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Intellectual Property Rights in the Seed Industry: Barriers to Sustainable Agriculture

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Intellectual Property Rights in the Seed Industry:
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Abstract

The dynamics of the dominant industrial agriculture system restrict the seed industry's innovative landscape, leading to significant negative consequences including an exacerbation of environmental risks which threaten global food security. This thesis explores how exclusionary intellectual property rights (IPRs) in the context of the seed industry constrict innovation, evolutionary pathways, and opportunities for the implementation of sustainable agriculture methods. To overcome these barriers, the application of an open source framework to seed innovation, specifically through the platform of the Open Source Seed Initiative, is evaluated as a tool for enhancing innovative capacities in seed development while broadening the accessibility and growth of the plant genetic resource base. Using an open source framework alongside agroecological practices can enable the seed industry to shift toward a more decentralized structure, increasing opportunities for divergent plant evolutionary pathways in support of securing the future of food production.

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I dedicate this thesis to my grandparents, who planted all the seeds that brought me here.

Table of Contents

Chapter 1: Introduction

As the consolidation of the seed industry continues, simultaneously eroding biodiversity and access to plant genetic resources by way of seed privatization, the future of the global human population becomes more fragile. Agriculture plays a critical role in the welfare of all – including farmers, consumers, economies, ecosystems – and will determine how well and for how long humans are able to survive and thrive on this planet.[1] As of 2020, four transnational corporations (TNCs) own the majority share of the agrichemical and seed markets.[2] Consequently, these few firms hold great power over determining the directionality of plant evolution and agricultural methods available to farmers. The operations of these dominant firms, in combination with the application of exclusionary patent law to plant genetic resources, lead to a plethora of socio-economic inequities and environmental risks, including rapid plant biodiversity loss which will be a focal point of the issues discussed in this thesis.

The trends of increasing organizational integration, cross-subsidization, IPR consolidation, and the advancement of bioengineering and monoculture practices have spurred many negative consequences which are absorbed largely by marginalized groups,

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[1] The potential of human survival and future welfare will define the notion of sustainability throughout this thesis.

[2] Mary K. Hendrickson et al., "The Food System: Concentration and Its Impacts," November 19, 2020, https://farmactionalliance.org/wp-content/uploads/2021/05/Hendrickson-et-al.-2020.-Concentration-and-Its-Impacts_FINAL_Addended.pdf.

developing countries, farmers, independent breeders, and the environment. The dominant agrichemical-seed corporations and are not held legally accountable for social or environmental damages incurred as a result of their operations. While the framework of patent law protects patent holding corporations from the theft of their inventions, it also absolves them of taking responsibility for the consequences of their experimental R&D methods, facilitating further exploitation of communities and ecosystems on a global scale. The agendas of industrial agriculture, plant biotechnology, and seed privatization, representing the primary interests of agrichemical-seed TNCs, spread across the globe rapidly with the support of international policy. In the process, the plant genetic landscape of the earth becomes increasingly privatized, and seeds are removed from ecosystems replacing food and seed sovereignty of farmers with market dependence and homogenized land surfaces.

The alarming trend of biodiversity loss, along with myriad other environmental emergencies – many of which are a direct result of industrial agriculture[3] – increases the vulnerability of the global food supply and future generations of human beings. More recently, these factors have led global organizations like the United Nations (UN) to determine the best alternative approach to agriculture, resulting in a consensus around the need for increased implementation of agroecology.[4] Founded on a set of principles for sustainability, agroecology has been accepted by interdisciplinary experts as an

[3] Vandana Shiva, *Earth Democracy: Justice, Sustainability, and Peace* (Berkeley, California: North Atlantic Books, 2015).

[4] "UN Report: Nature's Dangerous Decline 'Unprecedented'; Species Extinction Rates 'Accelerating' – United Nations Sustainable Development," May 6, 2019, https://www.un.org/sustainabledevelopment/blog/2019/05/nature-decline-unprecedented-report/.

appropriate and viable system of agriculture, the expansion of which will benefit the welfare of societies and ecosystems. However, the legal and economic structures surrounding agribusiness often make it challenging for farmers to adopt practices that stray from industrial methods of agriculture. To address the barriers imposed upon the seed industry by IPRs, this thesis will be organized as follows.

Chapter two introduces the historical transitions and current structure of the seed industry and agriculture at large. A political economy analysis will center privatization of resources as a key market driver, as well as international policy initiatives including the Green Revolution and the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs). From the process of land and seed commodification to the specific current dynamics of the global seed market, this chapter will examine the competitive landscape of agribusiness to shed light on resulting economic imbalances, land use contradictions, and consequences of agricultural input consolidation and genetic resource restriction. In addition to implications for the seed industry itself, this chapter will give a brief overview of the consequences associated with the dominant industrial agriculture model. The final section will introduce agroecology as a sustainable alternative to industrial agriculture and perspectives on the barriers to its implementation at scale to understand where the use of open source platforms may offer unique benefits for sustainable agriculture systems.

Chapter three describes the details of plant breeding and IPRs as they relate to the seed industry. Differences in types of plant breeding methods and an overview of who engages in plant breeding will help to explain the inequities that arise when applying the traditional system of IPRs to plant genetic resources. This foundation leads the way into an analysis of the advantages and disadvantages of seed breeding within the legal frameworks of traditional IPRs and open source. A case study examining the Monsanto v Schmeiser lawsuit between the dominant agrichemical-seed corporation at the time and a Canadian farmer, demonstrates how the dynamics of patent law described in the previous sections unfold practically and highlights the troubling oversights that come with the application of exclusionary patent law to seeds.

Chapter four provides a deeper analysis of the potential benefits and risks of introducing an open source platform into the IP-dominated seed industry, its capacity as a tool for increasing innovation compared to that of exclusionary IPRs, and how it can be used to support the success of sustainable agriculture at scale. Exclusionary IPRs and open source are not only applicable to the seed industry, and their use is also a significant factor in the software industry. The types of IPRs and open source agreements used across these industries are remarkably similar. However, the extreme research restrictions imposed through patents in the seed industry, as well as the complex evolutionary implications of patenting living organisms are cause for concern, especially in light of the unfolding environmental changes. Issues arising from research restrictions will be discussed in chapter four, as well as the associated consideration of path dependence and lock-in.

Specifically analyzing the Open Source Seed Initiative (OSSI), a US-based nonprofit organization leading the charge to form a protected commons of plant genetic resources, this chapter aims to show how radical empowerment within the existing industry is possible immediately. While other forms of movements toward sustainable agriculture are underway and just as necessary, OSSI carries the potential to sidestep barriers set up by IPRs toward seed sovereignty without relying on defensive action or time-consuming policy changes. This chapter will show how the business model of OSSI presents unique opportunities within the seed industry that are especially instrumental in the transition and maintained viability of agroecological practices.

This thesis will explain the barriers to transitioning to a more sustainable systems of food production, paying particular attention to the effects of IPRs over seed which create gridlocks within the industry that have counterproductive effects on biodiversity, plant evolution, and innovation. In turn, the opportunities offered by the incorporation of open source practices into the field of seed breeding will be analyzed as a potentially disruptive tool for innovation and social empowerment. Opportunities presented by using open source in the seed industry include the empowerment of farmers and breeders, biodiversity growth, and enhanced innovative capacities in the area of plant genetic resources.

Chapter 2: An Overview of the Seed Industry

2.1 Introduction

Seed breeding is an inevitable step in the process of agriculture. For the entire history of agriculture until the recent emergence of biotechnology, seeds needed to be saved in order to engage in food production. From the decentralization of breeding to farmers emerged a wealth of cultivated seed varieties adapted to all sorts of climates, conditions, and ecosystems – an extremely vital resource to have in the face of unpredictable climate change. In a state of environmental emergency, such reserves of differently adapted seeds could be the difference between human life on Earth flourishing or disappearing.

However, the invaluable resource of plant biodiversity is being extinguished at an alarming pace. Pat Mooney published a study about this trend of biodiversity loss: "we found that about 93% of seed varieties sold in the US in 1903 were extinct by 1983."[5] Ongoing socio-economic and political changes have molded a pattern of convergence of ownership, rights, and access, reducing the number of pathways available for seed adaptation. The jurisdiction and operations of few corporations has quickly spread into all parts of the food system worldwide. This monopolization of power allows a small

[5] Pat Mooney, "Protecting the Food Ark," *Rural Advancement Foundation International-USA* (blog), July 7, 2011, https://www.rafiusa.org/blog/protecting-the-food-ark/.

number of corporations to influence policy decisions, global supply dynamics, the ecological makeup of the earth, and future stability of human populations.

This chapter will provide an overview of the seed industry. The first section will introduce the key historical changes in the political economy of seeds. The next section will describe the key characteristics of the dominant industrial agriculture model. Following this is a discussion of negative consequences associated with this structure, including the resulting social, biological, and economic implications. The final section will introduce agroecology as a sustainable alternative to industrial agriculture.

2.2 Evolution of the Seed Industry in the Global Economy

The seed market and agriculture at large have traveled through a series of political, legal, and economic evolutions to arrive at today's structure. Developments including commodification, changes in legal frameworks, and international policy initiatives like the Green Revolution have all contributed to a fundamental reorganization of the industry – each bringing a redistribution of ownership or a shift in conceptualization of property. For example, the Enclosure Movement in England, beginning in the sixteenth century,[6] initiated the transition from the feudal system to agrarian capitalism.[7] Enclosure, or the privatization of the commons, led to market dependence and ultimately a capitalist market that necessarily follows these conditions,

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[6] Ellen Meiksins Wood, *The Origin of Capitalism: A Longer View* (Brooklyn, NY: Verso, 2017), 108.

[7] Wood, *The Origin of Capitalism: A Longer View*.

as Ellen Meiksins Wood describes: “It can and must constantly accumulate, constantly search out new markets, constantly impose its imperatives on new territories and new spheres of life, on all human beings and the natural environment.”[8] Therefore, to meet these conditions and secure its continued existence, capitalism required the establishment of private property laws.

The privatization of fields in the Enclosure Movement allowed for the increased ability to profit from land improvement.[9] Similarly, the privatization of seeds through IPRs increases the ability of companies to profit from seed evolution by inserting a barrier in the growing cycle which farmers have historically been able to perform independently. Collecting seeds for the following growing season gave farmers the ability to maintain the renewable nature of their resources in the food production process. This ability makes seed growers sovereign insofar as they are able to recreate the necessary conditions for their growth. IPRs create a legal disruption to this condition of seed sovereignty. As Jack Kloppenburg explains: “For capital, the challenge has been to find ways to separate farmers from the autonomous reproduction of planting material and to bring them into the market for seed every growing season.”[10] The legal framework for the privatization of genetic resources has allowed businesses to reach and colonize new

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[8] Wood, 97.

[9] Wood defines agricultural improvement as, “the enhancement of productivity by means of innovative land use and techniques”; Wood, 54.

[10] Jack Kloppenburg, “Re-Purposing the Master’s Tools: The OSSI and the Struggle for Seed Sovereignty,” *The Journal of Peasant Studies* 41, no. 6 (November 2, 2014): 1227, https://doi.org/10.1080/03066150.2013.875897.

territories more effectively than ever before. For private property to exist, there needs to exist a framework for owning and controlling the type of property in question.

The spread of control and ownership was facilitated by the movement to commodification, which paved the way for the market society that exists today. "Commodities are here empirically defined as objects produced for sale on the market; markets, again, are empirically defined as actual contacts between buyers and seller." [11] A market economy was thus born from the commodification of land, labor, and money.[12] The adoption of this logic to the transformation of agriculture continued through the 18th and 19th centuries.[13] The commodification of labor and land allowed for efficiency increases through lowered costs. Consequently, division of labor and specialization, as well as the imperative of land 'improvement' under agrarian capitalism, necessitated the continuously increasing exploitation of labor and land.

Industrialization brought a wave of technological innovation kicking off in the second half of the 1800s that changed the dynamics within and between economies,[14] pushing profit opportunities to new horizons. Trade formed an instrumental part of industrialization and globalization. The invention and spread of the railroad was but the first boom of transportation and machinery which revolutionized trade and the role of

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[11] Karl Polanyi, *The Great Transformation: The Political and Economic Origins of Our Time*, 2nd ed. (Boston: Beacon Press, 2001), 75.

[12] Polanyi, 74.

[13] Eric Hobsbawm, *Industry and Empire: The Birth of the Industrial Revolution*, 99th ed., vol. 4 (New York: The New Press, 1999).

