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Yields of Dreams: Marching West and the Politics of Scientific Knowledge in the Brazilian Agricultural Research Corporation (Embrapa)

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Abstract

Public agricultural research plays a fundamental role in the transformation of agrarian landscapes around the world. The global nature of technologies produced at these institutions provides a crucial look at how the politics of agricultural science and technology is linked to the political economy of agrarian change. This paper historicizes the Brazilian Agricultural Research Corporation (Embrapa), a public research institution that has overseen the transformation of Brazilian agriculture. Over the past forty years, their work in the Cerrado took Brazil from being a net agricultural importer to now one of the world's largest exporters. This paper uses the case of Embrapa's work in the Cerrado to analyze the global politics of agricultural research and to understand the ways in which U.S. science was strategically used to underpin Brazil's agricultural transformation. I argue that the material conditions of the Cerrado combined with foreign interests to produce an agricultural research institution capable of converting the region's scrubland into the modern agribusiness utopia it is today. The paper is based on over twenty interviews with Embrapa staff and archival work conducted in Brazil and the United States. Within the context of the Green Revolution, U.S. philanthropic organizations and the government worked in Brazil during the 1950s and 1960s to figure out the basic scientific problems in the Cerrado and to lay the institutional groundwork necessary for wholesale agricultural modernization of the region. This paper extends the geographical and ideological basis of the Green Revolution into Brazil and demonstrates how the alliance between the state, capital and science constructs access to natural resources and creates new agrarian frontiers. While there has been numerous scholarship on the consequences of the Green Revolution, little attention has been paid to the legacies of public agricultural research, like Embrapa, in the continued transformation of agrarian landscapes. As Brazil rises on the global stage as an agricultural powerhouse, Embrapa is increasingly being used as a tool of foreign policy abroad. Their activities in over 40 countries throughout the developing world signify an important shift for how science and technology is being used to remake agriculture in the tropics.

Keywords: *sustainability; climate change; neoliberalism; biopolitics; feminist theory*

Introduction

Brazil's capital city, Brasília, is located far into the interior of the country and was built in a mere three years from 1957-1960 as the centerpiece of a new vision for Brazilian development – one where old colonial legacies of social inequality and political corruption would give way to a modern and planned urban utopia under the banner of Brazilian nationalism. The sheer vastness of the city is impressive: from the fourteen-lane superhighway running down the middle of the airplane-shaped residential 'wings' to the oversized lawn in the city center that showcases an organized array of government bureaucracies. This cityscape is the product of two experts: an architect Oscar Niemeyer and an urban planner Lúcio Costa. These two modernists were given the responsibility to oversee the design and construction of a capital to represent a future Brazil. Despite their optimism, social inequality in Brazil remains rampant and Brasília is a bastion of corruption – from the ministries on the central esplanade to the mansions on the artificial lake surrounding the city.

At the extremities of Brasília's north 'wing' is a less talked about example of Brazilian modernist aspirations, in this case in the pursuit of a rural utopia. The Brazilian National Agricultural Research Corporation, known by its Portuguese acronym Embrapa (*Empresa Brasileira de Pesquisa Agropecúaria),* is a national research institution headquartered in Brasília that serves as a hub of experts and expertise to produce an agricultural sector "based on science and technology" (Perreira et al, 2012). In this paper, I present a genealogy of Embrapa and its expertise to analyze the historical development and political economy of public agricultural science and technology in Brazil. A genealogical approach historicizes and deconstructs Brazilian agricultural expertise while also accounting for the differences in knowledges, political and economic interests and the institutional structure of scientific research within the country. As such, the production of scientific knowledge and technologies for agricultural development are not universal or inevitable but emerge out of particular material conditions, social relations and politics. In the case of Brazil, international interests primarily from the U.S. – through technology transfers and scientific training – underpinned the production of science and technology that enabled and legitimized the rapid industrial development of Brazil's agricultural sector.

Since its establishment in 1973, Embrapa has branded itself as a world leader in tropical agricultural technology that, according to former Embrapa president Pedro Arraes Perreira, "is increasing the human capacity to research, learn, oversee, predict and grasp a holistic vision of the world" (IFPRI Forum, 2010). This vision starts from the institutes model based on its 42 research centers spread around the country that focus on specific agricultural commodities, themes or biomes. Decades of scientific research at these centers, with a specific focus on modernizing Brazil's agricultural sector through problem solving, has elevated Embrapa as an example of how to "get it right" when it comes to developing national agricultural research (Correa and Schmidt, 2014). These claims of scientific excellence are based on a transformation of Brazilian agriculture over the last forty years.

In the 1940s, Brazil was still a net food importer with very low levels of export-crop productivity, high concentrations of land ownership and a reliance on a few crops for export (principally coffee and sugar cane). However, Brazil is now one of the world's largest exporters of several key crops such as soybeans, corn, sugar cane and cotton. Much of this growth in export production has taken place in the center-west region of the country where Brasília was constructed. This area known as the *Cerrado* is where, according to the Brazilian government, a vast region of empty, or underused, land with severely acidic soil could be transformed into agro-industrial production zones for export (Graziano da Silva, 1993; 1995; see also Abelson and Rowe, 1987). The vision set forth to colonize the Cerrado's acidic soils was based on the use of modern science and technology to establish a chemical and biological formula that could 'fix' the over 115 million hectares of potentially arable land for the production of agricultural commodities on a monumental scale (Borlaug and Dowswell, 1997). Over the last forty years, Embrapa carried out this vision to transform the Cerrado into one of the world's largest breadbaskets. Grain production in this region expanded from 8 million tons in 1970 to over 48 million tons in 2006 (Santana and Nascimento, 2012: 23) and soybean production alone expanded from an area of just under one million hectares to over 23 million while productivity per hectare

increased threefold (Personal interview, 01/17/2014). What was once a vast savannah with limited infrastructure and material development now has fleets of John Deere combines reaping fields of yellow gold.

However, such tremendous yield productivity growth wasn't merely the product of creating and supporting a public research institution such as Embrapa. The development of national agricultural research institutions, and their role in transforming agriculture, must be understood in relation to the Green Revolution, an initiative that was based on the deployment of U.S. scientific experts and expertise abroad following WWII (Perkins, 1997; Smith, 2009). The civilizing mission of the Green Revolution used technology transfers to modernize the world's agricultural sectors but was epitomized in the high-profile cases of Mexico (Fitzgerald, 1986), India (Saha, 2013) and the Philippines (Cullather, 2004), to name a few. It was in these politically strategic countries where the Rockefeller and Ford Foundations worked primarily with the Consultative Group of International Agricultural Research Centers (CGIAR) during the 1940s-1970s to train scientists abroad and develop new hybrid seeds all with the aim to export the ideal modernized farm based scientific principles of productive efficiency and industrial inputs (Patel, 2013; Parayil, 2003; Perkins, 1997). Beyond those cases, however, the advance of Western agricultural science couched within the Green Revolution took on many different forms across the global and involved an array of actors – from governmental and philanthropic to academic and corporate – working with a variety of commodities, producers and ecologies.

