SEEDS FROM PARADISE: THE RISE OF HAWAII'S SEED CORN INDUSTRY

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Abstract:

My thesis traces the emergence of Hawaii's seed corn industry (HSCI), an industry that consists of seed corporations conducting seed corn improvement. The second chapter follows the political economic development of corn and the emergence of contemporary seed corporations. The third chapter investigates the technoscientific development of commercial seed corn and Hawaii's evolving role in this process. The fourth chapter looks at structural advantages that led to the growth and expansion of HSCI operations. The fifth chapter examines HSCI's political ecology, focusing in particular on a statewide GM produce labeling bill and a Kaua'i County bill which targeted seed corn operations. In the conclusion I argue that the future viability of HSCI is threatened more by sociopolitical conflict than biological or economic limitations. HSCI lies at the nexus of a fascinating intersection of economic, scientific, biological, and sociopolitical trends and provides insights into both agro-food networks and scientific controversies.

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List of Abbreviations

Bt.....Bacillus thuringiensis

BST .....Bovine somatotrophine

CTAHR.....College of Tropical Agriculture and Human Resources

DHHL .....The Department of Hawaiian Home Lands

EIA.....Environmental Impact Assessment

EPA.....Environmental Protection Agency

FDA.....Food and Drug Administration

GM .....Genetically Modified

GMO .....Genetically Modified Organism

GUP.....General Use Pesticide

HCIA.....Hawai‘i Crop Improvement Association

HSCI .....Hawaii’s Seed Corn Industry

IAL.....Important Agricultural Lands

IRB.....Internal Review Board

NASS .....National Agricultural Statistics Service

R&D .....Research and Development

rBGH.....Recombinant-Bovine Growth Hormone

RUP.....Restricted Use Pesticide

TNCs.....Transnational Corporations

USDA.....United States Department of Agriculture

UHM .....University of Hawai‘i at Mānoa

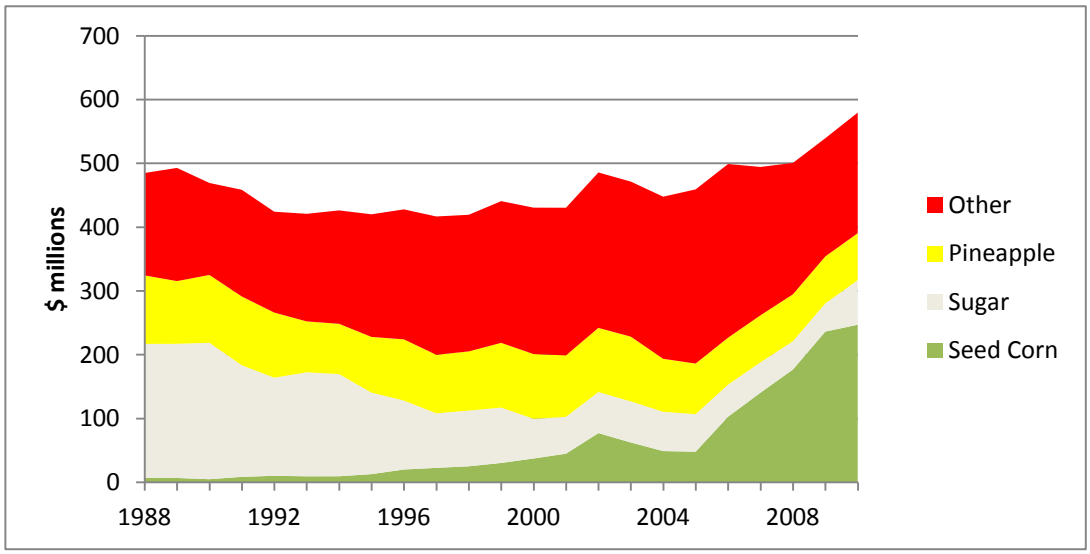
VEETC.....Volumetric Ethanol Excise Tax Credit

Chapter 1: An Introduction to Hawaii's Seed Corn Industry

1.1 Introduction

Seed corn grew to become the most valuable crop in Hawaiʻi, more valuable than sugar, pineapple, macadamia nuts, and coffee combined (Statistics of Hawaii Agriculture Multiple Years). Plantation production of sugar and pineapple steadily declined over the past quarter of a century. Hawaii's[1] seed corn[2] industry (HSCI) on the other hand increased dramatically since the mid-2000s to supplant sugar and pineapple as Hawaii's economically dominant agricultural industry. The chart below demonstrates these trends:

Figure 1.1 Value of Hawaiian Agricultural Industries 1988-2010 (unadjusted)



[1] I use the ʻokina in Hawaiʻi but omit it in the word "Hawaiian" and "Hawaii's." I conjugate Kauaʻi similarly, but I omit the ʻokina in Oʻahu and Molokaʻi.

[2] I use the term Hawaii's seed corn industry as opposed to Hawaii's seed crop industry because Hawaii's seed crop industry is almost exclusively corn. In 2011, seed corn accounted for 96% percent of Hawaii's seed crop industry (Hawaii Seed Crops 2011). Seed corporations grow crops other than corn, but corn is by far the most dominant crop. Consequently, I use the term Hawaii's seed corn industry to indicate that even though other crops are grown, corn is the main driver of the industry.

(Statistics of Hawaii Agriculture Multiple Years)

In 1988, HSCI had a value of $7.2 million which grew to $247[3] million in 2010, increasing from 1.5% of Hawaii's crop revenues to 42.6% (*ibid.*). Meanwhile, sugar and pineapple decreased by 54% from $317 million in 1988 to $143 million in 2010 (*ibid.*).

Unlike the commodity crops pineapple and sugar, seed corn is enmeshed within contemporary seed corporations' research and development (R&D) strategies. With the emergence of new regimes in seed production, determining the scale and size of these seed industries is challenging. For instance, seed industries could be evaluated in terms of acreage or in terms of economic investments in staff and infrastructure. Using the latter criteria, economic investments, HSCI represents the largest seed corn industry in the world. There is no precedent for HSCI, where crop improvement for multinational corporations becomes the economically dominant agricultural industry for a state within the US.

My research focuses on different aspects of HSCI, responding to the overarching research question: "*What factors affected HSCI's growth as Hawaii's other industrial agricultural industries decreased?"* The answer is at once simple and multi-layered. Unlike pineapple and sugar production, HSCI is highly profitable, but contextualizing that profitability requires an understanding of the economy of industrial corn and the particularities of contemporary seed corporations. HSCI also enlists actors, both human and non-human, which are particular to Hawai'i in the production of seed corn. Indeed, the first three chapters of my analysis are devoted to explaining the economic factors behind HSCI's growth, contextualizing how HSCI fits into seed corporations' broader R&D strategies, and identifying structural factors that led to the production of seed corn in Hawai'i.

[3] These numbers are not standardized for inflation.

In the fourth chapter of analysis, I examine HSCI as a highly visible and volatile site of political contestation. While I was conducting my research between 2011 and 2014, HSCI had significant media coverage including numerous front page stories in Hawaii's largest newspaper, the *Star-Advertiser*, and national coverage in *The New York Times*. These contestations are by far the most compelling aspect of HSCI for both the public and popular media as local opposition threatens the future viability of HSCI. I use the term "HSCI critics" to refer to people who are opposed to seed corn operations in Hawaiʻi and more generally to seed corporations.In the current climate, I am pessimistic about the potential for productive dialog or collaborations between HSCI and its critics.

The focal point of my analysis is seed corn operations that are located in Hawaiʻi. HSCI operates simultaneously on multiple scales as singular seed corn operations, a statewide industry, and a node in larger seed corporations. By categorizing HSCI as an industry, I draw attention to economic and material impacts that seed corn operations have on Hawaiʻi.

1.2 Research methodology

My central research question is "*What factors affected HSCI's growth as Hawaii's other industrial agricultural industries decreased?*" I broke this question into sub-questions listed below, and tried to answer them through persons and documents related to the industry. My data sources consist of interviews, public events, academic literature, and archival materials such as government and corporate reports. For primary data, I interviewed seventeen different informants. Our conversations ranged from casual conversations of fifteen minutes in length to recorded interviews of several hours. I received Institutional Review Board (IRB) approval from

the University of Hawaiʻi at Mānoa (UHM), and due to the controversial aspects of HSCI, I guaranteed all interviewees that I would not attribute any quote to them without first getting their approval. In order to honor the trust and time of those I interviewed, I strove to avoid creating any problems for them. Consequently, my analysis rarely cites primary ethnographic data although this data guided my research.

Guiding these interviews was a set of different working questions. The first working question examines the political economy of HSCI: "What is HSCI's role within industrial corn networks?" This question examines the history of corn as a commodity that is increasingly crucial to U.S. agro-industrial networks.

My second operative research question investigates the biophysical nexus of Hawaiʻi and seed corn: "What biophysical properties make Hawaiʻi and seed corn such a strong pairing?" To answer this question I examine the techno-scientific methods these corporations use to improve their varieties.

The third question situates HSCI within Hawaii's agricultural landscape: "How have shifts in Hawaii's agricultural land use and ag-related policies influenced the seed corn industry?" In answering this question, I contextualize HSCI within larger socioeconomic, land-use, and policy changes occurring throughout Hawaiʻi.

Below are the three working questions, examples of operational questions, and data sources:

Figure 1.2 Operational Questions and Data Sources

Working Questions	Tangible observation / questions	Source of Data
1) What is Hawaii's role within industrial corn networks?	• How did seed corporations reshape HSCI? • What caused Hawaii's seed corn industry to increase tenfold from $22.8 million in 1997 to $247 million in 2010? (more demand? Ethanol? Why so much more money on R&D?) • What do these increases in operating expense measure? (more employees, land, test plots, machinery?) • What R&D progress is made in Hawai‘i as opposed to mainland laboratories? (Just inbred line development or something more? What types of decisions are made here?) • How central is agricultural biotechnology to HI's seed corn industry?	Key informants • Seed corn executives • Seed corn scientists • Activists Archival materials • Newspapers • Legislative documents, testimonies, • Corporate docs • HCIA

2) What biophysical properties make Hawai‘i and seed corn such a strong pairing?	• What makes Hawai‘i preferable to other locations? • What makes Hawaii's seed crop industry almost exclusively corn? (If it's such a great place for seed crops then why not other crops too?) • How does the seed corn industry manage challenges presented by growing temperate corn in a tropical environment? • What technoscientific R&D is conducted in Hawai‘i on seed corn?	Key informants • Seed corn executives • Seed corn scientists • Seed corn integrated pest management

3) How have shifts in Hawaii's agricultural land use and ag-related policies influenced the seed corn industry?	• To what extent do vacated plantation lands factor into the seed corn industry's rise? • How does tax policy impact agricultural lands? • How did the high-tech tax credit impact the seed corn industry? • How do seed corporations fit into large land-owners' rent-seeking strategies? (liability, solid semi-permanent tenant, holding strategy until land can be developed) • Roughly how big is the seed corn industry? (critics: 40,000-60,000. NASS: 10,000. HCIA: 20,000.)	Key informants • Seed corn executives • Gov employees Archival materials • Audit reports • Newspapers • Legislative documents

My interviews were semi-structured as I usually had several questions or themes to cover with each interviewee. Many interviewees expressed an interest in reading my thesis, and I have tried to develop collaborative as opposed to extractive relationships with my interviewees (see for example Lassiter 2005).

I sought different information based on the expertise of the interviewee. For example, when speaking with HSCI proponents I focused on the logistics, science and economics of HSCI. When speaking with HSCI critics, I tried to understand their concerns regarding HSCI. When speaking with government employees, we discussed the evolution of public institutions and policies.

Many of my interviews involved people with power and this power dynamic created several challenges. Rice (2010) advises that when interviewing elites, one needs to keep in mind that these conversations represent a break from their typical work schedules and are an opportunity for them to reflect on larger issues. In my interviews, I introduced academic debates and also the research questions that were guiding my project.

I attended fourteen public events related to agriculture in Hawai‘i. The format of the public events included panel discussions, public hearings, workshops, conferences, festivals, and

protests. These events helped me understand the unique set of issues associated with HSCI. Videos posted on Youtube were also an excellent source of information. Both proponents and critics of HSCI have videos posted. These helped me understand their respective positions and observe several events that I could not attend in person. Videos such as the Public Broadcasting Service "Insights Hawaii" (2013) panel discussion of Genetically Modified Organisms (GMOs), for example, documented a public debate between leading HSCI proponents and critics.

1.3 Literature Review

Unlike other industries such as car manufacturing, the development of capitalist production in agriculture faced biophysical barriers that prevented the industrialization of agriculture (Mann and Dickinson 1978). A combination of technoscientific and economic innovations gradually eroded these biophysical barriers, enabling the use of industrial methods in agricultural production. Goodman, Sorj, and Wilkinson (1987) distinguish between appropriationism, which are innovations that enable the industrialization of agricultural inputs, and substitutionism, which are innovations that enable the industrialization of agricultural products. The introduction of tractors and synthetic fertilizers are examples of appropriationism while the refinement of high fructose corn syrup and corn ethanol for fuel are examples of substitutionism. Agricultural industrialization, rather than primarily benefiting farmers, creates lucrative and predictable revenues for industries that form around supplying agricultural inputs or processing agricultural commodities, industries that form around appropriationism and substitutionism.

Beginning with legislation passed by the Roosevelt Administration during the Great Depression, the US government began to craft policy that altered the dynamics of agricultural production. These laws were intended to safeguard the welfare of farmers, but over time transitioned to encourage farmers to increase their productivity. With an assurance regarding minimum price levels and increasing uses for select agricultural commodities, farmers began to focus on increasing productivity and adopted more industrial practices.

Industrial farming is premised on the idea that farmers who increase productivity will increase their profitability. Thompson (1995) labels this strategy for capital accumulation through increased yield "productionism." Producers who are successful under this framework produce vast quantities. For farmers, however, increased production can ironically undermine the demand for their products along with their profitability. Cochrane (2003) dubs this dynamic the "agricultural treadmill" as farmers produce so much that it decreases the value of their agricultural commodities. As the agricultural treadmill alters the production of grains such as corn and soybeans, farmers must rely further on advances in tractor, agrochemical, and seed technologies. As a result, larger farm operations benefit the most from the efficiency of a large-scale operation, and fewer farmers cultivated more land.

The introduction of GM crops by seed corporations deepens capital's penetration of agricultural production. Farmers are spending more money to cultivate multi-trait GM crops and treat them with agrochemicals. While these products make agricultural production less labor intensive and more predictable, much of the additional revenue is captured by seed corporations rather than farmers. HSCI is an agricultural industry that conducts R&D for seed corporations and seed corporations are further deepening appropriationism.

Kaup (2008) surveyed farmers in Minnesota and Wisconsin to determine their reasons for either adopting or abstaining from a type of GM corn called Bt (bacillus thuringiensis) corn which produces a toxin that kills corn borer. The most common reason farmers gave for using Bt corn was "to allow better insect control." The most common reason given for not using Bt corn was that the "price of Bt corn is too high." Kaup draws attention to how farmers navigate both expert and local knowledge and the pragmatic criteria they use to make decisions. Russell (2008) examines the use of GM cotton in New South Wales, Australia, concluding that GM crops are potentially beneficial and contingent on local contexts. For these farmers, GM crops are evaluated based primarily on economic rationales.

HSCI is a polarizing industry and strong group solidarity forms among both critics and proponents of HSCI. Schurman and Munro (2010) describe the different perspectives of seed corporations and anti-GM activists as different lifeworlds. The industry lifeworld focuses on science and the anti-GM lifeworld focuses on community and the envrionment. The use of the concept of lifeworlds draws attention the disparate truths and values held by these two groups and the difficulty in communication across a deep cultural divide.

The development of group unity through conflict can be understood through Georg Simmel's essay "Conflict as the Basis of Group Formation." Simmel (1955, 99) writes, "Conflict may not only heighten the concentration of an existing unit, radically eliminating all elements which might blur the distinctness of its boundaries against the enemy; it may also bring persons and groups together which have otherwise nothing to do with each other." Brubaker (2004) coins the term groupness to explain the way that the intensity of group affiliation fluctuates like

an event. The HSCI controversy increases the groupness of HSCI critics and advocates who both experience strong feelings of cohesion and same-group affiliation.

As opposed to approaching corn as an inert object that is acted on by humans, corn can also be considered an independent agent. Using this approach Warman (2003) and Pollan (2006) refer to corn as the "protagonist" and the "hero" of their respective stories. Agro-food network approaches such as Whatmore and Thorne (1997) stress the importance of the connections between different actors that are inherent to food production and consumption. Rather than being limited to living organisms that we typically consider actors, this approach encompasses the impact that plants, viruses, machines, and markets have on agricultural production. The concept of agro-food networks helps us make the connections between HSCI and broader agro-food networks. The demand for corn is not limited to food, although that is the most tangible way in which corn most people experience corn, and so agro-food networks is a concept that connects the broad web of uses for corn and the multitude of actors who are enlisted in its production and consumption.

Political ecology analysis draws attention to how access and control over the environment are negotiated (Robbins 2004). Political ecologists examine the interplay between humans, the environment, and the economy to elucidate processes surrounding natural resource management and production-consumption networks. Applying political ecology analysis to HSCI helps us evaluate how seed corporations were able to displace sugar and pineapple producers in Hawaii's agricultural landscape. Other types of agricultural, economic, and environmental potentials existed for the land that is currently in seed corn nurseries, but seed corporations had both the capital and the impetus to acquire that land.