[14] Hobsbawm.

specialization for economies. The continued search for efficiency led to the formation of factories and corporations. Economies of scale made firms the optimal competing entity and division of labor the burgeoning trend – resulting in a furthering separation of workers from the factors of production. Over time, family structures shifted and people migrated closer to factories – transforming the function and structure of cities,[15] and the legal definition of personhood changed to include incorporated entities (i.e., businesses). As corporations grew, they scaled, purchased, and consolidated. The synthesis of these socio-economic changes has resulted in an oligopoly with considerable stakes in all parts of global food system and diminishing food and seed sovereignty, stemming from the gradual separation of people, land, and money.

Today, corporations lobbying the global political infrastructure for the strengthening of IPR privileges continuously expand their ownership and control. The result is the expansion of minimum IPR requirements which benefit exclusively the aforementioned companies, further concentrating capital and creating new opportunities for exploitation of the genetic landscape. The TRIPs Agreement was passed during the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) in 1995 by the World Trade Organization (WTO) to enforce the IPR framework globally. This policy action required all WTO members to impose minimum intellectual property protection (IPP) laws.

[15] Lewis Mumford, The City in History: Its Origins, Its Transformations, and Its Prospects., 1st ed. (New York: Harcourt, Brace & World., 1961).

In some member countries, this policy goes against the constitution and cultural beliefs of the nation. This is the case in India, for example, where granting IPRs over seed directly opposes the dominant cultural philosophy. As Vandana Shiva (2000) states: "This ruling forces India to recognize U.S.-style patent regimes, and is in essence a decision against Indian democracy."[16] In this way, agrichemical-seed corporations have been able extend their positions of power within the competitive landscape of the industry all the way to sovereign governments.

Furthermore, the TRIPs Agreement lends way to seed and intellectual piracy.[17] By entering the IPR framework, seeds that have been cultivated by farmers over centuries become subject to patenting. Prepared for the process of patenting, with both experience and financial resources, corporations with existing patents were and remain in a position to beat breeders in countries new to the IPR framework to patenting a seed variety from the moment of the passed legislation. Laws governing IPRs view seeds that have been cultivated for centuries without being presented for a patent application as a raw material, but those that have been bred for one extra cycle by a corporation as a novel invention worthy of being patented.

The Uruguay Round of the GATT required developing countries to open their food economies to free market principles while protecting the United States and the European Union through export subsidies. "By externalizing these subsidies, U.S. and

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[16] Vandana Shiva, *Stolen Harvest: The Hijacking of the Global Food Supply* (Cambridge, MA: South End Press, 2000), 89.

[17] Shiva, *Stolen Harvest: The Hijacking of the Global Food Supply*.

EU exports are competing with artificially low prices."[18] Furthermore, decoupling farm payments from commodity prices helps the US and EU retain indirect subsidies. This leads to agro-export dumping which ultimately destabilizes farmers, export economies, and the environment.[19]

The Green Revolution is another policy initiative that promised to improve the welfare of farmers in developing countries but accomplished the opposite. The premise of the Green Revolution was to replace indigenous, polyculture agriculture systems in the Third World with crop varieties developed to produce higher yields given the use of specified farming methods, namely energy and chemical input-intensive monoculture techniques.[20] Deployed in the 1960s and the 1970s, the policy introduced rice and wheat varieties developed by privately funded international agricultural research centers (IARCs).[21] In addition to sudden increases in yield, the implementation of the global policy changes making up the Green Revolution also resulted in the following consequences:

> These include the exacerbation of regional inequalities, generation of income inequalities at the farm level, increased scales of operation, specialization of production, displacement of labor, accelerating mechanization, depressed product

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[18] Philip McMichael, "Global Food Politics," in *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, ed. Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel (New York, NY: Monthly Review Press, 2000), 126.

[19] Agro-export dumping is the termed coined in the GATT for exporting agricultural products at a price below the cost of production; Sophia Murphy and Karen Hansen-Kuhn, "Counting the Costs of Agricultural Dumping" (The Institute for Agriculture and Trade Policy, June 2017), 3.

[20] Shiva, *Earth Democracy: Justice, Sustainability, and Peace*.

[21] Jack Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology*, 2nd ed. (Madison, Wisconsin: The University of Wisconsin Press, 2004), 6.

> prices, changing tenure patterns, rising land prices, expanding markets for commercial inputs, agrichemical dependence, genetic erosion, pest-vulnerable monocultures, and environmental deterioration.[22]

The Green Revolution, thus, resulted in massive negative consequences for countless economies, countries, and individuals. The policy initiatives described above have played a defining role in the formation of today's agrichemical-seed market. The following two sections will describe the dominant agricultural system that has emerged through the industry's evolution and the consequences associated with its dominance.

2.3 The Seed Industry Today: Defining Characteristics

Prior to the commercialization of agriculture, food systems worldwide were fully decentralized, meaning that families were self-sufficient and autonomous in each stage of the process, from seed to plate, to the next season's seed. The entire cycle of food production could be reproduced from year to year by individual families. Through the changes described above, this closed cycle was torn apart, only to be claimed and reconstructed by agribusiness giants.

The processes of land and seed dispossession and the international enforcement of seed privatization policies described in section 2.2 opened the door to a significant redistribution of power within the industry. As concentration continues to reshape the industry, it acts less like a competitive industry, and more like a monopoly. Heffernan

[22] Kloppenburg, 6.

(2000) describes the agricultural market during the early stage of capitalism, before this massive movement of consolidation:

> This was the agriculture and food system that was held as a model of a competitive system in which (1) no firm bought or sold enough of the total goods or services to influence the price; (2) there was relatively easy entry and exit from any stage, and (3) information regarding the price of the goods and services along the total food chain was available to all.[23]

This representation of free-market competition no longer characterizes the structure of the seed industry. Market concentration in the seed industry has reached the point of oligopoly, with five companies controlling 84% of the seed industry in 2016.[24] These majority share companies are agrichemical transnational corporations: 32% DuPont, 30% Monsanto, 10% Syngenta, 6% Bayer, and 6% Vilmorin. Between 2016 and 2019, Dow and Dupont, Syngenta and ChemChina, and Bayer and Monsanto, respectively, have undergone mergers, reducing the number of leading firms to four by 2020.[25] These percentages represent estimations rather than precise values due to limitations in publicly available information.[26] A variety of methods are used to estimate the market share distribution of the seed industry, one of which uses patents as a proxy for market

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[23] William D. Heffernan, "Concentration of Ownership and Control in Agriculture," in *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, ed. Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel (New York, NY: Monthly Review Press, 2000), 62.

[24] Mooney, "Protecting the Food Ark."

[25] Hendrickson et al., "The Food System: Concentration and Its Impacts," 1.

[26] Koen Deconinck, "New Evidence on Concentration in Seed Markets," *Global Food Security* 23 (December 1, 2019): 135–38, https://doi.org/10.1016/j.gfs.2019.05.001.

concentration, and an emphasis on continuously high rates of new M&As persists across evaluations of the industry structure.[27]

Companies consolidate through integration to increase their influence over price and trade opportunities to collect higher profits.[28] This trend leads to a convergence of ownership, accompanied by a loss of smaller businesses and farms, agricultural methods, ways of knowing, ecosystem functions, and biodiversity. Simultaneously employing three directions of integration, transnational agrichemical corporations span each facet of agriculture beginning with, but not limited to, the seed industry. The following headings indicate the business strategies, specifically the use of organizational integration and cross-subsidization, technologies and innovations in the area of bioengineering, and patent law which collectively shape the global industrial agriculture complex.

2.3.1 Integration: Horizontal, Vertical, and Contractual

Horizontal integration refers to the acquisition of other companies in the same industry and area of business operations while spreading geographically. This happens through expansion of the existing company or through mergers and acquisitions (M&As) with other existing companies in the industry. Horizontal integration remains within one domain of business activity (e.g., seeds, fertilizers, machinery, processing, or

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[27] Koen Deconinck, "Concentration in Seed and Biotech Markets: Extent, Causes, and Impacts," *Annual Review of Resource Economics* 12, no. 1 (2020): 129–47, https://doi.org/10.1146/annurev-resource-102319-100751.

[28] Philip H. Howard, *Concentration and Power in the Food System: Who Controls What We Eat?* (Bloomsbury Academic, 2016), 4, https://doi.org/10.5040/9781474264365.

distribution).[29] Importantly, Heffernan also notes that horizontal integration is used as an argument against antitrust accusations under the premise that any firm can be purchased by another and in this manner, be eliminated from the market.[30]

Vertical integration is the expansion of business functions to include areas of operation that were previously separate parts of the supply chain, fulfilled by partners or suppliers. Whereas horizontal integration would look like a seed company buying another seed company (M&A), vertical integration might look like a seed company buying a distribution company or creating its own network of distributors to fulfill the next step in the supply chain.

One benefit of vertical integration is having more control at each step of production, therefore supporting profit-maximization for the umbrella company without the added cost and risk that would otherwise be involved in negotiations between companies. Beyond granting more decision-making power, vertical integration allows companies to increase their efficiency through cost-cutting and overhead minimization. The lengthening chains of production in growing firms need to be carefully organized and meticulously tracked. Big data and artificial intelligence allow for extraordinary feats of operations management at a large scale, making them most easily applicable to monoculture methods of agriculture, and increase opportunities for the expansion and profitability of transnational seed corporations.

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[29] Heffernan, "Concentration of Ownership and Control in Agriculture," 64.

[30] Heffernan, 65.

Big data, defined as “a conglomeration of digital information,”[31] enables a variety of processes like spraying fertilizers digitally, gene sequencing, and supply chain management. Access to mass quantities of data provides opportunities for major efficiency advancements through automation. An example of this is the use of automation for delegating tasks to different sides of the world based on where the task will be cheapest and most flexible according to the country’s legislation. The increased complexity granted by big data requires an expensive shift in business operations that is unattainable to small seed companies. Because of the integration of complex data systems into the seed industry and the incentives to merge and monopolize that it provides, further legislation is needed in order to protect smaller companies,[32] which are otherwise pushed out of the market because of a lack of economic profit. The emergent organizational structure which consolidates information and automates operations puts smaller seed companies at a competitive disadvantage.

With a decreasing number of suppliers of raw materials for production (e.g., seeds, fertilizers, etc.) and heavy market dependence, the operational decision-making capacity available to farmers lessens. Agrichemical companies create packages for their genetically modified (GM) seeds that include specific machinery, pesticides, fertilizers, and growing methods that all need to be purchased to maximize the profitability of (or in some cases, simply to sustain) the GM seeds. In addition to the effects of ownership on

[31] Pat Mooney, “Blocking the Chain: Industrial Food Chain Concentration, Big Data Platforms and Food Sovereignty Solutions” (ETC Group, July 2018), 6.

[32] Mooney, “Blocking the Chain: Industrial Food Chain Concentration, Big Data Platforms and Food Sovereignty Solutions.”

surplus accumulation, this style of vertical integration chains farmers to one supplier for all the necessary means of production. Associated investments in large-scale, industrial machinery are another driving factor that gets farmers trapped in the cycle of buying repeatedly from the same company even after they begin to see patterns of land degradation and diminishing returns. With this business model, the financial burden falls on the farmer while the surplus extracted goes to the agrichemical corporation. Consolidated control over inputs limits the options available to farmers and depletes their bargaining power, furthering their inequitable absorption of negative consequences.

Aside from reducing the number of owners, decision-makers, and options, M&As in the seed industry also lead to companies dropping certain products (in this case, seeds varieties) from production for a variety of reasons.[33] Seeds that are highly adapted to specific bioregional climates or alternative growing methods and that fall out of line with the business strategy of the acquiring company face the risk of being taken out of stock. When seeds are taken off the market, other breeders and growers lose access to them and they can quickly go extinct. This is one of the ways in which M&As directly contribute to biodiversity loss.

The third method of integration implemented by agribusiness corporations is contractual integration. By using leasing agreements instead of traditional, ownership-transferring sales for their patented seeds, TNCs further strip farmers of their autonomy and trap them in a cycle of debt and dependence. Through leasing agreements,

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[33] "Free The Seed! Podcast," Gypsy Queens, accessed October 27, 2020, https://osseeds.org/free-the-seed-podcast-s2e1-gypsy-queens/.

agrichemical corporations secure the rights to seeds and their genetic byproducts. Importantly, these rights are accompanied by the transfer of operational decision-making power. When farmers sign a leasing contract by buying genetically modified seeds, they essentially become laborers with less rights than in other industries.[34] The result of integration in the seed industry is the opposite of the divergent evolution of biodiversity that proliferated prior to corporate privatization germplasm.

2.3.2 Cross-Subsidization

Employing the strategy of cross-subsidization between business areas, TNCs build diverse revenue streams by integrating into multiple markets,[35] allowing them the financial security to invest in risky technologies like bioengineering. Being integrated horizontally in the seed industry allows TNCs to have losses in the short term in one or more areas and still make a profit overall.[36] When a corporation is able to create a pillow of security through financialization, if losses occur the investment is recovered through profits from other geographic locations or commodity markets.