Of the so-called success stories of the Green Revolution, Brazil is rarely mentioned despite achieving significant yield productivity gains, industrializing agriculture at-scale and working closely with U.S. experts – precisely the objectives and methods of the Green Revolution. I contend that the reason Brazil is left out of the Green Revolution narrative is because of the involvement of different actors and the contested claims for the ownership over the "Miracle of the Cerrado" (the Economist, 2010a). The scientific work that underpinned the agricultural modernization of Brazil's Cerrado was first undertaken in the 1950s by scientists employed by Nelson Rockefeller's personal development organizations in cooperation with Brazilian national agricultural research (prior to Embrapa). Rockefeller's direct cooperation with Brazilian actors differed from the more interventionist and largely top-down approach of the U.S. Foundations and CGIAR in other countries (Patel, 2013; Silva, 1997). I argue that the material conditions of the Cerrado combined with the economic and political interests of Nelson Rockefeller produced the basic scientific groundwork to grow agricultural commodities in the Cerrado based on imported industrial inputs. But, in order for the science to matter, political elites from both Brazil and the U.S. worked together to redesign national agricultural research (Embrapa) so that technologies would be generated for a wholesale industrial transformation of the Cerrado over the proceeding decades. This crucial connection of early scientific work, conducted by Nelson Rockefeller's scientists in the Cerrado, with U.S. and Brazilian political elites ensured that industrial agriculture in Brazil would yield an economic return and political stability for decades. Using science and technology as a vehicle for development ensured that Rockefeller's private initiatives and broader U.S. economic interests would be fulfilled by the public mission of Brazil's research institution. The reason much of this early work and cooperation with U.S. expertise remained largely invisible is due to Embrapa's ongoing concern with maintaining visibility and ensuring political support as a public research organization. Despite these concerns, Embrapa has continued to support the industrial development of Brazil's agriculture by design.

Although the Green Revolution is one of the most lauded examples of U.S. scientific expansionism, it is only one of many initiatives that fit within post-WWII U.S. foreign policy and the rise of development-as-modernization (Engerman et al., 2003). The expansion of U.S. geopolitical interests under the umbrella of President Truman's "Point IV"[1] program exported a range of U.S. scientific

[1] Truman's "Point IV" program was institutionalized by the United States Agency For International Development and was based on the fourth point raised in his inaugural address that stated, "we must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas… The United States is pre-eminent among nations in the

capabilities around the developing world through both direct government initiatives and by financing the work of U.S. based foundations. In the context of Cold War politics, this program sought to utilize science as a tool to civilize nations within the developing world while also attempting to corral a capitalist political bloc of countries opposed to the Red Revolution of communism. U.S. scientific experts served as foot soldiers in the territorial and ideological battle against communism by intervening in foreign institutions of scientific knowledge production. It was with these institutional partnerships that the diffusion of 'modern' science through training, technology transfers and the reproduction of research models (Basalla, 1967). However, this transfer of science and technology did not occur in a linear way as different social relations, cultures and ecologies shaped the uptake of new technology and the reproduction of scientific knowledge (Prieto, 2013).

Agriculture is a prime example for how these contingencies and contradictions emerged within the geopolitics of U.S. scientific expansionism. In the postwar period, the U.S. positioned itself as a hegemon in global agriculture by using state power to create foreign food import dependence and undercut potential competitors through the expansion of subsidies, food aid and the substitution of tropical food imports with synthetic products (Friedmann and McMichael, 1989, see also McMichael, 2009). However, as one of the most strategically important countries in the Western Hemisphere, Brazil ran counter to the U.S.-dominated food regime. Due to vast untapped natural resources (including potentially arable land) and being the largest economy and country in Latin America, U.S. interests had long held Brazil as a crucial diplomatic and economic partner. The influx of political instability due to social upheaval and the threat of revolution in Brazil during the 1950s and early 1960s, meant that cooperation, not competition, drove U.S.-Brazil relations during the Cold War (Silva, 1997). It was through this relationship that U.S.-based science and technology helped to fuel productivity growth in the Cerrado and inevitably challenged the competitiveness of U.S. grain[2] exports. I suggest that this contradiction was initially born out of Rockefeller's experts seeking to turn on the productive potential of the Cerrado with science while U.S. and Brazilian political elites established an alliance to promote the internationalization and stabilization of Brazil's economy. The establishment and development of Embrapa in the early 1970s marked a key moment to consolidate these combined interests and nationalize the scientific research necessary to ensure favorable politics and profits in the long-term. In other words, the economics of agricultural science (Tyfield, 2012a; 2012b) were grounded in the soils of the Cerrado with privately contracted scientists but the broader structure of the political economy institutionalized research for the production and reproduction of scientific knowledge at a truly international scale.

This paper is based on research conducted in Brazil and the United States throughout 2013 and 2014. I conducted 28 semi-structured interviews with Embrapa employees in June/July of 2013 and January 2014 at Embrapa headquarters in Brasília and the Embrapa-Cerrados field laboratory in Planaltina, just outside of Brasília. The majority of these interviews were conducted with management who were trained as agricultural scientists and at one point worked at one of Embrapa's research centers (a common career path for Embrapa staff). By interviewing these senior staff, I was able to understand the institutional founding and building of Embrapa, including the connections to U.S. scientific expertise. Additionally, I spoke to former U.S. scientists who had worked in Brazil for Nelson Rockefeller during the 1950s and 1960s on research related to the Cerrado. At Cornell University, I utilized archival records of Dr. Reeshon Feuer and Dr. Kenneth Turk who also worked on agricultural development with USAID and Rockefeller's organization in the Cerrado during the 1950s and 1960s. Their archives contain field notes, correspondences, memos and official reports that were fundamental to understand the historical and international relations of knowledge production and problem setting for agricultural development in Brazil's Cerrado. I also accessed the personal archives of Jerome Harrington, the former president of the Rockefeller's research organization. His archive was passed

development of industrial and scientific techniques. The material resources which we can afford to use for assistance of other peoples is limited. But our imponderable resources in technical knowledge are constantly growing and inexhaustible" (see the full speech at: http://www.trumanlibrary.org/whistlestop/50yr_archive/inagural20jan1949.htm)

[2] Especially soybeans, a crop of significant geopolitical importance; see Oliveira, 2015

down to me personally from a former colleague of his now at Embrapa. I utilize a genealogical approach to tie together seemingly disparate data constituted by varying spheres of scientific knowledge, technologies and economic interests as a way to understand how the Cerrado transformation occurred and why it became the industrial agricultural landscape it is today.

This article begins by explaining how early scientific work in the Cerrado was spearheaded by Rockefeller's experts seeking to understand how to turn on the agro-industrial potential of the region's acidic tropical soils. I then introduce the development of agricultural research in Brazil and the ways in which U.S. agricultural experts and expertise were strategically incorporated into Brazilian agricultural modernization before and during the development of Embrapa. The next section brings together both Rockefeller's scientists and Brazilian agricultural research to analyze how geopolitics and science combined with the materiality of the Cerrado to produce a region where agricultural production would be based on the use of imported industrial inputs. I end by highlighting some of Embrapa's more recent aspirations that shed light on Brazil's rise as a major force in international agricultural development and the importance of claiming development in the Cerrado as a national and institutional treasure.

1 Performing Agricultural Science in the Cerrado

Brazilian ambitions to realize the productive potential of its vast interior date back to the colonial era in the 18th century and the Paraguay war in the 19th century, when the state was concerned with border maintenance and the control of potential mineral resources. Later, in the 1930s, then president Getúlio Vargas promoted a "March to the West" that envisioned an exodus of settlers from the coast and south moving west and north into the vast Cerrado where farms would dot the land and increase the resource export potential of the country (Inocêncio, 2010). According to the 1950 national census, this area only constituted approximately 3 percent of the Brazil's total population despite constituting around 1/3 of the country's area (IBGE, 1950). Centuries of neglecting to develop infrastructure in the interior, combined with a historical focus on supporting coffee and sugar cane export production in the South and Northeast (Furtado, 1965), meant that the acidic soils in the Cerrado were never fully incorporated into the national or international economy. However, the construction of Brasília as the new national capital in the Cerrado signified a symbolic shift from the colonial legacies of corruption and inequality present in historical coastal cities (such as Rio de Janeiro, the capital at the time). By moving the capital far into Brazil's interior, the government hoped that it would also promote the movement of Brazilians inland to exploit their country's vast interior. Ironically, the government solicited the help of U.S. scientists in determining where the capital would be built.