In drawing attention to how access and control are negotiated, political ecology is also a useful prism for evaluating contestations regarding HSCI. As one of the most hotly debated issues throughout the state, HSCI is enmeshed in some of the classic tensions that confront political ecologists. Although industries can acquire land, nearby communities also have connections to that land and can mobilize if they perceive that those industries are adversely affecting them. On Kaua‘i in particular, HSCI is confronted by citizens who are deeply concerned about the adverse effects of agrochemicals and GM crops on human health and the environment. This conflict also spills into other related arenas such as the push for statewide GM food labeling laws. A political ecology approach focuses on analyzing the different mechanisms through which control over land, regulations, and labeling are enacted.

Chapter 2: Industrializing Corn

2.1 Introduction

To understand the market forces that created the conditions for the development of HSCI, we must first trace out the connections that make corn's little golden kernels indispensible to industrial agriculture. HSCI only emerged because corn is lucrative. In 1939, 2.3 billion bushels of corn were produced in the US at an average yield of 30 bushels per acre (NASS Multiple Years). [4] That was considered a decent harvest. A bumper harvest in 2009 produced 13.1 billion bushels of corn as farmers averaged 165 bushels per acre (*ibid.*). In 70 years, the average corn yield increased more than five times over.

This chapter traces the emergence of industrial corn through the interplay of agricultural innovations, corn farmers' increased productivity, state intervention, and downstream innovations in the uses for corn. I will review the development of hybrid varieties in the 1930s; government intervention to ensure minimum price levels for corn; innovations in downstream uses for corn; and the emergence of contemporary seed corporations that integrate seed improvement with GM trait and pesticide research. The immense capital flowing through industrial corn networks and seed corporations is the lifeblood that enabled the recent growth of HSCI.

[4] The USDA National Agricultural Statistics Service (NASS) statistics are represented this way because they cover a fiscal year. I cite multiple years because I cite NASS throughout the paper for different years, but it is from the source.

2.2 Development of hybrid corn

After the Civil War and until the introduction of hybrid corn, corn yields in the US were stagnant due in part to the biophysical limits of open-pollinated corn. Open-pollinated corn is easy to replant and genetically diverse. It also is difficult to selectively improve, non-uniform, and relatively unreceptive to fertilizer. Cronon (1991) describes how homestead farmers moved to the Great Plains in the 1840s and began converting prairies into farmland using steel plows which were newly introduced by John Deere. Agricultural commodities from the Great Plains were transferred through Chicago to meet demand in the eastern US and Europe. Transportation and storage infrastructure developed in Chicago along with emerging markets for agricultural commodities. In 1856, the Chicago Board of Trade set the standard for Number 2 corn which is still the main classification for commercial corn.[5]

The land grant universities and the United States Department of Agriculture (USDA) were founded by the US government in 1862 to help farmers adopt an economic approach to agriculture. The land grant extension service encouraged farmers to use basic accounting methods to measure and improve the profitability of their farms (Fitzgerald 2003). Extension agents also urged farmers to think of their farm as a business as opposed to a lifestyle (*ibid.*). Although farmers at first resisted advice from universities and government representatives, land grant universities and extension agents were gradually able to influence farmers' best practices. The governmental institutions supporting agricultural production and Number 2 corn certification created the preconditions needed for the widespread adoption of hybrid corn.

[5] To meet the standards of contemporary Number 2 corn, it must weigh at least 54 pounds per bushel, have less than 3% broken kernels and foreign material, and have less than 5% damaged kernels.

Hybrid corn was first adopted in Iowa where farmers tested it on small plots before planting hybrid corn on their entire farm. The land grant extension service provided an infrastructure for the dissemination of hybrid corn which rapidly displaced open-pollinated corn, increasing from under 10% of Iowa corn production in 1935 to over 90% of corn production in 1940 (Bogue 1983). After Iowa farmers adopted hybrid corn, it spread gradually out from Iowa to the rest of the Corn Belt and then beyond (Griliches 1960). Farmers preferred hybrid corn to open-pollinated corn because it was easier to selectively improve, more receptive to synthetic fertilizer, more uniform, and higher yielding. The seeds of hybrid corn lose their uniformity as well as hybrid vigor and consequently cannot be replanted by farmers without significant losses in yield. Kloppenburg (2004, 93) writes, "Hybridization thus uncouples seed as 'seed' from seed as 'grain' and thereby facilitates the transformation of seed from a use-value to an exchange-value."

Using hybrid corn caused farmers to adopt different agronomic practices. Goodman, Sorj, and Wilkinson (1987, 34) write, "All agro-industrial sectors, from farm machinery through chemicals to processing, were forced to adapt their growth strategies to incorporate the revolutionary opportunities created by hybrids and the new plant genetics." At the same time as hybrid corn was adopted, tractor and synthetic fertilizer use increased while the use of horses and mules decreased (Bogue 1983).

2.3 Rising corn production and government intervention

With the introduction of hybrid corn, production increased and corn farmers faced the threat of overproduction. In the midst of the Great Depression, the producer price of corn

bottomed out at 19 cents[6] per bushel during the winter of 1932-33 (NASS Multiple Years). The Great Depression also coincided with the Dust Bowl, where environmental stresses combined with farming methods that eroded topsoil, wreaked ecological and socioeconomic devastation. In response, the Roosevelt administration passed the Agricultural Adjustment Act of 1933 with the aim of curbing harmful farming methods and simultaneously encouraging farmers to continue production despite the depressed value of agricultural commodities. A system of price supports was instituted to encourage both conservation and to ensure a minimum value for select crops. The US government identified particular grains such as corn, soybeans, wheat, and rice for price support subsidies while other agricultural products such as perishable fruits and vegetables were excluded.

This act was the first US legislation to intervene directly in agricultural production. The act's central activities of

> production control, acreage allotment, commodity storage and minimum price programmes were accompanied by a broad array of new farm policy initiatives. These included emergency farm mortgage relief, the expansion of federal farm credit programmes, soil conservation, surplus food distribution, and support for rural electrification. (Goodman and Redclift 1991, 117)

These broad-ranging interventions demonstrated the federal government's active role in agricultural production. Large farmers were the biggest beneficiaries of this legislation because they received more subsidies from price support programs and could afford to place more land in conservation programs (Dixon and Hapke 2003). Despite the introduction of conservation and production control programs, overall yield continued to increase. With a minimum price support level in place, most farmers focused on increasing the yield of their subsidized crops.

[6] This figure is unadjusted for inflation.

The US government also helped create export markets for US agricultural commodities. In 1954, the US legislature passed an Agricultural Act which created the "Food for Peace" Public Law (PL) 480 program. This program turned to export markets as a release valve for excess agricultural commodities. The US government used surplus agricultural commodities as a form of food aid to further US geopolitical goals.[7] With corn enmeshed in the geopolitical aims of the US, farmers were exposed to the vicissitudes of US foreign policy most notably regarding the Soviet Union. Corn prices spiked when the US agreed to sell 30 million tons of corn to the Soviet Union in 1972 and was depressed by a grain embargo against the Soviet Union in 1980.

As corn production grew increasingly industrialized so too did other agricultural industries, and the number of full-time farmers in the US decreased rapidly. Between 1940 and 1970, the US farm population dropped from 23% of the US population to 5% (Lobao and Meyer 2001). The agricultural workforce similarly dropped from 8 million in 1950 to 3.2 million in 1970 (Warman 2003, 188). Price supports for farmers decreased throughout the 1950s and 1960s.[8] By the 1970s, the US government explicitly embraced the productivist model of agriculture. President Nixon's Secretary of Agriculture Earl Butz famously admonished farmers to "Plant fencerow to fencerow" and "Get big or get out."

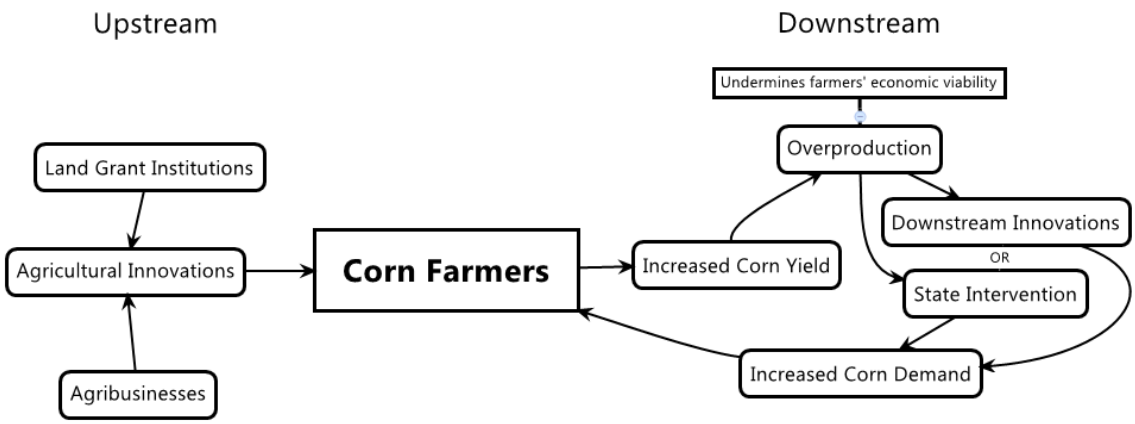
While the market dynamics and extension agents were encouraging farmers to increase investments in their operations, farmers were facing extremely trying economic conditions. Many farmers were facing "massive debts with reduced incomes. Whereas farm prices stood at 71 percent parity in 1979, by 1986 they had declined to 51 percent of parity, a lower level than

[7] Food aid in this form is often criticized for undermining local food producers (see for example De Janvry 1981; Bello 2009).
[8] For example, the farm Bill in 1954 requested "a gradual reduction of price supports to a range of 82.5-90 percent" and the Agricultural Act of 1958 reduced parity levels "to 65 percent by 1961" (Dixon and Hapke 2003, 149).

during the Great Depression" (Dixon and Hapke 2003, 162). Another factor contributing to farmers' woes was over-investment by farmers following the price spike in 1972 and low interest rates which were followed by a price collapse and high interest rates in the 1980s. The number of farm bankruptcies tripled between 1982 and 1986, and these trying times for farmers are often referred to as the "Farm Crisis" (Barlett 1993). With the rash of bankruptcies, the farms that remained in production grew increasingly large, and the barriers to entry into subsidized crop production became increasingly prohibitive. Most of the farmers who entered were either independently wealthy or had family connections.

The US government's policy since the 1933 Agricultural Adjustment Act continues to promote increasing US crop farmer yields. The dynamic is illustrated in the figure below:

Figure 2.1 Sustaining Corn Farmer's Increasing Productivity

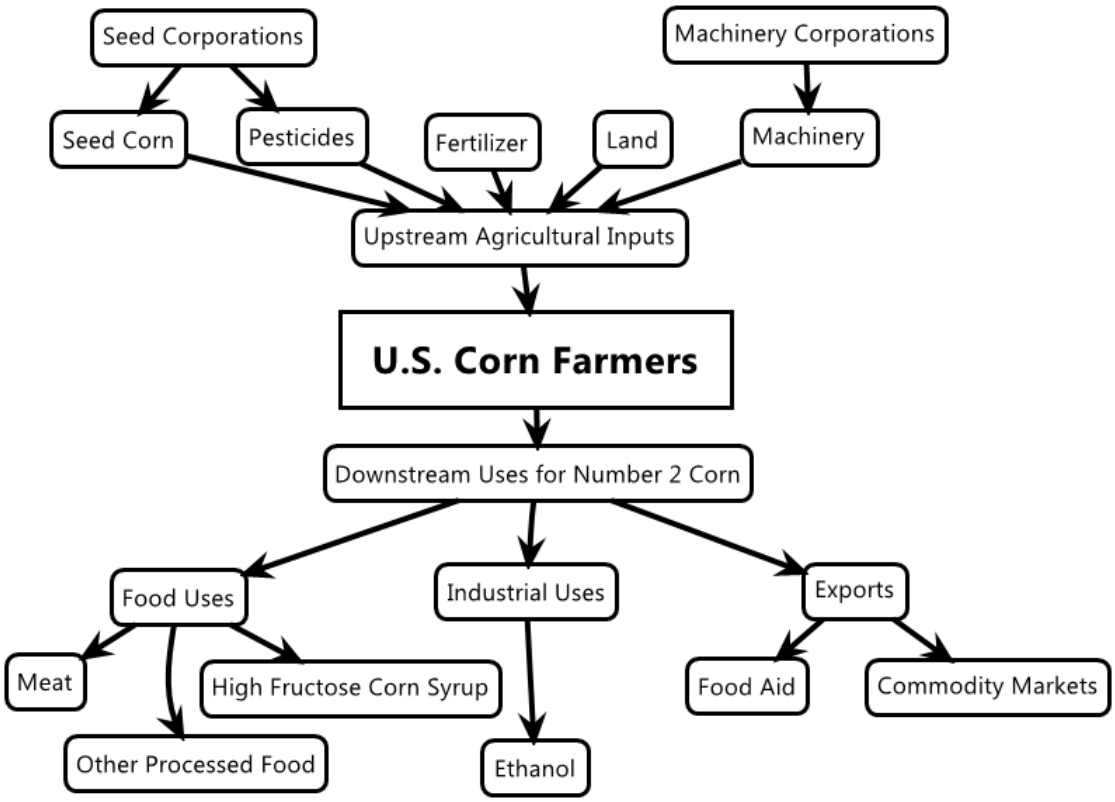


With the introduction of agricultural innovations, the yield of corn farmers increases. This leads to overproduction. Consequently, downstream innovations in combination with state intervention are needed to maintain demand in the face of increasing productivity.

2.4 Increasing downstream demand

Corn farmers are the crucial actors who use their labor and knowledge to transform agricultural inputs—land, seeds, machinery, fertilizer, agrochemicals, etc.—into Number 2 corn. Industries upstream and downstream of corn farmers continue to grow along with increased demand for industrial corn. Figure 2.2 below situates US corn farmers in relation to agricultural inputs and outputs:

Figure 2.2 Corn Farmers Within Industrial Corn Networks



Corn farmers purchase commercial seed corn from seed corporations, grow it, and then market the product as Number 2 corn.

The development of corn and soybean processing techniques for livestock feed coupled with innovations in livestock production contributed to the production of more meat at cheaper cost. Between 1940 and 1960, chicken production increased 12.5 times over from 140 million heads annually to 1.8 billion heads (Boyd and Watts 1997). The economic advantage of vertical integration and economies of scale also led to industrialization throughout the turkey, cattle, and hog industries (Hart 2003). Innovations in livestock production include the use of antibiotics, growth hormones, and animal confinement facilities which raised concerns about animal welfare (Goodman and Redclift 1991). Regardless, these innovations enabled the price of chicken to be cut almost in half "from 60 cents per lb in 1955-7 to 34 cents in 1976-8" (Goodman and Redclift 1991, 111).

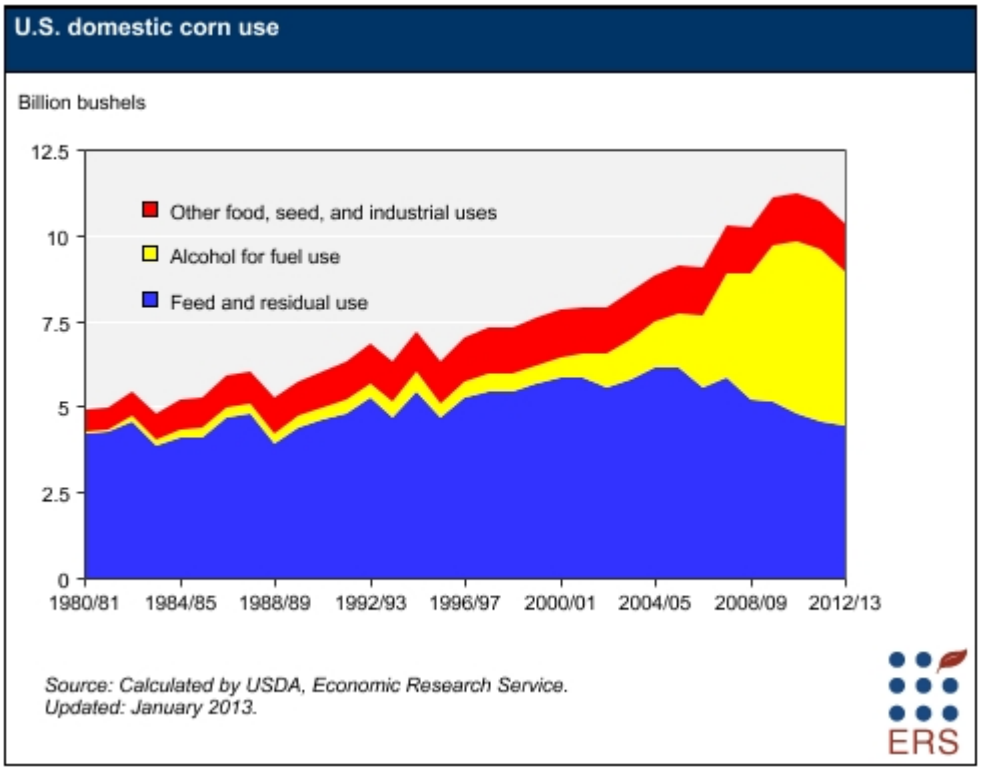
With a surfeit of cheap corn, entrepreneurs developed other downstream uses for corn. Goodman, Sorj, and Wilkinson (1987, 95) demonstrate that as early as the 1980's there was already a plethora of uses for Number 2 corn. For food uses, high fructose corn syrup is a ubiquitous sweetener which is refined from corn. In soda, for example, high fructose corn syrup is used instead of sugar.[9] Beginning in the 1970s, high fructose corn syrup gained popularity with food processers as an alternative to cane and sugar beet (Beghin and Jensen 2008). The average per capita annual consumption of high fructose corn syrup and corn sweeteners increased from 28.2 lbs in the 1970s to 132.3 lbs in the 1990s (*ibid.*, 482). Meanwhile cane and sugar beet consumption dropped over that same period from 96.0 lbs to 64.7 lbs.

