PESTICIDES IN PARADISE

HAWAI'I'S HEALTH & ENVIRONMENT AT RISK

HAWAI'I CENTER FOR FOOD SAFETY

MAY 2015

ABOUT CENTER FOR FOOD SAFETY

CENTER FOR FOOD SAFETY (CFS) is a non-profit public interest and environmental advocacy membership organization established in 1997 for the purpose of challenging harmful food production technologies and promoting sustainable alternatives. CFS combines multiple tools and strategies in pursuing its goals, including litigation and legal petitions for rulemaking, legal support for various sustainable agriculture and food safety constituencies, as well as public education, grassroots organizing and media outreach. For over a decade, CFS has worked alongside Hawai'i organizations and advocates to advance the vision of a safer, healthier food system. Since opening the Honolulu office in 2014, CFS has provided legal and scientific advice to activists, worked with the legislature, convened workshops and conferences, supported local farming, secured funding for our partners, and grown its Hawai'i True Food network membership.

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SUMMARY OF KEY FINDINGS

Hawai‘i’s agriculture is dominated by experimental genetically engineered (GE) crops grown by five of the world’s six major agrochemical-seed multinationals: Monsanto, Dow Chemical, DuPont-Pioneer, Syngenta and BASF. Like the plantation agriculture that preceded them, these GE seed crop operations claim much of Hawai‘i’s prime farmland, make no contribution to the state’s food needs, and involve intensive use of toxic pesticides.

HISTORICAL OVERVIEW OF AGRICULTURE IN HAWAI‘I (SECTION 2)

- The GE seed industry’s rapid expansion onto former plantation lands has contributed to steadily declining food security; once food self-sufficient, by 2013 Hawai‘i supplied less than 12% of its food needs (2.3).
- The seed industry accounts for less than 0.5% of Hawai‘i’s jobs and gross domestic product, while agriculture redirected to greater food self-sufficiency would create more jobs and bolster Hawai‘i’s economy (2.3.2 & 2.3.3, inset on “Diversified Agriculture”).

GENETICALLY ENGINEERED CROPS IN HAWAI‘I (SECTION 3)

- Hawai‘i leads the nation in GE crop field trials, with tests on 1,141 sites in 2014 alone, representing a far higher density of field tests than on larger mainland states (3.1).
- The majority of GE crops tested in Hawai‘i are corn (67%) or soybeans (24%), while virtually no GE crops relevant to Hawai‘i’s food needs are being tested (3.2).
- The most commonly tested GE “trait” is herbicide-resistance (82% of field releases over the past two years), which permits heavier and more frequent spraying of herbicides than is otherwise possible (3.2 & 3.4).

PESTICIDE USE ON HAWAI‘I (SECTION 4)

- GE seed corn in Hawai‘i involves much more intensive use of pesticides than mainland field corn, for instance, 17 times more restricted use insecticides (4.1 to 4.4).
- From 2007-2012 on Kauai, DuPont-Pioneer alone applied 90 different pesticide formulations representing 63 active ingredients on 2/3 of the days each year, with on average 8.3 to 16 applications per application day in various years of this period (4.3).
- Large agricultural users of more hazardous “restricted use pesticides” (RUPs) – mostly seed firms – account for 99.8% of agricultural RUP sales on the Islands (4.6).

ADVERSE IMPACTS OF PESTICIDES REPORTED IN HAWAI‘I (SECTION 5)

- Pesticide drift frequently sickens Hawai‘i’s schoolchildren, triggering nausea, vomiting, dizziness and difficulty breathing, among other symptoms, and in some cases necessitating decontamination showers, school evacuations and hospitalization.
- Children and adults in Waimea, Kaua‘i, downwind of DuPont-Pioneer fields, have been particularly hard hit by pesticide drift and “fugitive dust;” Kaua‘i physicians report “almost daily” respiratory complaints, as well as nose bleeds and dermatitis; and they suspect pesticides as a possible cause of high cancer and birth defect rates.
- Hawai‘i’s lack of a pesticide poisoning surveillance system, as found in 11 other states, means that pesticide drift is likely far more common than realized.

HEALTH IMPACTS OF PESTICIDE EXPOSURE (SECTION 6)

- Farmworkers and children are at greatest risk from pesticides, due to high exposure and greater sensitivity, respectively. Fetuses (via maternal exposure) are the most vulnerable.
- In a major review of the medical literature, the American Academy of Pediatrics found strong evidence linking pesticide exposure of kids to childhood cancers, neurobehavioral and cognitive deficits, adverse birth outcomes, and asthma. Many of the implicated pesticides (e.g. chlorpyrifos, atrazine) are heavily used in Hawai'i (6.2).
- Adults exposed to pesticides have higher risk of various cancers, Parkinson's disease, depression, and reproductive problems, such as low sperm counts (6.1).
- Studies suggest that even one-time (acute) pesticide poisoning episodes can sometimes have long-term health impacts (6.4).

