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

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By
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ABSTRACT

Over the past forty years, Brazilian agriculture has rapidly industrialized elevating the country as one of the world's largest exporters of key commodity crops such as corn, soybeans and cotton. Much of the credit for this transformation has gone to the Brazilian Agricultural Research Corporation (Embrapa) for their work in the center-west region of the country. This area, known as the Cerrado, industrialized rapidly starting in the early 1970s with the introduction of chemical fertilizers and new seed varieties to fix its acidic soils. This paper historicizes the political and social relations behind the industrial transformation of the Cerrado by focusing on the establishment of Embrapa. I argue that U.S. political relations and corporate interests helped to lay the scientific and institutional groundwork for public research in Brazil to ensure long-term industrialization of the Cerrado. This research is based on interviews conducted at Embrapa headquarters and field research sites in Brazil as well as historical archives in both Brazil and the U.S.

BIOGRAPHICAL SKETCH

Ryan Nehring is a PhD student in the department of Development Sociology at Cornell University. His research interests include the political economy of development and agricultural research in Brazil, and local food policies in Latin America. He received a B.A. in Languages and International Studies for the College of Saint Scholastica and an M.A. in International Development from Saint Mary's University (Halifax).

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1. Introduction

"The true meaning of Braziliannes is the march west"
President Getúlio Vargas, Guanabara Palace at midnight, December 31st, 1937

Production increases from industrial agricultural in Brazil over the last several decades have elevated it as the world's first tropical food-giant. In the 1940s, the country was a net food importer with high concentrations of land ownership and a reliance on a few agricultural commodities. Today, Brazil is one of the world's largest producers and 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, an area is known as the *Cerrado*. According to the Brazilian government, this vast region of 'empty', or 'underused', land with severely acidic soil could be transformed into an agroindustrial production zone for export (Graziano da Silva, 1993; 1995). The vision set forth to colonize the Cerrado 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 (Borlaug and Dowswell, 1997). 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 (Honoso and Hongo, 2016). What was once a vast savannah with limited infrastructure and material development now has fleets of John Deere combines reaping fields of yellow gold.

At the center of this transformation is the Brazilian Agricultural Research Corporation, known by it's acronym Embrapa (*Empresa Brasileira de Pesquisa Agropecúaria*). Embrapa is a public research institution headquartered in Brasília that, according to a former Embrapa president, "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 47 research centers spread around the country that focus on specific agricultural commodities, themes or biomes. Decades of scientific research at these centers has elevated Embrapa as an example of how the World Bank says to "get it right" when it comes to agricultural research (Correa and Schmidt, 2014).

In this paper I argue that Embrapa and its expertise, as exemplified by the transformation of the Cerrado, is the product of two related processes that intersected at a historical conjuncture. First, the material conditions of the Cerrado – its acidic soils and relative underdevelopment – combined with the economic interests of businessman and philanthropist Nelson Rockefeller. He hired scientists to work on technological solutions to make a profit on the idea of industrializing the region. The early research of his scientists in the Cerrado produced the basic scientific groundwork that legitimated agricultural modernization on the basis of imported industrial inputs. Secondly, once Rockefeller's scientists demonstrated the industrial potential of the region, political elites from both Brazil and the U.S. worked together to redesign national agricultural research (culminating in the establishment of Embrapa). This allowed for modern technologies to be generated for a wholesale 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 for decades.

Embrapa has long held a special role in the Brazilian state as being an agency that is centered around expertise and efficiency, which stands in stark contrast to the corrupt ministries. This image of apparent scientific neutrality has helped them to garner significant political support that is crucial for their continued existence as a public institution. But, even their own origins are heavily politicized because of the claims to domestic and international fame in mondernizing the Cerrado. That is why much of the early research conducted by U.S. and non-Embrapa Brazilian scientists has largely been written out of the story by former Embrapa executives and in-house historians (see Cabral, 2005; Embrapa, 2002; Alves, 2016). Part of historicizing Embrapa and the transformation of the Cerrado, then, involves rewriting Brazil's role into the wider process of the Green Revolution, or the deployment of U.S. agricultural experts during the Cold War (Perkins, 1997).