Of all recent industrial uses for corn, the largest increase is in the demand for ethanol, which is a biofuel primarily used in automobiles. The US government's investment in corn-based

[9] Industrial food is often criticized for an over-reliance on processed corn products like high fructose corn syrup. Critics of industrial food claim that processed food with high sugar and salt contents contribute to health issues such as obesity and diabetes (see for example Pollan 2006).

ethanol was framed in terms of promoting energy dependence and slowing global warming. In addition to existing tariffs on ethanol imports, the US government introduced direct subsidies for ethanol producers in 2004 through a tax credit called the Volumetric Ethanol Excise Tax Credit (VEETC) (Baker Institute 2010, 19). This subsidy was originally set at $0.51/gal but was later decreased to $0.45/gal in 2008 before being scrapped altogether at the end of 2011 (Baker Institute 2010; Llanos 2011). The chart below shows a strong correlation between the implementation of VEETC tax credits and the increase in corn-based ethanol's share of US domestic corn use:

Figure 2.3 US Domestic Corn Use, 1980-2012

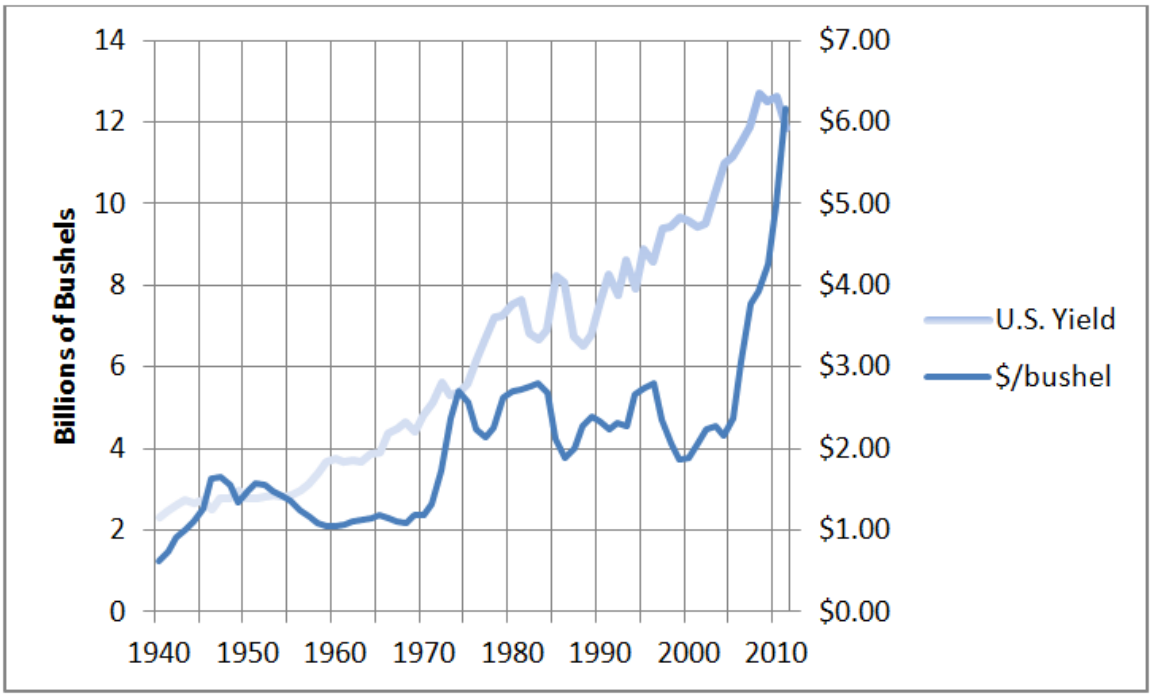


(USDA 2013)

Between 2002 and 2012, domestic corn use for ethanol production increased from 1 billion bushels to 4.5 billion bushels (USDA 2013). If ethanol is excluded, domestic use of corn actually decreased between 2002 and 2012 by over one billion bushels (*ibid.*).

While the amount of corn produced in the US steadily rose, the unadjusted price of corn was stagnant from 1975 to 2005. Beginning in 2005, the price of corn rose dramatically.

Figure 2.4 US Corn Production and Corn Bushel Value (unadjusted 1940-2011)



(Economic Research Service Multiple Years) [10]

As farmers faced the threat of overproduction, US state intervention and downstream innovations yet again combined to maintain the value of corn. The vast majority of ethanol is refined from

[10] I averaged each year with the preceding and following year. Substantial annual variation can otherwise obscure trends.

Number 2 corn, so corn is directed from food uses and toward fuel uses. McMichael (2009, 162) calls the linking of energy sources to food prices the "fuel-food complex."

2.5 Emergence of agricultural biotechnology and seed corporations

The growth of the seed corn industry is linked to downstream demand for corn that prompted corn farmers to produce more and more corn per acre on larger and larger farms. Iowa produces more corn than any other state, and between 1950 and 2000, the number of farms in Iowa halved as average farm size doubled and average corn yields increased threefold (Statistics of Iowa Agriculture Multiple Years).[11] In the Corn Belt, farmers use their labor and knowledge to transform agricultural inputs into commodity corn on a massive scale. With more corn being produced, huge industries formed around supplying agricultural inputs to corn farmers and processing commodity corn.

As early as the 1940s, emerging seed companies worked alongside land grant institutions in the development and marketing of commercial corn lines. Over time, seed companies gradually displaced land grant universities as the purveyors of hybrid seeds (Goodman, Sorj, and Wilkinson 1987; Lacy and Busch 1989; Goodman and Redclift 1991; Kloppenburg 2004). As seed corn research became more capital intensive, these emerging seed companies were better situated than public research institutions to make R&D investments in staff, infrastructure, and

[11] More specifically regarding the data for Iowa farms, the number of farms decreased from 206,000 farms in 1950 to 94,000 in 2000. Average farm size increased from an average of 169 acres per farm in 1950 in to an average of 346 acres per farm in 2000. Meanwhile, the average corn yield per acre increased from 48.5 bushels per acre in 1950 to 144 bushels per acre in 2000.

distribution networks. Seed corn companies also used mergers and acquisitions to acquire proprietary seed stock from their competitors.

As commercial seed corn R&D grew to operate within for-profit seed businesses, agricultural scientists at land grant universities shifted their focus towards the emerging field of agricultural biotechnology that combined molecular biology and crop improvement. University agricultural departments "sought access to prestigious federal grants (e.g., NSF, NIH) that supported molecular biology research" (Buttel 2005, 279). From a scientific perspective, the technology to study crops on a molecular level was just emerging in the late 1980s. In addition, legal developments caused molecular biology to become a potentially lucrative field of research.

Legislation and legal rulings created many opportunities for innovation and capitalization on improved crop varieties. The 1930 Plant Patent Act and the 1970 Plant Variety Act laid the foundation for patenting crop varieties (Haraway 1997, 88). The 1980 *Diamond v. Chakrabarty* US Supreme Court decision was a landmark case that radically expanded patent protections to allow for the patenting of DNA sequences or organisms into which those DNA sequences were inserted (*ibid.*). These rulings on biotechnology problematically extend private ownership over living organisms and facilitate what Haraway calls the corporate colonization of life (*ibid.*).

One corporation in particular, an agricultural chemical corporation from St. Louis called Monsanto, began aggressively pursuing agricultural biotechnology. Monsanto is a useful case study, because in the mid 1990s Monsanto was the first corporation to develop commercially viable GM crops. The two leading traits crops Monsanto introduced were Round-up Ready (glyphosate resistance) for soybeans and Bt (bacillus thuringiensis) for corn. Round-up Ready soybean seeds enabled farmers to spray their entire soybean field with Round-up, a herbicide

which killed all of the plants except for the Round-up Ready soybeans. Bt corn was engineered to produce a Bt toxin which is lethal to some of corn's most persistent pests, particularly corn borer. For both of these GM traits, Monsanto had successfully developed and patented a DNA sequence, but Monsanto could not produce commercially viable GM seeds on their own. Instead, Monsanto was dependent on legal mechanisms to ensure that they could continue to generate revenue from these GM traits. For instance, Monsanto explicitly prohibited farmers or seed businesses from reusing GM seeds or incorporating Monsanto's GM traits into other seeds. Monsanto also required that companies selling bags of Round-up Ready soybeans emblazon "Round-up® Ready" in big letters on seed bags (Charles 2001).

In the early 1990s, Monsanto entered into talks with Pioneer Hybrid, which had sought to pay a one-time fee for the permanent use of several of Monsanto's GM traits. The negotiations were protracted and Pioneer adeptly played Monsanto's pesticide division against the biotech division, suggesting that if more farmers grew Round-up Ready soybeans then Monsanto would profit because they would sell more Round-up[12] (Charles 2001). Monsanto eventually yielded by accepting $38.5 million to give Pioneer lifetime rights to sell Round-up Ready soybeans and Bt corn (Charles 2001, 120-121). At the time, the fact that Pioneer was willing to pay money for these traits was seen as a meaningful endorsement of Monsanto's biotech division (*ibid.*). By 1995, however, it was clear that Pioneer had got the better end of the deal as Pioneer figured to generate more than $100 million annually based on their agreement (*ibid.* 159). Monsanto basically gave away their best GM traits and belatedly realized that they gave these traits away to their biggest competitor.

[12] At the time, Monsanto also owned a patent on the glyphosate, more commonly known as Round-up, which expired in 2000. If Pioneer sold more Round-up Ready soybeans then Monsanto stood to generate additional profits since farmers would apply more Round-up.

After the Pioneer fiasco, Monsanto resolved to purchase seed companies so that they could integrate GM traits into their own proprietary germplasm (Schurman and Munro 2010, 48). In the late 1990s, Monsanto changed the seed crop industry by expending $6.5 billion in separate acquisitions to purchase Holden Seeds, DeKalb, Delta and Pine Land, and Cargill International. Monsanto was the first seed corporation to integrate traditional crop improvement, biotech research, and agrochemical research. Monsanto's competition was forced to adapt to this new corporate structure or be at a competitive disadvantage. In 1999, Pioneer was bought by DuPont for $9.4 billion, signaling a new era of crop breeding that is modeled after Monsanto. Today a handful of seed corporations—Monsanto, DuPont Pioneer, Syngenta, BASF, Dow Agroscience and Bayern—emerged to dominate the seed crop industry. With the exception of Bayern, these seed corporations have operations in Hawai'i and comprise HSCI.

The emergence of contemporary seed corporations is related to broader shifts in the global economy. Economic geographers identify transnational corporations (TNCs) as the main "movers and shakers of global economic change" (Peck and Yeung 2003, 7). TNCs operate simultaneously on multiple scales as global, national, regional, and local entities. Each of these scales provides a new set of challenges and opportunities. In some cases, there are clearly demarcated scales with distinct institutions, regulations, and leaders, but more often there is significant overlap.

Some of the TNCs participating in HSCI are conglomerates, which mean that the TNC orchestrates diverse subsidiaries under a broader corporate umbrella. Seed corporations[13] consist

[13] For a conglomerate TNC, the parent corporation would be situated above the agricultural subsidiary.

of a corporate headquarter which directs different divisions such as an agrochemical division, a seed improvement division, a GM trait division, and a sales division. Dicken (2010, 290) writes:

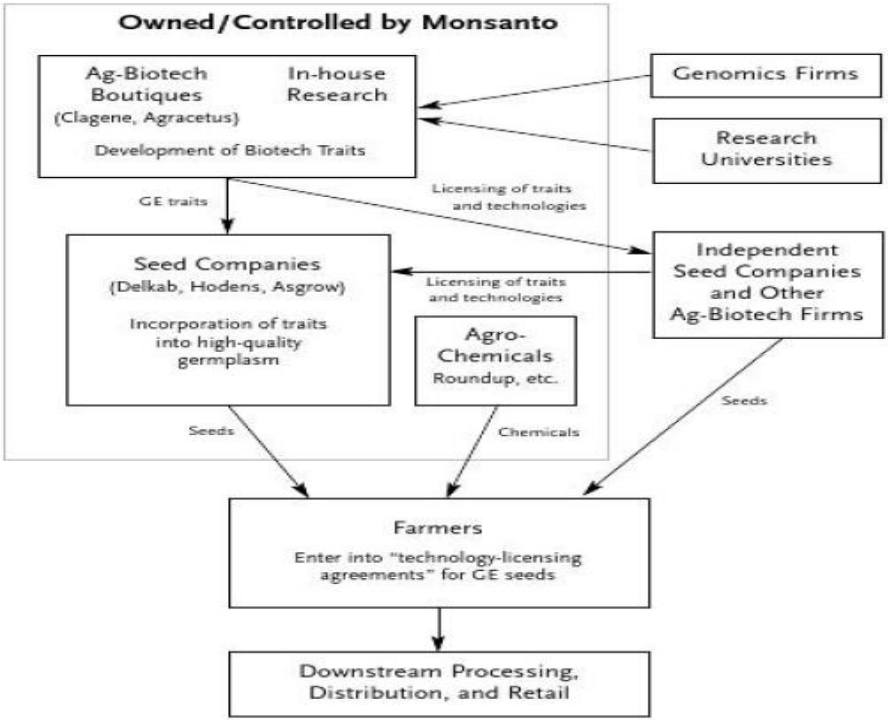
> [Agro-food industries] have been among the most takeover-intensive industries in recent years, as firms have striven not only to acquire a wider portfolio of brands (as well as drive out competition for their own existing brands) but also to extend their reach into new geographical markets.

For example, Pioneer is the agricultural subsidiary of DuPont and DuPont has other subsidiaries which develop and market pharmaceuticals, electronics, and industrial chemicals. Similarly, BASF and Dow Agrosciences have an agricultural division among their many subsidiaries. Monsanto and Syngenta, however, both focus exclusively on marketing agricultural inputs.

Since seed corporations combine proprietary seed stock with molecular biotechnology research, the capital and technical barriers to entry are extremely high. Seed corporations rely on vertical integration to organize the production of seeds and agrochemicals which they market to farmers. Vertical integration occurs when corporate headquarters coordinate multiple steps of the production process. Corporations seek to add value at each step in this process.

Seed corporations coordinate research on conventional crop breeding, GM traits, and pesticides—but each of these tasks are carried out by discrete R&D operations which are usually in different locations. The figure below depicts the corporate structure of seed corporations:

Figure 2.5 Ag-biotech firm structure (Monsanto), ca. 2002 (Boyd 2003, 29) [14]



Although conventional crop breeding, agricultural biotechnology, and agrochemical divisions may all be owned by the same corporation, their research priorities are strictly separated. The vast majority of HSCI operations fit into the box which Boyd calls "Seed Companies."

2.6 Genetically modified food enters the food chain

Monsanto received a favorable ruling from the US Food and Drug Administration (FDA) regarding GM crops in 1992. Not only did the FDA approve the introduction and human consumption of GM crops, but they also ruled that GM crops were substantially equivalent to non-GM crops (Sato 2007). This ruling meant that farmers could market GM corn as good old

[14] In the "Farmers" box, the term "GE seeds" refers to genetically engineered seeds. For the purposes of my study, "GE seeds" is synonymous with "GM seeds."

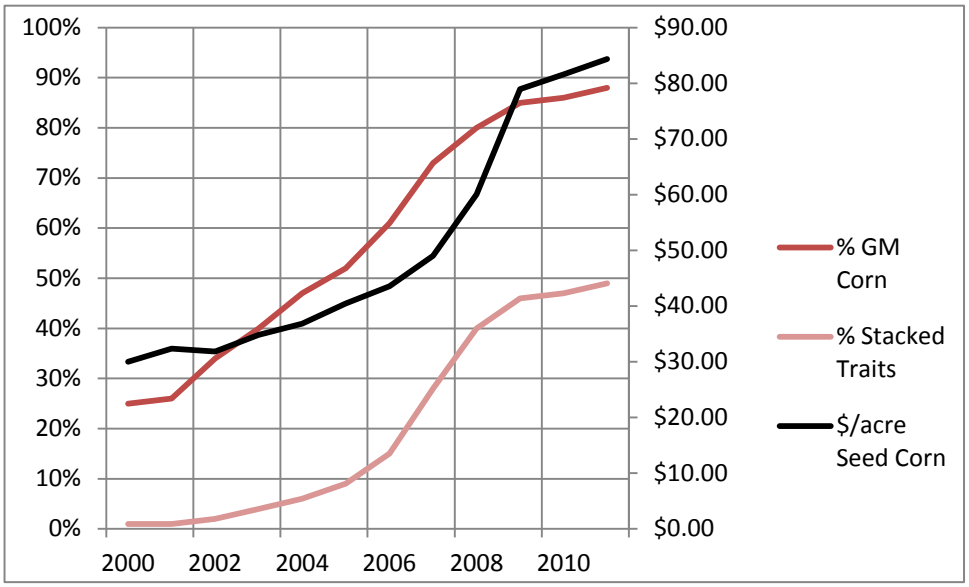
Number 2 corn. For consumers in the US, the FDA's ruling meant that GM crops were now ubiquitous in the food chain. Yet GM crops were also curiously invisible since consumers experienced no perceptible difference. The taste and labeling of food remained the same.

