# Chapter 12: Political ecology of soybeans in Southern America

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## Abstract

Soy production fundamentally reshapes entire ecosystems in South America. Simultaneously, it repositions countries in international trade and geopolitical affairs, and restructures class relations in their countryside. It is a highly mechanized, modernist production system relying on packages of standardized seeds and agrochemicals, with flexible production relations. These relations encompass small-scale independent producers, fragmented contract farming and land-leasing operations, and transnational vertically integrated corporations that manage mega-farms and entire agroindustrial commodity chains. The flexible production processes also attract various financial, biotechnological, and energy firms through the integration of livestock feed, vegetable oil, biodiesel, and other industrial markets. Precisely because of this flex-crop framework, soy has expanded dramatically over remarkably distinct ecologies, homogenizing diverse socio-ecological relations in the processes. This chapter draws upon empirical narratives from history, geography, and critical agrarian studies, and the rich tradition of Marxist political economy to produce a political-ecological analysis of soybeans in South America. By employing the concept of "agroindustrial flexing" the chapter discusses the political economy of "who benefits" and "who does not" from the expansion of soy across South America. Through the concept of "neo-nature", the chapter examines not simply the environmental impacts of soy production, but more fundamentally the production of nature itself through agroindustrialization.

**Keywords: Political ecology; historical geography; flex crops; neo-nature**

## 1. Introduction

Deforestation rates in the Amazon are once again rising, while South America's dry land forests such as the Chiquitania in eastern Bolivia and the Chaco across northern Argentina and Paraguay also decline at alarming rates due to the expansion of agriculture and logging (Fair 2019). The intensification of soy production across the grasslands of the Cerrados of Brazil and the Pampas of Argentina is now extending into the edges of these ecosystems, displacing cattle ranching deeper into neighboring forests. South American soybean agribusinesses are sacrificing entire landscapes in the name of agroindustrial modernization and capital accumulation. Indeed, this is a highly mechanized, modernist production system relying on packages of standardized seeds and agrochemicals, leveraging political and economic forces that reposition whole countries in international trade and geopolitical affairs, and restructuring class configurations in their countryside. This reconfiguration of property and labor relations occurs through flexible production relations that interconnect small-scale independent producers, fragmented contract farming and land-leasing operations, and transnational vertically integrated corporations managing mega-farms and entire agroindustrial commodity chains (Oliveira 2016; Oliveira and Hecht 2016). Flexible production also intertwines various financial, industrial, biotechnological, and energy firms through the integration of livestock feed, vegetable oil, biodiesel, and other

industrial markets (Oliveira and Schneider 2016). Precisely because of this "flex crop" framework (Oliveira and Schneider 2016), soy has expanded dramatically over remarkably distinct ecologies, interlinking and homogenizing highly diverse socio-ecological relations.

While this expansion undergirds the creation of a new rural middle class, elite agribusiness professionals, and leading transnational firms from South America, there are certain benefits that have accrued primarily to these rising elites, and South American states that balance international trade and consolidate rural development and geopolitical strategies. Meanwhile, rural areas subsumed by soy production have hollowed out. Indigenous peoples and other traditional populations have been dispossessed, small farmers are squeezed out or adversely integrated in soy systems, and landless rural workers are exploited (Eloy et al. 2016; Goldfarb and van der Haar 2016). Moreover, the environmental effects of agroindustrial soy expansion are not limited to deforestation alone, but encompass a complex set of interlinked ecological calamities, as entire biomes risk collapse. Some of the main environmental impacts include connectivity loss across ecosystems, soil erosion and compaction, water and soil pollution, changes in water cycling and availability (both locally and regionally), increasing prevalence of pest outbreaks due to monoculture expansion, and loss of biodiversity due to habitat loss and use of agrochemicals (Altieri and Pengue 2006, Pacheco 2012; Elgert 2016). These compounding ecological impacts in turn are responsible for many negative socioeconomic outcomes. Some of these impacts include public health outcomes (including cancer and death) through exposure to agrochemicals, as well as increased vulnerability through the displacement of traditional food crops, reduced rural employment opportunities, slavery and labor rights violations, land and wealth concentration, and violence against indigenous, traditional, and peasant communities (Rulli 2007; McKay and Colque 2016; Leguizamón 2016).

This chapter draws upon empirical narratives from history, geography, and critical agrarian studies, and the rich tradition of Marxist political economy to produce a political-ecological analysis of soybean production, use and trade in South America. By employing the concept of "agroindustrial flexing" from the literature on "flex crops", this chapter discusses the political economy of "who benefits" and "who does not benefit" from the expansion of soy across South America. Through the concept of "neo-nature" the chapter examines not simply its environmental impacts, but more fundamentally the production of nature itself through agroindustrialization. This reveals the blind spots and contradictions of the eco-modernist discourse that attempts to frame soybean agribusiness as the preeminent mechanism to conjoin economic development and nature conservation through agroindustrial intensification. Instead, the chapter seeks to demonstrate how these socio-ecological dynamics are ultimately a constitutive process of capital accumulation and concentration that has soy at its core, and necessarily reproduces the social exclusion and ecological exploitation of capitalism.