In 1954, Cornell University soil scientist Reeshon Feuer was sent to the Cerrado as a consultant for D.J. Belcher and Associates[3] in order to map out the agricultural potential of the vast central plateau (*Planalto*) in the heart of the Cerrado where the future capital was to be constructed. His soil surveys concluded that the soils held potential for industrial agriculture; however, "without the prospect of industrial and economic development… there can be little or no hope of achieving the potential high level of soil productivity in the [Federal] District" (Feuer, 1956: 365). Feuer, like many of his contemporaries, operated under the assumption that a modernized agricultural sector required rapid industrial development to "use the excess manpower, no longer necessary in modern agriculture… to create a large market for farm production by the part-time and off-farm workers" (Feuer, 1956: 365). In this way, the scientific basis of agricultural production for Feuer was intimately linked to the (potential) economic and social transformation of the land. His time in the Cerrado was spent traversing the plains and valleys of the Cerrado landscape to take soil samples, document the landscape and visit farms. Most of his field notes describe local production consisting of extensive grazing of Zebu cattle but they also highlight the "good corn yields when grown" and the "local use of steamed bone meal used to counteract the acidity of the soils, sometimes up to 1.5 tons per alequer

[3] D.J. Belcher and Associates was founded by Cornell University professor of engineering, Donald Belcher, and was contracted for US$600,000 by the Brazilian government to "pick the right place in the wilderness for that country's new capital city" (Belcher, 1954; Gilman, 1955: 121).

[sic]" (Feuer, 10/02/1954). He described a local corn variety as 'Caeono' and related to one of the planting methods by noting, "beans always planted in corn as in old New England farms" (Feuer, 9/27/54). Depending on what and how different crops were grown, Feuer noted that the Cerrado had numerous areas of fertile soils capable of agricultural productivity but not at the scale required for exporting commodities to the global market.

Early technicians like Feuer were instrumental in shaping science and the scientific rationale for the future development of the Cerrado. Instead of working with local practices and crops, Feuer's scientific standard for agricultural production was from the U.S. where temperate commodity crops dominated. For the Cerrado to achieve the same levels of productivity with these crops it was understood that scientific expertise was deemed necessary to 'fix' its acidic soils. According to an early U.S.-Brazil Cerrado planning document, this scientific modernization would be "executable in an epoch in which man [*sic*] conquers the cosmos" (CTE, 1966). Such a faith in science is embedded within the assumption that U.S. technological superiority could and should be used to 'civilize' the ecological and social ills of the developing world (Adas, 2009).

Shortly after Feuer's soil survey, and after having purchased a plantation of over 120,000 acres in western Brazil (*Fazenda Bodoquena*), Nelson Rockefeller became intensely interested in profiting from expanded and intensified production of agricultural commodities. The Cerrado region, in particular, interested Nelson Rockefeller ever since a meeting in 1942 with former president Franklin Roosevelt who had recently returned from a diplomatic mission to Brazil. Looking at a map of Brazil, Roosevelt pointed to the center-west plains and told Rockefeller, "Some day thas [*sic*] will be the most important area of development in the world, the whole history of our West will be repeated. Never forget one thing, when this war is over the hope for the future is going to rest in the new world" (Dalrymple, 1968: 169)

Figure 1: The Cerrado in Brazil

Source: Jerome Harrington Files

Rockefeller built on his extensive relationships within the Brazilian government who also sought the scientific expertise of U.S. scientists to provide the technological key for agricultural modernization and expansion. According to Colby and Dennett (1995), the government leaders in Brazil were convinced having seen "the promise of replicating the U.S. conquest of its own West and the historic link between the conquest and its current power and prosperity" (669). Rockefeller established two organizations to work on development: the American International Association for Social and

Economic Development (AIA) in 1946 and the International Basic Economy Corporation (IBEC) in 1947. The AIA and IBEC were the respective non-profit and profit organizations operating under the same goal of exporting American-style capitalism or, as Time magazine put it in 1946, "enlightened capitalism" [4]. Profits generated from IBEC could be funneled into AIA and enact capitalist development through institution-building and technology transfers through agricultural extension services, licensing businesses, establishing stock markets and the exportation and development of scientific knowledge all based on U.S. models and experiences (see Colby and Dennett, 1997; Cobb, 1992; Durr, 2006; Marcio da Silva, 2011; 2013).

Modernizing agriculture was one of the main goals of both IBEC and AIA because agriculture had the most profit potential and the greatest impact on the majority of the population. Rockefeller drew on his decades of experience in international affairs as the assistant secretary of state and the Coordinator of Inter-American Affairs together with his management of family businesses to "improve human welfare" while making a profit (Rivas, 2002). To generate new technologies with U.S.-based agronomic sciences, he established the IBEC Research Institute (IRI), a subsidiary research arm created in 1950 under the for-profit IBEC which later transferred to the non-profit AIA. According to Rockefeller, this move would support "new highways for the march of science and technology over the obstacles of language, race and customs. AIA is one way of bridging these gaps between people so that the benefits of science and the new technology can spread more widely over the earth" (Dalrymple, 1968: 15).

IRI established field stations and experimental farms to work on a variety of agricultural problems from the development of new grasses for cattle imported from the U.S. to establishment of field plots with corn, soybeans and cotton to understand the soil chemistry of the Cerrado and its potential for industrial agriculture (Borlaug and Dowswell, 1997). Dr. Andrew McClung, a soil scientist from Cornell University, was hired by the IRI to work in the Cerrado in 1958. His work became well known and accepted in Brazil after presenting at the 1961 Symposium of the Cerrado in Sete Lagoas, Minas Gerais where Brazilian soil scientists convene annually (see Avellar and Silva, 2000). It was at this meeting that an early debate took place around the key shortcomings of the Cerrado's soils and the best way to 'fix' them. José Martins de Oliveira Filho was one of several Brazilian scientists who determined that the main fertility problem of the Cerrado's soils was lack of physical organic material combined with a poor understanding of how native plants function, and in many cases thrive in those soils (Filho, 1963). However, Dr. McClung and his colleagues concluded that "these areas [of the *Cerrado*] are capable of supporting a much more intensive agriculture than they do at present, and there is an indication that economic returns may be obtained through improved fertility practices" (Freitas, McClung and Lott, 1960 see also McClung et al., 1958). Those fertility practices were to use chemical inputs to correct the imbalance of sulfur and the overall acidity of the soils so they would be more productive for commodity crops. Instead of understanding the native vegetation and developing different, perhaps local, crops and seeds varieties (Borlaug and Dowswell, 1997), the IRI team had "selective ignorance" (Elliot, 2012) by being fixated on constructing soil with chemical inputs. Follow-up work by his team incorporated more possibilities on the economic viability of the area by including the prices of inputs, transportation and the rising market price of key commodities (see Freitas, Mikkelsen, McClung and Lott, 1963).