In Europe, however, there was a strong backlash against GM crops and food derived from GM crop ingredients. The outbreak of Mad Cow Disease in the United Kingdom in 1996 heightened concern about food safety and intensified the distrust of agro-food corporations and state regulations. In 1996 and 1997, the US exported GM soybeans and corn to the European Union (EU) which angered European consumers because food containing GM crops were unlabelled (Charles 2001; Schurman and Munro 2010). Criticisms of seed corporations then garnered international visibility during the November, 1999 protests against the World Trade Organization in Seattle (Schurman and Munro 2010). That same year, Monsanto was criticized for trying to use a "terminator gene" (Charles 2001).

In response to these various food safety and justice concerns, a sophisticated movement emerged in the EU to contest the introduction of GM crops and GM food. The anti-biotech movement successfully targeted several weaknesses in the commodity chain, particularly "food processors and retailers" (Schurman 2004, 253). The movement countered pro-GM advertisements by dismissing GM food as "Frankenfoods" and vilifying Monsanto as "Mutanto" and "Monsatan" (*ibid.*, 253). A key victory for the anti-biotech movement was when a supermarket chain in Britain called Iceland Foods decided to stop carrying GM food in March of 1998. By June of 1999, the anti-biotech movement culminated in changes to the EU regulatory framework and a "*de facto* moratorium on new crop approvals in Europe" (*ibid.*, 255).

Despite being barred from the EU, GM corn is still widely used by US corn farmers. By 2011, 88% of corn planted in the US was GM corn and more than half of all corn had multiple GM traits (NCGA 2012). In their economic calculations, farmers must first estimate the market value of corn and then whether the expected additional yield will generate more revenue than the cost of using GM corn.[15] The chart below shows how the cost of seed increased as farmers adopted GM seed corn:

Figure 2.6 US Average Seed Corn Price per Acre and GM Corn Adoption Rate



(Economic Research Service Multiple Years)[16]

Between 2001 and 2011 the average price paid by a farmer for corn seed increased 260% from $32 to $84 per acre (*ibid.*).[17] When seed corporations develop improved varieties of seed corn,

[15] A Purdue Agricultural News Report (Leer 2012) estimated that in 2013 corn farmers will spend from under $200 to up to $300 for a bag of 80,000 corn seeds. Farmers typically plant between 2.5 and 3 acres per bag. Although the price for corn seed was anticipated to grow between 5-7%, the expected return on an acre of corn was projected to increase by 24% to $560 for 2013.

[16] GM corn refers to all commercial seed corn which contains one GM trait or more. Stacked traits refer to all GM corn which contains two GM traits or more. Figures are not adjusted for inflation.

they explain the increased cost as a way of splitting the profits with farmers. As former Monsanto CEO Richard Mahoney succinctly put it: “You increase the productivity of the farmer; you keep half [the profits] and give him half” (Schurman and Munro 2010, xvii).

2.7 Conclusion

Although both the amount and value of corn produced over the past decade have increased dramatically, much of the wealth was captured by agribusinesses not farmers. Located at the nexus where agricultural inputs are transformed into agricultural commodities, corn farmers are vulnerable to both biophysical challenges posed by agricultural production and economic challenges posed by fluctuating markets and government policies. Farmers’ inputs and outputs are increasingly penetrated by capital and integrated into industrial production networks. Goodman, Sorj, and Wilkinson (1987) termed the piecemeal industrialization of farm inputs "appropriationism" and the industrialization of farm outputs "substitutionism."

Romanticized notions of farmers depict persons who are self-reliant and who produce bounty from the dirt. Corn yield per acre in the US is increasing, but this increased productivity is mostly due to technoscience innovations, and farmers must expend capital to utilize these innovations. Farmers calculate how much additional revenue they expect to generate if they adopt a given innovation and compare it to the cost of the new technology. Farmers face increasingly high costs of agricultural inputs in the form of land, fertilizer, seeds and other technoscience innovations.

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[17] Other factors influenced the increase in the price of seed corn such as the global financial crisis. This graph demonstrates, however, the rapid rate with which UM farmers are adopting single and multi-trait GM corn.

As the capital flowing through industrial corn networks increases, the ability of farmers to assert their priorities within these networks diminishes. Corn farmers' participation in industrial corn networks is abetted by government subsidies. Despite the vast number of actors in industrial corn networks, these networks link together particular places and actors. As the capital flowing through these networks increases, more and more places are drawn into both the production and consumption of industrial corn.

With the introduction of hybrid corn, seed corn became a crucial agricultural input and industries began to form around seed corn production. After seed businesses were purchased by chemical corporations, the newly formed seed corporations integrated conventional seed corn improvement with GM trait research and agrochemical research. The extensive scale of industrial corn and emergence of contemporary seed corporations created the conditions in which HSCI could rapidly grow.

Chapter 3: Improving Corn in Paradise

3.1 Introduction

Hawaii's seed corn industry (HSCI) first emerged in the late 1960s as seed businesses sought to accelerate their rate of seed corn improvement by using Hawaiʻi as a winter nursery. The first part of this chapter focuses on the origins of HSCI, the process of hybrid corn improvement, and HSCI's role as winter nursery between the late 1960s and the late 1990s. The second part examines the changes that happened after contemporary seed corporations increased investments in Hawaii. In addition to using GM traits, crop breeding was also revolutionized by the use of marker assisted selection (MAS), a technique which systematically analyzes crop DNA. By utilizing MAS and HSCI's year-round production capabilities, seed corporations collapsed the time needed to improve seed corn.

Measuring HSCI's contribution to seed corn improvement is difficult, because HSCI is integrated within broader seed corn R&D strategies. As I hope this chapter demonstrates, HSCI serves a very specific purpose for crop improvement, monitoring, and propagation. I spoke with ten HSCI insiders, and these interactions ranged from multiple recorded interviews to unrecorded farm tours or informal conversations over coffee. The goal of this chapter is to explain how HSCI fits into seed corporations' seed corn improvement strategies. HSCI seed corporations generally follow the same strategies for capital accumulation and seed corn improvement.

3.2 Origins of Hawaii's seed corn industry

Professor James Brewbaker from UHM's College of Tropical Agriculture and Human Resources (CTAHR) was a leading early advocate of Hawaii's potential for seed corn production. He anticipated the possibilities well before there was any commercial development. In 1961, Brewbaker first tested growing winter corn in Hawaiʻi on the island of Molokai and he later collaborated with corporate growers in 1966-67 (Brewbaker and Hamill 1967). In 1969 Brewbaker conveyed the favorable results of corn breeding in Hawaiʻi at a conference on the US mainland held by the American Seed Trade Association in Denver, Colorado.

Following his address in Colorado, Brewbaker helped found the "Hawaii Crop Improvement Association" (HCIA) in 1969-70. HCIA was originally established to help promote seed production throughout the state of Hawaiʻi. From 1969 onwards, HCIA sponsored an annual conference on seed crops in Hawaiʻi. The attendees at the early conferences included UHM CTAHR staff, plantation employees, mainland seedsmen, and Hawaiʻi politicians. The early HCIA conferences were in late January, so mainland seedsmen who were working in winter nurseries could attend at no additional travel expense.

In 1969 HSCI was a $500,000/year industry with 500 acres in production (Brewbaker 1969). There were small seed corn operations on Maui and Kauaʻi and no production on either Oahu or the Big Island. The majority of HSCI was concentrated in two operations on Molokai. One company called Molokai Seed Service was a contract grower on 140 acres for twelve different companies including Cargill. Another company, Hawaiian Research Service Inc. was supervised by Ronald Holden who inherited his father's company Holden Seeds in 1971 and would eventually sell it to Monsanto for one billion dollars.

3.3 The process of hybrid corn improvement

In order to explain the impetus for seed corn businesses relocating seed corn nurseries to Hawai‘i, I need first to explain the process through which corn reproduces and hybrid corn is created. Conventional seed corn improvement is constrained by the biophysical process of corn’s sexual reproduction. In the preceding chapter I briefly explained the difference between hybrid and open-pollinated corn. Here, I will elaborate further on those differences and how HSCI figures into seed corn R&D strategies. Corn reproduces when pollen from the tassel located on the top of the corn plant pollinates the silks that protrude from the husk of a corn cob. These pollen grains move up the silk and become kernels on the cob. The double-helix DNA in new kernels is formed by one DNA sequence from the silk combining with another DNA sequence from the pollen. When a kernel is planted and grows into an adult corn plant, the DNA will divide randomly into two new sequences for the silk and pollen of the plant.

Corn is naturally open-pollinated, meaning that corn plants reproduce with neighboring corn plants as pollen is randomly blown about by the wind. Open-pollinated corn is heterozygous which means that there are many differences between the two different strands of DNA, differences which vary between every singly kernel. Corn breeders operating in an open-pollinated setting select for the phenotype (physical appearance) of specific ears of corns. Yet the kernels from selected plants might contain pollen with undesirable traits, especially if those traits were recessive, because the characteristics of only one parent can be (partially) known or controlled. Individual farmers could mimic most of the selection processes used by corn breeders and freely save open-pollinated seed for subsequent plantings. Consequently, major seed corn businesses never formed around open-pollinated corn since there was little incentive for farmers

to continue purchasing open-pollinated seed corn as an annual input when they could replant corn harvested from their own fields the following year without too much difficulty.

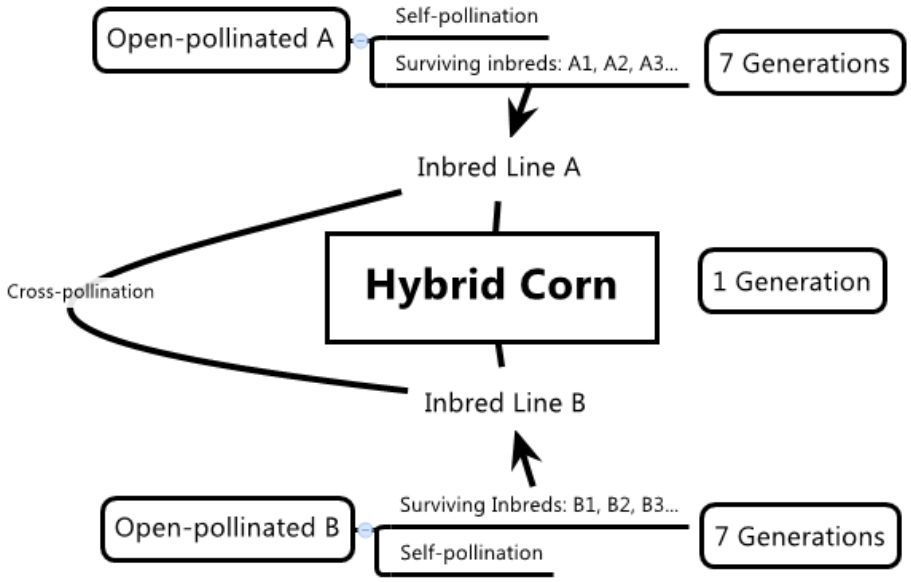
Hybrid corn, on the other hand, needs to be purchased as an annual input. Compared to open-pollinated corn, hybrid corn has three major benefits improved ability for varieties to be precisely bred; greater uniformity in crops grown from hybrid seeds; and increased corn yields due to hybrid vigor. Instead of allowing corn pollen to blow about and pollinate silks randomly, hybrid corn breeders control corn's sexual reproduction. The first step in the creation of hybrid corn is developing inbred lines through self-pollination. Breeders self-pollinate corn by gathering pollen from the tassel in a bag and then placing the bag of pollen over the silks of the same corn plant. Corn is self-pollinated for six or seven generations before it is considered homozygous or genetically uniform, meaning both strands of the corn plant's DNA are almost identical. During the self-pollination phase, the vigor of the plant decreases with each successive generation. As corn breeders refine new inbred lines, the vast majority of potential inbred lines are discontinued before they become fully homogeneous because its genetic load is revealed, displaying undesirable traits.

When breeders take pollen from one inbred line of corn and place it on the silks of a different inbred line, that offspring is called hybrid corn, which is genetically uniform and more robust than either of the parent lines. This robustness is due to hybrid vigor or heterosis, which is an increase in yield and crop vigor that occurs when two inbred lines are crossed. Naturally, some inbred lines combine better than others and so breeders must experiment with many different combinations of inbred lines to determine which create the best hybrid variety. As a general rule, more genetic variation between two inbred lines increases heterosis and leads to a

stronger hybrid. The progeny of hybrid corn lack both hybrid vigor and uniformity, because the distinctive qualities of each hybrid variety can only be created by cross-pollinating the two original self-pollinated inbred lines. This biophysical barrier makes farmers who plant hybrid corn dependent on purchases of seed corn as an annual input.

The figure below represents the process through which hybrid corn is created:

Figure 3.1 Hybrid Corn Development Process



[18]

Ideally, a new variety of hybrid corn can be refined in eight generations. In the Corn Belt, every generation takes a year, so it takes a minimum of eight years to develop an improved variety of hybrid corn. Another time-consuming process often used in hybrid corn development is backcrossing (discussed later), where a single desirable trait such as disease resistance is incorporated into an inbred line for use in a commercial hybrid variety. Backcrossing also takes approximately eight generations to complete.

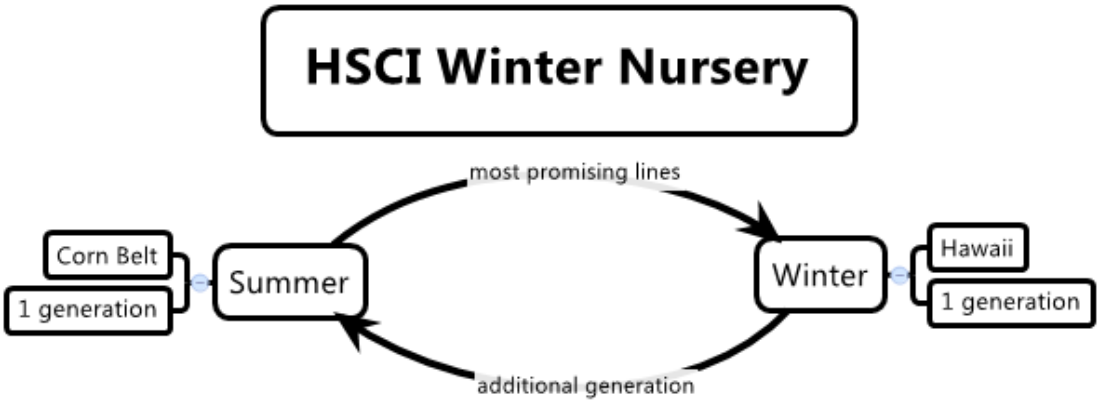
[18] The estimate of the number of generations needed to develop an inbred line varies from 5-7 generations.

Desirable traits for corn are wide ranging and include standability (ability to stay upright), dry down (ability to have the desired moisture content), drought resistance, disease resistance, and pest resistance. The characteristic which crop breeders cultivate above all others is yield, because this is the trait from which farmers generate their income. Still, there are many different factors which influence corn yield and so there seems to be endless room for improving hybrid corn especially with the huge diversity of corn germplasm with which corn breeders can experiment.

3.4 Hawaii's seed corn industry as a winter nursery

From the late 1960s until the mid 1990s, Hawaiʻi was primarily used as a winter nursery, providing an additional growth cycle during the winter and speeding up the process of hybrid corn production (Brewbaker 2003). The figure below depicts the role of HSCI's winter nursery:

Figure 3.2 HSCI Winter Nursery



Since it takes about eight generations to develop a new variety of hybrid corn or incorporate a desirable trait into an inbred variety, the time required for corn's sexual reproduction hinders rapid seed corn improvement. Crop breeders brought their most promising lines to Hawai‘i during the winter so they could produce two generations annually. Although Hawaii's climate helped increase the speed of crop development, the R&D conducted in HSCI's winter nurseries was basically crop propagation. Crops were typically planted, self-pollinated and then shipped back to the mainland.

An annual trip to Hawai‘i must have been a welcome reprieve for seedsmen who were arriving from the sub-freezing Midwest. A company from Carmel, Indiana created a flyer (Appendix #1) to promote a research trip and vacation to Hawai‘i in 1971. The flyer includes idyllic images of a tropical vacation. Seed businesses trying to hire top-notch US crop breeders to work for them can lure employees to work for them with the prospect of working in Hawai‘i. The paradise image contributed to the formation of the industry and facilitated connections between mainland growers and Hawai‘i that continue today.

3.5 Year-round seed corn and agricultural biotechnology

The introduction of commercially viable GM crop traits was soon followed by the emergence of contemporary seed corporations. Both the new agricultural biotechnology and the restructuring of seed supply directly impacted HSCI. I begin this section by explaining the development of agricultural biotechnology. Then I turn to how HSCI expanded along with contemporary seed corporations.