Section 2 outlines the methodology used in this chapter including the theoretical underpinning, historical analysis approach, and data. Section 3.1 describes the history of soy production in Southern America, while Section 3.2 discusses how the "agroindustrial flexing" of soy catalyzes the dialectical process of socioeconomic and ecological transformations (Section 3.2.1), and the usefulness of the concept of "neo-nature" to critically examine the process of agroindustrialization (Section 3.2.2). Section 3.3 synthesizes through which mechanisms and

trajectories soy has become an agent of ecological and socioeconomic transformation in South America.

## 2. Methodology

Political ecology as an academic field hinges on the theorization of human-environment relations as always and everywhere political. Rather than identifying "purely" economic, technological, demographic, or cultural interpretations of environmental problems (and similarly for designing proposals for environmental policy and management), political ecology insists on analyzing *power relations* as essential to comprehend environmental problems and formulate solutions (Watts et al. 2010; Svarstad et al. 2018). The pioneering and most well-established practice in political ecology entails the use of Marxist political economy for analyzing agrarian and ecological change (e.g. Watts 1983/2013; Hecht and Cockburn 1989; Peluso 1992, 2012; Castree 2000; Ahmed et al 2018). Such studies focus on how historically produced social structures (i.e. land distribution, labor relations, and other class articulations with legacies of colonialism and ongoing forms of imperialism) condition the agency of individual smallholders, elite land owners, government officials, and other actors. Thus, this theoretical framework calls for examining a broad set of empirical material, which can often be gleaned from historical and geographical narratives that inform critical agrarian studies.

Given the large scope of actors, multiplicity of relevant sites of interaction, and multi-scalar relations of production, commercialization, investment, and political struggle that structure the subject of analysis, this chapter draws primarily upon empirical narratives from the secondary literature on the history and geography of soybeans in South America. This material is supplemented with personal interviews with soy farmers, agrochemical and seed salesmen, and soybean agribusiness officials and sectorial representatives undertaken between 2012 and 2015 across multiple locations (primarily in the Cerrado ecosystem of central Brazil). This methodological engagement enables my theoretical analysis of the central guiding questions of Marxist political economy, namely "who owns what", "who does what", and "who gets what", which Bernstein (2010) has popularized as central pillar of critical agrarian studies more generally. This analysis is undertaken in relation to two concepts from the literature of critical agrarian studies and political ecology, namely "agroindustrial flexing" and "neo-nature".

Agroindustrial flexing reflects that agroindustrial production has become increasingly dynamic in terms of the variety of agricultural inputs that are incorporated by processing firms, and their increasingly malleable operations to attend a growing number and diversity of markets (e.g. food, livestock feed, fuel). This is what Borras et al. (2016, 94) have called the rising "flexible-ness and multiple-ness" of "flex crops and commodities." For example, biofuel producers around the world may opportunistically shift the composition of their inputs between sugarcane, soybeans, maize, palm oil, rapeseed, jatropha, and animal fats according to shifting price signals and government policies. Similarly agroindustrial trading companies juggle supplies not only between North and south American soy exporters, Southeast Asian oil palm giants, and European rapeseed processors, but also bring them into competition with each other as almost any "flex crop" can often substitute for another in the production of meal for livestock feed, vegetable oil, and the multiple derivative industrial products that can be synthesized from basic biochemical components (Gasparatos et al. 2015; Oliveira and Schneider 2016; McKay et al.

2016; Borras et al. 2016; Oliveira, McKay and Plank 2017). Thus, agroindustrial flexing must be examined as a central category in the shifting political economy of soy in South America, which is reshaping relations of property, production, and consequent distribution of both economic goods and ecological impacts.

Neo-nature, as a concept, emerges from the literature in geography and Marxist political ecology on the "production of nature" (Castree 2000). Elsewhere, Oliveira and Hecht (2016) and Oliveira (forthcoming) have theorized the biotechnological mutations and ecosystem-wide transformations undertaken by South American soybean agribusiness as the production of a neo-nature. Yet this does not refer simply to the innovations in biotechnology that produce novel varieties of soybeans, nor merely to the anthropogenic landscapes of soybean monocultures that replace rainforests and grasslands alike, but conceptualizes new sorts of socio-natures that emerge through the *commodification* of "nature's products, places, and processes" (Peluso, 2012: 79; Castree, 2000). This neo-nature, in other words, is the ecological expression of the neoliberal "commodification of everything" (Watts et al. 2010), which renders even ancient varieties of soybeans and other crops valuable now for the genetic material they may provide for future genetic engineering (Kloppenburg 2010). It can be argued that this casts soy farms that consistently lose money as financial assets that are still valuable, and can be dubbed as "developed land" that can be profitably leveraged in the portfolios of pension funds and hedge fund managers (Fairbairn 2014; Ouma 2014; Ducastell and Anseew 2015; Pitta and Mendonça 2015).

Attending to the political economy of soybean agribusiness as the production of a neo-nature, therefore, extends the analysis of power relations from the structural transformations of agroindustrial flexing itself to post-structural and discursive forms of power that imbue socio-natures with multiple forms of value (Watts et al. 2010; Svarstad et al. 2018). Thus, this chapter sets out to examine the empirical material ahead by analyzing the interlinking struggles over the economic value of capital accumulation, the socio-cultural values of traditional livelihoods and modernization, and the political values mobilized to cast these conflicts as crisis or opportunity for South Americans across the continent.