For instance, many organic companies are purchased by TNCs which also operate in the biotech sector. "When a firm has a dominant position in several commodity

[34] Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel, "An Overview," in *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, ed. Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel (New York, NY: Monthly Review Press, 2000), 11.

[35] Heffernan, "Concentration of Ownership and Control in Agriculture," 67.

[36] Losses occur regularly in agriculture since harvests are susceptible to a variety of dangers like weather, pests, or natural disasters.

markets, it can cross-subsidize."[37] In this way horizontal integration also leads to a qualitative shift, granting access to other commodity markets within agriculture such as the organic sector, leading to a diversification of income streams for the consolidating firm. Furthermore, TNCs that dominate the agricultural industry also engage in the development and sales of pharmaceuticals, biological growth regulators, and microbial crop symbionts.[38] Yet another significant opportunity is offered by globalization, which opens the door for cross-subsidization between countries, providing a safety net for the profits of transnational corporations based on the dispersion of environmental conditions.[39]

2.3.3 Monoculture and Bioengineering

Monoculture, designed for maximum surplus extraction in the short-term, governs industrial agriculture methods. It involves growing a single crop on a large area of land, while using large-scale machinery that facilitates the maintenance of the high-input and energy-intensive operation sold by TNCs. The excessive use of agrichemical inputs negatively impacts soil fertility which makes farmers dependent on additional inputs to maintain the necessary ecosystem conditions to repeat the food production cycle again. However, this cycle of heavy input use is not sustainable in the long term; ecosystem functions are disrupted and replaced with market dependency. The ecosystem services that are interrupted by monoculture practices which do not directly and immediately

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[37] Heffernan, "Concentration of Ownership and Control in Agriculture," 67.

[38] Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology*, 209.

[39] Heffernan, "Concentration of Ownership and Control in Agriculture," 71.

influence food production are not given consideration by the companies that sell agrichemical inputs, and these losses become externalized costs that are incurred by communities and ecosystems. The replacement of existing, diverse ecosystem relationships with agrichemical inputs is not accounted for in the expenses of agrichemical firms contributing to these damages.[40]

In this way, monoculture expends a steady and large quantity of energy to support itself. Monoculture is only able to deliver high yields in the short term but remains dominant because it manufactures a new conception of productivity based off the established input dependencies. This insidious process of ecosystem management is about productivity as control: “Monocultures spread not because they produce more, but because they control more.”[41] By creating rifts in ecosystems, agrichemical corporations justify the replacement of living webs of organisms with technology and the anthropocentric management of nature. Policymakers are able to overlook these issues because such biological and socio-economic considerations are attributed to externalities, which in the mainstream economics paradigm considered in their decision-making, do not factor into the economic value of a proposed endeavor (as can be witnessed in the tolerance of widespread negative consequences that accompanied the Green Revolution).

Biotechnology is used by TNCs for genetically modifying organisms to create seeds with properties that have evolved in other plant or animal species. By picking and

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[40] Vandana Shiva, *Monocultures of the Mind: Perspectives on Biodiversity and Biotechnology* (New York, NY: Zed Books Ltd., 1993), 39–40.

[41] Shiva, 7.

choosing desirable traits, bioengineers attempt to control how a seed will behave. They make changes to seeds that, when combined with complementary chemical products, will produce a higher yield in the short term. In the long term, such bundles of chemicals and genetically modified organisms (GMOs), otherwise referred to as asset complementarity,[42] tend to deplete the fertility of soil, destroy entire ecosystems, and accelerate biodiversity loss.

Genetic modification of seed by biotech corporations is motivated by securing a higher profit. Note: this does not equate to the seeds becoming more productive in terms of yield, cost, diversity, or resource-efficiency. Rather, these changes create opportunities to extract more surplus from the same resource while reducing its viability in the future – the resource being the seed and its growing environment. Biotechnology could be applied in a variety of innovative directions, with infinite potential results. Dismissing the popular idea that biotechnology is inherently harmful, Middendorf et al. explain that the real danger of bringing biotechnology into the plant breeding field is the accompanying constriction of decision-making opportunities.

> When choosing problems, scientists have a range of possibilities before them. For example, they could work on developing crops that more effectively shade out weeds, or intercropping and rotation systems for better weed control, or they could genetically modify plants to be resistant to herbicides.[43]

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[42] Deconinck, "Concentration in Seed and Biotech Markets."

[43] Gerad Middendorf et al., "New Agricultural Biotechnologies: The Struggle for Democratic Choice," in *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, ed. Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel (New York, NY: Monthly Review Press, 2000), 118.

Technology develops in the direction which is chosen by the operating decision-makers of the firms using the technology, and decisions made in the early stages of biotechnological R&D dismiss other pathways once the research goal is achieved and a new technology is ready to be sold. The organizations that control biotechnology will determine its potential to be a positive agent of evolution, as it is hypothetically capable of being harmful or beneficial to the environment depending on how its power is deployed.

2.3.4 Patents and IPRs

Once a seed breeder or company develops a new seed variety, they may protect the seed with a patent which grants them a set of monopoly rights over their invention. The traditional economics approach to incentivizing innovation has involved striking a balance between incentives for innovation and hoarding of information.[44] Mainstream economists believe the protection of an invention by way of IPRs to be a necessary incentive for people to keep inventing by eliminating the fear of others taking advantage of their ingenuity. According to recent studies, IPRs in the seed industry accomplish the opposite in practice. Although their promise is to stimulate innovation for the good of society at large, when IPRs are combined with heavy consolidation of ownership, the opposite begins to occur. Intellectual property protection (IPP) in the seed industry has reached a level of diminishing marginal returns with regard to productivity in stimulating

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[44] Richard A Posner, "Intellectual Property: The Law and Economics Approach," *Journal of Economic Perspectives* 19, no. 2 (April 1, 2005): 57, https://doi.org/10.1257/0895330054048704.

innovation. In their economic welfare model, Lence et al. (2015) show that the degree of IPP used in the seed industry exceeds the optimal level intellectual property protection.[45]

Beyond legal protections, there are also extreme cases of IPP such as genetic use restriction technologies (GURTs), which use biological controls to protect intellectual property.[46] Such biological controls may look like additional technology (e.g., a chemical activator necessary to activate a trait such as the fertility of a seed) which is often held as a trade secret.[47] By combining patents with trade secrets and biological methods of enforcement, it becomes possible to extend an intellectual property protection term indefinitely.

The privatization of seeds by way of exclusionary patents gives the inventor the right to charge those that want to reap the benefits of the invention a price higher than the marginal cost, and/or exclude them from the right to use the patented seed or gene sequence. A patent can be held for a given amount of time determined by the type of invention. However, this window of time becomes an issue when the patent is not for technology with an infinite life as it the case with software inventions, but for living seeds.

To maintain their vitality, seeds need to be planted yearly or be stored in a seed vault which is extremely expensive, though done by some corporations and governments

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[45] Sergio H. Lence et al., "Welfare Impacts of Intellectual Property Protection in the Seed Industry," *American Journal of Agricultural Economics* 87, no. 4 (2005): 951–68, https://doi.org/10.1111/j.1467-8276.2005.00780.x.

[46] Lence et al.

[47] Lence et al., 953.

for security. This storage is not financially feasible for farmers, many of whom are also independent breeders. Furthermore, the seeds that have been stored for the duration of the patent have not been able to adapt to new diseases and changing climates, making them fall behind their environment.[48] Those that have not been stored will lose their viability before the patent expires if they have been patented with a seed-saving restriction. While seed patents are imposed, strains die out or undergo permanent changes to their DNA as they are replaced, genetically modified, or chemically treated. The differences in organizational structure between types of seed breeders extend to the ways in which IPRs affect them. These dynamics will be discussed at length in the following chapter.

2.4 Negative Consequences of Modern Industrial Agriculture

Inequities that accompany the advancement of industrial agriculture and biotechnology result in socio-economic imbalances and increased environmental risks. Patterns of market concentration, structural ownership changes, and the proliferation of IPRs lead to increasing barriers to entry. Because of the power dynamic formed by oligopolistic market concentration, the resulting challenges will be difficult to reverse without diverse access to seeds because of the imposed restrictions on competition. By accumulating ownership of genetic resources, biotech corporations reduce the opportunities of other breeders to be innovative, to grow regionally-adapted plants, and to

[48] Cary Fowler and P. R. Mooney, *Shattering: Food, Politics, and the Loss of Genetic Diversity / Cary Fowler and Pat Mooney.* (Tucson: University of Arizona Press, 1990).

sustain their livelihoods as breeders – eventually pushing them out of the industry or into acquisition.

In the long-term, even the largest and wealthiest firms rely on rich seed diversity for continued innovation and making necessary adjustments according to environmental changes. Despite the risk of future losses and diminished innovative capacity due to less germplasm diversity, individual majority-share companies maintain a steady profit in the short-term, benefitting from the income from royalties on patented seeds and organizational cross-subsidization. Innovation in regional breeding is a necessary measure for adapting to ecological emergency. By removing the possibility of regional adaptation of seed varieties, the pool of resources decreases quickly, given that each year is pivotal in the process of a seed's evolution. If seeds are not planted on a regular basis, they lose their viability and go extinct. The deadweight loss of such negligence is infinite.

The introduction of genetically modified plants leads to a variety of ecological and economic consequences when introduced into an open environment because of the naturally occurring process of accidental gene transferring. If a genotype changes naturally through accidental gene transferring, the ripple effects reach far and wide. Besides causing ecological destruction, this phenomenon leads to legal challenges for farmers. When accidental gene transfers are discovered in the crops of farmers that do not buy genetically modified seeds, they become susceptible to legal action by corporations who own the genetic sequence, the fear of which TNCs intentionally agitate.[49] While

[49] For example, Monsanto financed the research for the article: "Seed Patent Growth Prompts Litigation and Licensing Fears," *Managing Intellectual Property*, 2018.

there is an opportunity in the market to buy intellectual property insurance, this adds costs for those farmers who are already at an economic disadvantage to wealthy corporations.

Biotechnology allows corporations to make changes to the genetic makeup of plants which influences the entire surrounding ecosystem, irrevocably. When one piece (in this case, genotype) of an ecosystem is altered, the rest of the ecosystem must adapt, but companies selling genetically modified seeds are not held accountable for moderating the implications of such changes. TNCs do not assume the responsibility of restoring all the ecosystem services they have disabled. Furthermore, seeds produced using genetic engineering intentionally require complementary fertilizers and pesticides, which are dangerous to surrounding wildlife, especially to pollinators upon which open pollinated seed varieties, including wild plants, depend.

In addition to environmental risks, the modern industrial agriculture system entails a variety of social consequences. These include mass hunger despite overproduction, public health risks, and the destruction of peasant and subsistence farming. The dynamics of globalization and trade liberalization policies have made third world countries especially vulnerable to food insecurity, debt, dependency, and degradation of local ecological processes. Vandana Shiva (1993) argues that social impact assessments should be conducted by third-party scientists rather than businesses, given that they have the full breadth of information in their hands.[50] Since the damages of

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[50] Shiva, *Monocultures of the Mind: Perspectives on Biodiversity and Biotechnology*, 100.

agricultural practices and uncertainties of climate change are difficult to assess, the integration of third-party scientists and researchers should be considered in the operation of biotech companies. However, the walls built up by the industry – including research restrictions written into some forms of patents – are too high to allow for this kind of intervention. IPRs, in their current form, sign over scientific autonomy in the field which the protected corporation operates. IPRs present many dangers in return for privileging corporations with the most financial resources. As this thesis will hypothesize, they may be considered the ultimate gridlock of the industry, barring out the potential success of sustainable agriculture.

2.5 Sustainable Agriculture: Agroecology

The history of sustainable farming that preceded industrial agriculture offers hints at solutions to the recent erosion of biodiversity and diverse cultural knowledge. Altieri and Nicholls (2012) acknowledge the rich knowledge base of developed agroecological systems:

> The basis for such new systems are the myriad of ecologically based agricultural styles developed by at least 75% of the 1.5 billion smallholders, family farmers and indigenous people on 350 million small farms which account for no less than 50% of the global agricultural output for domestic consumption.[51]

Interdisciplinary professionals, scholars, scientists, and government agencies have begun to advocate for the adoption of agroecology as the alternative, sustainable approach to industrial agriculture. In fact, the intention of facilitating the global scaling of

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[51] Miguel A. Altieri and Clara I. Nicholls, "Agroecology Scaling up for Food Sovereignty and Resiliency," in *Sustainable Agriculture Reviews* (Springer, 2012), 1.

agroecological practices has been recognized as a primary goal of the United Nations (UN) in support of Zero Hunger and several other Sustainable Development Goals.[52] The development and deployment of strategies to make this possible is underway.