What makes Brazil such a unique case is that Nelson Rockefeller's cooperation with the Brazilian state differed from the more interventionist and largely top-down approach of U.S. foundations and the Consultitve Group for International Agricultural Research (CGIAR) who are typically identified as the key protaganists in the Green Revolution (Patel, 2013; Silva, 1997). These different actors and approaches also reinforced Embrapa's story of the Cerrado as an endogenous and apolitical process. Nevertheless, I suggest that Brazil achieved significant yield productivity gains and industrialized agriculture at scale by working closely with politically-charged U.S. experts – precisely the objectives and methods of the Green Revolution. A quick library search on cases of the Green Revolution will yield hundreds of results from high profile countries as India, Mexico and the Phillippines but few, if any, will focus on Brazil and/or the Cerrado. This article offers a new way to look at the Green Revolution through the lens of

Brazilian agricultural research and historical relations of knowledge production that underpinned the transformation of the Cerrado. The origins of Embrapa's expertise in the Cerrado presented here challenges an essentialized account of science, modernization and a rationality based on purely social or environmental forces (Mitchell, 2002).

Brazil's center-west has largely become a built environment as a result of the scientific and political work to transform it from savannah to an export commodity production zone. Such an understanding is building off of decades of research in political ecology and Science and Technology Studies (STS), as well as the fruitful engagement between the two (Goldman, Nadasdy and Turner, 2010). The Cerrado wasn't merely an ecological backdrop or the environmental context where knowledged was produced. Rather, early scientific research was grounded in its acidic soils and agroindustrial possibilities were based on relative underdevelopment and production at scale (Brown and Purcell, 2005). In other words, the production of scientific knowledge was situated in the region but also that scientific knowledge is inherently power-laden, political and relational by focusing on the transmission of U.S. environmental expertise abroad (Teisch, 2011; Perkins, 1997; Fitzgerald 1986; 2003). Alternative modes of production and knowledges were selectively ignored through training, government support and the hegemony of modernists ideals (Engerman, 2003). The construction of the scientific "facts" (Latour and Woolgar, 1979) around modernized agriculture in the this case are thus based on the circulation of experts, expertise and the "open-air laboratory" of the Cerrado (Latour, 1999; see also Rojas, 2015) operating within the political economy U.S.-Brazil relations. These relations resulted in the Cerrado as representing the archtype of industrial agriculture in Brazil. Post-WWII economic and political relations between the U.S. and Brazil

facilitated the concurrent replication and integration of the U.S. food regime into Brazil (Friedmann and McMichael, 1989; Friedmann, 1993). Rockefeller's experts and connections with Brazilian technocrats worked to create a national agricultural regime based heavily on the importation of industrial inputs. The establishment of Embrapa and industrial agriculture in Brazil's Cerrado eminates from the intersection of: new tropical ecologies with relative underdevelopment; social relations of scientific knowledge production and; the power of political interests to establish an agricultural sector dependent on U.S. agro-inputs.

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 just outside of Brasília. Most 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. I utilized archival records of Dr. Reeshon Feuer and Dr. Kenneth Turk who also worked on agricultural development with the U.S. Agency for International Development (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 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 Nelson Rockefeller's research organization and the online archives of USAID. The combination of historical archives and interviews with Embrapa employees reveals the disjuncture between the contemporary politics of public agricultural research in Brazil with the historical production of scientific knowledge in the Cerrado. My own positionality as a research at Cornell University has allowed for a prviliaged position to access these sources and place the different actors, categories and meanings around the ecological and political origins of agricultural research in Brazil.

I start the next section by explaining how early scientific work in the Cerrado was primarily spearheaded by Rockefeller's experts seeking to understand how to turn on the agro-industrial potential of 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 last section explains how geopolitics and the materiality of the Cerrado were structuring forces for how technology produced at Embrapa colonized the Cerrado for agricultural export crops based on the use of imported industrial inputs. I conclude 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 treasure and model for industrializing agriculture in the tropics.