Section 3.1 summarizes the historical geography of soy production across all of South America through the critical synthesis of the extensive literature. Section 3.2 focuses on the critical aspects of agro-industrial flexing and neo-natures using some primary information collected through interviews in Brasilia, and across rural areas of Goiás, Tocantins, and Bahia states in the Brazilian Cerrado. Section 3.3 synthesizes through which mechanisms and trajectories soy has become an agent of ecological and socioeconomic transformation in South America.

## 3. Results and discussion

### 3.1 Historical geography of soybeans in South America

It is possible to identify four main periods in the history of soy production in South America (Table 1), spanning its early introduction (Section 3.1.1), small-scale establishment (Section 3.1.2), expansion and shift to large-scale production (Section 3.1.3) and accelerated growth and concentration (Section 3.1.4),

**Table 1. Chronology and characteristics of soy production in South America**

| Period | Duration | Areas | Characteristics |
|---|---|---|---|
| Introduction | 1880s – 1930s | - Throughout South America | - Experimental introductions<br>- Non-commercial production by Japanese immigrants for food consumption |
| Small-scale establishment | 1940s – 1960s | - Argentinean Pampas<br>- Brazilian Pampas and southern pine forests | - Limited commercial production in rotation with wheat and/or maize for green fertilizer or edible oil production, mostly by small-scale migrants from Japan and Europe (<100ha farms)<br>- Commercial introduction in Paraguay and Bolivia |
| Expansion and shift to large-scale production | 1970 – 1995 | - Argentinean Pampas<br>- Southern Brazilian Cerrados<br>- Paraguayan and Bolivian forests on Paraná basin | - Government support for geographical expansion and growth of soybean farms<br>- Government-developed non-GM varieties adapted for sub-tropical climates and acidic soils<br>- Establishment of domestic soybean agribusiness companies, and expansion of average farm sizes (100-1,000ha)<br>- Entrance of transnational trading companies<br>- Soy becomes key livestock-feed input |
| Accelerated growth and concentration | 1995 – present | - Argentinean Pampas and Chaco<br>- All Brazilian Cerrados and southern Amazon<br>- Paraguayan forests on Paraná basin<br>- Bolivian lowland forests<br>- Uruguay | - Introduction of GM varieties and privatization of R&D<br>- Removal of taxes on whole-bean exports from Brazil<br>- Concentration of seed and input industries among transnational companies<br>- Government support for expansion into marginal and vulnerable ecosystems<br>- Intensification over pastures and displacement of other crops<br>- Increase in cross-regional and global investments<br>- Land concentration and expansion of very large farms in Brazil (>1,000ha)<br>- Establishment of large-scale *pools de siembra* in Argentinean pampas and beyond<br>- Promotion of soybeans for biodiesel and other industrial uses<br>- Vertical integration of production systems |

Source: Author's own elaboration based on Shurtleff and Aoyagi (2009), Oliveira and Hecht (2016), and Oliveira (2016)

*3.1.1 Introduction and small-scale establishment*

Soybeans were first introduced in South America for agronomic experiments in Brazil in 1882, and subsequently for similar reasons in the French Guyana (1893), Suriname (1905), Argentina (1908), Uruguay (1911), Venezuela (1913), Paraguay (1921), Peru (1928), Colombia (1929), Chile (1934), and Ecuador (1936) (Schurtleff and Aoyagi 2009). All these introductions in tropical climates failed to advance beyond agronomic experiments, and until the 1920s the steady production of soybeans only took place in temperate climates by Japanese immigrants. In 1908 there is the earliest documented instance of Japanese migrants bringing soybean seeds to Brazil. However, South American commercial farmers did not adopt these pre-industrial soybean varieties, which had been selected for their nutritional qualities and characteristics, and ability to be manually harvested and incorporated into diversified farming systems.

The earliest efforts to establish soybeans as a commercial crop in South America took place in 1924, when the Argentinean government imported 15,000 kg of soybean seeds (from 15 varieties) from the United States, and distributed them to 8,000 wheat and maize farmers (Schurtleff and Aoyagi 2009). These US varieties had straighter stems and pods that opened more easily to facilitate mechanized harvesting, and they were co-developed with the machinery itself. This suggests that the expansion of soy production in South America has been intimately related not simply to soy as a "natural" resource, but more specifically to a particular neo-nature characterized by chemical-intensive and mechanized agricultural production. Their underlying economic driver was the incipient agroindustrial flexing of multiple grains for the production of vegetable oil and animal feed.

The first known exports of soybeans from South America took place in 1929, when Brazil exported 800 tons of soybeans, with Argentina not exporting soybeans until 1962 (Schurtleff and Aoyagi 2009). Thus, until the 1960s, soybeans were not planted in South America for export to international markets, but were sporadically introduced in agricultural experiments throughout the continent, as an instrument of producing neo-nature.

Eventually, production expanded slowly in the Argentinian and Brazilian pampas, where small-scale (<100ha) commercial farmers, many recently emigrated from Europe, began integrating soybeans in rotation with wheat and/or maize. They did so primarily as green fertilizer or fodder, and secondarily for the emerging domestic vegetable oil and animal feed industries. In 1946-1947, soybeans were grown on 1,650 ha in Argentina, of which 460 ha yielded a total of 572 tons of grain/seed, and the remaining used as fodder and green manure. Argentinian production remained stable around an average of 1,000 tons per year throughout the 1950s, but there was a much faster growth in Brazil during this period. During the 1940s, the state of Rio Grande do Sul state contained almost all soy production in Brazil at around 10,000 tons. As soy consolidated and expanded to Paraná state, production grew tenfold to over 100,000 tons by the 1950s (and 10,000 tons exported to Japan in 1957 alone). By 1969, soy production grew tenfold once again in Brazil, reaching 1 million tons. Until then, production remained geographically limited to southern Brazil and the Argentinian pampas, and soybean uses gradually shifted from green fertilizer, fodder, and self-consumption among smallholders, to the emerging vegetable oil and livestock-feed markets in South America and abroad (Shurtleff and Aoyagi 2009).