Prior legislative action was based on the promises of monoculture to feed the rapidly growing human population due to efficiencies of scale that homogenized farming techniques offer, while other methods could not. However, extensive research has debunked the misconception that agroecology would be unable to produce enough food to sustain populations. Due to their decreased dependency on agrichemicals and other complementary inputs, methods used on smaller farms that are labeled as organic, sustainable or agroecological have proven to be more productive than large farms[53]. Along with higher productivity, agroecology benefits rural livelihoods and cultures, fosters greater resilience to climate change, lowers the impact of food production on the aggravation of climate change, promotes better stewardship of biodiversity and ecosystems, and empowers food producers by increasing their autonomy through decreased reliance on inputs and debt.[54]

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[52] IISD's SDG Knowledge Hub, "FAO Launches Initiative to Scale Up Agroecology in Support of the SDGs | News | SDG Knowledge Hub | IISD," accessed June 7, 2021, https://sdg.iisd.org:443/news/fao-launches-initiative-to-scale-up-agroecology-in-support-of-the-sdgs/.

[53] FAO, ed., "Agroecology for Food Security and Nutrition Proceedings of the FAO International Symposium. 18-19 September 2014, Rome, Italy: Biodiversity & Ecosystem Services in Agricultural Production Systems" (Rome, Italy: FAO, 2015), 299–300, http://www.fao.org/publications/card/en/c/d1f541b5-39b8-4992-b764-7bdfffb5c63f.

[54] FAO, 300.

Agroecology is defined as “a set of principles that take technological forms depending on the socio-cultural, economic and environmental realities of each community or situation,”[55] meaning that it can take on many forms depending on the context and decisions made by farmers. The ten guiding principles of agroecology are: diversity, synergies, efficiency, resilience, recycling, co-creation and sharing of knowledge, human and social value, culture and good traditions, responsible governance, and circular and solidarity economy.[56] By translating more of these principles into practice through their operations, farmers move toward agroecology at differing paces, styles, and abilities.

Inevitably, the decisions available to farmers within their practices are influenced and shaped by their surrounding economic conditions. While agroecology may be a desirable option for farmers because of its increased long-term sustainability over industrial methods, many farmers are unable to pursue such pathways given the parameters set in place by the market conditions described in previous sections. The Food and Agriculture Organization of the United Nations (FAO) is actively strategizing to create a large-scale shift in the market toward agroecological practices.

Considering the variety of proposed and implemented methods of sustainable agriculture which fall under the umbrella of agroecology, Altieri notes, “the goals are usually the same: to secure food self-sufficiency, to preserve the natural resource base,

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[55] FAO, 314.

[56] FAO, *The 10 Elements of Agroecology: Guiding the Transition to Sustainable Food and Agricultural Systems* (Rome, Italy: FAO, 2018), http://www.fao.org/documents/card/en/c/I9037EN/.

and to ensure social equity and economic viability."[57] By approaching sustainable agriculture under the umbrella of one set of principles, it becomes easier to create a collective social movement toward its adoption. However, the policy-focused approach driving this transition underestimates the weight of structural gridlocks that keep industrial methods in place and reinforce centralized power over seed and food systems, technologies, information, and research goals.[58] Attempts to create new pathways should address the factors that have led to the need for interventions in the first place. The following chapters will explain the significant role of IPRs in enforcing this gridlock that keeps agrichemical-seed TNCs and their industrial methods at the helm of agriculture, focusing particularly on the agroecological principles of biodiversity and resilience.

A shift to agroecology requires a stable resource base of diversely adapted seeds that can resist certain climates, pests, and diseases without the use of energy-intensive chemical pesticides. The methods of agroecology, the education around them, and incentives for their implementation are given much attention by the FAO. These necessary initiatives will not be able to succeed in the long term if the underlying issues around biodiversity loss resulting from IPR-based restrictions to evolutionary pathways are not addressed. A diverse, decentralized, and autonomous system of agriculture must include well-adapted plant resources and accessibility to small-scale, regional breeding

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[57] Miguel A. Altieri, "Ecological Impacts of Industrial Agriculture and the Possibilities for Truly Sustainable Agriculture," in *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, ed. Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel (New York, NY: Monthly Review Press, 2000), 88.

[58] Clara I. Nicholls and Miguel A. Altieri, "Pathways for the Amplification of Agroecology," *Agroecology and Sustainable Food Systems* 42, no. 10 (November 26, 2018): 2, https://doi.org/10.1080/21683565.2018.1499578.

operations to continue the process of specialized seed evolution. Chapter four will consider the potential of open source in creating opportunities to break through barriers set up by IPRs and support the long-term success of alternative, sustainable agriculture models and food security at large.

2.6 Conclusion

The complexity of the seed industry's organizational structure and rights over resources makes the leading agrichemical corporations strong against possible resistance movements toward sustainable agriculture. The history and characteristics of the industry described in this chapter set the stage for an analysis of the complex dynamics between actors in the seed innovation space. The structural characteristics that shape the industry reinforce the dominant position of TNCs, encouraging the continued spread of the industrial agriculture method of food production.

The recent international recognition of agroecology as a means to achieve sustainability goals is encouraging, but barriers set in place by the industry's oligopolistic structure and supporting legislative actions slow the progress of scaling agroecology. The next chapter will examine the specific implications of IPRs for different methods of seed breeding and for different types of breeders, from farmer-breeders to the R&D departments of agrichemical TNCs. Evaluating how the legal and economic infrastructures impact various stakeholders will pave the way for a discussion about frameworks for shifting to a sustainable agricultural model. The last chapter will build upon this understanding and propose solutions to the constraints posed by IPRs in the agrichemical-seed industry.

Chapter 3: Dynamics of Intellectual Property Rights in Plant Breeding

3.1 Introduction

The dynamics discussed in the previous chapter, particularly the patterns of ownership and rights consolidation, create a monopolistic landscape within the seed industry. Combined with the restrictive character of IPRs, innovative capacities are skewed toward few corporate actors, reducing the diversity of seed breeders by blocking their access to plant genetic resources (consequently reducing the variety of plant genetic resources themselves). While IPRs in the seed industry are often compared to IPRs in the non-biotechnological software industry, important differences lead to dire consequences for farmers, independent and organic breeders, and the earth's ecosystems at large. This chapter will examine the specific impact of IPRs on different types of plant breeders and the breeding methods they use. Inequalities in the competitive landscape of the seed industry arise from the distinct interactions between types of IPRs that are available, seed breeders, and methods of plant breeding. The sections of this chapter will cover each of these categories, and an example of the imbalances will be highlighted in a case study covering the 2004 Monsanto v. Schmeiser landmark case.

3.2 Types of IPRs in the Seed Industry

Types of IPRs differ in the areas of legal enforceability, details of coverage, duration, allowances of seed saving and/or plant cuttings, allowances of research and/or breeding, marketing rights, and associated cost. The available methods of associating IPRs with a seed and/or genotype in the United States are: plant patents, plant variety protection (PVP), utility patents, trademarks, trade secrets, contracts, and the Open Source Seed Initiative (OSSI) Pledge. All the types listed above are legally enforceable, except for the OSSI Pledge, which may or may not be, pending confirmation.[59] Rather than relying first and foremost on legal enforcement, OSSI focuses on the philosophical, moral, and social motivations behind reserving seed for the commons, but its success at scale may depend on the ultimate recognition of the pledge's validity in legal practice. Unless a lawsuit brings forth a precedent, this will remain unclear.

What is covered by different types of IPRs also varies and determines which is appropriate for the germplasm in question. For example, a plant patent covers asexually reproduced plants only, whereas utility patents can be applied to finished varieties, plant parts, genetic traits, and more, as long as they are deemed novel, non-obvious, and useful inventions. Because of the breadth of material that can be patented under utility patents, they may be the most at risk of stifling innovation and putting other breeders at a

[59] A precedent is required to understand the legal validity of the OSSI Pledge. Until the OSSI Pledge is challenged and upheld in court, its enforceability remains uncertain.; "Intellectual Property Rights (IPR) on Seed" (Organic Seed Alliance, n.d.), https://seedalliance.org/wp-content/uploads/2020/11/IPR-Table_Organic-Seed-Alliance_SPW_4.pdf.

disadvantage. PVP can be awarded to sexually reproducing varieties that are new, unique, uniform, and stable. All three of these types of patents apply to all users regardless of how they obtain the patented material – as the Monsanto v. Schmeiser case study will highlight later in section 3.5, being unaware of possession does not diminish the validity of the patent holder's rights.

Subject to renewal, these types of IPRs last for 20 years, except for PVP which enters the public domain after the patent expires. During this time, PVP entirely restricts marketing and sales rights for non-patent holders, plant patents allow the potential to propagate for a royalty and with restrictions, and utility patents allow owners to sell licenses for selling propagated plants. Royalties and licenses over patented varieties are additional to the high R&D cost associated with new varieties. Furthermore, utility patents allow owners to exclude others from any kind of use, including seed saving and research, without a license. When this happens, seed varieties are entirely removed from the ecosystems they have been adapting to previously and are subject to unrestricted and unsupervised experimentation by the patent holder, which reinforces risks stemming from a lack of transparency about scientific research.

The same three types of IPRs are the most expensive. Posing the highest financial barriers to entry and competition for independent breeders who rely mostly on income from farm produce sales – are plant patents, plant variety protection (PVP), and utility patents, costing $4,000 to $8,000+, $5,150, and $5,000 to $10,000, respectively. Costs vary according to the attorney fees associated with the transaction. Trademarks cost between $200 and $600,[60] plus the cost of maintaining and enforcing a trademark. The additional cost of weak enforcement of a trademark can result in the deterioration of a brand name, which can ultimately be detrimental to the company's success beyond the trademark associated with a given seed.

Trademarks are associated with a brand name and can be applied to a name of a specific variety, without making claims on the variety itself. The trademark acts as a protection for the name, but farmers may sell their harvested produce under a different name without needing a license. An example of this is the Pink Lady apple, which requires farmers to buy a license for selling their Cripp's Pink harvest apples using the name 'Pink Lady'.[61] Selling 'Pink Lady' apples gives the seller a marketing advantage, meaning they may be able to sell them at a higher price. Trademarks can be and usually are combined with other forms of IPRs to impose additional restrictions. This type of IPR is awarded for 10 years with the opportunity to reapply for 10 more years.[62]

Trade secrets differ from the forms of IPRs mentioned above primarily in their independent nature – they are not awarded by the United States Patent and Trademark Office (USPTO) but are only maintained through confidentiality within the company. A trade secret is valid as long as secrecy is maintained. While they are independently

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[60] "Intellectual Property Rights (IPR) on Seed."

[61] Claire Luby et al., "A Primer on Plant Breeding and Intellectual Property Rights in Organic Seed Systems," *EOrganic* (blog), April 17, 2019.

[62] "Intellectual Property Rights (IPR) on Seed."

maintained, they are protected by state law in most US states and are included in the TRIPs Agreement.

Contract law is another form of intellectual property protection used over seed. Contracts are individualized agreements that are maintained between breeders, between farmers and breeders, or in any other relationship that is explicitly described in the contract (unlike utility patents, which apply to anybody who happens to be in possession of the patented material). The details of coverage, duration, and allowances vary by contract, and are usually combined with another form of IPR,[63] in which case the goal of the contract is to increase protection rights beyond those granted by a single patent type.

Finally, the outlier of the IPR types used over seed is the OSSI Pledge. Founded as a method of resistance to privatization of seed varieties, it acts as a patent for the commons.[64] The most recent (2021) iteration of the OSSI Pledge reads:

> You have the freedom to use these OSSI-Pledged seeds in any way you choose. In return, you pledge not to restrict others' use of these seeds or their derivatives by patents or other means, and to include this Pledge with any transfer of these seeds or their derivatives.[65]

The intention of this pledge is to protect public access to germplasm for saving, growing, researching, and breeding. The OSSI seal and pledge are granted by the OSSI Variety Review Committee for free, and 415 varieties have been pledged to date. This form of

[63] "Intellectual Property Rights (IPR) on Seed."

[64] Jack Kloppenburg, "Impeding Dispossession, Enabling Repossession: Biological Open Source and the Recovery of Seed Sovereignty," Journal of Agrarian Change 10, no. 3 (2010): 367–88, https://doi.org/10.1111/j.1471-0366.2010.00275.x.

[65] "About," Open Source Seed Initiative, accessed January 7, 2021, https://osseeds.org/about/.

IPR will be discussed at length in chapter four and evaluated as an option to increase opportunities for breeders and farmers.

