, and Pablo Pacheco. “Actor-Specific Contributions to the Deforestation Slowdown in the Brazilian Amazon.” *Proceedings of the National Academy of Sciences of the United States of America* 111, no. 43 (2014): 15591–96.

Hager, Alice. *Frontier By Air: Brazil Takes the Sky Road*. New York: Macmillan, 1942.

Klanovicz, Jó, Gilmar Arruda, Ely Bergo de Carvalho, and Alessandro Casagrande. *História Ambiental No Sul Do Brasil: Apropriações Do Mundo Natural*. São Paulo: Alameda Casa Editorial, 2012.

Kline, Ronald, and Trevor Pinch. “Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States.” *Technology and Culture* 37, no. 4 (1996): 763.

Langfur, Hal. *The Forbidden Lands: Colonial Identity, Frontier Violence, and the Persistence of Brazil’s Eastern Indians, 1750-1830*. Stanford: Stanford University Press, 2006.

Latrubesse, Edgardo M., Eugenio Y. Arima, Thomas Dunne, Edward Park,

Victor R. Baker, Fernando M. d’Horta, Charles Wight, et al. “Daming the Rivers of the Amazon Basin.” *Nature* 546, no. 7658 (June 2017): 363–69. <https://doi.org/10.1038/nature22333>.

Lavenère-Wanderley, Néelson Freire. *História Da Força Aérea Brasileira*, 1975.

Lefebvre, Henri. *The Production of Space*. Translated by Donald Nicholson-Smith. Malden MA: Blackwell, 2007.

Levi-Strauss, Claude. *Tristes Tropiques*. Translated by John Weightman and Doreen Weightman. New York: Penguin Classics, 2012.

Martinez, Paulo Henrique. *História Ambiental Paulista: Temas, Fontes E Métodos*. São Paulo, SP: Editora Senac São Paulo, 2007.

McCann, Frank D. “Aviation Diplomacy: The United States and Brazil, 1939-1941.” *Inter-American Economic Affairs* 21, no. 4 (Spring 1968): 35–50.

———. *The Brazilian-American Alliance, 1937-1945*. Princeton, N.J.: Princeton University Press, 1974.

“Minas e a Sinalização de Suas Cidades.” *Aviação*, November 1941.

Monmonier, Mark. *How to Lie With Maps*. 2. ed. Chicago: Univ. of Chicago Press, 1996.

“O Que Se Pode Transportar Por Via Aérea.” *Asas*, April 1944.

Pinto, Lili Lucas Souza. *Assim e Voava Antigamente*. Porto Alegre: Livraria e Editora Magister, 1990.

Porto, Newton Marcos Leone. “O Correio Aéreo Nacional.” *O Popular*. February 23, 2002.

Scott, James. *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven: Yale University Press, 1998.

Seed, Patricia. *Ceremonies of Possession in Europe's Conquest of the New World, 1492-1640*. Cambridge: Cambridge University Press, 1995.

Smith, Stacey Vanek. "Tired Of Paying For Checked Baggage? You're Actually Getting A Good Deal." *All Things Considered*. National Public Radio, January 21, 2015. <http://www.npr.org/2015/01/21/378905601/tired-of-paying-for-checked-baggage-youre-actually-getting-a-good-deal>.

Sonnenburg, Carlos Rolando. "INPE Remote Sensing Program. [Brazil]." São José dos Campos, SP: Instituto Nacional de Pesquisas Espaciais, August 1, 1978. <https://ntrs.nasa.gov/search.jsp?R=19790005297>.

Sonnenburg, Claudio Rolando. "Overview of Brazilian Remote Sensing Activities. [Amazon Region]." São José dos Campos, SP: Instituto Nacional de Pesquisas Espaciais, August 1, 1978. <https://ntrs.nasa.gov/search.jsp?R=19790005263>.

Theije, Marjo de, and Ton Salman. "Conflicts in Marginal Locations: Small-Scale Gold-Mining in the Amazon." In *Between the Plough and the Pick*, edited by KUNTALA LAHIRI-DUTTA, 261–74. Informal, Artisanal and Small-Scale Mining in the Contemporary World. ANU Press, 2018. <https://www.jstor.org/stable/j.ctt22h6r60.17>.

Tota, Antônio Pedro. *The Seduction of Brazil: The Americanization of Brazil during World War II*. Translated by Lorena B. Ellis. Austin: University of Texas Press, Teresa Lozano Long Institute of Latin American Studies, 2009.

Wilford, John Noble. *The Mapmakers*. New York: Vintage Books, 1982.

Young, Alex. “Diplomacy in Space: The Final Frontier of International Law.” *Harvard International Review* 35, no. 3 (2014): 6–7.