This initial stage of agroindustrial flexing and soybean neo-natures was essentially a modernist compromise between smallholders, European colonists in the Brazilian and Argentinian pampas, agroindustrial traders and emerging entrepreneurs, and urban consumers. Soy farmers gained a new instrument that delayed soil fertility loss, and diversified their incomes to cope with the declining rate of return on wheat/maize rotations due to technological treadmills and international competition (Mazoyer and Roudart 2006). Agroindustrialists gained a new and cheap input for flexing innovation, and urban consumers gained a relatively low-cost source of food and oil.

Yet the early adoption of soy production in South America also consolidated a neo-nature that highly excludes indigenous people and landless rural workers, and set the foundation for technological treadmills of the mechanization and chemicalization of agricultural production that would ultimately result in the dramatic ecological degradation currently observed throughout the continent.

*3.1.2 Expansion and shift to large-scale production*

The major turning point of soybean production was in the 1970s, when the US government imposed moratoria on soybean exports due to shortages of domestic production, and the collapse of Peruvian anchovy production (until then the most important protein input for animal feed) that triggered a rush for alternative protein sources for the fast-growing confined animal feeding operations (CAFOs) of the United States, Soviet Union, Europe, and Japan (Morgan 2000). Japan then began collaborating with South American governments to expand soybean production by providing cheap credit and infrastructure for expanding soy production. At the same time, Brazilian and Argentinian governments implemented scholar exchange programs and sponsored South American agronomists for training at Midwestern US universities, who upon return began adapting soybean varieties to South American conditions. Given that the bulk of South American soybean expansion has occurred in Brazil, the role of the Brazilian state-owned agricultural research company Embrapa is especially noteworthy in adapting soybean to the sub-tropical climates and acidic soils of the Cerrado (Nehring 2016).

In addition to this public investment in technology, soybean production and consumption was included in multiple agricultural and development programs in Brazil and Argentina. These included the extension of transport and grain storage infrastructure, price support mechanisms, cheap credit and other fiscal and financial incentives for the purchasing of seeds, agrochemicals, and large-scale planting and harvesting machinery (Jepson et al 2010; Gordillo 2014). Commercial farmers seized these government incentives and responded avidly to the high prevailing prices on international markets, reinvesting profits into more intensive soy monocultures and converting additional land into production, even if it meant moving deeper into the Cerrados of central Brazil or even across borders into Paraguay to find sufficiently cheap land (Hecht 2005; Oliveira 2016). By 1978, South America had surpassed Asia to become the second largest soybean-producing region in the world. Soybeans became one of the major feedstocks for the vegetable oil industry and the emerging CAFOs across Europe, Asia, and South America itself (Oliveira and Schneider 2016).

Thus it can be argued that agroindustrial flexing and the production of a neo-nature in South America placed soybean agribusiness at the vortex of political economic and agrarian transformations across the continent. This rendered the production of soybean neo-natures as some of the most important mechanisms for capital accumulation, discursive formation of modernity, and political ecological articulation of agroindustrial intensification as the main mechanism for "sparing land for nature" (cf. Oliveira and Hecht 2016; Thaler 2017). By this point, however, the consolidation of such commercial agriculture over the Brazilian and Argentinian pampas, and its expansion into the Cerrados of central Brazil and the eastern lowlands of Paraguay was propelled by much more than economic interests in capital accumulation and modernist desires for development. In particular, peasant uprisings and communist organizers demanding land redistribution and agrarian reform were questioning the political economic foundation that sustained agroindustrial flexing and soybean neo-natures (Patel 2013; Oliveira 2016). And so the consolidation of soybean neo-natures across the southern cone of the South American continent was also a political project, implemented through military coups and brutal dictatorships that imposed capitalist relations of property and production at the expense of peasants, workers, and any landscapes that would not conform to agroindustrial neo-natures.

*3.1.3 Accelerated growth and concentration*

The military dictatorships of South America embarked in an international debt-fueled developmentalist modernizing project, which collapsed with the Volcker Shock of 1979 and the imposition of neoliberal structural adjustment and austerity measures in the decades that followed (Harvey 2005). Particularly since the mid-1990s, Brazilian, Argentinian, and Paraguayan governments encouraged commercial farmers and transnational corporations to drastically accelerate the expansion of soy production in South America in order to generate revenues in US dollars to repay mounting international loans. A few soy farmers that had previously organized themselves into cooperatives to facilitate input purchase and harvest sale established their own soybean export companies and crushing facilities (Chase 2003, Fajardo 2005, Jepson et al 2010). Yet the transnational trading corporations that had an oligopoly over US soy exports (i.e. Bunge, Cargill, Louis Dreyfus, and later ADM) also began investing in soybean storage, processing and trade in South America, which have since made them dominant exporters from South America as well (Goldsmith et al 2004; HighQuest Partners and Soyatech 2014; Turzi 2011). Until 1995, these companies only owned about 10% of soybean crushing capacity in South America, but by 2002 they controlled about 50% of crushing capacity and 85% of whole bean exports from South America (Wesz Jr 2016).