3.3 Types of Plant Breeders

Seed breeding is done by public and private parties. One of the ways seed breeding is sponsored publicly is through land grant universities (LGUs),[66] which have cultivated seeds since the Morrill Act of 1862, though their prominence is decreasing. The royalties collected from varieties patented through LGUs go back to sponsor the operations of those universities. The government also sponsors seed breeding conducted at LGUs and other research stations commissioned by the United States Department of Agriculture (USDA). The goal of new seed varieties developed by USDA sponsorship is to create value for the benefit of society rather than maximizing profit, and they are released via the ARS Office of Technology Transfer. New germplasm released by the USDA may or may not have any type of IPR associated with them.[67]

Private plant breeders include seed companies, freelance/independent breeders, farmer plant breeders, and non-government organizations (NGOs). Seed companies range dramatically in size, type of breeding, and style of operation. Depending on the type of seeds they produce and the capacity of their R&D department, they may patent seeds

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[66] LGUs are higher education institutions that received benefits from the Morrill Acts to develop the agricultural and mechanical fields.; Luby et al., "A Primer on Plant Breeding and Intellectual Property Rights in Organic Seed Systems."

[67] Luby et al., "A Primer on Plant Breeding and IPRs in Organic Seed Systems."

heavily with multiple types of IPRs or they may produce F1 hybrids while holding a trade secret over the parent lines.[68] Some seed companies are transnational biotech giants holding monopolies over a range of crops, and other seed companies forgo patenting entirely and focus on selling regionally-adapted heirloom seeds, or patent to the public domain using the OSSI Pledge.

Independent breeders tend to develop seeds that meet a need otherwise unmet by the institutional seed breeding industry. They often cater to farmers using organic, low-input methods which require continuous development given changing environmental conditions.[69] Freelance breeders either sell their novel varieties through a seed company, or they grow and sell crops from the varieties they develop. Freelance breeders usually release their varieties pledged to OSSI or as F1 hybrids with a trade secret. Farmer-breeders similarly are not associated with institutional R&D, but instead engage in R&D on their farms and are significantly less involved in the seed sales ecosystem than other types of developers. They either grow for their own use or partner with an independent breeder who then releases the variety informally on the farmer's behalf.[70]

NGOs are active in farmer-participatory plant breeding, domestically and internationally, developing seeds with the needs of farmers in mind. While NGOs have historically released their seeds without IPRs, they have been attempting different models

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[68] Luby et al.

[69] Luby et al.

[70] Luby et al.

to redistribute the benefits of community investment toward R&D.[71] The largest international NGO plant breeding initiative is the Consultative Group on International Agricultural Research (CGIAR), which holds a collective 14% of the world's plant genetic resources.[72]

Seed breeders have unique goals and strategies, and the major distinguishing factor between them comes down to the plant breeding methods the use. While organic produce must undergo a certification process involving rules about the uses of chemical inputs, the most important factor to bear for organic seed breeders is which methods of breeding are not permitted to be certified organic. This restriction of breeding methods is one that enforces integrity and ecological philosophy as part of the consideration for the organic label. By considering how scientific advancements interact with natural biological processes, breeders enter into a conversation and business strategy that moves beyond profit centralization.

3.4 Methods of Plant Breeding

To breed a plant ultimately means to steer its evolution toward a desired result, whether it be higher yield, agronomic efficiency, or a particular taste preference. IPRs over seed act to regulate competitors' access to germplasm which is a necessary raw

[71] Luby et al.

[72] Pat Mooney, "The Law of the Seed – Another Development and Plant Genetic Resources," *Dag Hammarskjöld Foundation*, no. 1983:1-2: 26, accessed January 7, 2021, https://www.scribd.com/document/125632361/MOONEY-Pat-Roy-The-Law-of-the-Seed-Another-Development-and-Plant-GeneticResources.

material for growing plants. New plants can be produced from seeds, or they can be transplanted by way of propagation, from cuttings of plants of tubers. The independent potential of plants to reproduce – and subsequently of humans to gain access to future resources for growing plants, presents an issue for the commodification of the industry. To overcome these barriers to privatization – which is necessary for the success of an ever-expanding capitalism economy[73] – two obstacles were introduced, one being scientific (hybridization) and the other, legislative (IPRs).[74]

While hybrids can be successful at producing some desirable agronomic characteristics, the increase in productivity is related more to the control of ownership and the marginal increase in short-term profit than it does to a long-term economic benefit. As Jack Kloppenburg explains, "The motivation behind hybrid research is less the prospect of realizing an enhanced yield than it is the prospect of achieving a more complete commodification of the seed."[75] Biotechnology furthers the agenda of privatization by creating pathways around the limitations of hybridization. Because hybrids can only be derived from few organisms and produce limited characteristics, biotechnological advancements further the attempt to protect corporate ownership rights.[76] One example of this goal to protect ownership is Monsanto's 'terminator gene' –

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[73] Wood, *The Origin of Capitalism: A Longer View*.

[74] Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology*, xvii.

[75] Kloppenburg, 242–43.

[76] R.C. Lewontin, "The Maturing of Capitalist Agriculture: Farmer as Proletarian," in *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, ed. Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel (New York, NY: Monthly Review Press, 2000), 100.

a technology that produces synthetically sterile seeds. While this technology raised mass resistance from consumers, farmers, and breeders, and was ultimately shelved,[77] this is only one potent example of how corporations attempt to circumvent foundational biological processes to increase their profit without taking responsibility for the mitigation of ecological risks.

Some plant breeders choose to sell F1 hybrids while holding a trade secret over the parent lines, making their reproducibility nearly impossible, though attempting to do so is legally allowed.[78] This is one reason why F1s are generally associated with trade secrets – their proprietary status is implicit in and protected by their genes. If a breeder does not know which inbred lines were used to create the F1 hybrid, they will not be able to recreate the same variety. F1 hybrids also are created in a way that does not allow for seed saving – not because of legal barriers, but because their inbred nature makes them unstable past the first generation.

Methods of plant breeding are especially critical in the distinction between organic and conventional crops. The 'conventional' versus 'organic' labels are determined to a large degree by the types of breeding methods used to produce a seed, aside from organic growing methods and other qualifications that need to be met to obtain an organic label. Organic production implies restrictions of certain breeding methods. The methods of breeding that are excluded from the organic label are

[77] Shiva, *Stolen Harvest: The Hijacking of the Global Food Supply*.

[78] Luby et al., "A Primer on Plant Breeding and IPRs in Organic Seed Systems."

determined by the National Organic Standards Board (NOSB). Excluded methods are defined as: "A variety of methods used to genetically modify organisms or influence their growth and development by means that are not possible under natural conditions or processes and are not considered compatible with organic production."[79] As of 2019, breeding methods excluded from organic production include: cell fusion, microencapsulation and macroencapsulation, and recombinant DNA technology (including gene deletion, gene doubling, introducing a foreign gene, and changing the positions of genes when achieved by recombinant DNA technology). Methods that the NOSB allows in organic breeding include: traditional breeding, conjugation, fermentation, hybridization, in vitro fertilization, or tissue culture.[80] New methods are continuously being evaluated by the Materials/GMO Subcommittee of the NOSB. Depending on the breeding method used, certain types of IPRs may be inapplicable to germplasm. For example, plant patents can only be used for asexually reproduced seed, excluding many methods used in organic breeding. Accordingly, the forms of IPRs that can be associated with organic production are not as strong, leaving unprotected seeds subject to piracy.

Furthermore, Kloppenburg (2004) highlights, more opportunities exist than ever before for breeding, because new technologies have made it possible to combine genetic material that is sexually incompatible (for instance, biotechnology has made it possible to

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[79] "MS Excluded Methods Proposal Fall 2019" (National Organic Standards Board, August 13, 2019), 2.

[80] "Materials/GMO Subcommittee Proposal," 2.

insert genes from animals into plant cells).[81] This type of breeding, which requires genetic engineering, falls into the category of excluded methods in organic production, further widening the gap of competitive opportunities between biotech firms and organic seed breeders. The increased opportunities for genetic engineering do not come with increased accountability in regard to biosafety. As the next section will showcase, social and environmental costs are left out of the conversation when patent rights are on the table, explicitly prioritizing patent holders' rights over biosafety and farmers' real property rights.

3.5 Case Study: Monsanto v. Schmeiser

This study will examine the reasoning and results of the Monsanto v. Schmeiser legal case to demonstrate the unequal power dynamics at play when IPRs are present in disputes regarding seeds. In this 2004 landmark case, Monsanto Canada Inc. sues Mr. Schmeiser, a Canadian farmer, for infringement of Monsanto's patent held over Roundup Ready canola – a genetically modified strain of canola that is resistant to the Roundup Ready herbicide.

The premise of the invention of Roundup Ready canola is that by controlling the environment (i.e., chemically eliminating living beings that engage in biological processes and perform ecosystem services), the technology delivers a more stable and higher yield of canola. Mr. Schmeiser did not purchase Roundup Ready canola seeds, but

[81] Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology*, 270.

they appeared on his property amongst other strains of canola that he was growing intentionally. Many neighboring farmers did buy and grow Roundup Ready, and while the court officially deemed that the origin of the seeds was unknown, their suspicion was that the wind brought Monsanto's seeds to Mr. Schmeiser's property.[82] The case established several precedents, including a hierarchical distinction between real property rights and IPRs and the unilateral treatment of biological patent disputes.

Insofar as IPRs reign over real property rights, as was upheld by the court in this case, patents carry the right to deconstruct ecosystems into independent elements – disposing of the complexity carried in the interconnected web of living organisms. Attempting to retain autonomous control of his farm, Mr. Schmeiser made the case that he should have the right to maintain the offspring of seeds that have appeared on his property, as would be the case with livestock.[83] However, the court ruled that this would be an infringement of Monsanto's patent and would therefore not be allowed. Because Mr. Schmeiser does not have control over neighboring land or the patterns of natural genetic migration, he is left exposed to the possibility of patent infringement without intent. Not only is he at risk of a hefty fine (in this case it was avoided because of the chosen settlement method and his lack of profit from the situation), having found Monsanto crops growing on 60% of his land, his operations reduced to 40% of his original effort and investment. Furthermore, if this had occurred on the land of an organic

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[82] Philippe Cullet, "Monsanto v Schmeiser: A Landmark Decision Concerning Farmer Liability and Transgenic Contamination," *Journal of Environmental Law* 17, no. 1 (2005): 102.

[83] Cullet, 104.

plant breeder, the rest of the seeds would be compromised due to the genetic drift that would disqualify the crops from being labeled organic.

> Since the definition of organic agriculture implies that there should be no genetically modified plants, contamination by genetically modified seeds would immediately disqualify the organic farmer from selling his/her crop as organic and would lead to a loss of earning since organic products fetch in general a higher price than non-organic ones.[84]

The judgement did not take this liability into account when settling the dispute. If this had indeed been a case against an organic plant breeder, their entire operation would likely have been invalidated, leading not only to losses during a given harvest, but a loss of long-term R&D investments into the evolution of their seed varieties, as many organic breeding methods take several uninterrupted years of replanting and selecting before entering the market and earning revenue.

Aside from the liability and implicit risk of genetic drift affecting non-licensing farmers and breeders, biotech corporations do not hold any responsibility for biosafety or the ecological effects on neighboring farms. As is illustrated in the Monsanto v. Schmeiser case, the costs incurred by non-patent holders are disregarded.

> The patent dispute looked exclusively at the question of whether Mr. Schmeiser had infringed a patent. The biosafety dispute would have also looked at the issue of whether Monsanto should be deemed responsible for introducing into the environment a transgenic construct which has the potential to self-replicate.[85]

[84] Cullet, 106.

[85] Cullet, 106.

A significant right that is granted to patent holders is the right to conduct field testing, which involves planting untested seeds and using experimental chemical compounds, without any requirements for a social or environmental impact analysis. This lack of regulation is extremely dangerous when it allows the release of genetically modified living organisms into open ecosystem because the effects are not reversible.[86] Once a new gene combination is introduced, is causes a ripple effect on its surroundings, destabilizing the established ecosystem. The ruling of the Monsanto v. Schmeiser case proved the superiority of patent law over farmers' real property rights or damages, and its ability to act as a scapegoat for biosafety concerns. In combatting such imbalances, adopting patent law through open source may open new doors for legal interpretations of rights. The potential of this approach remains uncertain until a precedent is set but presents exciting opportunities for combatting the exploitation of rights associated with exclusionary IPRs.

3.6 Conclusion

The dynamics of IPRs in the seed industry grant more power to one category of breeders than others and are significant to the proliferation of inequity and competitive barriers to entry. IPRs, though only one piece of the puzzle, uphold these competitive imbalances legislatively and create a gridlock against systemic change. Backed by financial advantages and exclusionary rights, biotech corporations gain control of land

[86] Shiva, *Monocultures of the Mind: Perspectives on Biodiversity and Biotechnology*, 107.

they do not even own, as exemplified in the Monsanto v. Schmeiser dispute, and facilitate the environmental changes they alone determine to be desirable (i.e., profitable).