IRI's research on soil fertility in the Cerrado, combined with their public outreach activities, helped to establish a new imaginary of the Cerrado as one with immense production potential limited only by the application of modern agricultural technology and chemical inputs. Regular publications called "IRI Bulletins[5]" were sent to governments and research institutes around the world to share the techniques and knowledge gained from Brazilian agricultures and ecologies. As early as 1962, Brazil's then Minister of Agriculture Dr. Renato Costa Lima asked the U.S.'s Point IV representative in Brazil for "help in conducting a preliminary survey to determine the feasibility of carrying out a complete

[4] Time Magazine. 1946. "Enlightened Capitalism," Vol. 48. Issue 2, p. 44.
[5] The IRI Bulletins (#1-37), Technical notes (#1-7), and Miscellaneous Pubs (#1-4) are all available in a four volume bounded set (1951-1970).

evaluation of the physical and economic potential of the region [Cerrado]" (Costa Lima, 1962). In practice, one of President Truman's confidants admitted that "[Nelson] Rockefeller was the real leader of the Point IV program",[6] which led to an intimate relationship between Rockefeller's scientists, the Brazilian government and USAID. USAID became involved in the industrialization of agriculture in the Cerrado by contracting IRI and Rockefeller's non-profit AIA to conduct surveys and oversee other problem-setting activities in the Cerrado. Then working with the Brazil's Department of Agricultural Research and Experimentation - DPEA (Embrapa's precursor), IRI and USAID established a "cooperative program in agricultural research and extension covering every field from soil fertility, horticulture, field and forage crops, to livestock nutrition and improvement. And, of course, to train Brazilian technicians" (Aliança Reporter, 1967). Soil fertility problems of the Cerrado were identified followed by technological solutions under the assumption that if the Cerrrado was to be industrially productive at scale, then land, labor, capital and science would all have to come together in an orchestrated effort.

Land was abundant in the Cerrado and, in 1950; of the 79,750 farms (3.8% of the national total) in the region few had formal rights to land and could be dispossessed with the issuing of new titles (AIA, 1961: 59). Expansive tracts of public land were put on the market and newly titled land sold for as little as US$0.42 per acre just north of Brasília while private lands sold for more; sometimes US$25 to $80 per acre at the heart of the Cerrado, near the city of Goiânia (AIA, 1961: 73-74). Additionally, it was estimated that some "20 firms from the United States engaged in selling land in this region" possibly inflating the private market (AIA, 1961: 74).

The issue of who would farm the Cerrado soils was first taken on by Nelson Rockefeller's aides, who supported the idea of settling the unruly landless peasants from Brazil's Northeast that would "dwarf the 'virgin lands' development program of the Soviet Union" (Boardman, 2001). By moving landless peasants to the region, they could quell any potential rebellion and consolidate a democratic Brazil. There was widespread fear that the landless of the northeast would be inspired by the Cuban revolution[7] to engage in rebellion against plantation owners and disrupt political stability. However, Brazilian officials objected to this idea and supported settling the peasants in the Amazonian region where they could provide cheap labor for the burgeoning manganese mines (Colby and Dennett, 1997: 613-614). Moreover, the AIA officials were concerned with finding farmers with the technological know-how and knowledge of modern equipment they deemed necessary to transform the Cerrado soils and produce commodity crops at scale. They looked to the south where there is a history of more equitable land tenure and family farming (in contrast to the slave-landlord history in the Northeast). It was here, they reported, that "the people in these areas of European colonization, more than any other in Brazil, have demonstrated ability to solve their problems, unaided or with only a little assistance. If however, they should receive adequate help in readjusting to present-day requirements, the transition would be speeded up, with greater productivity resulting" (AIA, 1961: 39).

From 1961 to 1969 USAID provided US$106,123,000 (over $680 million today) to finance activities from conducting surveys to training Brazilian scientists all with the goal to modernize Brazil's agriculture and support long-term development planning (Adams, 1970: 25-26). Several surveys were funded by USAID to locate minerals while at the same time they set up a US$35 million loan to import fertilizes from U.S. suppliers (Adams, 1970: 8). Chemical fertilizers such as lime, calcium and potassium were considered crucial to "fix" the acidic soils at an industrial scale. In order for large-scale commodity production to be possible, local practices such as using steamed bone meal to correct the soils would need to be abandoned in favor of using modern inputs that would orient Brazilian agriculture to, and consequently rely on, the global market. Here, IRI worked closely with international agribusinesses that had ties to both Rockefeller's financial holdings and Brazilian

[6] "Oral History Interview with John M. Cabot." Interview by Richard D. McKinzie. Harry S. Truman, July 18th, 1973, accessed March 18th, 2015. < http://www.trumanlibrary.org/oralhist/cabotjm.htm>.
[7] See New York Times article "Northeast Brazil Poverty Breeds Threat of Revolt; Brazil's Poverty Breeding Unrest", by Tad Szulc from October 31st, 1960.

scientists and investors. The agricultural input company Agroceres[8] was controlled by IBEC's majority shareholding and was the largest agricultural input company in Brazil whose products, technology and expertise were mostly imported from the United States to serve the Brazilian market (Stal, 1993). IRI also worked with domestic fertilizer companies such as Brazil's largest – Manah S.A. – who were thrilled with the scientific research of IRI because "for the first time in history significant orders are being received for fertilizer on pastures" (Quinn, 1961). IBEC also founded a company to import farm implements (*Empresa de Mecanizaçao Agrícola, S.A.*) and established an aerial spraying enterprise. The tremendous financial stakes were directly linked to the ability of science and Brazilian politics to build a vast agro-industrial export zone in the Cerrado.

The conclusion that scientists, politicians and investors alike arrive at regarding the "problem of the Cerrado" was that they needed to build an integrated research program combining local, state-level and federal research institutions) that would "tap part of the United States' scientific capacity, join it appropriately with that which exists in Brazil, and make a substantive contribution to the development of the country's agriculture" (Turk, 1971). If the work of IRI's scientists was to be profitable then the Brazilian government would need to take a significant role in promoting and adopting the technological prescriptions throughout the region and even country-wide. Indeed, the combination of political will and expediency, exuberance of international collaboration and a combined faith in the scientific planning of agricultural production led to the development of agricultural research as a key factor behind agrarian change in modern Brazil.

2 Agricultural Research in Brazil: If You Build it, Yields Will Come

Agricultural research in Brazil can be traced back to colonial scientific ventures in the 19th century, such as the Botanical Garden (*Jardim Botânico*) in Rio de Janeiro that was established to document Brazilian flora and fauna and to increase worker (typically slave) productivity and import crops with more profit potential (Lacy et al., 1995: 155-159. However, it wasn't until 1943, when the National Service of Agronomic Research (SNPA – *Serviço Nacional de Pesquisa Agronômicas*) was established that a countrywide research system was supported by the government to transform agricultural productivity for the domestic food market and support an urban workforce for industrialization (Rodrigues, 1987). But, the SNPA was limited in scope as it didn't incorporate all regional research centers and it lacked integration with national economic development goals due to a historic bias against developing agriculture and existing state research agencies that had longer histories in specific commodities and stronger connections to local agro-industries. Almost twenty years later, in 1962, the government established the Department of Agricultural Research and Experimentation (DPEA – *Departamento de Pesquisa e Experimentação Agropecuária*) in Rio de Janeiro with increased political support and more integration within the goals of Import-Substitution-Industrialization (ISI) policies.