Similar concentrations of transnational companies have also taken place in the seed and agrochemical input sectors. Brazilian and Argentinian state-owned agricultural research companies has undertaken most agronomic research and development of soybean varieties adapted to the South American landscapes and sub-tropical climatic condition during the 1970s. Domestic seed companies played leading roles until the 1980s, when Brazil and Argentina served as "incubators" for sub-tropical and tropical soybean production technologies that were then transferred to Paraguay, Uruguay, and Bolivia (Craviotti 2016). But the development of transgenic technologies by US and European chemical companies has since displaced these public and domestic enterprises, even though they continue to play key roles in developing

soybean varieties that contain patented transgenic material from transnational companies, as well as multiplying and commercializing seeds with traits from transnational companies (Kloppenburg 2010; Craviotti 2016). Transgenic varieties tolerant to herbicides (particularly glyphosate) were approved in Argentina in 1995 and smuggled into Brazil, Paraguay, and Bolivia until the respective governments also approved their use between 2003 and 2005. During this period a handful of transnational chemical companies from the Global North have come to dominate soybean seed and associated agrochemicals markets. Currently, the top three companies, Bayer (with Monsanto), ChemChina (with Syngenta), and Dow-DuPont, control over 55% of global soybean seed markets, with this concentration being even greater in South America where GM varieties predominate. The top four companies (those listed above and BASF) control 69.5% of global agrochemical markets, and the first three alone control over 49.1% of the USD 11.5 billion agrochemical market in Brazil (EcoNexus 2013, Silva and Costa 2012).

Globally the restructuring of the soybean agroindustrial complex since the 1990s is characterized by the simultaneous concentration of input and trading markets by transnational corporations and the deconcentration of soybean production and processing from North America and western Europe. Between 1990 and 2014, US share of global soybean production declined from 50% to 31%, while Brazil's share increased from 18% to 31% and Argentina's share increased from 10% to 19%. Soybean processing industries also shifted from the US (where the share of global soybean crush declined during between 1990 and 2014 from 37% to 19%) to Brazil (increased from 15% to 16%), Argentina (increase from 8% to 16%), and China (jumped from 4% to 29%) (FAOSTAT 2014, USDA-FAS 2014). As South America surpassed the United States in soy production, therefore, the processing industry shifted radically, particularly from North America and western Europe to the newest and fastest growing market for soybean exports in China.

In short, neoliberal reforms that accelerated the growth of soy production in South America catalyzed a relative loss of market-share for US farmers and South American state-owned seed companies. However, US agroindustrial companies gained both market share and profits through their expansion into South America, where smaller-scale farmers have been squeezed by entities able to reinvest a larger amount of capital into farmland expansion, the acquisition of larger machinery, and the constant upgrading of agrochemical and biotechnological seed packages.

Although this period has often been characterized as a neoliberal "corporate food regime" (McMichael 2012), there has been continuous state support for cross-regional and global investment patterns. These essentially push soybean producers to expand horizontally onto increasingly more marginal land and vulnerable ecosystems, such as the Argentinean Chaco, the Brazilian Amazon, and the semi-deciduous forests of Paraguay and Bolivia, and replace degraded pastures and less profitable crops with intensive soybean monocultures, such as in Uruguay, the Argentinian Pampas, and the central Cerrados of Brazil (Oliveira 2016, McKay and Colque 2016, Goldfarb and van der Haar 2016, Elgert 2016). These increasingly large-scale soy monocultures in South America concentrate farmland, wealth, and power in the hands of fewer and fewer large-scale farmers and transnational agroindustrial companies, benefiting from the increasingly flexible and multiple markets this agroindustrial input supplies. Thereby, they also consolidate a soybean neo-nature in which cleared lands and soils drenched with agrochemicals become increasingly barren substrates for the reproduction of a particular sort of agroindustrial capital and modernity.

## 3.2 The dialectic of socio-economic and ecological transformation

### *3.2.1 Soybean neo-natures: commodification, concentration, and uniformity*

The high costs of specialized harvesting equipment imported to South America meant that only adopted among well-capitalized commercial farmers could adopt soy cultivation. Furthermore, once the fertility gains from the nitrogen-fixing bacteria in soybeans were exhausted, the increasing use of chemical fertilizers and pesticides further increased the production costs of wheat-soy production systems in southern Brazil and the Argentinian pampas. Wherever such 'green revolution' production systems were adopted, farmers became entrapped in a technological treadmill that required continuous reinvestment for chemical inputs, larger production areas, and bigger machinery. This constant commodification of production inputs and farmland concentration "expelled" the smaller and least productive farmers, and favored land and wealth concentration among the larger and more capitalized farmers (Mazoyer and Roudart 2006, Oliveira 2009, van der Vennet et al 2016, Mier y Teran 2016; Leguizamón 2016). Consequently, by the 1970s it also became increasingly difficult for the youth in these families to inherit enough land for an economically viable farm in southern Brazil or the Argentinian Pampas. It was this crisis of social reproduction that triggered a process of outmigration that conditioned the trajectories of soy expansion across South America. As explained by a soy farmer whose family planted soy in southern Brazil in his youth, "at that time the government wanted us to move to the Cerrado, *clear everything*, and plant soy. And my father's farm [in southern Brazil] wasn't enough for me and my three brothers, so we didn't have any choice but to come here where land was cheap enough" (Personal Communication: soy farmer in Goiás, Brazil, April 2014).