While the term biotechnology is broad, I use the terms agricultural biotechnology, biotech, and GM in reference to specific technoscientific innovations which were first commercialized in the mid 1990s. GM traits consist of altering the DNA of a crop by directly inserting a particular DNA sequence into the crop's DNA. While the development of hybrid strains entails controlling genetic characteristics of corn seeds, it is the direct modification of the DNA sequence that distinguishes GM corn from conventional corn. The first GM corn variety was created in 1986, by inserting the desired genes directly into cultures of corn tissue with a "gene gun" that was developed by John Sanford at Cornell University (Charles 2001). GM traits can also be inserted through a vector, which is where a carrier such as a bacterium is used to modify corn DNA and insert a desired genetic sequence (Thompson 2011).

Initially, many crop breeders were skeptical that adding or altering a single gene could have a large impact on crop productivity. The prevailing thinking was that successful high quality commercial seed required thousands of desirable genetic sequences to align. However, when inserted into high quality commercial seed, a single GM trait can make a significant impact. For example, crop scientists were unsure how much corn yield was lost to corn borers until Bt corn was introduced and yields immediately increased (Charles 2001).

Although seed corporations continue to invest significant resources in GM trait research, the initial herbicide resistant and pest resistant commercial products remain the blueprint for future GM traits. Farmers who purchase these GM traits instead of (or together with) other agricultural inputs (such as herbicides) can directly estimate the cost-effectiveness of that decision based on changes in their yield and the costs of their inputs. Most of the new traits such

as Round-up® Ready 2 or new kinds of Bt corn are improvements on older technology.[19] The second wave of GM traits currently being developed focus on enhanced nutritional benefits and resilience to ecological stresses such as drought.

New GM traits can be patented for twenty years, but the cost of developing a new trait is high. Consequently, GM trait research is heavily influenced by the cost and the commercial promise of a new trait. A report by Phillips McDougal (2011) estimated that it costs an average of $136 million[20] to develop a new trait, $35 million of which goes to regulatory expenses. Seed corporations are exploring the use of GM technologies to enhance corn's drought resistance, nutritional content, and ability to fix nitrogen. Currently several seed corporations have introduced drought resistant GM corn but increased nutritional content and nitrogen fixing traits are still highly speculative.

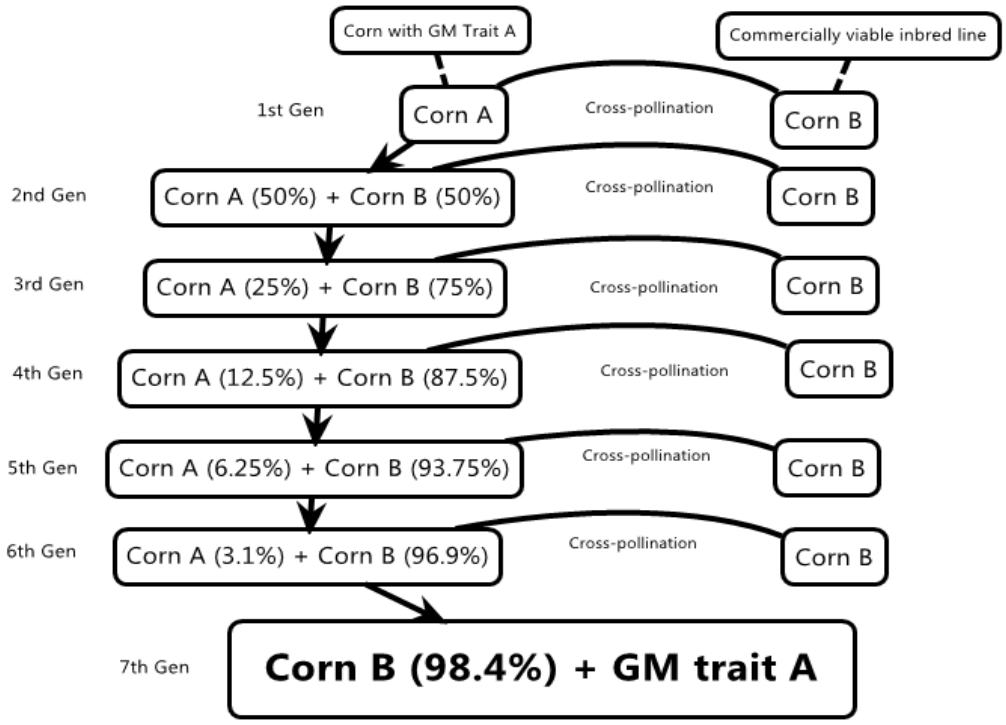
GM traits are initially developed outside of Hawaiʻi by seed corporations' biotech divisions as well as outside researchers (see Figure 2.5). Biotech scientists in mainland laboratories will insert a new GM trait into a corn plant. Once a trait is favorably fixed in a corn plant, the biotech division sends the corn plant with the newly minted GM trait to a seed corn nursery such as HSCI. In seed corn nurseries, crop breeders use a crop improvement method called backcrossing to transfer select traits from one variety of corn to another. Backcrossing works for both GM and conventional traits.

[19] Patents on GM traits are good for twenty years, and Monsanto's patent on Roundup Ready soybeans is set to expire in 2014, which could significantly decrease the cost of Roundup soybeans (Pollack 2009). As patents on the first wave of GM crops are set to expire, there may be a democratization of access to GM crops.

[20] The average cost had a standard deviation of $85.6 million so the $136 million figure is not definitive. This is the only publically available report that attempts to document the cost of developing a new trait and all major seed corporations responded to the survey. This report is also useful because it breaks the expenses down into different categories.

Backcrossing begins with a corn variety which contains the desirable trait “Corn A” and another variety “Corn B” to which the crop breeder intends to transfer Corn A’s desirable trait. The crop breeder begins by crossing Corn A with Corn B. The offspring's DNA is half Corn A and half Corn B. The crop breeder then selects for the offspring which express the desirable trait from Corn A and then crosses it again with Corn B. This process is repeated for multiple generations and with each generation more of Corn B is recovered. After seven or eight generations, Corn B's DNA is almost entirely recovered with the exception of the desirable trait from Corn A. Below is a diagram of the backcrossing process, which depicts a GM trait being incorporated from Corn A into Corn B:

Figure 3.3 Introgression of a Trait Using Backcrossing



[21]

[21] The percentages next to “Corn A” and “Corn B” represent the percent of the parent variety present in each generation under ideal conditions. For HSCI, the minimum standard is to recover 95% of the desired parent.

For crop breeders, backcrossing is a straightforward process, but it takes many generations.

A second technique called marker assisted selection (MAS) further increased the speed with which new varieties are developed. MAS involves the use of DNA markers in plant breeding (Collard and Mackill 2008, 557). The identification of DNA sections of interest enables crop breeders to make decisions based on a plant variety's DNA instead of its physical appearance, on genotype instead of on phenotype. Identifying which DNA sections are linked to specific traits and the significance of those markers relies on R&D teams working on the Marker Development Pipeline (Collard and Mackill 2008). In seed corn development, these pipelines are a systematic process through which favorable genetic sequences are identified and mapped onto the corn genome.

For seed corporations, increasing the number of markers and better understanding existing markers improves the rate and efficiency of seed corn improvement. The location of MAS labs varies based on the seed corporation, but there are MAS labs in Hawai‘i, the continental US, and various locations around the world. These MAS labs use automated processes to analyze key segments of the corn plant's DNA. Large seed corporations use MAS to process millions of samples in a year, creating billions of data points.

The most profound impact of MAS is that crop breeders are able to make most of their decisions using spreadsheets of data instead of observations in the field. While previously corn breeders needed to examine a plant's physical characteristics after germination, contemporary corn breeders can analyze genotypic data to determine which kernels to select and plant. MAS allows plant breeders to refine new varieties more quickly and with more accuracy.

Taking Figure 3.3 as an example, the crop breeder can move a trait from Corn A onto Corn B more quickly. The conventional backcrossing procedure recovers on average half of the desired parent after each generation. While the 3rd generation population is made up of 25% Plant A's DNA and 75% Plant B's DNA, there is significant variation within the population. Some plants may contain more of Plant B and vice versa. MAS enables crop breeders to select for plants which express the most of Plant B's DNA while still retaining the GM trait from Plant A. By using MAS, crop breeders can now incorporate new traits in three generations instead of eight[22] (see Figure 3.3). MAS can also accelerate the rate of inbred line development, because crop breeders can ensure that desired DNA sequences are present.

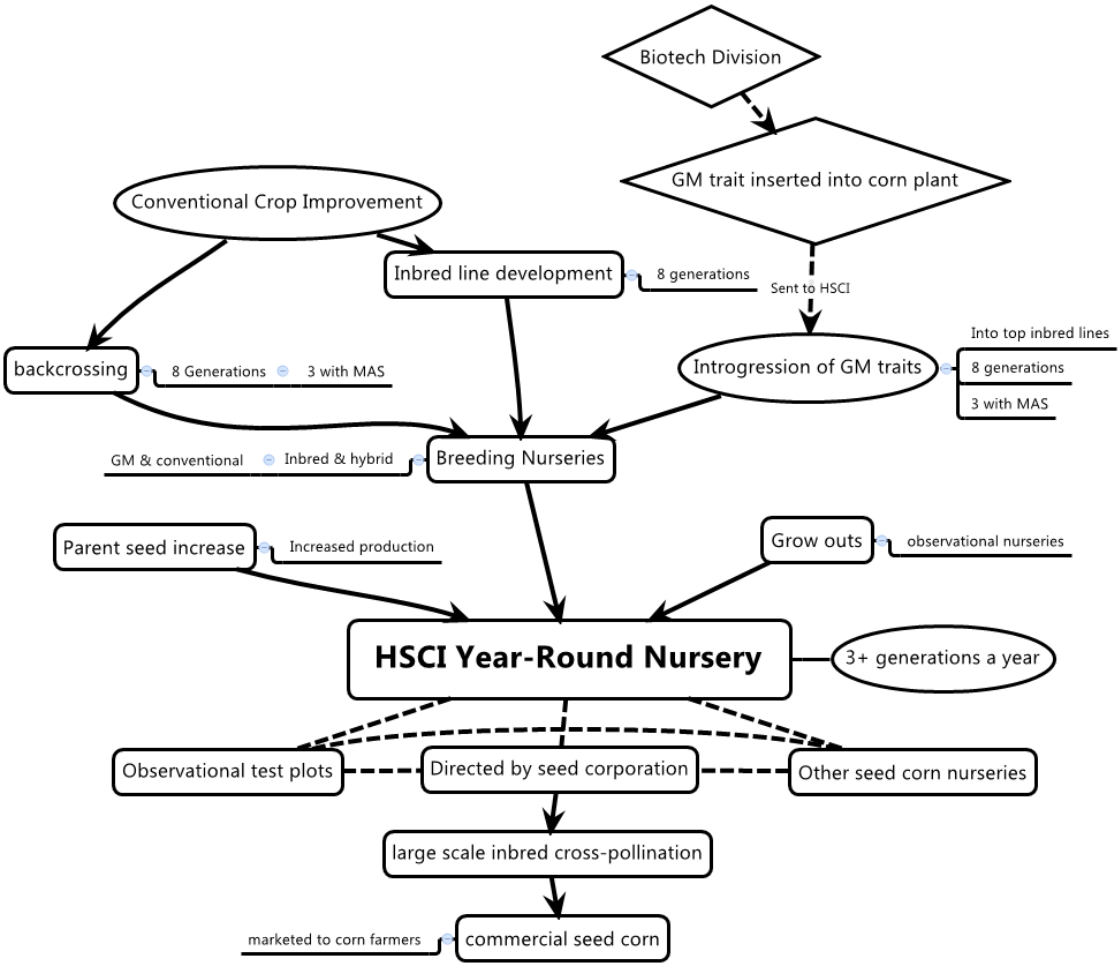
3.6 Hawaii's role in seed corporations' research and development operations

As seed corporations develop innovations to speed up seed corn improvement, they also become paced by this technological treadmill. Since seed corporations are in constant competition with each other, investing in tropical year-round corn nurseries and MAS is now a requirement. In tropical nurseries such as those in Hawai‘i, three to four crops per year can be grown. Further, these two innovations (year-round nurseries and MAS) augment each other so that both are now central to seed corporations' seed corn improvement strategies.

The figure below depicts HSCI as situated within seed corporations' broader seed corn improvement strategies:

[22] The precise number of generations is contingent on the trait, goal of the backcrossing procedure, and seed corporation's standards.

Figure 3.4 Hawaii's Role as a Year-Round Nursery



For seed corporations, the two most important contributions of HSCI are conventional crop improvement and the introgression of GM traits. Hawaii's climate more than triples the rate at which generations of corn can be produced. Seed corporations recognized the comparative advantage of HSCI's tropical climate and increased their investments in HSCI.

Since hybrid corn is created by cross-pollinating two distinct inbred lines, GM traits must be incorporated into inbred lines. Seed corn nurseries such as Hawai‘i are responsible for incorporating up to three different GM traits into an inbred line. Crop scientists currently believe

that six is the maximum number of traits which can be present in the same hybrid corn plant before the traits begin to lose their effectiveness. HSCI crop scientists screen different lines to ensure that only the intended GM traits are present.[23] Although GM traits are not developed in HSCI, GM traits are incorporated into commercially viable GM corn varieties in HSCI through backcrossing.

Two other tasks conducted by crop researchers in HSCI are parent seed increase and grow out fields. Grow outs are fields which are used for monitoring the quality of existing lines. Parent seed increase is where production is ramped up for an inbred or hybrid variety. A seed corporation does this if they need more of a variety which they intend to test or sell. Although parent seed increase is straightforward, it is time sensitive. Varieties must be produced rapidly in order for seed corporations to introduce their top seed corn varieties on schedule. Although parent seed increase and grow outs are conducted in HSCI, neither of these tasks is as time or labor intensive as conventional seed corn improvement or the introgression of GM traits.

Seed corporations coordinate research among different seed corn nurseries and observational stations as they strive to develop the best varieties of commercial corn. In addition to observation test plots in Hawaiʻi, seed corporations have observation test plots around the world but they are concentrated in regions that specialize in corn production. When varieties are tested in observational test plots, the scale is much smaller than when a variety is about to be introduced as a commercial hybrid variety. The last stage of pollination is when two inbred varieties are planted next to each other and systematically cross-pollinated. This stage is often carried out by contract farmers who follow seed corporations' specifications. These contract

[23] The Starlink food scare in 2000 resulted from Starlink GM corn being present in food products, a use for which it was not approved. Since then, seed corporations became more careful about ensuring that only the intended traits are present.

farmers do not require specialized knowledge of crop breeding, but must follow detailed protocols to ensure the desired pollinations are successful.

HSCI's position within seed corporations' R&D strategies is often a source of confusion for those outside of the industry. HSCI conducts seed corn improvement which includes the introgression but not the development of GM traits (see Figure 2.5). Additionally, all GM crops which are grown outside of a laboratory must first be approved by the USDA and the Environmental Protection Agency (EPA). HSCI's seed corn improvement contributes towards the development of improved varieties of commercial corn, but contemporary seed corn improvement is complex (see Figure 3.4). Seed corporations coordinate research across many different nurseries and observational stations. The varieties which are improved in HSCI also benefit from researchers and operations outside of Hawaiʻi. Still, HSCI is a crucial node within many seed corporation's seed corn improvement strategies.

3.7 Conclusion

Despite the fact that Hawaiʻi has some of the highest costs of agricultural production in the world, seed corporations are still increasing their investment. HSCI's growth is the result of a favorable intersection of political, economic, technoscientific, and biophysical factors. The climate in Hawaiʻi is exceptional for corn breeding. On a fundamental level, the ability to produce up to four generations in a year is HSCI's foundation.

Hawaiʻi also benefits from having relatively few pests that target corn, a favorable condition that is abetted by two factors. Firstly, Hawaiʻi is geographically isolated with special

laws in place intended to limit the agricultural pests from entering and leaving the islands. Secondly, Hawaiʻi, unlike the Corn Belt, lacks a history of intensive corn cultivation. If growers spot a virus such as corn rust, there is the possibility of eliminating the virus by halting or shifting production, a technique which is far less feasible in the Corn Belt.

When compared to other tropical corn nurseries such as Puerto Rico, the biggest asset in Hawaii's favor is its consistency as a solid investment for seed corporations. HCIA created an institution which helped facilitate the growth of the industry and an exchange of best practices. As seed corporations reconfigured in the 1990s, they prioritized expanding their year-round seed corn nurseries, and by that time Hawaiʻi was considered the best location in the world for seed corn nurseries. This reputation is backed up by results. In an industry where the failure of a crop can result in pushing back the introduction of a new line and the loss of millions of dollars, consistent results are a key asset that draws seed corporations to locate seed corn nurseries in Hawaiʻi.