At the same time, then President João Goulart had implemented several progressive social reforms, such a plan to nationalize oil refineries, which halted foreign investment, destabilized the economy and concerned the U.S. government. The fear was that the U.S. was losing its grip on Latin America's largest economy and a turn to the left signaled the potential influence of communism in the region. Goulart's generals also became fearful of communist infiltration and the loss of traditional values in Brazilian institutions. With U.S logistical support, the Brazilian military lead a successful coup in 1964 which reinforced the confidence of U.S. economic interests in the country by re-opening the Brazilian economy. Aagriculture was at the center of those interests (Parker, 1979). The DPEA became a crucial tool to modernize the agricultural sector and shifted its goal from expanding the domestic food supply to exporting agricultural goods for the international market (Rodrigues, 1987;

[8] Agroceres was originally funded when the commercialization of hybrid corn seeds arrived in Brazil. The company was founded by University of Viçosa professor Antonio Secundino de São José who brought over 100 varieties of corn to Brazil from Iowa State Univeristy in 1937. Shortly after, Secundino went to work for a Brazilian subsidiary of General Mills and as Agroceres was purchased by a group of U.S. scientists and investors. When the company went public, Rockefeller's IBEC became a majority stakeholder (see Stal, 1993; Colby and Dennett 1995).

Conde Aguiar, 1986: 77). The abandonment of ISI policies combined with a focus on industrializing by attracting foreign capital and technology shifted the objective of agricultural research in the country. International cooperation was then at the center of the DPEA and the Joint Brazil-U.S. Commission for Economic Development established guidelines to orient Brazilian agriculture for the global market with a focus on increasing the production of five specific commodities: rice, beans, corn, soybean and cattle (USAID, 1978; Regina de Medonça, 2012). Following the coup, this commission was set up to provide strategic advice on economic development in Brazil which included lowering trade barriers and utilizing fiscal policy to reign in inflation to attract and benefit foreign investment (Hirst, 2013: 43-46; see also Priest, 1999). It was through such cooperative institutions that the U.S. government worked with Brazilian technocrats to ensure U.S. economic and political interests.

Cooperation continued with USAID funding numerous programs to transform every aspect of public agricultural research in the country, even Brazil's federal university system. A project named the Special Program for Agricultural Research (PEPA – *Programa Especial de Pesquisa Agropecuária*) established partnerships between four land grant colleges in the U.S. with four counterparts in Brazil to "exert a strong collective influence over the agricultural production and rural development of this strategically important country" (Peterson, Schaeffer and Capener, 1969). Rodrigues (1986) states that this project was the "embryo" for what would later become Embrapa. The close collaboration of Brazilian and U.S. scientists and technocrats between IRI, USAID and the DPEA resulted in the identification of serious shortcomings in the national agricultural research system such as: the lack of integration with extension services; excessive oversight from the federal government and; inadequate training amongst the research staff.

The rapid influx of loan programs from abroad, principally from USAID, the World Bank and the Inter-American Institute for Cooperation on Agriculture (IICA), challenged the financial and institutional capacity of the DPEA structure as burdensome bureaucratic rules made accepting and managing funds difficult (USAID, 1973). The response of the federal government was to appoint a High Level Commission (*Comissão de Alto Nível*) to redesign national agricultural research so that it could absorb international support – both financially and logistically. The Commission was put together in July of 1970 and consisted of seven experts: Mozart Teixera Liberal; Salomão Aranovich; Otto Lyra Schrader; Plinio Cordeiro Molleta; António Secundino São José; Clibas Vieira and; Carlos Arnaldo Krug[9]. According to Regina de Mendonça (2012), the Commission was characterized by two distinct blocs of expertise that were fundamental to the epistemological foundation of Embrapa.

The first group (Mozart Liberal, Otto Schrader and Plinio Molleta) consisted of scientists from the Ministry of Agriculture and SNPA/DPEA who were intimately familiar with Brazil's history of public agricultural research because they had been working in the government for the majority of their career. The second group (Salamão Aranovich, Secundino São José, Clibas Vieira and Arnaldo Krug), however, was composed of industry professionals mostly educated in the U.S. and with close ties to international agribusinesses. For example, Secundino São José earned a PhD in agronomy at Iowa State University and had started the first hybrid corn company in Brazil – Agroceres – of which Nelson Rockefeller's IBEC was a majority stakeholder (see footnote 8 above). This Commission of experts helped to establish specialized technical working groups for the same commodity crops identified by the U.S-Brazil Joint Commission and also recommended increasing the autonomy of agricultural research from the federal government, allowing for more control over the research agenda. This new arrangement, under the leadership and guidance of the Commission, created a more flexible research agenda that could integrate U.S.-Brazil technology transfers and facilitate the influx of U.S. agricultural experts and expertise to reach the primary 'users' of their technological products: large-scale, highly-capitalized farmers (Freitas Filho, 1986).

The end result was the creation of Embrapa as a public enterprise under the law no. 5.851 on December 7th, 1972 (see Federal Government of Brazil, 1972). As a public enterprise, Embrapa would

[9] For more complete biographies of all the commission members see: Regina de Mendonça 2012: 79.

have autonomy over research objectives, budget allocation and the establishment of partnerships with private or public institutions, whether foreign or national (see Nogueira, 1978: 59-62). In this arrangement, the public enterprise is granted an annual budget that needs to be approved by the federal government but the internal administration and activities is determined by the institution's own by-laws. The move to consolidate agricultural research in Brazil as a public enterprise solidified the connection between national politics, agricultural research and international science and capital in the modernization of Brazilian agriculture (Conde Aguiar, 1986)

3 The Institutional Anatomy of Embrapa

The exact origins of Embrapa are contested as it's founding is deemed internally as being primarily the result of domestic politics and the inevitable search for agricultural modernization in the Brazilian frontier in the 1970s. According to one of Embrapa's biographers and its first president, J. Irineu Crabral, Embrapa was the product of an official government Working Group that met on April 18th, 1972 to discuss the future of agricultural research in Brazil (Cabral, 2005; see also Embrapa, 2002). The result of the Working Group was a document that is now referred to as the "Black Book", due to the color of its cover at printing. This book is now often referred to as the "bible" of Embrapa because of its symbolic importance to employees (Embrapa, 2006 [1972]; personal interview, 06/10/2014). The "Black Book" outlines the contemporary technological challenges to Brazilian agriculture in general and the technical deficiencies of Brazilian agricultural research in particular. Following previous recommendations from the USAID-IRI partnership and the High Level Commission, the Working Group identified a lack of expertise due to insufficient and inadequate training as well as a lack of national integration with other public research institutes. Lastly, steady financial resources, including more competitive salaries, from the state were considered essential in the long-term to ensure a continuous research program and the recruitment/training of Brazil's top scientific talent (Embrapa, 2006 [1972]: 8-21). This was also the reason why Embrapa was based on the Brazil's public corporation structure, similar to the now wholly private Brazilian Aeronautic Corporation (Embraer - *Empresa Brasileira de Aeronáutica*) and Brazilian Petroleum (Petrobras – *Petróleo Brasileiro*). These corporations were all based on strong support from the military dictatorship in the early 1970s and embedded within the process of internationalizing the Brazilian economy under the alliance of the Brazilian and U.S governments with international and national capital interests (Afronso and Sousa, 1977; Evans, 1979).