2. 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 such as gold. For decades, the region's native grasses supported vast cattle ranches but few farms outside of the fertle river valleys. It wasn't until the 1930s that the then-president Getúlio Vargas promoted a "March to the West". This initiative was based on subsidies as an incentivize for settlers to move inland from the densely populated coastal areas where soils had long been exhausted from intensive coffee plantations. The hope was that this migration into the vast Cerrado would result in farms dotting the landscape, increase exports and unite the country politically and territorily (Inocêncio, 2010; Vargas, 1938: 124). According to the 1950 national census, this area represented approximately 3 percent of the Brazil's total population despite constituting around 1/3 of national territory (IBGE, 1950). Limited state capacity and poor infrastructure, 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 (see Klink and Moreira, 2002). In the 1950s, however, the construction of Brasília signified a symbolic and material shift from the colonial legacies present in Rio de Janeiro (the capital at the time) and São Paulo. 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 interior. In order to fulfill this modern dream and tame the interior, they looked to U.S. scientific expertise for help in determining the optimal location to build this future capital.

In 1954, Cornell University soil scientist Reeshon Feuer was sent to the Cerrado as a consultant for D.J. Belcher and Associates[1] . His duty was 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. Based on preliminary surveys, he 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). His time in the Cerrado was spent traversing the plains and valleys of the Cerrado to take soil samples, document the landscape and conduct farm visits. Most of his field notes describe local production consisting of extensive grazing of Zebu cattle but he also highlighted farms in valleys with "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[2] [*sic*]" (Feuer, 10/02/1954). He compared the local planting methods with that of the U.S. by noting, "beans always planted in corn as in old New England farms" (Feuer, 09/27/54). 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.

[1] D.J. Belcher and Associates was founded by Cornell 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" (Gilman,
[2] The term alqueire is a colonial term that refers to an area of productive land but varies by region from around 2.5 to 10 hectares.

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 agriculture was located in the U.S. where temperate crops dominated. Translating this to the Cerrado meant that in order to achieve the same levels of productivity it was understood that only chemical fertilizers could 'fix' its acidic soils for improved varieties of temperate crops to grow at tropical lattitudes. At the moment, such a feat had not yet been achieved at such an enormous scale. But, 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, Nelson Rockefeller purchased a plantation (*Fazenda Bodoquena*) of over 120,000 acres in western Brazil. He was deeply 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. With a map of Brazil, Roosevelt pointed to the center-west plains of the Cerrado 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: Brazil's Cerrado (in green)

Source: Jerome Harrington Files

According to Colby and Dennett (1995), the government leaders in Brazil were convinced to work with Rockefeller's scientists 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 development organizations for this work: 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"[3] that supposedly supported capitalist growth with a social purpose (Rivas, 2002). Their activities consisted of agricultural extension services, licensing businesses, establishing stock markets and the exportation and development of scientific knowledge all based on U.S. models and

[3] Time Magazine. 1946. "Enlightened Capitalism," Vol. 48. Issue 2, p. 44.

experiences (see Colby and Dennett, 1997; Cobbs, 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 and business. He had already been the assistant secretary of state and the Coordinator of Inter-American Affairs, while also managing his family businesses for decades. These previos posts inspired him to fulfill a mission of "improving human welfare" while making a profit (Rivas, 2002). The IBEC Research Institute (IRI) was established to export U.S. argonomic expertise and conduct field experiements with contracted scientists. According to Rockefeller, this move would support "new highways for the march of science and technology over the obstacles of language, race and customs… so that the benefits of science and the new technology can spread more widely over the earth" (Dalrymple, 1968: 15).

IRI established field stations to work on what they saw as technological shortcomings in Brazilian agriculture. At these stations they developed and adapted new varities of grasses for cattle imported from the U.S. and planted field plots with corn, soybeans and cotton to understand the soil chemistry of the Cerrado and its potential for industrial agriculture. 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 understood in Brazil after presenting at the 1961 Symposium of the Cerrado in Sete Lagoas, Minas Gerais where Brazilian soil scientists convene annually to this day (see Avellar and Silva, 2000). It was at this meeting that an early

debate took place around the shortcomings of the Cerrado's soils and the possibilities for agriculture. José Martins de Oliveira Filho was one of several Brazilian scientists who determined that the main fertility problem of the Cerrado's soils was a lack of physical organic material combined with a poor understanding of how native vegetation functions, and in many cases thrives, in those soils (Filho, 1961). 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). Instead of understanding the native vegetation and developing local crops and seed varieties (Borlaug and Dowswell, 1997), the IRI team had "selective ignorance" (Elliot, 2012) by being fixated on constructing soil with chemical inputs..