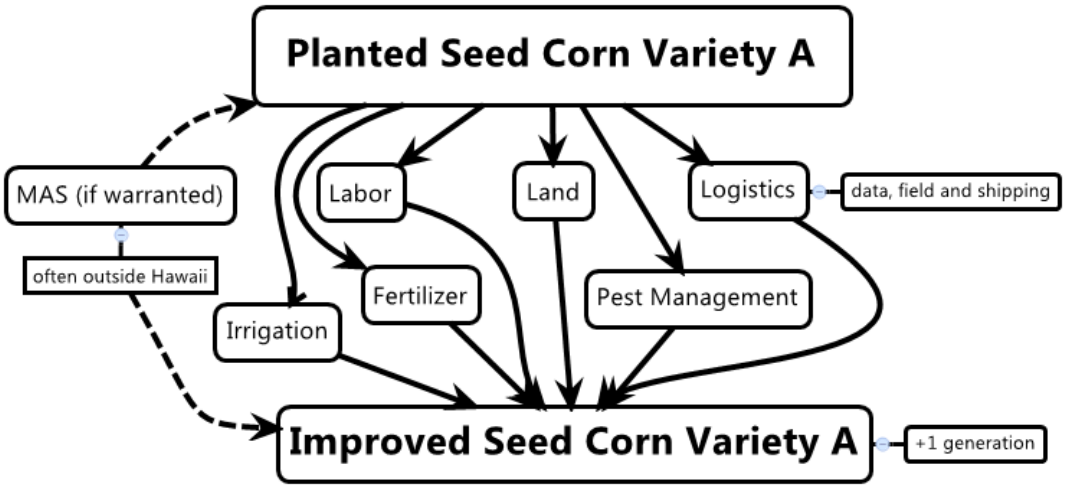
Chapter 4: Hawaii's Structural Advantages: Infrastructure, Land Policy, and Labor

4.1Introduction

The previous chapter focused on the technoscience behind seed corn improvement and the development of Hawaiʻi as a site for seed corn production. This chapter shifts the focus to the structural advantages that led to the rapid expansion of HSCI in Hawaiʻi. Hawaiʻi has an ideal climate for seed corn production and fewer pests. But in addition to these biophysical factors, Hawaiʻi has three main advantages that set it apart from other regions. First, the sugar and pineapple plantations preserved large tracts of agricultural land, much of which has valuable infrastructure such as irrigation. With the decline of sugar and pineapple, seed corporations were well-positioned to begin seed corn production on former pineapple and sugar land. Secondly, Hawaii's agricultural land policy seeks to keep agricultural land in production through a combination of farm preservation policy and tax incentives. Thirdly, Hawaiʻi has a strong labor force with a combination of skilled and unskilled workers.

In order to conduct seed corn improvement in Hawaiʻi, seed corporations must coordinate numerous inputs. Below is a figure that illustrates this process:

Figure 4.1 Requirements for Seed Corn Improvement



For many of these requirements, Hawaiʻi is better positioned than other regions. For land and irrigation, the decline of plantation agriculture freed up significant irrigated land, some of which was acquired by seed corporations. Hawaiʻi also boasts fewer pests and an attractive work force. Seed corporations also benefit from Hawaii's status as a US state. Seed corporations thus encounter less bureaucracy than in other comparable tropical islands. In spite of the higher costs of agricultural inputs such as land, labor, and fertilizer, seed corporations determined that the advantages outweigh the drawbacks and concertedly located seed corn nurseries in Hawaiʻi.

4.2 Plantations and land policy

Key to the emergence of the seed corn industry in Hawaiʻi is its plantation legacy and the resulting land policies. As a US territory from 1898 until statehood in 1959, power and land ownership were concentrated in the hands of large plantation owners. The original Big Five—American Factors, Castle & Cooke, Alexander & Baldwin, Theo. Davies & Co., and C. Brewer

& Co.—controlled Hawaii's political and economic scene throughout the first half of the 20th century (Daws 1968). As other regions with cheaper production costs entered the market and emulated Hawaii's technological innovations, plantation agriculture in Hawaiʻi became less profitable. Following WWII and statehood in 1959, military and tourism supplanted plantation agriculture as the bedrock of Hawaii's economy.

As Hawaiʻi became a territory and later a state, its elites were closely connected to the plantation interests. Plantation production established large plots of agricultural land with irrigation infrastructure. Since statehood, agricultural legislation in Hawaiʻi was shaped by a series of issues arising from its plantation legacy. Hawaiʻi faced unprecedented development pressures that threatened to drastically change land use as scattered subdivisions encroached into both agricultural lands and wilderness areas. In response, legislators passed the 1961 Basic Land Use Law, which zoned all land as either urban, conservation, rural, or agricultural (Suryanata and Lowry Forthcoming). These land classifications continue to be important today. The table below demonstrates the acreage in these land classifications as of 2006:

Figure 4.2 2006 Estimated Acreage of Land Use Districts in Hawaiʻi

	Total	Urban	Conservation	Agricultural	Rural
Acres	4,112,388	197,663	1,973,631	1,930,224	10,870
% of Hawaiʻi	100%	4.8%	48.0%	46.9%	0.3%

(State of Hawaii Data Book 2010)

In 2006, 47% of all acreage in Hawaiʻi, 1,930,224 acres, was zoned agricultural even though agricultural production when it peaked in the 1940s and 1950s used only about 300,000 acres (Kelly 1998). The majority of the land zoned agricultural is not suitable for intensive agriculture, but the 1961 Basic Land Use Law positioned the agricultural classification as a bulwark against

rampant development (Garrod and Plasch 1993). The classification of land as agricultural is considered by many to be an important way to preserve open undeveloped landscapes throughout Hawaiʻi. And the protection of large tracts of agricultural land from development facilitated the growth of the seed corn industry in Hawaiʻi.

Since its inception in the late 1960s, HSCI was concerned about development pressures on agricultural lands. In his 1969 speech to the American Seed Trade Association in Denver, Colorado, Professor Brewbaker cautioned that Hawaiʻi faces "an exploding tourist population and increasing costs of research and production, land, water, etc." Although Hawaii's high costs of agricultural production persist, the Basic Land Use Law helped to preserve agricultural land throughout Hawaiʻi. Developers wishing to convert land out of agricultural classification must navigate a rigorous process that includes assessing the environmental impacts, allowing for citizen's input, and getting approval from the Land Use Commission.

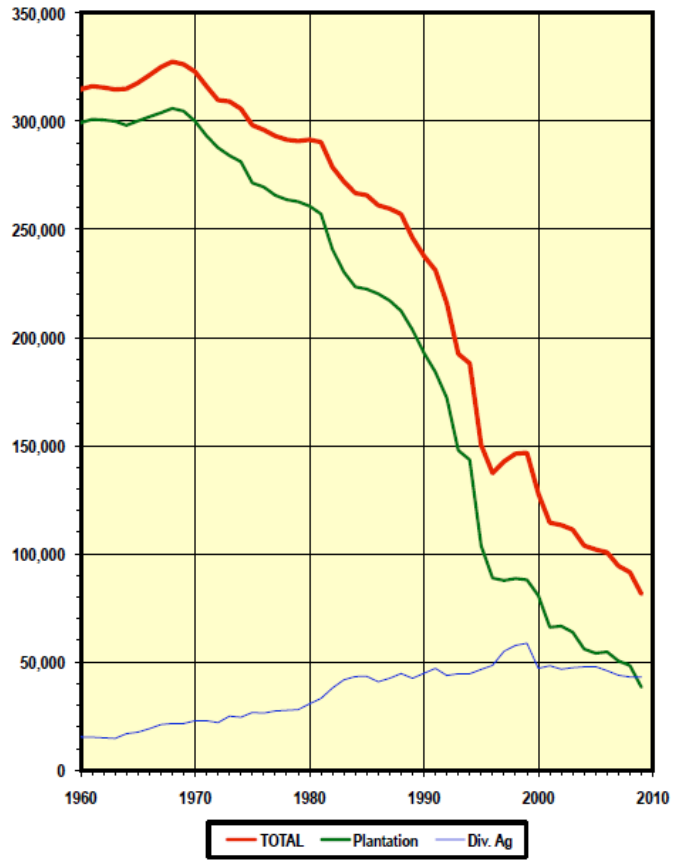
Barriers to agricultural land development ensured that with the decline of plantation production, agricultural land was amply available. More than any other agricultural industry in Hawaiʻi, HSCI has consistently increased production in former sugar and pineapple land. HSCI shares many similarities with plantation production as they both are owned by large corporations and export-oriented agricultural industries.

As sugar and pineapple plantations began faltering in the 1970s, there was anxiety about the future of agricultural production in Hawaiʻi (Suryanata and Lowry Forthcoming). In 1978, lawmakers amended the Hawaiian constitution requiring the state to "promote diversified agriculture, increase agricultural self-sufficiency and assure the availability of agriculturally

suited lands" (Article XI Section III). Each of these clauses signified important trends in Hawaii's agriculture landscape.

"Diversified agriculture" was a catchall phrase coined to refer to all operations that were not sugar and pineapple plantations, showing the extent to which sugar and pineapple dominated Hawaii's agricultural landscape.[24] The chart below shows the acreage for all crops, distinguishing between plantation agriculture (pineapple and sugar) and diversified agriculture (everything else):

Figure 4.3 Hawai'i Crop Acreage: All Crops



(Plasch Econ Pacific LLC 2011)

[24] "Diversified agriculture" and "plantation agriculture" are historical terms. Depending on how plantation agriculture is framed, HSCI could be considered a form of plantation agriculture. Here, I am simply adhering to the historical use of the terms and not making a political statement about whether or not HSCI should be considered "diversified" or "plantation" agriculture. In Hawai'i, these classifications have political implications.

By 1978, sugar and pineapple plantations were in decline. From 1970 to 2000, the land in plantation production decreased by 73% from about 300,000 acres to about 80,000 acres.

In order to assure the availability of agricultural land, policy makers in Hawaiʻi attempted to designate land best suited for agricultural production. In 2005 and 2008, the Hawaiʻi legislature passed the Important Agricultural Land (IAL) Laws in an attempt to distinguish between the broad category of land that was zoned agricultural and land best-suited to agricultural production. Farmers are encouraged to designate their land IAL and large landowners are required to designate a portion of their prime agricultural land as IAL.

4.3 Irrigation

Seed corn production requires sufficient water and fertilization. Hawaii's former plantations provided the infrastructure that HSCI's nurseries require for consistent irrigation. Seed corn nurseries are irrigated by drip or sprinkler irrigation which enables HSCI to apply liquid fertilizer through their irrigation systems. Most of HSCI's nurseries are located on former plantation land towards the leeward side of their respective islands. In general, the leeward side is drier and hotter than the windward side which is cooler and has more precipitation. The leeward sides of Kauaʻi, Maui, and Oahu have favorable heat units, meaning that the weather conditions translate into good crop growth. Around the peak of their influence, sugar plantations built irrigation systems that diverted water from the windward side to irrigate crop production in the leeward side. Given environmental concerns and community objections, the building of such massive irrigation ditches is not even considered an option today, but the existing irrigation ditches are functional relics of Hawaii's plantation legacy.

On Oahu, the main region for HSCI is in Kunia, located on the leeward side. Mean irrigation requirements for seed corn in Kunia are 1,150 gallons of water per acre daily in the winter and 3,860 gallons per acre daily in summer (DNR and CTAHR 2008). Kunia is irrigated by the Waiahole ditch. Hawaii's Commission on Water Resource Management estimates that 12.5 million gallons from the Waiahole Ditch are allotted while another 14.5 million gallons are available for allocation. Although these statistics indicate a surplus of water, there is a long history of community protests regarding the Waiahole ditch (see for example Lasky 2010). In 2009, three seed corporations accounted for 30% of Waiahole Ditch's current water resource total allotment: Monsanto (2.63 million gallons/day); Pioneer (470,000 gallons/day); and Syngenta (590,000 gallons/day) (Commission on Water Resource Management 2009).[25] HSCI operations are significant stakeholders in Hawaii's irrigation systems and water usage. HSCI benefits from irrigation infrastructure which they can afford to upgrade and maintain.

4.4 Availability of labor

The expansion of the seed corn industry in Hawaiʻi was contingent on the availability of a labor force that could meet the demands of increased production. Below is a chart with labor statistics on HSCI:

[25] The Board of Water Supply figures included here are the upper limits but each permit also includes a lower permit as well. Throughout the state as a whole, more operations violated the lower as opposed to upper limits.

Figure 4.4 Seed Corn Labor Statistics

Year	direct workers	direct worker wages	indirect + induced workers	indirect + induced wages
2006	1077	$23 million	721	$20 million
2009	1863	$68 million	924	$53 million
2012	1397	$69 million	1034	$182 million

(Loudat and Kasture 2006, 2009, 2012)

HSCI both directly manages seed corn nurseries and contracts seed corn cultivation to local farm operations. Between 2009 and 2012, the number of direct workers declined while the number of indirect and induced (contract) employees remained fairly stable. Subcontracting and outsourcing enable seed corporations to adapt to seasonal and fluctuating labor needs as well as decrease their visibility.

Seed corn operations require workers who can conduct the necessary agronomic and logistical tasks (see Figure 4.1). Although many HSCI jobs require skilled labor, others, such as hand pollination, do not. Hand pollination is HSCI's most basic and time consuming task as it involves taking the pollen from a corn tassel and placing it in a bag over the silks of the appropriate plant. These jobs are repetitive and the worker must carefully follow the instructions so that the correct pollinations are carried out. Many of these workers are recent Filipino migrants and signs on many HSCI operations are posted in both English and Tagalog. The majority of the part-time and seasonal jobs in HSCI are these hand pollination jobs which peak during the winter.

Most of HSCI's skilled workers are university graduates trained in agricultural sciences. Although some are from the mainland, seed corporations seek out qualified workers from

Hawai‘i. Many are recruited from UHM's CTAHR, Hawaii’s agricultural specialty school.[26] More than any other agricultural industry in Hawai‘i, HSCI has job openings for agricultural scientists with advanced degrees. Prospective employees are enticed with the opportunity to work with other crop scientists and to be on the cutting edge of agricultural biotechnology research. Seed corporations also hold seminars and lectures for their skilled employees. They even offer opportunities for employee exchanges at their other seed operations around the world.

Seed corn operations in Hawai‘i must be carefully structured to keep seed corn varieties, data, and field plots organized. One of the major logistical requirements is ensuring that seed varieties are correctly labeled and planted in the field. One HSCI insider asserted that an acre of seed corn can grow simultaneously up to one thousand unique varieties. Different technologies such as radio frequency identification and global positioning systems are used to track the location of seed corn varieties. Similarly, all of the information from MAS, which can contain thousands of data points per kernel, must be kept appropriately linked to a seed corn variety either in storage or in the field. Since each company is coordinated by their parent operations, data is shared on internal servers. These corporations regularly ship and receive seed corn varieties to and from seed corn operations around the world.

Since HSCI does not produce traditional agricultural commodities, the value of HSCI in Hawaii's economy is estimated through its operating expenses. In a study commissioned by Hawaii Crop Improvement Association (HCIA) – a pro-HSCI advocacy group – Loudat and

[26] HSCI critics claim that UHM’s CTAHR is unduly influenced by HSCI’s agenda. This was most pronounced when an “Occupy UH” group camped out in tents on the sidewalk by the UHM campus for several weeks in the Fall 2012 semester. Monsanto gifted $500,000 to CTAHR to create the Monsanto Scholarship Fund (Schrire 2011). Since HSCI is Hawaii’s dominant agricultural industry, there are many connections with UHM’s CTAHR. Seed corporations offer summer internships to students. A professor may make introductions if he or she believes a company is a good fit for a student. This debate relates to the role of land grant institutions and is beyond the scope of my research.

Kasture (2012) claim that HSCI directly contributes $264 million and indirectly induces $287 million for a total contribution of $551 million to Hawaii's economy. Loudat and Kasture (2012, 6) write:

> The economic impact of the seed crop industry we measure is conservative given the high likelihood of the industry contributions not measured in our study in the form of an increased knowledge base for Hawaii's life sciences sector stimulating more local investment in research & technology, economic activity, related labor income and job creation, and an increased tax base.

HSCI is Hawaii's fastest growing industry although the huge growth spurt of the 2000s appears to be tapering off in the 2010s (Loudat and Kasture 2012). Critics argue that much of the value generated by HSCI accrues to seed corporations and not Hawaii's economy (Redfeather and Bondera 2012). Further, they point out that estimates of HSCI's contributions to the Hawaiian economy overlook costs to the environment, human health, and alternative agriculture.

4.5 Conclusion

TNCs pit different regions of the world against each other in an effort to secure the most favorable terms for conducting business (Christopherson and Clark 2007). Hawai‘i is pitted against other regions with similar tropical climates that enable year-round nurseries for seed corn. Hawaii's biggest competitors are Puerto Rico and more recently Chile. As of 2009, Puerto Rico's seed crop industry reportedly contributed up to $30 million to Puerto Rico's economy, providing full-time employment to 163 local workers and part-time or seasonal employment to more than one thousand workers (Batra 2009).

Hawai‘i and Puerto Rico are both important nodes for seed corn production because of their favorable climates and status within US sovereignty. The costs of production are lower in

Puerto Rico, but Hawai‘i has fewer pests and is a fully fledged US state. In addition, as discussed in this chapter, Hawai‘i has advantages because of its plantation legacy, land use zoning and available labor force. Multiple sourcing production enables corporations to avoid overly relying on any one location and minimize costly disruptions (Dicken 2010, 142). If Hawai‘i became untenable for seed corn, seed corporations could relocate their seed corn nurseries to Puerto Rico and other tropical locations. The infrastructure investments which seed corporations make in land, buildings, workforce, and machinery indicate that seed corporations consider HSCI a long-term investment.