Especially detrimental to organic farmers and breeders, IPRs cause societies to surrender third-party evaluation or consensus when it comes to altering the environment. When combined with the monopolistic nature of the industry, IPRs put the fate of evolution into the hands of a few profit-driven corporations with access to powerful technology and permission to disregard the associated risks. These risks are not overlooked by the rest of the seed industry, and attempts are being made on the grassroots level to mitigate the effects of mass germplasm privatization and monopolization. The Open Source Seed Initiative is doing this by using contract law to restrict privatization of germplasm. The following chapter will examine the potential of this movement to empower farmers and breeders that are committed to sustainable methods of agriculture, as well as challenges that need to be overcome, and potential solutions.

Chapter 4: An Open Source Approach to Sustainable Agriculture

4.1 Introduction

There are three primary approaches to combat the threats of a highly consolidated and privatized industrial agriculture system to farmers, breeders, and the environment. The first is the ongoing political campaign for farmers' rights. The second consists of direct bilateral agreements facilitated by NGOs and advocacy groups to provide support for indigenous communities or individual scientists where companies and governments have been neglectful. The final approach encompasses a variety of attempts to exploit the TRIPs Agreement by experimenting with forms of IPP that enforce collective access to plant genetic resources.[87] All three avenues pursue vital goals in the movement towards an equitable food system, but the one that offers the most disruptive and promising solution to biodiversity loss and the erosion of seed sovereignty is the attempt to use patent law in a creative way to strengthen the position of independent farmers and breeders while simultaneously protecting the genetic diversity and evolutionary opportunities of the earth.

[87] Jack Kloppenburg, "Seeds, Sovereignty, and the Vía Campesina: Plants, Property, and the Promise of Open Source Biology" (Workshop on Food Sovereignty: Theory, Praxis and Power, St. Andrews College, University of Saskatchewan, Saskatoon, Saskatchewan, 2008), 7.

While the first two methods – farmers' rights and direct bilateral agreements – offer defensive recourses against the injustices of the food system and the legal structure that upholds it, open source proposes something more. "Open source offers at least the prospect of a shift from continuous defensive actions to the creation of a positive, relatively autonomous space in which capital might be effectively prohibited – by its own rules – from trespassing."[88] By leveraging the framework of patent and contract law to create a 'protected commons,' OSSI interrupts the reach of TNCs into the plant genetic landscape and introduces a platform for open access to germplasm and improved seed varieties. While agents pursuing the first two methods continue their work, the dominant patent holders in the industry continue to expand their reach over germplasm.[89] The creation of an open access platform offers the opportunity to take action immediately rather than waiting for the consent of lawmakers in a potential future.

This chapter will examine the potential of OSSI to serve as a tool that expands opportunities for innovation through theoretical and technical comparisons to the intended IPR function of increasing innovation. The case study analysis of innovative capacities of exclusionary IPRs versus an open source platform is followed by an examinations of the inherent risks of using open source, as well as specific risks that OSSI faces given its evolving business model. The final section will examine the unique

[88] Kloppenburg, "Re-Purposing the Master's Tools," 1243.

[89] Kloppenburg, 1243.

opportunities that an open source approach brings to the seed industry and how it may benefit the pursuit of sustainable agriculture alternatives described in chapter two.

4.2 Case Study: OSSI as a Tool for Innovation

Created in 2011 by a group of concerned interdisciplinary stakeholders including breeders, farmers, NGOs, activists, academics, seed companies and policymakers,[90] OSSI is a nonprofit organization based in the United States whose mission is to maintain "fair and open access to plant genetic resources worldwide"[91] as a means of maintaining the existence of seed diversity for future generations. OSSI applies the legal framework of IPRs and contract law to protect seed varieties from being privatized by corporations or individuals. In stark contrast to most other types of IPRs, the conditions of the OSSI Pledge guarantee users' freedom to: save, replant, share, trade, or sell seed, conduct and share research about germplasm, and use germplasm in further breeding – disposing of any exclusionary aspect of intellectual property protection present throughout the existing patent law paradigm.[92]

As a potential contender of exclusionary IPRs in the commodification of seed, open source should be able to fill a similar gap in the industry. To evaluate the potential

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[90] Claire H. Luby and Irwin L. Goldman, "Freeing Crop Genetics through the Open Source Seed Initiative," *PLOS Biology* 14, no. 4 (April 19, 2016): 3, https://doi.org/10.1371/journal.pbio.1002441.

[91] "About."

[92] "About."

of open source in an industry dominated by IPRs, it is necessary to understand the effectiveness of both in performing the intended function of patent protections, that is, incentivizing innovation. As stated by the US Supreme Court, the primary purpose of patent law is the promotion of innovation, rather than the reward of individual effort."[93] This is done both by adding information to the public domain after the expiration of a patent and by providing an incentive to inventors – traditionally by granting monopoly rights and the associated financial premium over a resource for the duration of the patent.[94] This section will evaluate IPRs and OSSI's mechanism for their potential to stimulate innovation in the seed industry, followed by an elaboration of the risks and unique opportunities that come with the use of open source in the seed innovation landscape.

The effectiveness of IPRs in achieving these two conditions of innovation has been called into question. In reference to the first condition of innovation – the addition of material to the public domain – exclusionary IPRs over seed can accomplish the opposite effect. The quality of genetic resources that are released following a patent protection period may be lower than at the start of the patent date. The quality of the resource in this case refers to its capacity to adapt to new environmental conditions. Separated from the intended farming methods and potentially necessary complementary assets for the manifestation of enhanced benefits for which the patent was granted,

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[93] Lisa Mandrusiak, "Balancing Open Source Paradigms and Traditional Intellectual Property Models to Optimize Innovation," *Maine Law Review* 63, no. 1 (January 1, 2011): 307.

[94] Mandrusiak, 307.

patented seed varieties lose the advantages they held during the period of restriction. Alternately, in the most restrictive case of utility patenting which does not allow for any research or saving of seed and can be used to restrict individual genetic traits/plant characteristics,[95] the original seed variety that was transformed to create the patented seed (the parent line of the seed variety) may go entirely extinct by the end of the patent period. As discussed in chapter three, the patenting of living organisms implies an interruption of adaptation or total loss of seed varieties, depending on the patent type, due to their mortality. This example illustrates the potential losses to plant genetic resources following the release of seed varieties subject to traditional exclusionary IPRs back into the market.

Seed varieties that are OSSI-Pledged, however, do not incur the same losses because they do not undergo a period of separation from their environments or from other breeding projects that may be underway. OSSI-Pledged varieties can be used to pursue several innovative pathways at once without periods of restriction. When germplasm is pledged to OSSI, the public collection of genetic resources and the knowledge associated with their development and cultivation only grows. Unlike the transfer of monopoly rights during a traditional patent period, no resource is ever removed from the innovative landscape. In the area of adding material to the public domain, OSSI is significantly more capable than exclusionary IPRs.

[95] Claire H. Luby et al., "Enhancing Freedom to Operate for Plant Breeders and Farmers through Open Source Plant Breeding," *Crop Science* 55, no. 6 (2015): 2481–88, https://doi.org/10.2135/cropsci2014.10.0708.

In terms of OSSI's ability to provide incentives for innovation, the determining factor rests upon the potential return on breeders' R&D investments. Lisa Mandrusiak (2011) studies the case of the Science Commons, an organization working to promote innovation in the area of biotechnology, albeit not specifically plant biotechnology, by way of open access. She concludes that the Science Commons is not successful because despite contributing novel material to the public domain, it does not incentivize inventors with rights and associated benefits.[96] A similar concern transfers to the use of open source platforms in the seed industry. However, OSSI recognizes the need to provide incentives to breeders and allows for royalties to be attached to pledged seed varieties to help offset breeders' R&D costs. This option helps breeders retain a share of the benefits of their inventions while continuing to provide open access to germplasm for others who wish to use it for their own purposes and directions of inquiry.

Examining the effectiveness of traditional IPRs as mechanisms for incentivizing innovation from a different perspective, Lence et al. (2005) concluded through economic modeling that the level of innovation achieved by the industry via gene patenting falls below the optimal level of incentivization. Their analysis results in a confirmation of the hypothesis that seed firms typically experience an increase in benefits from increased levels of IPP. However, they conclude that the level of IPP used in the seed industry

[96] Mandrusiak, "Balancing Open Source Paradigms and Traditional Intellectual Property Models to Optimize Innovation," 305.

extends beyond the optimal point in considerations of welfare of consumers and producers and could be reduced to increase this level of welfare.[97]

Their results support a reduction of IPP if the goal is increased socio-economic welfare, despite leaving out several factors that would strengthen this conclusion. In this model, the welfare of the environment and the richness of plant biodiversity is disregarded. While they note that open-pollinated varieties do not reach the optimal level of IPP, this may change if the open-pollinated varieties become OSSI-Pledged. As Lence et al. note, hybrids carry a higher level of IPP than self-pollinated varieties, but while they may offer a higher incentive for innovation, the resulting product provides an intentionally lower yield in following years, negatively impacting the future welfare of farmers and consumers.

This model provides insights into incentivization of seed innovation but is skewed by the assumption that the financial premium to be received from an improved variety is the only determining factor in farmer and breeder decision-making processes. The same welfare considerations that are modeled hold the potential to be incentivizing forces in and of themselves for mission-driven actors. IPRs do provide adequate incentives for innovation for the portion of the industry which can afford the associated initial investment. Breeders pursuing methods that would be compatible with agroecology, however, do not tend to fall into this category. The incentives of exclusionary patents do

[97] Lence et al., "Welfare Impacts of Intellectual Property Protection in the Seed Industry," 967.

not provide equal opportunities and they stifle the diversity of innovation in the seed industry.

In the mainstream economics framework which underlies this type of modeling in which ‘optimal’ levels are determined using the analysis of cost-benefit analysis (CBA) – even in models where rate of time discounting is applied to account for future environmental costs – estimates are biased and increasingly sensitive with longer time frames.[98] The high level of uncertainty inherent to the seed industry amidst climate change makes mainstream models prone to errors in such calculations.

Furthermore, in decisions regarding which technologies or directions of innovation to adopt among a range of promising options, errors in projected outcomes committed at the beginning of a research process can lead to varying degrees of path dependence and lock-in, according to W. Brian Arthur’s (1989) observations.[99] To remediate these oversights of mainstream static analysis,

> A dynamic approach might also point up two new properties: *inflexibility* in that once an outcome (a dominant technology) begins to emerge it becomes progressively more ‘locked in’; and *non-ergodicity* in that historical ‘small events’ are not averaged away and ‘forgotten’ by the dynamics – they may decide the outcome.[100]

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[98] Robin Hanhel, Green Economics: Confronting the Ecological Crisis (New York, NY: Routledge, 2015), 20–21.

[99] W. Brian Arthur, “Competing Technologies, Increasing Returns, and Lock-In by Historical Events,” The Economic Journal 99, no. 394 (1989): 116–31, https://doi.org/10.2307/2234208.

[100] Arthur, 117.

Outcomes become locked-in not by their inherent superiority but due to two effects that follow initial adoption of a technology: the gradual improvement of technology through development, and the decreasing uncertainty about the performance of the technology which comes with additional trials.[101] Limiting applications of germplasm through patent-enforced research restrictions increases the risk of third-degree path dependence ("inherited inefficiencies that purportedly are, or were, remediable,"[102]) by cutting off the development of alternative pathways. A dynamic analysis, thus, might prudently alter the treatment of an 'optimal' level of IPP after considering the risks of path dependence, lock-in, and environmental uncertainty.

While open source must be evaluated bearing in mind the "tragedy of the commons" risk that may present opportunities for seed piracy through excessive public access, IPRs should be evaluated for preventing social benefits through excessive privatization. A professor at Michigan Law School, Michael Heller, coined the term "tragedy of the anticommons" to describe this phenomenon,[103] indicating the loss of opportunities for further downstream research blocked by patents. The prospect of divergent evolutionary pathways through the development of derivatives is greatly decreased or eliminated after germplasm is privatized. Excessive access and excessive

[101] Stan Liebowitz and Stephen Margolis, "Path Dependence, Lock-In, and History," *The Journal of Law, Economics, and Organization* 11 (April 1, 1995): 212–13, https://doi.org/10.1093/oxfordjournals.jleo.a036867.

[102] Liebowitz and Margolis, 224.

[103] Mandrusiak, "Balancing Open Source Paradigms and Traditional Intellectual Property Models to Optimize Innovation," 311.

restrictions both bear risk, but the latter is a short-cut to a dead-end of innovative and adaptive capacity.