While a substantial number of young people from soy-farming families in the Brazilian and Argentinian pampas migrated to cities, many (such as the farmer interviewed above) moved to agricultural "frontier zones" where land was cheaper and state policies encouraged expansion of commercial farming (e.g. the Cerrados of Brazil, the Argentinian Chaco, and eastern Paraguay) (Desconsi 2011, Galeano 2013, Goldfarb and Van der Haar 2016). These who refused to migrate to cities but lacked capital to purchase farms elsewhere became landless, and some even self-organized into social movements for agrarian reform, as illustrated most famously in the origins of the Landless Rural Workers' Movement (MST) in southern Brazil (Stédile and Fernandes 1999). Although soy production is not labor-intensive, its massive expansion into relatively unpopulated areas also created a demand for migrant and temporary farm labor, often originating in poverty stricken areas (e.g. northeastern Brazil) where agroindustrial production did not expand at the same pace (Rumstain 2011). Consequently, most areas of soybean expansion are produced by complex migration patterns, which are marked by sharp cultural differences, tension, and even conflicts between migrants and locals (Gordillo 2014), or between distinct groups of migrants such as *gaúchos* (southerners) and northeasterners in central Brazil (Desconsi 2011, Rumstain 2011).

Simultaneously, the expansion of soybean production to "frontier zones" should not be understood as a simple linear trajectory leading solely towards concentration to large-scale farms. This is a long-term *trend* that has been visible and documented across the continent. However, multiple regional factors and historical particularities allow for a relatively broad spectrum of

farm sizes and their associated production practices. In the Argentinean Pampas, for example, most soy is grown on farm units that range from 150 to 1,000 ha. However, the figure of the independent 'soy farmer' has been splintered into multiple different characters, as smaller scale landowners rent their farms to companies that hire agronomists, farm managers, machinery operators, and other specialized laborers to run the soy production system. These companies, known as *pools de siembra*, collect their capital from many different investors, ranging from rural and urban individuals to institutional investors and finance corporations. Consequently, while each farm unit might remain "medium-sized", these might ultimately be operated by companies that manage hundreds of thousands of hectares across Argentina and elsewhere in South America, while small farmers themselves become proletarianized (Oliveira and Hecht 2016).

Some of the leading *pools de siembra* and soybean production companies are expanding into Paraguay and Bolivia as well, but local conditions have not allowed for a similar consolidation of the *pool de siembra* system as in the Argentinian pampas. Yet similar forms of farmland concentration through the technological treadmill and land-leases have also been taking place in Bolivia and Paraguay through very different social dynamics, whereby many of the farmers who previously gained small (approximately 50 ha) plots under colonization schemes found themselves without any other option but to lease their land to neighboring soy farmers that gradually increased their land to a few hundred hectares (McKay and Colque 2016; Correia 2019).

In some areas of southern Brazil, relatively small soy farms (<300ha) continue to exist. Yet they are only economically viable in so far as they are able to capture price premiums from niche markets or integrate soybeans as part of a more diversified farming system (van der Vennet et al 2016). In the Cerrado region of central Brazil, most soy farms are medium in terms of size (300-1,000 ha), but it is large farms (1,000-30,000 ha) that account for the overwhelming majority of production. In some areas, for example, farms larger than 1,000 ha account for over 90% of the cultivated area (Mier y Teran 2016). Moreover, large-scale farm management firms are increasing rapidly their operations in the Cerrado region, with multiple farms that range from 10,000 to 30,000 ha. Soy farms in the Amazon are predominantly large (more than 3,000 ha) and the expansion of soy production has been very fast, yet these still represent a very small portion of the overall production in Brazil (Sauer 2018). However, across all these varied landscapes and scales of soybean production in Brazil, it is possible to observe the same technological package of transgenic seeds and their associated chemical products and production practices. Furthermore, in all these settings the pressure for soybean farmers is to "get big or get out". In other words, across the entire southern cone of South America there is remarkable homogeneity in the agronomic techniques and technologies of production, from the smallest to the largest farms. In this sense the multiplicity of socio-economic actors and the flexible variations of production and commercial relations that interconnect them contrasts powerfully with the highly simplified and homogenous production of soybean neo-natures across the continent.

The long-term tendency towards farmland expansion and concentration for soy production was aggravated with the incorporation of transgenic seeds since the late 1990s, which enabled intensification of production with no-till practices that facilitate double-cropping. No-till techniques are certainly better in terms of soil erosion control and more economically efficient

from a farm-management perspective, but eco-modernist discourses that this intensification "spares land for nature" is highly disingenuous (Oliveira and Hecht 2016; Elgert 2016; Thaler 2017).