Chapter 5: Political Ecology of Hawaii's Seed Corn Industry

5.1 Introduction

Up until now, I have emphasized the factors that caused HSCI to grow. The industrialization of corn, the process of seed corn improvement, the emergence of contemporary seed corporations, and trends in Hawaii's agricultural landscape all contributed to HSCI's dramatic increase. This chapter focuses on how the increase in the size and prominence of HSCI over the past decade was paralleled by increased opposition from Hawaiʻi citizens. Since this thesis focuses on factors that influence the growth of HSCI, I argue that far more than economic or scientific factors, sociopolitical contestations are the biggest threat to the future viability of HSCI.

5.2 Two opposing worldviews

Many of the allies who are now unified into either supporting or opposing HSCI disagree with each other in other contexts. Seed corporations have a long history of litigating claims and counter-claims about infringement of intellectual property against each other. For instance, Monsanto was awarded $1 billion from Pioneer in August, 2012 because a federal judge found that Pioneer improperly used Monsanto's Round-up Ready trait with Pioneer soybeans (Piller 2012). In response, Pioneer filed an anti-trust suit in a federal court and plans to appeal the verdict (*ibid.*). While seed corporations are competitors, each seed corporation has HCIA

members, and HCIA coordinates lobbying efforts and annual meetings to promote the interests of seed corporations in Hawaiʻi.

Beyond seed corporations there are many other individuals and institutions which support HSCI although they seek to avoid incurring public criticisms associated with seed corporations. Many large landowners, business leaders, and politicians see HSCI as being able to provide important economic benefits while keeping agricultural land in production. Large farmers also gain access to agricultural technology including machinery and agrochemicals. These farmers can also benefit from contract farming seed corn for seed corporations.

HSCI's critics are similarly drawn from a diverse base. Opposition to HSCI provides a unique avenue for collaboration among proponents of Hawaiian sovereignty, alternative agriculture, and environmentalism. Indeed, using "HSCI critics" as a frame for analysis implies a negative oppositional orientation. I knowingly use this frame despite its shortcomings because my analysis focuses precisely on this opposition. People who oppose HSCI also frame their activism positively as a movement in support of local organic agriculture, food sovereignty, and environmental sustainability among other issues. For instance, a prominent anti-HSCI organization called Hawaiʻi SEED describes itself as "[A] nonprofit organization and coalition of grassroots groups, farmers activists and community from five islands working to educate the public about the risks posed by genetically engineered organisms and to promote diverse, local, healthy and ecological food and farming" (Hawai'i Seed 2013). Signs opposing HSCI are ubiquitous along roadsides, at progressive political gatherings, and even surfing competitions.

Hawaiʻi residents have a long history of active involvement in projects and industries which affect the local environment and community. Several prominent examples include the

Hawaiʻi Super-ferry, the current Honolulu Rail Transit Project, and the Hoʻopili housing project. Focusing on resource contestation in Hawaiʻi, Suryanata and Umemoto (2005) examine the Environmental Impact Assessment (EIA) process regarding the introduction of new marine aquaculture technologies on Hawaiʻi Island. They find that the EIA process focuses on tangible impacts when many of the grievances are related to intangible concerns such as the "fear of 'losing greater control' over the future direction of their community and local environment" (751). Another fear which was pronounced throughout the EIA process was the fear of the unknown which related to the "fear that outsiders and multinationals may lack the sensitivity and commitment to the preservation of the environment and concern for the welfare of their neighbors" (757).

In examining four Hawaiʻi based marine firm applications, Suryanata and Umemoto found that the most successful firm conducted additional outreach including informal consultations with local leaders and native Hawaiian elders (kupuna). Additionally, that firm treated objections from the local community as valid concerns and their communication and outreach helped to reduce some of the community leaders' fears. There are significant differences between marine aquaculture and HSCI, but many of the issues observed by Suryanta and Umemoto are similarly present in criticisms of HSCI. Two major differences are that HSCI garners more public attention and there is no formal process like that of EIA which requires HSCI operations to receive approval from local constituencies.

Longtime Hawaiʻi reporter Joan Conrow summarized the vitriol surrounding the conflict by writing, "In my quarter-century of covering all the big issues on this little island [Kauaʻi]—

and there are more than one might imagine for a place dubbed "paradise"—I've never seen such fervor, heard such hyperbole" (Conrow 2013). She continues:

> Though the community is polarized, Bill 2491 can't be blamed for the ugly divisiveness that is tearing us apart. It has merely served to spotlight all the ways we have always been divided: haole, local, windward, leeward, north shore, westside, rich, poor, white collar, blue collar, malihihi (sic), kamaaina. It's not pretty, and it's not paradisiacal. But then, the truth rarely is. (Conrow 2013)

Conrow succinctly elucidates how although HSCI is a focal point, there are numerous underlying tensions.

5.3 Native Hawaiian opposition to Hawaii's seed corn industry

Advocates of Hawaiian sovereignty are a key constituent in opposition to HSCI. When I write about Hawaiian sovereignty, I am referring to contemporary interpretations of what it means to be Hawaiian and how this identity is expressed to increase native-Hawaiian autonomy and pride. An important ritual in traditional Hawaiian society was the recitation of the oli, which are Hawaiian genealogical chants. In a central creation oli, kalo[27] is born first followed by humans. Trask (2012, 76) writes, "For Hawaiians, the kalo is literally part of their genealogy as well as the staff of life." In 2002, the University of Hawaiʻi patented three varieties of hybrid taro and then experimented with creating GM taro.

Members of the native Hawaiian community opposed attempts by UHM CTAHR to patent taro and develop GM taro and mobilized to protect the sanctity of kalo. In response, the state legislature passed a resolution in 2007 which banned the genetic modification of taro statewide and created a "taro research and security team to address growing concerns" (The State

[27] Kalo is the Hawaiian word for taro.

of Hawaii Department of Agriculture 2008, 4). In Hawaiʻi, taro is legally enshrined as a sacred plant which is protected from genetic modification. The legal status of taro is in marked contrast to seed corn that has a relatively short and instrumental history in Hawaiʻi.

Following successful mobilization to protect taro, members of the native Hawaiian community then turned their focus on HSCI which by 2007 was emerging as an area of public concern. At numerous anti-HSCI events I attended, leaders conveyed how opposition to GM crops in Hawaiʻi began with taro and then transitioned to GM food and HSCI. They also highlighted the parallels between corn and taro saying that Hawaiians who recognize the importance of protecting kalo should support other indigenous people who believe corn is sacred. Vandana Shiva, renowned indigenous rights advocate and GMO critic from India, spoke at numerous well-attended events and rallies throughout Hawaiʻi in January of 2013. She framed the struggle against HSCI as linked to other indigenous sovereignty movements around the world.

Although Hawaiian sovereignty is often invoked in opposition to HSCI, not all native Hawaiians feel the same about GMOs or HSCI. Two Hawaiian institutions, Kamehameha Schools and the Department of Hawaiian Home Lands (DHHL), are facing scrutiny because they lease land to Monsanto. A 2012 documentary by Hawaiʻi GMO Justice Coalition demanded that Kamehameha Schools “evict” Monsanto (Hawaii'i GMO Justice Coalition 2012). In response, Kamehameha Schools disclosed that they lease 1,033 acres to Monsanto, and they defended leasing land to Monsanto by noting that Monsanto is a good tenant, and that there was a lack of evidence regarding “GMO-related health claims” (Kamehameha Schools 2013).

A May 2013 front page article in the *Star-Advertiser*, Hawaii’s largest newspaper, described native Hawaiians contesting DHHL’s decision to lease 30 acres of land to Monsanto

on Molakai. The article begins, “For many Native Hawaiians who oppose the use of genetically modified organisms in Hawaii's farm fields, Monsanto is the enemy” (Perez 2013). Deputy Director of DHHL Darrel Young countered that the GMO issue is not “a major controversy within our homestead communities” (*ibid.*). The Kamehameha Schools and DHHL controversies show that although Hawaiian sovereignty is often invoked against HSCI not all native Hawaiians oppose HSCI. If opposing HSCI continues to be strongly connected with the Hawaiian sovereignty movement, native Hawaiian institutions will likely seek to minimize their partnerships with HSCI.

5.4 (in)visibility of Hawaii’s seed corn operations

The simplest way to measure HSCI would be by its size, but this metric is both hotly contested and unclear. According to Monsanto’s website:

> Companies keep the location of these trials confidential to protect their property against vandalism and theft, to protect the growers of these trials, and to protect confidential business information. Specific location information is provided to the USDA so that field inspectors can visit the sites to ensure that companies are adhering to the USDA guidelines. USDA makes general information regarding the county and state of planting publicly available, but keeps specific information confidential. (Monsanto 2013)

HSCI locations are kept confidential and patrolled by armed security. On Hawaiʻi Island, vandals destroyed GM papaya trees on several occasions, and many speculate that this was a form of protest against GM crops (Star-Advertiser 2011). While threats posed by vandalism, theft, and physical harm are important considerations, HSCI’s refusal to disclose the location of their operations reinforces the barrier between HSCI and the general public. And, in doing so, HSCI's

actions unintentionally provide ammunition for HSCI critics' portrayal of seed corporations as furtively taking over Hawaii's prime agricultural land.

While HSCI has an interest in presenting low acreage figures, critics conversely have an interest in presenting high figures. The logic is that low acreage use shows HSCI is a productive use of land while high acreage use shows that HSCI is impinging on the ability of potential farmers to access high quality agricultural land. According to the USDA, in 2011 HSCI occupied only 7,100 acres (Hawaii Seed Crops 2011). According to industry insiders, HSCI occupies between 20,000 and 25,000 acres.[28] Meanwhile, critics claim that HSCI owns or leases between 40,000 and 60,000 acres in Hawaiʻi (Hawaii'i GMO Justice Coalition 2012). Given that locations are provided to the USDA, it is surprising that the USDA estimate is so small. In several interviews, USDA Hawaiʻi staff cited budget cuts as a serious constraint. HSCI also contracts some of their operations with local farmers which further obscures the size of HSCI since this information is similarly confidential.

5.5 The unpleasant hue of labeling sound science

Food labeling is an issue that is often discussed in Hawaiʻi and there are significant legislative pushes for food labeling. Hawaiʻi citizens eat comparable amounts of GM food to residents in other US states.[29] For both HSCI and its critics, GM food labeling is related to opposition to HSCI operations. Two important themes that emerged in the legislative push for

[28] A fact-sheet from HCIA (2013) claims that HSCI farms 12,700 acres on Kauai, which is 20% of the 69,000 acres of the prime agricultural land on the island.
[29] GM papaya, which was introduced in Hawaiʻi in the late 90's by UHM CTAHR, is the sole area where Hawaiʻi GM food intake differs notably from other states.

labeling GM food were the incongruency between county, state, and federal regulatory actions and the role of science.

In 2013, the Hawai‘i House of Representatives passed HB174 which called for the labeling of imported GM produce with a 50-1 vote. Hawai‘i Attorney General David M. Louie advised the Senate that HB174 would likely be found unconstitutional on three different grounds:

> (1) [State] efforts to require GMO labels have been preempted by the federal government, (2) it violates the First Amendment protections of commercial speech, and (3) it violates the Commerce Clause. In addition, the Commerce Clause will prohibit the State from restricting the importation of GMO food into Hawaii that meets applicable federal requirements. (Louie 2013, 1)[30]

There appears to be minimal legal precedent for a US state to mandate labeling requirements because it would contradict federal requirements. Any such legislation would likely be challenged in court if there are significant economic stakes involved. Following the Attorney General's recommendation, the Senate committee tabled the bill. In response, the Hawai‘i House of Representatives unanimously passed a resolution calling for federal monitoring and labeling of GM food. There is currently a large push for GM food labeling in Hawai‘i which receives support from anti-GMO organizations outside of the state.

Jones (2000) provides an example of how recombinant-bovine growth hormone (rBGH), also referred to as bovine somatotrophine (BST), failed to gain approval in Canada despite being endorsed by both the USDA and the UN Joint Expert Committee on Food Additives. Jones distinguishes between the black boxes which are unopened, the areas of expertise which are

[30] Louie also describes the legal precedent which was set when the state of Vermont tried to require the labeling of milk which was produced by cows which were given growth hormones in 1996. The growth hormone that was targeted in the Vermont labeling law, recombinant-bovine growth hormone (rBGH), was originally developed by Monsanto. An upper appeals court ruled against Vermont, finding that requiring labeling went against both the Commerce Clause and the FDA's federal mandate.

accepted, and the black boxes which leak open, where technologies are critically examined by not just scientists but by citizens as well as politicians. Monsanto initially presented the science behind rBGH as a foregone conclusion. One top executive testified, "Over 2,000 independents scientific studies have been conducted, and we feel that the science is complete. The consensus of these studies is clear and definitive. Milk from BST-supplemented cows is the same as milk from untreated cows" (*ibid.*, 322). The approval of rBGH was thwarted as Monsanto's narratives on the potential impacts of rBGH on dairy farms, human health, and animal health all faced heavy scrutiny. The safety of these technological innovations was effectively contested at the national level.

These debates about new technologies draw attention to the role of science, but scientists regularly overlook that science is only a method. Science is never apolitical, never an end in itself. Scientists can rightfully assert that properly adhering to the scientific method is good science, but this assertion provides little insight into the real-world implication or public acceptance of new technologies. Busch et al. (1991, 36) write:

> Science is a human enterprise and all human enterprises are marked by interests, desires, goals, motives, and ideals, so to claim that science is, in essence (i.e. ideally), practiced with no regard whatsoever for these desires is to posit a scientific ideal that is practically if not logically impossible (Feyerabend, 1975).

Even scientific inventions that are perceived to benefit our quality of life—for example antibiotics and micro-computing—have significant socio-political impacts that accrue power to people and institutions while reshaping existing relations.

Currently, most of the discourse regarding HSCI is framed in ethical terms with both HSCI and its critics invoking "sound science" to support their position. For obvious reasons, whether or not HSCI is harming the environment and human health is a pressing question, but it

is outside the scope of my research to provide any new insights on this topic. Rather than examine who is using "good science" I will briefly touch on how these disagreements are negotiated.[31]

HSCI employs the concept of good science to claim that its methods are safe and to portray its critics as irrational and unreasonable. Caricatures of the opposition run both ways as seed corporations are derided by critics as evil and callous. The conflict over HSCI exhibits a self-reinforcing polarization where the two sides are drawn further and further apart. HSCI's inability to assuage community concerns incites over-the-top criticisms of HSCI that in turn are used by HSCI as evidence that they cannot engage with their critics. In this type of conflict, it is possible that neither side is genuinely interested collaborating with the other, that they are resigned to negotiate their differences through various legislative, legal, and media skirmishes.

Unfortunately, this conflict leaves members of both groups feeling aggrieved and has proved divisive in communities throughout Hawaiʻi, because members from both groups experience threats to their well-being. HSCI employees, executives, and allies face threats of violence and social ostracism from HSCI critics. Most recently, threats were made to Kauaʻi County Mayor Carvalho "via phone, email, and social media" after he decided to veto Kauaʻi County Bill 2914, discussed in the following section (Kaua'i Police Department 2013). Fred Perlak (2013), the Vice President of Research and Business Operations for Monsanto in Hawaiʻi, claims in an opinion piece for the *Star-Advertiser* that "The labeling debate has been an excuse to attack agriculture in Hawaii, specifically the seed industry and Monsanto. These attacks are

[31] I strive to resist normative evaluations of scientific sources on the safety of GMOs and agrochemicals. Prominent organizations both endorse and critique the safety of these products. See Thompson (2011) and National Academy of Sciences (2010) for perspectives that endorse GM crops or Lappé and Bailey (1998) and Gurian-Sherman (2009) for a perspective that criticizes GM crops.

not supported by sound science and have become personal." The physical intimidation experienced by HSCI leadership further increases the chasm between HSCI and members of the community. Perlak describes how these fears justify increased secrecy and security for HSCI operations.

HSCI critics conversely feel that HSCI is poisoning Hawaiʻi citizens and the environment. A recent documentary film titled "Stop Monsanto from Poisoning Hawaiʻi: Genetic Engineering Chemical Warfare" makes a clear link between the growing of GM crops in Hawaiʻi and the use of hazardous chemicals (Hawaii'i GMO Justice Coalition 2012). In the documentary, one North Shore resident from Oahu describes the lack of information available to people living near HSCI operations. This is generally true: with few exceptions, Hawaiʻi residents receive no information on the types of agrochemicals being applied or the timing of applications. But many HSCI critics go a step further to claim that agrochemicals used in HSCI operations are making people sick and harming the environment. With both groups feeling aggrieved and under siege, the conflict is tinged with an unpleasant hue.

5.6 Agrochemical regulations on Kauaʻi

HSCI executives point to federal legislation as the embodiment of the scientific consensus. Given that these are multinational corporations which navigate the regulatory frameworks of different countries, they are opposed to having different regulations imposed at the state or county level. HSCI critics, on the other hand, feel that their concerns are being ignored, that they are not able to assert their truth-claims or control over the land in the face of multinational corporations. Without an institutionalized procedure such as the EIA process

described by Suryanata and Umemoto (2005), HSCI has largely avoided responding to the complaints of nearby residents and community groups.

Efforts to pass tighter regulations on HSCI operations in Kaua‘i recently culminated in Kaua‘i County Bill 2491. The initial bill called for: the disclosure of both agrochemical usage and the location and type of GM crops; the establishment of pesticide buffer zones on RUP and General Use Pesticides (GUP) within 500 feet of roads, houses, and sensitive environments such as rivers and shorelines; and the imposition of “a temporary moratorium on the experimental use and commercial production of genetically modified organisms” until an Environmental Impact Statement was completed by the County of Kaua‘i. The last provision would have halted HSCI operations on Kaua‘i.