However, Embrapa is unique amongst this group in the sense that, unlike public corporations established to produce a direct profit, agricultural research's primary objective is to produce scientific knowledge and technology to boost agricultural productivity in the service of the national economy and for the benefit of Brazilian society (often these two are in conflict with each other; see Levidow, Søgaard and Carr, 2002). This is why legitimacy and public support is key to Embrapa's continued existence. The institutions own origins and claimed achievements in the Cerrado are crucial for long-term budget growth. According to one of Embrapa's former presidents, "if we don't have visibility then we don't have a budget… our problem everyday is to convince authorities to give money to Embrapa, so we have to prove that we are worth it. For you to have an idea, we have 150 journalists in Embrapa. They are treated [with the same respect] as researchers" (personal interview, 11/24/2014). Such a view sees the Brazilian public as potentially disruptive, or at least uncooperative, in furthering the political support of Embrapa and their research agenda (Thorpe and Gregory, 2010). The diffusion of Embrapa's successes through the popular press and official documents does a lot of work for the legitimation and extension of their research to the public but ultimately requires political support.

One manager from the original Working Group of Embrapa said their accomplishments in the Cerrado were due to "the political stability [of the dictatorship] that set clear priorities and goals", implying the centralized and strong-armed political support for modernization put Embrapa at the center of agricultural development (Personal interview, 01/23/2014. Embrapa is one of the few governmental institutions that has enjoyed widespread political support since its establishment – starting during the dictatorship and transcending the transition to democracy in the 1980s. At its inception, Embrapa

secured around US$200 million (much of it in international loans) in annual funds but has since expanded to around US$1 billion rivaling the U.S.'s agricultural research institution, the USDA-Agricultural Research Service (Stads and Beintama, 2009). The benefits from this funding have been meticulously calculated by Embrapa's annual "Social Return" report[10]. Embrapa's Social Return (2013a) highlights the economic and environmental return of agricultural technology and the general social value of public research in terms of job creation, food prices and spillovers into other sectors (see also Fuck et al, 2009). This report is crucial in the battle to ensure Embrapa's public legitimacy and demonstrate the value of their work to the government. The overall national importance of agriculture in Brazil is also highlighted as Embrapa plays a key role to increase the economic return of the agricultural sector. From 1975 to 2012, agriculture as a percentage of GDP doubled from around 15 percent to 30 percent (Filho, 2013) and in 2014 alone agricultural exports produced a surplus of over $82 billion (CNA, 2015). It is Embrapa's national research structure of that allows for a comprehensive approach to use modern science and technology on Brazil's diverse ecologies and commodities.

Embrapa's research model is based on a decentralized structure of specialized centers that focus their research within regional climates, biomes and crops. The headquarters is in Brasília and there are 42 research centers around the country: 17 eco-regional offices, 15 commodity centers (i.e. soy, corn, cotton, etc.) and 10 thematic hubs (i.e. diary, biofuels, biomedicine, etc) (Beintema et al, 2001: 18). All of the centers vary in size, both in terms of human resources and their physical size. Embrapa is overseen by an Administrative Council which consists of eight members: two members nominated by the Ministry of Agriculture (MAPA - Embrapa's mother institution) that work in agricultural research or agricultural science in technology (civil or government); three nominated from three different federal ministries[11]; a representative elected by Embrapa employees; the president of Embrapa and; the Minister of MAPA who serves as the director of the council (Federal Government of Brazil, 2012).

The Administrative Council determines agricultural research priorities of the country by advertising competitive calls for scientific projects. Interested Embrapa centers (and their scientists) can then submit proposals, which are evaluated based on the center's human resource capacity and relevant research capabilities. For example, should the governing board decides that there is a demand for a new type of wheat for making beer, proposals would likely come from: Embrapa-Wheat, Embrapa-Food Agroindustry and Embrapa-South (the biome where most of the wheat in Brazil is grown). When submitting proposals interested scientists need to integrate their research between centers. Embrapa has a mandate that each project must have at least one scientist from another research center in the country. According to the Research and Development Unit at Embrapa headquarters in Brasília, this helps to ensure that collaborative research gets carried out and new internal "knowledge networks" are constantly being created (Personal interview, 01/17/2014). The establishment of foreign laboratories (*Labratórios no Exterior* – LabEx[12]) in the United States (1998), France (2002), Ghana (2006), South Korea (2009), China (2012) and Japan (forthcoming) also form part of the international knowledge networks that support the continuation of technology transfers via the exchange of biological material, workshops and training. These laboratories were established to formalize the existing international scientific knowledge networks that were part of Embrapa's founding and continue to be at the center of their research approach. According to one of Embrapa's managers, their locations in both the global North and the global South, allows for Embrapa to serve as a hub of expertise that draws on existing

[10] Embrapa produces an annual report detailing the social returns of their public research. In the most recent issue, Embrapa's economists estimated that for every R$1 invested in Embrapa results in over R$9 returned to Brazilian society in some form of a benefit (lower food prices, increased income and/or new consumer goods, see Embrapa 2013a).

[11] The three ministries are the Ministry of Planning, Budget and Management, the Ministry of Finance and the Ministry of Agrarian Development. There are historical divisions in the interests and politics between these ministries, but notably between the Ministries of Agrarian development (MDA) and Agriculture, Livestock and Supply (MAPA). This division is primarily based on the former being representative of family farmers and peasants while the latter tends to represent large agri-businesses. In their oversight to Embrapa, they provide input for how their respective interests could benefit from research and development at Embrapa (personal interview, 01/17/2014; see also Embrapa, 2013b).

[12] See an outline of Embrapa's LabEx program here: https://www.embrapa.br/programa-embrapa-labex

scientific excellence in the North and share it with the South (personal interview, 07/07/2013). Along with sharing germplasms and other physical material, this network aims to strengthen the scientific capacity of all researchers involved by carrying out training and allowing them "to rub shoulders with leading top-notch scientific research teams" (Embrapa, 2012: 6; see also Alves, 2016: 148-152).

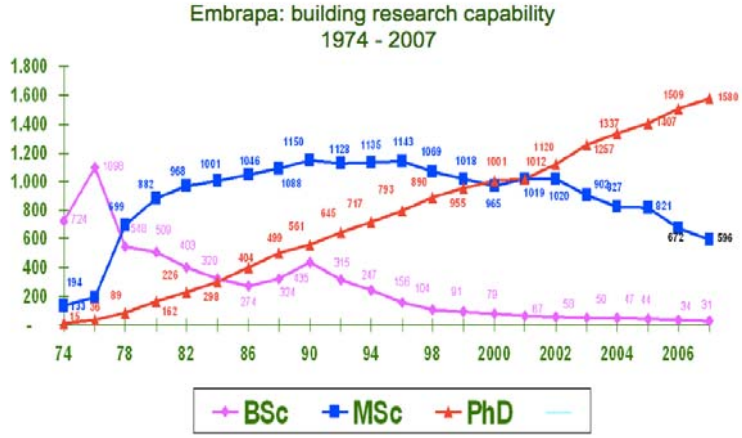
4 Education and Expertise

Academic achievement is highly valued by Embrapa's management and was built into the original objectives of the institution, leading to an astounding growth and concentration of scientific expertise. Starting in 1976, only 17 percent of Embrapa's 1300 researchers had a postgraduate education and 3 percent held PhD degrees. However, in just over thirty years, Embrapa now employs over 2,000 researchers (out of just under 10,000 staff), of which 99 percent have postgraduate degrees and 75 percent hold a PhD (54 percent of all PhDs were obtained abroad) (Beintema, Avila and Fachini, 2010: 3; also see figure 2). From the very beginning of Embrapa's conception, "the basic idea was to have a group of researchers with the same level of competence [as those] in the U.S." (Personal interview, 11/21/2014) The U.S.-Brazilian collaboration via USAID and Rockefeller's IRI also played a significant role in establishing agricultural research programs in many Brazilian universities (Sanders et al, 1989).