4.3 Risks of Adopting Open Source

Open source has been instrumental in the development of innovative technologies in the software industry and was the inspiration behind the growing open source seed movement. Having preceded OSSI, lessons learned from the software industry allow a more effective development of an open source seed platform.

One of the risks of operating under an open source paradigm in an industry governed by exclusionary IPRs is that the companies that patent their products are still allowed to use open source materials in their research that they may later patent – restricting access to the original, 'freed' material. In anticipation of this threat, however, OSSI molded their platform in a way that prevents the risk of non-reciprocal use. Kloppenburg (2014) describes OSSI's product as a "mechanism for germplasm exchange that allows sharing among those who will reciprocally share, but excludes those who will not."[104] He describes this as the difference between an 'open-access commons', which he acknowledges as insufficient, and a 'protected commons.' This approach circumvents the inherent risk presented by companies who would take advantage of a public good which could be privatized after a small degree of transformation.

[104] Kloppenburg, "Re-Purposing the Master's Tools," 1237.

Having anticipated the threat of theft, OSSI included in their contract that restrictions over derivative products will be prohibited. “This feature – called ‘copy-left’ – is what distinguishes ‘open-source’ from mere ‘open-innovation.’”[105] This type of agreement binds genetic material including any future seed varieties that use the original material to non-exclusionary access. Anyone is free to use the OSSI-Pledged germplasm in any way except privatization or restriction of any kind, but any derivative produced from the material is automatically OSSI-Pledged, as well. This stipulation allows OSSI to curtail the threat of “free riders,” or those who would take advantage of open-source germplasm by privatizing its derivatives.

This viral nature of pledge transferring seems to present the additional risk of making such an agreement unattractive to seed developers. If a breeder cannot offset the cost of R&D involved in developing the new germplasm, they will not likely be interested in pledging all future derivatives of their material to OSSI, unless on entirely moral grounds. Aware of the need to incentivize inventors through financial premiums, OSSI does not deny the benefits of royalty-bearing contract options. OSSI remains in favor of maintaining a royalty-bearing license so that breeders may offset the R&D costs involved in producing new varieties – thus preventing breeders from defaulting to the use of hybridization or exclusionary IPRs.

While the royalty-bearing characteristic of OSSI resolves this issue, it presents yet another hesitation among potential allies. Some organizations resist supporting OSSI on

[105] Kloppenburg, 1238.

the basis that this makes it similar to other restrictive forms of IPRs.[106] However, in considering royalty-bearing licenses, OSSI seeks to financially reinforce breeders so that they may continue to afford in the development of new germplasm for the protected commons, not to introduce any unfair advantages into the market. The opposition to royalties may deter some organizations with similar goals but different methodologies. Nevertheless, while royalties remain available for pledged seed varieties, the incentivization aspect of innovation is fulfilled by OSSI and minority-share breeders' interests are protected.

Perhaps the greatest risk facing OSSI is that it has not been challenged in court, meaning that the validity of its contract is not certain. Until the OSSI Pledge is contested, and upheld, potential allies and breeders may be hesitant to join, and those seed varieties that have been pledged remain at risk of piracy without repercussions. As of June 2021, there are 415 OSSI-Pledged seed varieties – meaning that 415 varieties *and* their derivatives are banned from being privatized, in theory.

The overarching hope of the founding members of OSSI was to create a legally enforceable 'copy-left' contract, meaning that pledged seed varieties and all their derivatives would be legally required to remain accessible. The legal team at OSSI did make this kind of contract, and this was the product underlying the first iteration of the

[106] Kloppenburg, "Re-Purposing the Master's Tools."

OSSI business plan.[107] However, as the organization quickly discovered, this legally enforceable contract was deterring breeders and farmers because of the complexity of the agreement. The fear of litigation that comes with a standard license over a patented seed variety transferred over to this agreement that was meant to encourage free access and use of germplasm.

So, the OSSI team began exploring the idea of regarding the main purpose of the Pledge as more of a social mechanism than a legal tool.[108] Another aspect of the original contract that made its success – at least in the sense of achieving the viral aspect that would bind all derivatives of an OSSI-Pledged variety to the same restrictions of privatization – was the difficulty of transferring the contract itself along with seeds. This dense, seven-page legal agreement was not the elegant solution that would create a large-scale shift if it deters participants and makes the operations of those who use and/or sell seed more difficult.[109] While seemingly benign, the last part of the OSSI Pledge – to include the pledge itself with any transfer of the pledged seeds – has proven to be restrictive, prompting changes to the business model.

The continuing uncertainty about which approach to prioritize – a moral argument or a development methodology – to market OSSI creates uncertainty about securing allies going forward. Whether stakeholders will be drawn to OSSI depends on how closely they

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107 Luby et al., “Enhancing Freedom to Operate for Plant Breeders and Farmers through Open Source Plant Breeding,” 2486.

108 Kloppenburg, “Re-Purposing the Master’s Tools.”

109 Kloppenburg, 1240–41.

align with the chosen value proposition and OSSI's ability to communicate the applicable benefits. On one side, the organic community holds skepticism about using the same format of legal licensing to attribute a formal structure of property rights to seeds similar to others that have been so destructive to farmers and breeders.[110] Philosophical differences held by OSSI and the organic community surrounding biotechnology present an issue because their main potential allies lie in the organic sector.

Another sector of potential allies exists in public agencies, viewing OSSI through the lens of a development framework focused primarily on breeding projects at the intersection of independent breeders and public research organizations. Allies in government agencies are likely to be drawn to OSSI based on its access-building mission. The diffusion of knowledge and access facilitated by such resource-sharing structures increases the potential to stimulate public innovation, making it an attractive area for public investment.

Expanding upon the risk of unlicensed use for private and non-reciprocal benefit, it is also challenging to track the usage of OSSI-Pledged germplasm. Alluding back to the caveat of patent enforceability – that the patent holder is responsible for the costs of monitoring the usage of the patented germplasm and imposing the consequences of infringement – the difficulty of enforceability holds for open-source varieties as well. If the OSSI Pledge were to be recognized by the USPTO, then this would be simpler. If an application for a patent over germplasm contained OSSI-Pledged germplasm, easily

[110] Kloppenburg, 1227.

searchable by the same organization, then this issue could be resolved. There are potential solutions to this given the advancing state of data-driven technology. For example, Pat Mooney suggests an application of blockchain to track germplasm.[111] Not without its difficulties, this is an example of the type of technologically advanced strategy that could push organizations like OSSI to achieve tangible systemic change in the global agriculture and seed markets.

The challenges outlined in this section are reflective of OSSI's novelty and should not discount its disruptive potential. By addressing the issue at the root – the exclusionary privatization of germplasm that limits evolutionary pathways and opportunities for large segments of farmers and breeders – OSSI presents a revolutionary solution. As Kloppenburg poignantly explains, this strategy blocks capital from transgressing without breaching its rules.[112] This approach does not require a full-fledged political upheaval before it can intervene in the erosion of biodiversity loss and continued concentration of germplasm ownership.

4.4 Opportunities Unique to Open Source in the Seed Industry

Integrating the use of open source into the seed industry presents an opportunity to overcome the dangers of a highly concentrated market structure, not only for smaller competitors, but for the economic system at large. In viewing improved seed varieties

[111] Mooney, "Blocking the Chain: Industrial Food Chain Concentration, Big Data Platforms and Food Sovereignty Solutions."

[112] Kloppenburg, "Re-Purposing the Master's Tools," 1243.

through the lens of an IPR framework – as technological inventions – there is economic reason to protect their accessibility. In his analysis of technology's role in evolution, Mokyr explains, "technological change will be hampered in an economic environment in which firms cannot freely enter or exit an activity, or where they are constrained by traditions and institutions to a fixed share of the market."[113] A lack of innovative opportunities for breeders leads to a diminishing pool of evolutionary pathways. Open source, on the other hand, can be an expansive tool for innovation – one that allows further evolution to proliferate in the seed industry, securing divergent opportunities for an uncertain future. While technology uses resources, technological innovation is also capable of making new resources[114] – new resources being improved seed varieties, in this situation. By constricting the innovative capabilities of other breeders, firms that accumulate exclusionary patents block the discovery and development of new resources.

The protected elements of seed stewardship, namely the exchange of information linked to the research and development of seed varieties (i.e., conducting and sharing research), allows the knowledge base that has been developed alongside improved genetic resources to be maintained as well. Access to physical ownership is not the only asset that is lost in the privatization of genetic resources, but entire libraries of cultivated cultural wisdom that go into and accumulate throughout intergenerational breeding

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[113] Joel Mokyr, *The Lever of Riches: Technological Creativity and Economic Progress* (New York: Oxford University Press, 1990), 283, http://catdir.loc.gov/catdir/enhancements/fy0723/89028298-b.html.

[114] Thomas R. De Gregori, "Resources Are Not; They Become: An Institutional Theory," *Journal of Economic Issues* 21, no. 3 (1987): 1241–63.

processes. Creating a mechanism for the sharing of such information and granting access to interdisciplinary experts in addition to farmers and breeders, as OSSI is doing alongside their germplasm exchange mechanism, will be instrumental in the resource-building process required for adapting to climate change and other environmental disruptions. "Resilience is generally defined as the ability of ecosystems and communities to decrease their vulnerability to sudden shocks, and to generate – through relationships and processes – options for adaptive change."[115] Agriculture methods that follow agroecology principles improve the prospect of humanity's resilience, and the protected-commons approach to open source offered by OSSI supports opportunities for the adoption and continued success of agroecological methods of agriculture.

Agroecology principles can be applied to a variety of farming systems, and indeed explicitly values diversity of resources as well as socio-economic elements, including increased learning and interactions embedded in the agricultural system. Enabling seed sovereignty through open source will allow more farmers to continue or return to their role as breeders, as well. By enabling localized food systems, communities are able to make decisions best suited to their ecological and cultural needs when it comes to food and can learn from and respond to seed adaptation needs more rapidly. By protecting access to resources for seed breeding, OSSI helps to decentralize decisions-making

[115] Mary Hendrickson, Philip H. Howard, and Douglas Constance, "Power, Food and Agriculture: Implications for Farmers, Consumers and Communities," SSRN Scholarly Paper (Rochester, NY: Social Science Research Network, November 1, 2017), 9, https://doi.org/10.2139/ssrn.3066005.

processes throughout the industry which ultimately grants farmers operational autonomy to transition to agroecological methods should they so choose.

The goal of organizations and individuals involved in the open source seed movement is to reserve seed varieties for public use, protecting them from the reach of private corporations and carving out pathways toward food and seed sovereignty. Open source in the context of seeds carries many advantages. While encouraging innovation, open source also stimulates cooperation among participants. Furthermore, since the information leading to developments of new seed varieties is added to the public domain, experts from a variety of fields are welcome to conduct research using this growing resource base. When facing a complex issue like climate change, interdisciplinary approaches provide the most security and constructive creativity through the consideration of additional perspectives. Embracing a platform that allows for the development of diverse seed varieties, evolutionary pathways, and learning opportunities will reinforce the efforts of an agroecological approach to stabilize human living conditions amid environmental changes and contribute to an equitable, sovereign network of food production that retains its viability in the long term.

The transformation of the food system requires the synergistic strengthening of a supportive framework for agroecological farming, and the enabling of access to plant genetic resources. If seeds are left subject to privatization through exclusionary patent law or hybridization with no alternatives, the issues of biodiversity loss and maladaptation will not be resolved. Conversely, implementing open source into the seed innovation space will push efforts toward food and seed sovereignty to scalable and long-term sustainability.

4.4 Conclusion

Open source generates opportunities for deep transformation of the seed industry by reversing economic inequities and increasing opportunities for diversified innovation. The addition of improved seed varieties to the public domain without periods of restriction enables divergent evolutionary pathways to unfold and a resource base for the commons to expand. Open access to germplasm allows the seed industry to engage with a wider variety of research goals, leading to more adaptations of seed, thus reducing the risk of environmental disruptions to the global food system. Through experience and continued iteration of its business model and appropriation of patent law, OSSI may become the engine toward seed sovereignty that is needed to survive the threats of concentrated exclusionary rights over germplasm.

Chapter 5: Conclusion

Plant biodiversity and its potential to persist as a growing and evolving resource for the resilience of food systems must be protected given its principal role in the pursuit of sustainability. The underlying success of agroecological practices depends on continued access to diversely adapted plant genetic resources. The consolidated, privatized, and exclusionary agrichemical-seed industry which dominates today exacerbates the dangers for humans that are associated with climate change by diminishing access to germplasm and autonomous decision-making opportunities for farmers though input dependency and destructive farming practices. Moreover, the current level of restrictions over plant genetic resources decreases the capacity for continued economic vitality and progress within the area of seed innovation, dangerously constricting evolutionary pathways in the midst of unpredictable changes in climate conditions.