In short, the claim is that intensification of production over land that is already cultivated, thereby curtails expansion into forested and marginal landscapes. Yet while agronomic research in experimental fields demonstrates some productivity gains and reduction of agrochemical use in small areas and over short periods (1-2 years), the larger-scale and longer-term observations challenge all these optimistic claims still made by these agribusiness companies (Cotacora-Vargas et al 2018). What in fact ensues is the aggravation of technological treadmills due to rising production costs, increasing pest and weed resistance, and increasing pressure for farmers to reinvest in larger-scale production to increase their incomes and to compensate for declining profit (Altieri and Pengue 2006; Mazoyer and Roudart 2006; Binimelis et al 2009, Cotacora-Vargas et al 2018).

Finally, the challenges imposed by "super weeds" that are resistant to glyphosate herbicides associated with transgenic soy, as well as pest outbreaks that require more frequent application of increasingly toxic pesticides, coalesce in the dialectical socio-economic contradictions of the production of this neo-nature. While the Brazilian Soybean Producers Association (APRSOJA) and the national landowners association (Confederaçao Nacional da Agricultura, CNA) publicly defend the use of transgenic soy varieties and push the Brazilian government to expedite the approval of transgenic varieties and agrochemicals, many soy farmers (including those in leadership positions in these associations) complain that "the chemical companies do not have our interests at heart", because "they are posting record profits while our production costs keep going up" (based on interviews and field notes, Goias, Brazil, March 2014). Some have even stated during an official meeting of soy producers at a major agribusiness fair that "we are being held hostage" by the agrochemical companies (based on interviews and field notes, Bahia, Brazil, July 2015). Indeed, agroindustrial inputs such as agrochemicals and seeds already accounted for 37-47% of production costs for soybean farmers in Brazil in 2011(Silva and Costa 2012). According to interviews with farmers in Goiás, Tocantins, and Bahia (Brazil) production costs have been increasing sharply between 2012 and 2015, to the benefit of agrochemical and seed companies, but to the detriment of soy farmers and the local ecosystems.

*3.2.2 Agroindustrial flexing: Concentration of wealth and power among agribusiness elites*

Given the direct role of farmers in the development of soy neo-natures, it is easy to imagine that they are the fundamental drivers and beneficiaries of this agroindustrial production system. However, this would ignore not only the class differences and ongoing process of differentiation between small-scale farmers (who are effectively trapped by technological treadmills until they become forced out of soy production altogether), and large-scale farmers (who incorporate their properties and their services as employees or independent contractors along this process). But soy production itself is only one element of the broader global political economy of agribusiness. The leading seed and agrochemical input manufacturers (alongside major soybean trading companies), effectively control the inputs and farming practices of most soy farmers across South America, and *lock in* prices and access to significant portions of their harvests through the prearranged supply of fertilizer, pesticides, herbicides, and seeds (West Jr. 2016; Craviotti 2016).

Smaller and less capitalized farmers might commit as much as two-thirds of their harvest to input providers and/or trading companies before the planting season. Even large and well-capitalized farmers frequently contract around a quarter of their harvest in exchange for fertilizers and other inputs (Personal Communication: Soy farmers in Goias, Tocantins, and Bahia, Brazil, 2012, 2014 and 2015).

Through these virtual seed and agrochemical monopolies, and soybean commercialization monopsonies in South America, a handful of transnational agribusiness companies have come to control soybean production systems, prices, and commodity flows throughout the continent. The four largest agroindustrial trading companies (i.e. ADM, Bunge, Cargill, and Louis Dreyfus, collectively known as the ABCDs) are estimated to manage about 80% of international soybean trade, and controlling 50% of installed crushing capacity and 85% of soybean exports in South America (Wesz Jr. 2016). Their power and market share has since been challenged by massive investments across the continent by the leading Chinese and Japanese trading companies, COFCO and Marubeni above all (Oliveira 2017). In both instances, it is the possibility of agroindustrial flexing through vertical integration or strategic partnerships across multiple markets and production chains that enable these soybean trading and processing companies to make such gains (Murphy et al 2012, HighQuest Partners and Soyatech 2011).

Agroindustrial suppliers and traders establish this power over soy producers the moment farmers take their harvest to their local warehouse, controlling much of the storage capacity, port terminals, cargo ships, and processing facilities that ultimately crush the soybeans into meal and vegetable oil (Morgan 2000, Goldsmith et al. 2004; Wesz Jr 2016). Their global reach in terms of sourcing soybeans and other flex crops around the world, controlling the chokepoints of transnational trading logistics, and an oligopolistic share of agroindustrial processing capacity provides them incomparable flexibility when sourcing from (and redirecting sales) to multiple markets around the world (Oliveira and Schneider 2016). They are even able to reroute cargo ships mid-ocean to gain marginal profits on large volumes, and speculating on futures markets with the privileged information gained through controlling significant shares of non-transparent markets (Salerno 2017). Ultimately, this bring them many benefits such as (a) increasing control over the soybean production chain and its price setting-mechanisms, (b) increasing profit margins, (c) reducing production and transaction costs, (d) minimizing risks, (e) profiting from future-market hedging and speculation, and (f) generating complementarities and synergies between the different sectors of the soybean production and processing complex (Oliveira and Schneider 2016; Salerno 2017).