IRI began funding training workshops and professional exchanges in the 1950s, which were then later supported more expansively under the USAID-financed PEPA (Special Program for Agricultural Research) program. From 1963 until 1978 this program facilitated and funded the establishment of agricultural research departments at Brazilian universities – from agricultural economics to soil science and plant genetics – that would train Embrapa scientists. According to a now-retired Embrapa agricultural engineer with a PhD from New Mexico State University, one of the most prestigious agricultural universities in the country, the Federal University of Viçosa in Minas Gerias, was modeled after Purdue University starting from collaboration in 1948 (Personal interview, 01/04/2014). Viçosa also worked with Rockefeller's extension programs in the state from the 1940s-1960s. The idea of the PEPA was to reproduce the U.S.'s Land Grant model in Brazil and strengthen the connection between academic research and extension[13]. According to Embrapa, they have "always invested heavily in the training of collaborators, in turn with or even ahead of the most advanced science produced in the world" (Embrapa, 2013: 6). This idea of producing science is exemplified in the history of territorial and technological frontier expansion in Brazil. One scientist even mentioned that, "the education of the scientists [at Embrapa] created a culture which was fundamental to our success" (Personal interview, 07/21/2014).

[13] As mentioned above, this project was named the Special Program for Agricultural Research (PEPA – *Programa Especial de Pesquisa Agropecuária)*. Four universities in Brazil were matched up with four Land Grant universities in the U.S. based on the geographic diversity of Brazil: University of Ceará in Brazil's northeast with University of Arizona; University of Viçosa in the east-central with Purdue University; Luis de Quiroz (University of São Paulo) in the south-central with Ohio State University and; University of Rio Grande do Sul in the South with University of Wisconsin

Figure 2: Highest Educational Attainment of Embrapa's Scientists (1974-2007)



Source: Embrapa, N.d.

Embrapa scientists have been attributed with 'creating' the tropical soybean. This development is hailed by Embrapa staff as a significant achievement for the world due to the fact that the soybean is a sensitive plant to light duration and intensity, making it particular to temperate latitudes (Schnepf et al, 2001; de Sousa and Busch, 1998). It is the pursuit of such scientific breakthroughs that fuels the workforce and maintains a dedicated push for scientific innovation. As several Embrapa researchers have mentioned, they were, and continue to be, part of a "vision to prepare Brazil for the future" (Personal Interview, 11/21/2014). And this is why they attract and train some of the top talent across the country – to apply technology for the benefit of Brazilian society, and increasingly the world.

The longstanding political relations between the U.S. and Brazil created an environment in which technological answers were given to solve the problems of Brazilian development. Agricultural production in the Cerrado exemplified one of the biggest development 'problems' in Brazilian history, so when U.S. expertise provided the technological key, the rationale had been made. Decades of scientific research, technology transfers, and the training of Brazilian researchers came together to conclude that a new research institution was needed in order for the large-scale industrialization of agriculture in the Cerrado. With the military dictatorship firmly in place, and the basic institutional and scientific groundwork laid out, Embrapa was in a position to fulfill the dream that was centuries in the making.

5 Putting Science to Work: Opening the Cerrado for Business

The *Sertão* is a general term used to describe the Brazilian frontier or hinterland that is viewed as an untamed and unruly territory. The idea of the *Sertão* has played a central role in the making of modern Brazil by providing abundant land and resources from the Amazon and *Caatinga* biomes in the north to the Cerrado in the west (Lombardi, 1975; see also Franco and Drummond, 2008). Centuries of attempts to push west and develop agriculture had failed due to poor infrastructure, low population density and weak investment from the state (Klink and Moreira, 2002). It wasn't until political centralization and authoritarianism with capital accumulation, or what Velho (1979) calls "authoritarian capitalism", that the western frontier could be effectively occupied, and then conquered with technology, to pave the way for industrial agriculture. This push to seriously colonize the Cerrado for the first time left little space for any alternatives, as the state support for technology was based on U.S. scientific models of export-oriented industrial agriculture. This bias was apparent not only in the scientific assumptions of agricultural modernization described in the first section but also in the distribution of government credit as farm size and crop type significantly determined credit distribution. From 1969-1990, establishments of 50 hectares or larger represented only 18 percent of country's total farms but received 76 percent of available credit while establishments less than 50 hectares made-up 82 percent of all farms of but only received 24 percent of government credit. Of that total during those 21 years, soybean producers received a combined US$2.4 billion in subsidies and

US$357 million credit which was almost twice the financial support of any other crop (Helfand, 2001).

IRI's early work in the Cerrado was focused on a variety of primary commodity crops but soybeans became the preferred choice because of the scientific formula and the economic prospects. The soybean plant's nitrogen fixing traits were part of the formula in producing a viable export crop in the Cerrado as the plant was able to overcome Nitrogen deficiency found in many of the region's soils. Additionally, soybeans could displace domestic consumption of food oils as well as act as an industrial input for processed foods and other 'value-added' products. An added push was aided by the moratorium of U.S. soy exports through the "Nixon Shock" in 1973, which provided the extra impetus to supply an increasingly lucrative international market. Problems of a negative balance of payments and increasing financial support from abroad helped channel funds into the fields of the Cerrado to generate the necessary revenue for government supported industrialization. The Japanese, in particular, became concerned about global soybean availability and had a vested interest in the establishment of new production zones around the world (Friedmann, 1993; Oliveira, 2015). Around US$300 million of Japanese investment through the Japanese International Development Agency (JICA) funded resettlement and infrastructure development projects[14] in the region to ensure proper production and transportation ensuring cheap access to the international market (Schlesinger, 2007; see also Soskin, 1998 and Warnken, 1999). The combination of this geopolitical context and material traits of both soybeans and the Cerrado soils placed an economic premium on soy as the center of Brazil's agro-industrial transformation.

6 Embrapa's Cerrado?

Embrapa's inauguration in 1973 signaled wholesale scientific planning for agricultural modernization in the Cerrado. According to Arraes et al. (2012), Embrapa's most important scientific 'discoveries' for the Cerrado were: "soil fertility, biological nitrogen fixing, new plant varieties and hybrids, use of no-tillage systems and integrated crop and livestock systems" (8). These technologies were based on scientific methods and assumptions partly developed by IRI researches and then transferred via training and through the transfer of seed germplasms (the genetic resource used for developing and transporting seed varieties) from USDA research centers in Mississippi and crossing them with Brazilian varieties. Those techniques and materials were then 'adapted' over years of lab work at Embrapa's headquarters in Brasília and the thematic or regional research centers (like Embrapa – Soybeans in Londrina, Paraná and Embrapa – Cerrados in Planaltina, Goiás). In 1975, Embrapa launched the Special Program for the Geo-economic Region of Brasília to roll out technological packages the throughout the region. National extension systems[15] were developed in conjunction with Embrapa to train farmers in the use of chemical fertilizers and new seed varieties. Limestone quarries were built on sites identified from previous surveys conducted in the 1960s and the arrival of family farmers from Brazil's southern states became the boots on the ground to plow the Cerrado soils. In short, problem setting during the IRI-USAID partnership days effectively ordered the problem-solving mission of Embrapa's "Miracle of the Cerrado" but it wasn't until the creation and support of Embrapa that technological packages could be put to work in the Cerrado necessary for industrial agricultural production.