The bill later was amended to focus more on the use of agrochemicals. The requirements for pesticide reporting were also revised with more specifics on the reporting requirements to nearby residents. The buffer zones were also made more detailed and in some instances significantly smaller. For instance, the buffer distance from roadsides, rivers, and shorelines was shortened from 500 feet to 100 feet. Most significantly, the final bill did not include a moratorium on GM crops, and instead of an Environmental Impact Statement, the bill proposes that the county conduct an Environmental and Public Health Impact Study.

HSCI critics are struggling to assert their sovereignty over technologies which were initially presented as black boxes, as safe technologies backed up by sound science. Having failed to successfully negotiate with seed corporations and finding the state and federal guidelines insufficient, HSCI critics are attempting to assert their sovereignty through the Kaua‘i County Council. Although Kaua‘i County Bill 2491 was passed by the Kaua‘i County Council,

the Mayor of Kaua'i, Mayor Carvalho vetoed the bill. In a letter explaining his decision, Mayor Carvalho writes, "I truly believe that we could have accomplished [the goals of Bill 2491] faster and in a legally sound manner by working cooperatively with the state, which has clear legal authority over buffer zones and pesticide disclosure" (Carvalho 2013, 2). The Kaua'i County Council member who proposed Bill 2491, Gary Hooser, counters that many legal experts have endorsed the bill and several have volunteered to defend the bill for free if it is challenged (Hooser 2013). Although these contestations are still unfolding, they will likely continue to be contested for years on the county, state, and maybe even national level.

5.7 Conclusion: democracy in action?

Speaking at the HCIA Annual Meeting in 2011, Governor of Hawai'i Neil Abercrombie said:

> I am not going to sit here and lament sugar and lament pineapple gone. That was a monoculture that had its time, had its place in other centuries. That's not the 21st century. Many of the people in this room today represent the seed industry which is I think the new foundation and basis for agricultural prosperity in the state. (HCIA 2011)

HSCI overtook the economic importance of plantation agriculture during the 2000s (see Chart 1.1) but precipitous growth has also paralleled increased opposition. If HSCI continues to be Hawaii's dominant agricultural industry, it will likely continue to be a focal point for political contestations in the state.

In some respects, the HSCI controversy is an example of US democratic principles. Citizens are able to voice their concerns and pressure their elected officials to change the current policy. Federal, state, and county law intersect to create the regulations under which HSCI

operates. Further, HSCI critics mobilize not just against HSCI but also in support of other issues. With consistent coverage in the media, HSCI faces increased scrutiny and HSCI critics are able to communicate their position to the broader public in an attempt to change the current policy.

Current legislative efforts by HSCI critics threaten the viability of the industry and so HSCI must respond. Perhaps this can be the start of a process that lowers the vitriol surrounding HSCI. Even though there is at times an emotionally raw aspect to the controversy, that happens when people are passionate and hold deep convictions. Aside from threats, which are a concern, HSCI critics are using the legal processes which are available to them. People are heeding what Kaua‘i County Council Chair Jay Furfaro said in the middle of a heated hearing on Bill 2491: “We need to keep ourselves in a position that is kina‘ole, without flaw, okay? We have to follow the procedure. It’s important as Kauaians” (Kauai Council 2013). That in itself is a stark story of how communities wrestle with new technologies and industries.

Chapter 6: Learning from Hawaii's Seed Corn Industry

In each chapter of this thesis I trace a different theme. The second chapter follows the political economic development of corn and the emergence of contemporary seed corporations. The third chapter investigates the technoscientific development of commercial seed corn and Hawaii's evolving role in this process. The fourth chapter looks at the structural conditions that led seed corporations to expand their operations in Hawaiʻi. The fifth chapter examines HSCI's political ecology, focusing in particular on a statewide GM produce labeling bill and a Kauaʻi County bill which targeted seed corn operations.

HSCI lies at the nexus of a fascinating intersection of economic, scientific, biological, and sociopolitical trends and provides insights into both agro-food networks and scientific controversies.

6.1 The novelty of Hawaii's seed corn industry

The rapidity with which HSCI became Hawaii's dominant agricultural industry is an example of how agricultural production responds to the market. With industrial agriculture came regional specialization and intensification. Since the late 19th century, sugar and then pineapple plantations were Hawaii's economically dominant agricultural industries. With their decline, HSCI emerged as the agricultural industry of the Hawaii's future. But HSCI is estranged from commonly held images of farming because none of its products are consumed directly by people or animals. Rather it is integrated within seed corporations' seed corn improvement strategies, and HSCI is one of several key nodes in the creation of commercial seed corn.

With some of the highest costs of production in the world, Hawai‘i agricultural producers must compete against cheap imports. Even if Hawai‘i is an excellent place for agricultural production, commercial farmers are constrained by economics—they must have profitable operations in order to maintain their social reproduction. The current state policy in Hawai‘i seeks to preserve agricultural land but does not privilege certain kinds of production over others.

Another consideration—and this is not limited to Hawai‘i —is that some regions will likely see the diminishment if not near disappearance of agricultural production. In Hawai‘i, both rural development and gentrification are significant land use pressures that figure to continue to impinge on remaining agricultural land. Maintaining land in agricultural production, and particularly agricultural production which increases self-sufficiency, is a goal for many regions. Unfortunately, there is no obvious way to translate this communal desire into an effective orchestration of farming operations that are ultimately the financial responsibility of individuals or corporations.

6.2 Connectivity to industrial agro-food networks

This thesis highlights a particular node in industrial agro-food networks and one that is often obscured. There are an overwhelming number of actors and relations embedded in industrial food production. Considering HSCI in relation to Midwestern US corn farmers and all of the uses for Number 2 corn is difficult. The emergence of seed corn in Hawai‘i is linked to the remarkable properties of corn, which is a key lubricant throughout industrial agricultural networks. Indeed, as much as this thesis is about Hawai‘i, crop scientists, and seed corporations, corn is a vital actor that makes HSCI possible. From a Marxist perspective, seed corn is a living

embodiment of labor that accumulates within crop DNA. Seed plants also contain the labor of many others, including crop breeders at land grant universities and indigenous farmers who passed away thousands of years ago. Seed corporations coordinate seed corn improvement and this labor continues to accumulate within their proprietary corn DNA.

Whatmore and Thorne (1997, 301) use the concept of connectivity to examine how food production, processing, distribution, retailing and consumption are constituted through a network comprised of numerous actors as opposed to "global totalities." This approach contradicts the framework developed by Campbell (2009) which claims that there is "food from somewhere" which can be contrasted with "food from nowhere." Scholars should be cautious about essentializing industrial agro-food networks as global and inferior to local agro-food networks. First, this approach elides the connections between the places and actors that are actively producing and consuming industrial food. Second, this approach assumes a certain kind of food, often food that is more expensive, is better for the environment and human health, two assumptions that are challenged by Freedman (2013) among others.

The vast majority of the food consumed by people in the US and increasingly around the world is the product of industrial agriculture. Industrial agro-food networks are monitored by regulatory institutions. People who consume industrial food products are implicitly placing their faith in these institutions to protect them. Castigating industrial agro-food networks will not make them disappear, and many people are financially or logistically unable to avoid them. There are, unfortunately, few avenues for community concerns and feedback to (re)shape industrial agro-food networks. Public campaigns are an effective way to get for-profit corporations to readjust to consumer criticisms. Concerned consumers have successfully

mobilized using social media to pressure corporations into changing the ingredients and labeling of some food (Strom 2013). Many fast food restaurants now list their calories and have healthier options. Similarly, new types of certification such as fair trade, organic, cage-free, and so forth have proliferated.

With third-party certification increasing, consumers encounter a myriad of different certifications in the supermarket which can quickly become overwhelming (Busch 2011). Busch warns that these private standards and certifications pose "an analogous, and perhaps more intractable, set of problems" (Busch 2011, 346). State governance, however, appears ill-equipped to alleviate citizen concerns. The decisions regarding agrochemicals, labeling, and GM crops are made at a federal level by regulatory experts and these decisions are commonly interpreted as either technocratic or overly politicized. Further, community concerns such as those raised in Kaua‘i are difficult to include in federal decision-making processes.

6.3 Local resistance to Hawaii's seed corn industry

Hawai‘i has active movements committed to environmentalism and Hawaiian sovereignty, so the increased presence of seed corn operations was likely to generate conflicts. The contours of these contestations are shaped by local as well as national and global debates regarding industrial agriculture, processed food, and seed corporations. This thesis examines the focal point of contestation in terms of relations different from those which are typically considered.

Trust develops when people become more familiar with new technologies and industries. With security concerns creating a structural barrier to transparency, Hawaiʻi citizens are unlikely to trust seed corporations in Hawaiʻi. HSCI critics often trust neither seed corporations nor the effectiveness of regulatory institutions such as the USDA, EPA and FDA. Those who work for HSCI are conversely very familiar with the methods used in seed corn improvement. Both HSCI and HSCI critics consider seed corn operations in Hawaiʻi to be ontologically fixed, as either safe or unsafe. Both invoke "good science" and in this instance "good science" is synonymous with scientific justifications for their position. As a node in seed corporations' seed corn improvement operations, HSCI is a focal point for a myriad of contested issues.

The strongest criticisms of HSCI relate to the molecular impact of GM crops and agrochemicals. The scientific understanding of these molecular reactions still contains much uncertainty and debate. Further, people are bombarded by commercials, media, scientific reports, and advice from within their social network. Using their personal experiences as a guide, people navigate this welter of information and choose various sources of information to trust.

Seed corporations submit documentation regarding the safety of GM crops and agrochemicals (See Appendix #2) to the federal government through the EPA, the USDA and the FDA. These institutions then determine whether the proposed product should be approved, and if so, how it should be regulated. HSCI touts this process as rigorous but critics deride it as rubber-stamping. Since the risk evaluation of agrochemicals and GM crops are highly technical, there are significant barriers to informed public discussions. Federal institutions create the regulations for GM crops and agrochemicals in Hawaiʻi. These decisions appear neither transparent nor

accessible for concerned citizens in Hawaiʻi who feel that federal institutions value the priorities of agribusinesses more than local Hawaiʻi communities.

The molecular understanding that enabled biotechnology was accompanied by citizens who became concerned about microscopic toxins and nutrients (Rose 2001). Braun (2007, 13) adds that "biotechnology's high capitalization and specialization means that immense challenges stand in the way of any sort of informed critique and public debate." Both proponents and critics make truth claims about GMOs which resonate with the public. Since the general public is unfamiliar with molecular risk analysis and the field is still in its infancy, experts on both sides interpret molecular risk in a way that supports their position on GMOs.

Citizens of Kauaʻi appear passionately committed to enforcing stricter regulations on HSCI. Meanwhile, the Executive Director of HCIA, Alicia Maluafiti, referred to Bill 2491 dismissively as a "pretty pissy bill" and spoke of "fear mongering by Mr. Hooser and the extremists on Kauai" (Cocke 2013). These comments underscore the difficulty HSCI leadership experiences when responding to community concerns. Indeed, the greatest threat to HSCI is an inability to assuage community concerns.

Along with conflicting truth-claims about science, HSCI and its critics also have different conceptions about what it means to be local and what is best for the future of communities in Hawaiʻi. HSCI finds natural and induced policy advantages in Hawaiʻi, but it encounters a ready-made opposition to GM crops and agrochemicals. Both paths lead through the physical and social space of Hawaiʻi, leading to growth and conflict surrounding HSCI.

6.4 Final thoughts

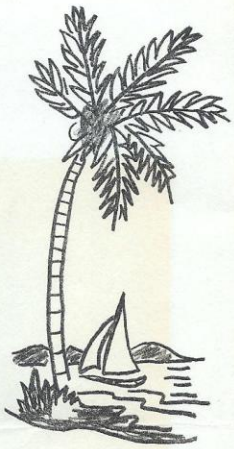
With increasing inter-connectedness, communities around the world are exposed to new technologies. Food and in particular GM crops are a compelling manifestation of these new technologies and risks to which communities must and will respond. Technologies and expertise are continuing to evolve and places are enlisted in these developments. How do places respond? And indeed, how can places benefit?

I want to elaborate further on the distinction between good science and community relations. I strove to avoid the question of which side has stronger scientific evidence when analyzing GM crops or agrochemicals, for this question quickly becomes enmeshed in larger political debates. HSCI leadership is remarkably convincing when speaking about science and regulation, but they struggle to speak—and in Hawaiʻi more importantly listen—in a way that inspires trust from local communities. HSCI critics are raising issues to which seed corporations, with their current orientation, cannot adequately respond. As I acknowledged earlier, perhaps neither group actually intends to directly engage with the other. Unfortunately, if this situation persists it will continue to generate tension and conflict.

There is an implicit need for corporations to adapt their practices to places where they operate even if they believe the reasoning of the people they accommodate is totally irrational. Hawaiʻi residents are only distantly connected to seed corn in the food chain, but they have managed to make HSCI consider their issues. As corporations and technologies continue to penetrate new places and link together different markets, significant tensions will continue to emerge. The contours of those tensions are shaped by particular contexts, and seed corn in Hawai'i is now a focal point for a myriad of different causes.

Appendix#1 Seedmen's Hawaiian Holiday

AGRI DISTRIBUTORS, INC.
931 N. Range Line Road
Carmel, Indiana 46032
(317) 846-6541



SEEDSMEN'S HAWAIIAN HOLIDAY

Just a short progress report on the Hawaiian trip for Seedsmen that we are coordinating. There has been a tremendous amount of interest in this educational trip. Reservations have been coming in rapidly and the seats will soon be filled. Remember, this is a business expense trip so it is a deductible item for income tax purposes.

Several seed companies are using this as an incentive type program for their sales organizations during the important selling months of November and December. Also, it offers an excellent opportunity for many owners, and management people to observe the fine winter research program that Molokai Seed Service offers to the seed industry.

We still have seats available but we urge you to send your reservations in promptly! This trip offers everyone an opportunity to combine a business and pleasure trip to the beautiful islands of Hawaii. Hope YOU can join us on this enjoyable trip!

Remember .... the Seedsmen's Hawaiian Holiday is being offered at the fantastic price of $390.00 per person which includes jet air fare, resort hotel accomondations on Waikiki Beach, and a day at Molikai Seed Service. In addition the plane will pick up passengers at Indianapolis, Indiana and Des Moines, Iowa.

11-4-71

Appendix #2 Pesticide Classification and Regulation

EPA scientists are in charge of conducting environmental and health assessments before approving pesticide products. When pesticides are approved the EPA classifies the pesticide as a Restricted Use Pesticide (RUP), General Use Pesticide (GUP), or Minimum Risk Pesticide.[32] RUPs can only be purchased and applied by certified pesticide applicators. GUPs can be purchased over the counter but if they are intended for commercial agriculture then they are supposed to be bought from a special retailer where the purchaser is instructed in their use. Minimum Risk Pesticides are exempt from regulations and include oil extracts of plants like rosemary, lemon grass, mint, citrus, and so forth. The EPA also controls the application of pesticides by setting out regulations for pesticides such as how much can be applied, how long people have to wait before entering an area, and limits on the wind speed at the time of application.

Agrochemical use in Hawai‘i is regulated by Hawaii's Pesticide Department. Program Manager Thomas Matsuda and his staff of sixteen have the daunting task of enforcing pesticide regulations throughout the state. According to the EPA, pesticides are used broadly to refer to any substance intended to prevent, destroy, repel, or mitigate pests and pests are broadly defined to include insects (insecticide), bacteria (bactericide), fungi (fungicide), mites (mitecide), and weeds (herbicide). The Pesticide Department is in charge of regulating not just agricultural pesticides but also pesticides used in schools, forestry, residential and commercial properties, restaurants, etc. On Hawaii's most populous island, Oahu, there are only two full time inspectors.

[32] Atrazine is an example of an RUP and glyphosate/Round-up is an example of a GUP. Both are used in HSCI.

The mantra used by Matsuda is “The label is the law.” He explained to me that many violations occur because people are unaware that pesticide labels are legally binding.

The Pesticide Department receives monthly reports of RUP sales from all licensed commercial pesticide dealers in the State of Hawaiʻi. These sales reports detail the RUPs purchased, along with information on the purchaser and the amount purchased. Although the parent corporation of a seed company may market a certain pesticides, seed corn operations must purchase pesticides from a pesticide dealer in Hawaiʻi, the same as any other farmer.

The Pesticide Department responds to complaints from the public about suspected inappropriate pesticide use. The typical complaint is based on a suspicious smell, and the investigation begins by trying to determine where the suspected pesticide odor originated and identifying the applicator. All relevant documentation records are scrutinized. The Pesticide Department will also take photographs of spray equipment and protective equipment. If warranted, samples are collected to ascertain if pesticide drift occurred. These samples include swab samples of surface areas, plants or soil. The Pesticide Department regularly receives citizen complaints about HSCI.

Disputes between agricultural operations and residents of nearby residential areas are common throughout the US, especially when residential areas are expanding into areas historically used for agricultural production. Bad odors and dust are common complaints. For HSCI, these tensions between residential and agricultural land uses occur between residents and seed corporations as opposed to residents and farmers. Where farmers seek to placate their neighbors by explaining their farming practices, HSCI operations lack traditional avenues to interact with nearby residents.

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