IRI's research on the Cerrado's soils, 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[4]" were sent around the world to share the techniques and knowledge gained from Brazilian ecologies. As early as 1962, Brazil's then-Minister of Agriculture Dr. Renato 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 evaluation of the physical and economic potential of the region" (Costa Lima, 1962). In practice, one of President Truman's confidants admitted that "[Nelson] Rockefeller was the real leader of the Point IV program",[5]

[4] 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).
[5] "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>.

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 (and IRI) 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). Centuries of colonial exploration and disease had limited indigenous occupation and opened the region for the government to control a vast majority of the territory (Santos, 2013). In the 1960s, these 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. 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: 73-74).

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 political stability in Brazil. There was widespread fear that the landless of the northeast would be inspired by the Cuban revolution[6] to engage in rebellion against plantation owners and disrupt the Brazilian government. 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, officials from the AIA wanted farmers with the technological know-how they deemed necessary to transform the Cerrado soils and produce commodity crops at scale. They looked to the south where there was a history of settler agriculture (in contrast to the slave-landlord history in the northeast) and increasing land conflict and scarcity. 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). Instead of establishing equitable land tenure in the Cerrado and building up the technological and financial capacity of peasants from the northeast, they chose to use southern 'family farmers' who could quickly carry-out the modernization process.

[6] New York Times, "Northeast Brazil Poverty Breeds Threat of Revolt; Brazil's Poverty Breeding Unrest", by Tad Szulc from October 31st, 1960.

From 1961 to 1969 USAID provided US$106,123,000 (~$680 million today) to finance various activities from conducting surveys to training Brazilian scientists all with the goal of modernizing Brazil's agriculture and supporting long-term development planning (Adams, 1970: 25-26). Several surveys were funded by USAID to locate minerals while at the same time making available US$35 million loan to import fertilizes from U.S. suppliers (Adams, 1970: 8). In order for large-scale commodity production to be possible, local practices, such as using steamed bone meal, would need to be abandoned in favor of using modern inputs available at scale 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 scientists and investors. The country's largest agricultural input company, Agroceres[7], was controlled by IBEC's majority shareholding. Companies like Agroceres served a dual purpose in expanding the industrial possibilities of the region by supplying imported inputs while also returning a profit to Rockefeller (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). Beyond Agroceres, IBEC founded a company to import farm implements (*Empresa de Mecanizaçao Agrícola, S.A.*) and established an aerial spraying enterprise. The tremendous personal financial stakes were reliant on the ability of science and Brazilian politics to build a vast agroindustrial export zone in the Cerrado.

[7] Agroceres 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. Secundino then went to work for a Brazilian subsidiary of General Mills as Agroceres was purchased by a group of U.S. investors. When the company went public, Rockefeller's IBEC became a majority stakeholder (see Stal, 1993).

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.

3. 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. These colonial ventures documented Brazilian ecologies and conducted crop trials to increase worker (typically slave) productivity and import crops with more profit potential (Busch 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 by the Brazilian government to transform agriculture 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. This fractured national research strategy was based on a historical bias against developing agriculture in the country and focusing on commodity exports (Schuh and Alves, 1970). Additionally, existing state research agencies had long been focused these few commodities

based on strong 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. Agricultural modernization would support ISI by increasing government revenues to subsidize industry and expand the urban labor market through a rural-urban migration.

At the same time, then-president João Goulart was in the midst of implementing major progressive social reforms. His plan in the early 1960s to nationalize oil refineries operating in Brazil halted foreign investment, destabilized the economy and greatly 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 influence of communism. 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 (Knippers Black, 1977). And, agriculture was at the center of those interests (Parker, 1979). The DPEA then shifted its goal from expanding the domestic food supply to exporting agricultural commodities for the international market (Conde Aguiar, 1986: 77). 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 commodities with the highest productivity and profit potential: rice, beans, corn, soybean and cattle (USAID, 1978; 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 and attract 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 "exert a strong collective influence over the agricultural production and rural development of this strategically important country" (Peterson, Schaeffer and Capener, 1969).