Against the efforts of agribusiness companies locating both up- and downstream from framing itself to control the production process and profits, soy farmers have often organized themselves into cooperatives to pool capital to purchase inputs, build storage and processing facilities, and increase their bargaining power vis-à-vis trading companies (Chase 2003, Fajardo 2005). Some of the largest scale farmers, such as the Maggi family in Brazil and the Grobocopatel family in Argentina (Oliveira and Hecht 2016), have even been able to expand vertically into the construction and operation of their own trading operations. Yet all farmers are still price takers in domestic and international soybean markets, which are controlled by a virtual monopsony of transnational trading companies. Thus, many soy farmers have sought to cope with their weak position relative to soybean crushers and trading companies, predominately through increasing

production and controlling the "quality" of their harvests through agrochemicals. Despite the failure of biotechnology to increase productivity and reduce production costs beyond the short-term, most soy farmers have avidly embraced glyphosate-resistant transgenic varieties to facilitate the management of their extensive soybean monocultures (Binimelis et al. 2009, Cravioti 2016; Cotacora-Vargas et al 2018).

Moreover, when farmers deliver their harvest to warehouses they receive a price deduction based upon the percentage of non-grain material in a sample. This is the only aspect of price setting over which farmers have any control. Since the intensive use of glyphosate and other herbicides drastically reduces the "contamination" of fields and harvests with weeds, leaves, and stems, farmers now consider glyphosate-resistant GM varieties necessary to achieve profitable farming operations, even if they must continuously increase the use of agrochemicals due to growing weed and pest resistance (Binimelis et al. 2009, Cravioti 2016; Cotacora-Vargas et al 2018). The result of this political economic pressure of agroindustrial flexing is the aggravation of technological treadmills, which further simplify agroecosystems and drive farmers to clear more land, increase agrochemical use, and reinvest (whenever possible) in the expansion of soy production.

### 3.3 Soybeans as a driver of socioeconomic transformation in South America

It is now possible to synthesize this analysis of the mechanisms and trajectories through which soy has become an agent of socioeconomic transformation in South America. The production of neo-natures and agroindustrial flexing have been present at every period and turning point in the historical geography of soy in South America, yet these processes have developed in a combined and uneven manner across the continent. Table 1 illustrates this combined and uneven development in terms of geographical typology and trajectory of socioeconomic transformation.

| Scope | Production of neo-nature | | Agroindustrial flexing | |
|---|---|---|---|---|
| Global and continental scale | Mechanism | Transformation of soy into a sub-tropical crop, and integration of South American agricultural heartlands and frontiers into global circuits of capital accumulation. | Mechanism | Incorporation of soy into flexible production chains for vegetable oil, livestock feed, biofuel, and industrial products. |
| | Trajectory | Placing South American farmers into competition with US farmers to attend consumer markets in Europe and East Asia. | Trajectory | Subordinating soy farmers to transnational agroindustrial and trading companies. |
| Established agricultural heartlands | Mechanism | Commodification of inputs, homogenization of farming practices, intensification of technological treadmills, consolidation of land. | Mechanism | Monopolization of inputs and trading, locking in prices for farmers, and financialization of commodity markets. |

| | | | | |
|---|---|---|---|---|
| | Trajectory | Increasing pressure for farmers to "get big or get out", and incorporation by agroindustrial and financial investors. | Trajectory | Splintering and proletarianization of farmers, and speculative gains for transnational agroindustrial and trading companies. |
| Agricultural frontiers | Mechanism | State support for expansion of commercial agriculture, land grabbing and clearing preexisting vegetation. | Mechanism | Downward pressure on soy prices for farmers in agricultural heartlands. |
| | Trajectory | Immigration of soy farmers from established agricultural heartlands and farm workers from marginalized regions, displacement of indigenous and other traditional populations. | Trajectory | Intensification of agroindustrial production, increasing debt and dependence for soy farmers and states. |

## 4. Conclusion

The high-profile deforestation of extensive tracts of forests and other ecosystems across South America for soy production is not simply just the most visible form of ecological degradation occurring through the expansion and intensification of this agribusiness, but it is more than a mere "environmental impact" of agrarian capitalism and agricultural modernization. This chapter has demonstrated that the political economic distribution of socio-economic goods and negative environmental impacts that unfold through soy production, processing, and trade are a dialectical outcome of the production of soybean neo-nature in the first place. This neo-nature is predicated upon, and further exacerbates, unequal power dynamics between transnational agroindustrial corporations and soy farmers themselves, not to speak of those indigenous peoples, poor peasants, and rural workers being displaced or adversely incorporated into this production system.

The main political implication emerging from this Marxist political ecology of South American soybeans is that by "blaming" soy farmers for this ecological degradation ignores the structural pressures under which they operate, and overlooks the power dynamics and class conflicts internal to this capitalist agroindustrial production system. Yet South American governments are just as much "hostage" to soybean agribusiness, due to their need for generating dollar-denominated revenue to repay Cold War-era debts incurred by developmentalist misadventures of military dictatorships, in the same way that soy farmers are "hostages" to the transnational agroindustrial input suppliers and traders that ultimately drive the homogenization of production practices and the landscapes on which they extend and intensify. Thus, it would be naïve to imagine that ecological sustainability could be prioritized by South American governments or soybean farmers, without first transforming the structural conditions of political economic dependence in which they find themselves, and the discursive power of modernist imaginaries of

progress and development that problematize diversified farming systems and glorify the homogeneity of soybean monocultures. The political economic power of soybean agribusiness elites across South America, therefore, rests on deeply seated and globally entrenched practices of agroindustrial flexing, which have generated neo-natures in which struggles for socio-ecological liberation must be revolutionary.

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