By reducing food and seed sovereignty through increased market dependency, ownership consolidation, and exclusionary IPRs, leading agrichemical-seed corporations maintain their oligopolistic control over the global food supply. Beyond the multifaceted socio-economic and environmental consequences of industrial agriculture for a breadth of stakeholders, excessive restrictions over plant genetic resources place the future of human populations in a more vulnerable position than what could be possible under a predominantly agroecological system. Exclusionary patent law precedents, as demonstrated in the Monsanto v. Schmeiser decision, support the rights of patent holders over farmers' property rights and biosafety considerations.

High costs associated with IPRs contribute to the imperative to extract short-term profit which they place on firms, binding patent holding corporations and the plant genetic resources in their legal possession to a specific set of financially driven goals. Disproportionately affecting organic breeders through excluded methods of production and subsequently decreased applicability of IPRs, the framework of traditional patent law keeps agroecological initiatives at a disadvantage to industrial agriculture methods. Exclusionary IPRs eliminate the potential for other research directions and developments of seed that might otherwise have led to beneficial inventions. By cutting off access to research opportunities, patent holding firms barricade the sustained evolution of plants used for food production, reinforcing market dependency and solidifying their position as the dominant suppliers of agricultural inputs.

The barrier presented by IPRs is not given due consideration in international policy despite the increasing focus on advancing sustainable agriculture alternatives to meet Sustainable Development Goals. Seed privatization through IPRs causes accumulated knowledge and potential creativity in seed breeding communities to disappear along with cultivated seed varieties, ultimately eroding both physical and intellectual resources. Restrictions that IPRs use to incentivize change are replaced with open access by OSSI to resolve these issues and facilitate a decentralized innovation process while building wealth for the commons and development opportunities for future generations. A restriction against germplasm privatization protects OSSI-Pledged seed varieties from piracy by corporations that would limit their access to other seed breeders and researchers. The implementation of open source in the seed industry, under the right conditions, can serve as an effective vehicle for empowering farmers and breeders to pursue agroecological practices and continue their contributions to the plant genetic resource base, ultimately benefitting ecosystems and society at large. A creative application of legal resources to technological innovation that builds open and protected access to seeds may well be humanity's saving grace in the face of impending ecological emergency.

Bibliography

Altieri, Miguel A. “Ecological Impacts of Industrial Agriculture and the Possibilities for Truly Sustainable Agriculture.” In *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, edited by Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel. New York, NY: Monthly Review Press, 2000.

Altieri, Miguel A., and Clara I. Nicholls. “Agroecology Scaling up for Food Sovereignty and Resiliency.” In *Sustainable Agriculture Reviews*, 1–29. Springer, 2012.

Arthur, W. Brian. “Competing Technologies, Increasing Returns, and Lock-In by Historical Events.” *The Economic Journal* 99, no. 394 (1989): 116–31. https://doi.org/10.2307/2234208.

Cullet, Philippe. “Monsanto v Schmeiser: A Landmark Decision Concerning Farmer Liability and Transgenic Contamination.” *Journal of Environmental Law* 17, no. 1 (2005): 83–108.

De Gregori, Thomas R. “Resources Are Not; They Become: An Institutional Theory.” *Journal of Economic Issues* 21, no. 3 (1987): 1241–63.

Deconinck, Koen. “Concentration in Seed and Biotech Markets: Extent, Causes, and Impacts.” *Annual Review of Resource Economics* 12, no. 1 (2020): 129–47. https://doi.org/10.1146/annurev-resource-102319-100751.

———. “New Evidence on Concentration in Seed Markets.” *Global Food Security* 23 (December 1, 2019): 135–38. https://doi.org/10.1016/j.gfs.2019.05.001.

FAO, ed. “Agroecology for Food Security and Nutrition Proceedings of the FAO International Symposium. 18-19 September 2014, Rome, Italy: Biodiversity & Ecosystem Services in Agricultural Production Systems.” Rome, Italy: FAO, 2015. http://www.fao.org/publications/card/en/c/d1f541b5-39b8-4992-b764-7bdfffb5c63f.

———. *The 10 Elements of Agroecology: Guiding the Transition to Sustainable Food and Agricultural Systems*. Rome, Italy: FAO, 2018. http://www.fao.org/documents/card/en/c/I9037EN/.

Fowler, Cary, and P. R. Mooney. *Shattering: Food, Politics, and the Loss of Genetic Diversity / Cary Fowler and Pat Mooney.* Tucson: University of Arizona Press, 1990.

“Free The Seed! Podcast.” Gypsy Queens. Accessed October 27, 2020. https://osseeds.org/free-the-seed-podcast-s2e1-gypsy-queens/.

Hanhel, Robin. *Green Economics: Confronting the Ecological Crisis*. New York, NY: Routledge, 2015.

Heffernan, William D. “Concentration of Ownership and Control in Agriculture.” In *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, edited by Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel. New York, NY: Monthly Review Press, 2000.

Hendrickson, Mary, Philip H. Howard, and Douglas Constance. “Power, Food and Agriculture: Implications for Farmers, Consumers and Communities.” SSRN

Scholarly Paper. Rochester, NY: Social Science Research Network, November 1, 2017. https://doi.org/10.2139/ssrn.3066005.

Hendrickson, Mary K., Philip H. Howard, Emily M. Miller, and Douglas H. Constance. "The Food System: Concentration and Its Impacts," November 19, 2020. https://farmactionalliance.org/wp-content/uploads/2021/05/Hendrickson-et-al.-2020.-Concentration-and-Its-Impacts_FINAL_Addended.pdf.

Hobsbawm, Eric. *Industry and Empire: The Birth of the Industrial Revolution*. 99th ed. Vol. 4. New York: The New Press, 1999.

Howard, Philip H. *Concentration and Power in the Food System: Who Controls What We Eat?* Bloomsbury Academic, 2016. https://doi.org/10.5040/9781474264365.

Hub, IISD's SDG Knowledge. "FAO Launches Initiative to Scale Up Agroecology in Support of the SDGs | News | SDG Knowledge Hub | IISD." Accessed June 7, 2021. https://sdg.iisd.org:443/news/fao-launches-initiative-to-scale-up-agroecology-in-support-of-the-sdgs/.

"Intellectual Property Rights (IPR) on Seed." Organic Seed Alliance, n.d. https://seedalliance.org/wp-content/uploads/2020/11/IPR-Table_Organic-Seed-Alliance_SPW_4.pdf.

Kloppenburg, Jack. *First the Seed: The Political Economy of Plant Biotechnology*. 2nd ed. Madison, Wisconsin: The University of Wisconsin Press, 2004.

———. "Impeding Dispossession, Enabling Repossession: Biological Open Source and the Recovery of Seed Sovereignty." *Journal of Agrarian Change* 10, no. 3 (2010): 367–88. https://doi.org/10.1111/j.1471-0366.2010.00275.x.

———. “Re-Purposing the Master’s Tools: The Open Source Seed Initiative and the Struggle for Seed Sovereignty.” *The Journal of Peasant Studies* 41, no. 6 (November 2, 2014): 1225–46. https://doi.org/10.1080/03066150.2013.875897.

———. “Seeds, Sovereignty, and the Vía Campesina: Plants, Property, and the Promise of Open Source Biology.” St. Andrews College, University of Saskatchewan, Saskatoon, Saskatchewan, 2008.

Lence, Sergio H., Dermot J. Hayes, Alan McCunn, Stephen Smith, and William S. Niebur. “Welfare Impacts of Intellectual Property Protection in the Seed Industry.” *American Journal of Agricultural Economics* 87, no. 4 (2005): 951–68. https://doi.org/10.1111/j.1467-8276.2005.00780.x.

Lewontin, R.C. “The Maturing of Capitalist Agriculture: Farmer as Proletarian.” In *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, edited by Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel. New York, NY: Monthly Review Press, 2000.

Liebowitz, Stan, and Stephen Margolis. “Path Dependence, Lock-In, and History.” *The Journal of Law, Economics, and Organization* 11 (April 1, 1995): 205–26. https://doi.org/10.1093/oxfordjournals.jleo.a036867.

Luby, Claire, Bryan Endres, Michelle Wander, and Carmen Ugarte. “A Primer on Plant Breeding and Intellectual Property Rights in Organic Seed Systems.” *EOrganic* (blog), April 17, 2019.

Luby, Claire H., and Irwin L. Goldman. "Freeing Crop Genetics through the Open Source Seed Initiative." *PLOS Biology* 14, no. 4 (April 19, 2016): e1002441. https://doi.org/10.1371/journal.pbio.1002441.

Luby, Claire H., Jack Kloppenburg, Thomas E. Michaels, and Irwin L. Goldman. "Enhancing Freedom to Operate for Plant Breeders and Farmers through Open Source Plant Breeding." *Crop Science* 55, no. 6 (2015): 2481–88. https://doi.org/10.2135/cropsci2014.10.0708.

Magdoff, Fred, John Bellamy Foster, and Frederick H. Buttel. "An Overview." In *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, edited by Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel. New York, NY: Monthly Review Press, 2000.

Mandrusiak, Lisa. "Balancing Open Source Paradigms and Traditional Intellectual Property Models to Optimize Innovation." *Maine Law Review* 63, no. 1 (January 1, 2011): 303–30.

McMichael, Philip. "Global Food Politics." In *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, edited by Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel. New York, NY: Monthly Review Press, 2000.

Middendorf, Gerad, Mike Skladany, Elizabeth Ransom, and Lawrence Busch. "New Agricultural Biotechnologies: The Struggle for Democratic Choice." In *Hungry for Profit: The Agribusiness Threat to Farmers, Food, and the Environment*, edited by Fred Magdoff, John Bellamy Foster, and Frederick H. Buttel. New York, NY: Monthly Review Press, 2000.

Mokyr, Joel. *The Lever of Riches: Technological Creativity and Economic Progress*. New York: Oxford University Press, 1990. http://catdir.loc.gov/catdir/enhancements/fy0723/89028298-b.html.

Mooney, Pat. "Blocking the Chain: Industrial Food Chain Concentration, Big Data Platforms and Food Sovereignty Solutions." ETC Group, July 2018.

———. "Protecting the Food Ark." *Rural Advancement Foundation International-USA* (blog), July 7, 2011. https://www.rafiusa.org/blog/protecting-the-food-ark/.

———. "The Law of the Seed – Another Development and Plant Genetic Resources." *Dag Hammarskjöld Foundation*, no. 1983:1-2. Accessed January 7, 2021. https://www.scribd.com/document/125632361/MOONEY-Pat-Roy-The-Law-of-the-Seed-Another-Development-and-Plant-GeneticResources.

"MS Excluded Methods Proposal Fall 2019." National Organic Standards Board, August 13, 2019.

Mumford, Lewis. *The City in History: Its Origins, Its Transformations, and Its Prospects.* 1st ed. New York: Harcourt, Brace & World., 1961.

Murphy, Sophia, and Karen Hansen-Kuhn. "Counting the Costs of Agricultural Dumping." The Institute for Agriculture and Trade Policy, June 2017.

Nicholls, Clara I., and Miguel A. Altieri. "Pathways for the Amplification of Agroecology." *Agroecology and Sustainable Food Systems* 42, no. 10 (November 26, 2018): 1170–93. https://doi.org/10.1080/21683565.2018.1499578.

Open Source Seed Initiative. “About.” Accessed January 7, 2021. https://osseeds.org/about/.

Polanyi, Karl. *The Great Transformation: The Political and Economic Origins of Our Time*. 2nd ed. Boston: Beacon Press, 2001.

Posner, Richard A. “Intellectual Property: The Law and Economics Approach.” *Journal of Economic Perspectives* 19, no. 2 (April 1, 2005): 57–73. https://doi.org/10.1257/0895330054048704.

“Seed Patent Growth Prompts Litigation and Licensing Fears.” *Managing Intellectual Property*, 2018.

Shiva, Vandana. *Earth Democracy: Justice, Sustainability, and Peace*. Berkeley, California: North Atlantic Books, 2015.

———. *Monocultures of the Mind: Perspectives on Biodiversity and Biotechnology*. New York, NY: Zed Books Ltd., 1993.

———. *Stolen Harvest: The Hijacking of the Global Food Supply*. Cambridge, MA: South End Press, 2000.

“UN Report: Nature’s Dangerous Decline ‘Unprecedented’; Species Extinction Rates ‘Accelerating’ – United Nations Sustainable Development,” May 6, 2019. https://www.un.org/sustainabledevelopment/blog/2019/05/nature-decline-unprecedented-report/.

Wood, Ellen Meiksins. *The Origin of Capitalism: A Longer View*. Brooklyn, NY: Verso, 2017.