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 Brazil's agricultural research institution as burdensome bureaucratic rules made accepting and managing funds difficult (USAID, 1973). One Embrapa official told me that, "in those days, if you took a trip and needed travel reimbursement, you would have to wait on a signature from the agricultural minister which could take weeks…" (personal interview 01/16/2014). 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 Liberal; Salomão Aranovich; Otto Lyra Schrader; Plinio Cordeiro Molleta; António Secundino São José; Clibas Vieira and; Carlos Krug[8]. According to Mendonça (2012), the Commission was characterized by two distinct blocs of expertise that were fundamental to the epistemological foundation of Embrapa.

The first group (Liberal, Schrader and 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 (Aranovich, São José, Vieira and Krug), however, was composed of

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

industry professionals mostly educated in the U.S. and with close ties to international agribusinesses. This Commission of experts helped to establish technical working groups for the same commodities 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 and budget. A more open research agenda could facilitate the influx of U.S. agricultural experts and expertise and then reach the primary 'users' of their technological products: large-scale, highly-capitalized farmers (Freitas Filho et al, 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). Embrapa would 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). As a public enterprise, the annual budget needs to be approved by the federal government but the internal administration and activities is governed by the institution's own by-laws. This 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.

3.1 The Institutional Anatomy of Embrapa

In contrast to the above history, Embrapa's founding is deemed internally as the result of domestic Brazilian politics and the inevitable path of agricultural modernization based on endogenous scientific research. This more endogenous understanding contests the degree to

which foreign experts and expertise were part of establishing Brazil's agricultural research to colonize the Cerrado. According to one of Embrapa's biographers and its first president, J. Irineu Crabral, Embrapa was born out of an official government Working Group. This group 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) and is often referred to as the "bible" of Embrapa because of its symbolic importance (Embrapa, 2006 [1972]; personal interview, 06/10/2014). The "Black Book" outlines the contemporary technical deficiencies of Brazilian agricultural research prior to Embrapa. It almost mirriors the recommendations of the High Level Commission two years prior by identifying a lack of expertise due to insufficient and inadequate training as well as a lack of national integration with other public research institutes. It also called for steady financial resources, including more competitive salaries, in the long-term to ensure a continuous research program and for the recruitment/training of Brazil's top scientific talent (Embrapa, 2006 [1972]: 8-21). This was also the reason why Embrapa was based on Brazil's public corporation structure, similar to the now privatized 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).

Embrapa is unique amongst this group, however, because unlike public corporations established to produce a direct profit, agricultural research's primary objective is to produce scientific

knowledge and technology. The aim is to boost agricultural productivity in the service of the national economy and for the benefit of Brazilian society (often these two are in conflict; see Levidow, Søgaard and Carr, 2002). Because Embrapa is mandated to serve Brazilian society, public support is key to their continued existence. So the institutions own origins and claims 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). The diffusion of Embrapa's successes through the popular press and official documents helps to legitimize their research to the Brazilian 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. 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 "Social Return" report[9]. This annual report highlights 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 and the public it intends to serve. The overall national importance of agriculture in Brazil is also highlighted as Embrapa plays a key role in increasing the economic return of the agriculture. 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).

Embrapa is overseen by an Administrative Council which consists of eight members: two nominated by the Ministry of Agriculture, Livestock and Supply[10] (MAPA - Embrapa's mother institution) that work in agricultural research or agricultural science in technology (civilian 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 Council determines agricultural research priorities of the country by advertising competitive calls for scientific projects. Interested Embrapa research centers (and their scientists) can then submit proposals, which are evaluated based on the center's human resource capacity and relevant research capabilities. 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

[9] Embrapa produces an annual report detailing the social returns of their 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).
[10] MAPA has historically been associated with plantation elites in colonial times and more recently agribusinesses. In the 1990s, the Brazilian government created the Ministry of Agrarian Development (MDA) to more closely serve smaller farmers and family farms.
[11] The three ministries are the Ministry of Planning, Budget and Management, the Ministry of Finance and the Ministry of Agrarian Development.

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. These offices support the continuation of technology transfers via the exchange of biological material, training and political consultations. The inspiration for offices overseas was to formalize the existing international scientific knowledge networks that were part of Embrapa's founding and to extend foreign policy directives of the Brazilian state (Wolford and Nehring, 2015). According to one of Embrapa's managers, their locations in both the global North and South, allows for Embrapa to serve as a hub of expertise that draws on existing 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" (Alves, 2016: 148-152).