[14] In 1973, JICA and the Brazilian government launched the Program of Directed Settlement of the Alto Parnaíba (PADAP) which granted public land for settlers to grow grain commodities, particularly grains. PADAP also established growth poles around the public lands extending transportation and communication networks (see Hosono and Hongo, 2016). Then in 1980, the philosophy of PADAP was extended region-wide under the Brazilian-Japanese Cooperation Program for the Development of the Cerrado (PRODECER). PRODECER was implemented in three waves from 1980-2001 starting in the western part of Minas Gerais and expanding north and west from there with a fourth wave currently under negotiation (Inocêncio and Calaça, 2009; Inocêncio, 2010; Shiki, 1997; see also Oliveira 2015)

[15] The development of rural extension systems in Brazil were also partly inspired and developed by AIA's projects in Minas Gerais (see Boardman, 2001; Oliveira, 1999)

7 Cultivating Profits

As USAID estimated in an internal report, improving agricultural research and transforming the Cerrado "will over time encourage U.S. private trade and investment for the very simple reason that the U.S. is a world leader in seed production, agricultural implements, fertilizer manufacture and food processing, all of which will receive a stimulus in Brazil… in the long run" (USAID, 1968: 12). The Cerrado accounts for 60 percent of grain production in Brazil and produced roughly half of national cotton production (de Paula, 2013; IBGE, 2006). And, the Cerrado is also the most input-dependent agricultural zone in the country, accounting for 49 percent of national fertilizer expenditures and 48 percent of national pesticide expenditures. The Brazilian pesticide market is considered the most attractive in the world with a forecasted market of around US$16 billion by 2020 if annual growth rates of 10 percent annually continue. Over 70 percent of this market is shared between eight agro-industrial multinationals (Syngenta, Bayer, BASF, FMC, DuPont, Dow Chemical, Monsanto and Iharabras) and the remaining share is divided between over 100 national and international suppliers (Hirata, 2014). Brazil also relies on importing fertilizers as 68 percent of total national use comes from abroad. The Cerrado's key export crops – Soybeans and Corn – account for half of all fertilizer use in the country and out of the two most important fertilizers in the Cerrado – phosphates and potassium – 32% are imported from the U.S. and Canada, respectively (Tavares and Haberli Jr., 2011). Countrywide, Brazil imported 46 percent of phosphates and 92 percent of potassium in 2008 (IFA, 2009 cited in Cella and Rossi, 2010). Multinationals also dominate the hybrid seed market, especially in maize and soybeans with Monsanto (who acquired IBEC's Agroceres in the 1990s), Dupont, Syngenta and Dow Agro Sciences owning over 80% market share (Fukuda-Parr, 2007: 113-114). Foreign producers or investors even own around 20 percent of the land under cultivation in the Cerrado (Correa and Schmidt, 2014). From the very beginning, the design of industrial agricultural production in the Cerrado was both aimed at the international market and dependent on it for inputs to maintain productivity (Rada, 2013).

The technological and material development in the Cerrado was not a result of a discovery, nor only a factor of global economic restructuring and geopolitics (Oliveira, 2015), but enacted through decades of scientific problem solving, international technology transfers and scientific institution building. A full decade before Embrapa rolled out its technological regime for development in the Cerrado the basic soil science problems and the challenges to access the key factors of production had been worked out and documented (Wallis, 1997: 84). Early scientific and political work in the region underpinned much of the technological development to transform grasslands and acidic soils into one of the world's largest breadbaskets. There was never an alternative ('scientific' or otherwise) to this agro-industrial colonization. The combination of developing technological packages, sparsely populated land, infrastructure projects and state-sponsored migration of industrial farmers from the South all unrolled across the Cerrado with astounding speed, subsuming the entire region. Nevertheless, ownership over this transformation is a contentious issue. For Embrapa, their role in producing the Cerrado as "the world's most important agricultural expansion zone for this century" (Landers, 2001) is important for public visibility – at home and abroad.

Conclusion

The official biography of Embrapa according to its first president and early researchers is one in which Brazilian agricultural technology is born out of political will and scientific innovation during the early 1970s in Brazil. Culminating in the agricultural transformation of the Cerrado, this narrative carries weight in the historical memory of Embrapa and helps bolster public support for agricultural research activities. However, decades of research by IRI scientists, training programs and problem-setting established crucial scientific rationale for how the Cerrado *should* be developed. Alternatives to intensified agricultural production never became realized on a national scale in the Cerrado precisely because of the longstanding history of scientific problem solving and relations of knowledge production between U.S. and Brazilian scientists and political elites. The inherent acidity of the Cerrado's soils do necessarily require a technical "fix" if they are to be productive for certain

commodity crops at scale. However, the ways in which such fixes were problematized, solved, legitimized and implemented have also shown to be environmentally problematic and reliant on an increasingly volatile global agricultural input market. The Cerrado has been labeled a "biodiversity hotspot" due to the tremendous loss of habitat and life in the world's most biodiverse savannah. Despite having over 12,000 endemic plant species – more than the Amazonian region – the Cerrado receives more attention as an economic engine than a biological or ecological one (see Spanne, 2014 and Wolford, 2008a; 2008b). Nevertheless, in an age of continued food price volatility and continued dominance of Western countries in the global food system, the rapid and profitable experience of the Cerrado is still seen as a tremendous success.

Embrapa's experience in the Cerrado is now held up as an example in the new wave of technical transfers within and between the countries in the global South. "Brazilian" agricultural science is sought after and viewed as distinct than that of the coercive imperial science of old. New sites of agricultural commodity production are now being sought after throughout Latin America and across the Atlantic into Africa (Wolford and Nehring, 2015; Oliveira, 2015; World Bank, 2007). When they once looked to the Agricultural Revolution in Europe or the American Midwest as the ultimate archetype of modernized agriculture, the Cerrado is now hailed as a crowning achievement of scientific mastery and a forward thinking state that accelerated development. During a long discussion on the differences between U.S. and Brazilian agriculture, one of the chief agricultural architects of the Cerrado transformation boasted without any apparent irony that, "what took the Americans almost a hundred years to do we did in less than fifty" (Personal interview, 01/16/2014).

This paper intended to show how agricultural research in Brazil wasn't linear, pre-determined or natural in the development of technologies for agro-industrial development in the Cerrado. Rather, U.S. interests in Brazilian agriculture in general, and the Cerrado in particular, were channeled through the deployment of scientific experts and expertise in the post-WWII era. The early work of Nelson Rockefeller's scientists envisioned and documented the scientific possibilities for industrial agriculture, which became central to the founding objectives of Embrapa and its later work throughout the country. Decades of investment from the U.S., Brazilian and Japanese governments funded the education and research of Brazilian scientists to carry-on solving agricultural development problems and ensured long-term growth with improved infrastructure. This structural context was based on the geopolitical interests and economic opportunities sought in Brazil. The resulting input-intensive production system propelled Brazil to the global spotlight as agricultural productivity has made Brazil the "world's first tropical agricultural giant" (the Economist, 2010b), which is heavily dependent on imports for agro-chemicals and fertilizers by design.

A genealogy of Embrapa and their work in the Cerrado demonstrates the ways in which foreign and domestic private and political interests are incorporated into public research institutions. Thus, instead of the direct commodification of bio-technologies (Kloppenburg, 1988) and on-farm means of production (Goodman, Sorj and Wilkinson, 1987) the international relations of scientific knowledge production between private and public organizations lays the technoscientifc foundation for the continual transformation of profitable agrarian landscapes and the legitimation of agro-industrial production for development. The history and ongoing development of public agricultural research provides a critical perspective on the nature of the relationship between corporate and political interests in the production of scientific knowledge and technology.

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