3.2 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 of formal training. This

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

idea of producing science is exemplified in the history of territorial and technological frontier expansion in Brazil. 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). From 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 aforementioned 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). 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. The idea of PEPA was to reproduce the U.S.'s Land Grant model and strengthen the connection between academic research and extension. 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, 2013b: 6). 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). 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 "special 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 was made. 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.

4. 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 often invoking similarities with U.S. expansionism in the 19th century (Lombardi, 1975; see also Franco and Drummond, 2008). But, attempts to push west and develop industrial agriculture had failed due to poor infrastructure, low population density and insufficient state investment (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). This unequal support has reinforced regional inequities in land tenure. In 2003, the average farm size[13] in the center-west region was 397.2 hectares while the average in the south was a mere 33.5 (Girardi, 2008).

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 (Hungria et al, 2005). Additionally, soybeans could displace domestic consumption of food oils and act as an industrial input for processed foods and other products. An added push was provided by the moratorium on U.S. soy exports through the "Nixon Shock" in 1973, which provided the extra impetus to supply an increasingly lucrative international market. The Brazilian state viewed this as an opportunity to correct a negative balance of payments and raise revenue with soybean exports. The Japanese, in particular, became concerned

[13] In the north, northeast and southeast regions, average landholdings were 261, 70.1 and 59.4 hectares, respectively.

about global soybean availability and had a vested interest in the establishment of new production zones around the world (Friedmann, 1993; Oliveira, 2015). The Japanese International Development Agency (JICA) provided around US$300 million for resettlement and infrastructure projects[14] in the region to ensure a steady flow of soybean exports (Schlesinger, 2007; see also Soskin, 1998; 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.

4.1 Embrapa's Cerrado?

Embrapa's inauguration in 1973 signaled a political consolidation to unleash 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

[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 grains. PADAP also established growth poles to extend 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)

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 cultivate the Cerrado soils.

4.2 Cultivating Profits

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). As USAID (1968) 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" (12).

Since 2010, the Cerrado has accounted for 60 percent of annual grain production in Brazil (de Paula, 2013). Consequently, the Cerrado is also the most input-dependent agricultural zone in the

[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)

country, accounting for half of national fertilizer and pesticide expenditures in 2006 (Rada, 2013). 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 (Silveira and Borges, 2007: 113-114). Foreign producers or investors even own around 20 percent of the land under cultivation in the Cerrado (Correa and Schmidt, 2014). The technological and material development in the Cerrado was not a result of a scientific discovery, nor solely the result of global economic restructuring and geopolitics, (Oliveira, 2015) but enacted through decades of problem solving, international technology transfers and scientific institution building.

5. Conclusion

"*what took the Americans almost a hundred years to do we did in less than fifty*" (Personal interview, 01/16/2014)

The 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 bolstering public support for Embrapa's 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. Existing forms of production and knowledge were selectively ignored and removed with the widespread deployment of farmers, credit and technology. The inherent acidity of the Cerrado's soils do require inputs if they are to be productive for certain commodity crops at scale. Still, 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 industrial dominance of Western countries in the global food system, the rapid and profitable experience of the Cerrado is still seen as a technological 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 coercive imperial sciences 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). Where 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. This apparent optimism overlooks the consequences of agro-industrialization, whether development induced displacement (Wilmsen and Webber, 2015) or as a sink to offload environmental externalities (Schneider, 2016).

This paper intended to show how agricultural research in Brazil wasn't pre-determined or natural for agro-industrial development in the Cerrado. Rather, U.S. interests in Brazilian agriculture in general, and the Cerrado in particular, were strategically channeled through the deployment of scientific experts and expertise in the post-WWII era to enact institutional change of scientific research in the country. 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 ensure long-term growth with improved infrastructure. 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, 2010), which is heavily dependent on imports for agro-chemicals and fertilizers by design.

Historicizing 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. These public agencies often are part of the direct commodification of bio-technologies (Kloppenburg, 1988) and on-farm means of production (Goodman, Sorj and Wilkinson, 1987). In addition, public scientists and their work constitute an international network of scientific knowledge production between both private and public spheres that lays the technoscientifc foundation for the continual transformation of profitable agrarian landscapes.

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