ENVIRONMENTAL IMPACTS OF PESTICIDES IN HAWAI'I (SECTION 7)

- Hawai'i's incredible biodiversity and many threatened and endangered species are at risk from intensive pesticide use on the Islands.
- For instance, atrazine contamination of surface water threatens amphibian life, while many insecticides heavily used in seed corn operations are toxic to bees.

DEFICIENT FEDERAL AND STATE REGULATION MAKES LOCAL ACTION NECESSARY (SECTION 8)

- EPA relies almost entirely on companies' tests on their own pesticides, fails to consider the toxicity of pesticide additives and exposure to multiple pesticides, and wrongly assumes perfect compliance with application regulations (8.1.1).
- Thousands of pesticide drift episodes occur each year despite EPA regulation, causing illness in both children and adults as well as crop damage; in 2009, public interest groups sued EPA for its failure to protect kids from hazardous pesticide drift (5.2, 8.4).
- Government scientists found that pesticide drift frequently sickens schoolchildren, and recommend "pesticide spray buffer zones around schools" (5.2, 8.4)
- Momentum is building to protect kids from pesticide drift. At least nine states and 14 counties have established no-spray buffer zones around sensitive areas such as schools, daycare centers and hospitals, among other regulations (8.4 & 8.5).
- Residents of three Hawai'i's counties passed ordinances regulating pesticide use and pesticide-intensive GE seed crop operations; rather than comply with these prudent laws, Hawai'i's pesticide firms have sued the counties to overturn them (8.3).

A growing movement, led by communities and local elected officials, is demanding protection of Hawai'i's environment and its citizens, especially its keiki, from pesticidal harms; and a sustainable food system that better meets the state's food needs.

PART ONE: INTRODUCTION

JUSTIN ZERN

In November 2013, 4000 people took to the streets of Kauaʻi in support of Bill 2491, a proposed ordinance that would require agrochemical companies to disclose the amount, location, and frequency of the pesticides they spray, as well as observe modest no-spray buffer zones around "sensitive areas" including homes, schools, hospitals, and waterways. That same year, on Hawaiʻi Island, Ordinance 13-121 was passed to provide farmers and residents of Hawaiʻi, their property, and the environment important protection from the impacts of genetically engineered (GE) crops, such as transgenic contamination and associated pesticide drift, while also banning the planting and outdoor testing of new GE crops. In 2014, Maui County followed suit, passing a temporary moratorium on GE operations until the companies funded an Environmental and Public Health Impact assessment. These historic actions are the work of a powerful and growing community-driven movement to protect citizens, especially our children, from the irresponsible practices of the multinational agrochemical companies that operate across the state of Hawaiʻi.

This report emerges from the frontlines of that movement. First, we describe the historical and economic context of the seed industry, its role in Hawaiʻi's agriculture and economy, and the missed opportunities for greater food security. This is followed by a detailed review of GE crop field trials and pesticide usage practices that characterize the seed industry in Hawaiʻi. We then discuss pesticide poisoning episodes in Hawaiʻi, and more broadly survey the medical and scientific literature addressing the human health and environmental impacts of pesticides. Finally, we describe the serious deficiencies in federal regulation in this arena, and the wave of initiatives taken by states and counties in response. Our hope is to build support for measures to protect Hawaiʻi's citizens, particularly children, from harmful pesticide exposure; and for measures to increase Hawaiʻi's local food production and food security.

PART TWO: OVERVIEW OF AGRICULTURE IN HAWAI‘I

HAWAI‘I STATE ARCHIVES & HAWAI‘I TOURIST BUREAU

2.1 ERA OF SUSTAINABILITY

Before we can delve into Hawai‘i’s current agricultural landscape, and the role that GE seed testing and production plays in that landscape, it is useful to consider the history of agriculture and resource management in the state. This history points to important socio-political dynamics that have dramatically reduced community access to land and water, transforming food from locally produced sustenance into a commodity to be exported or imported. Hawai‘i’s history of food self-sufficiency also inspires Hawai‘i’s food movement, as Native Hawaiians supplied all of their own food needs for thousands of years without needing to import food.

Although Hawaiian agriculture was long dominated by export-oriented sugar and pineapple plantations, for centuries prior the Islands’ agricultural system sustained thriving communities living on the most remote island chain in the world (Mitra

2014). The first Polynesians arrived in Hawaiʻi from the Marquesas between 500 and 700 AD. They introduced animals, including pigs and chickens, and brought essential plants for subsistence from their land of origin[1] (HDOA 2015a). All of these plants and animals provided the Islands' settlers with everything they needed to survive, including food, clothing, medicine, and materials for building shelter. These locally cultivated staple foods supported the nutritional demands of the early settlers, but fostered population growth that required more sophisticated systems of agriculture.

Taro (or kalo) was imbued with cultural significance, providing spiritual and physical sustenance simultaneously.

Over the next millennium, in almost complete isolation, the Hawaiians developed an agricultural system that included aquaculture, or fish ponds (*loko iʻa*), irrigated wetland taro patches (*loʻi kalo*), and rain-fed dryland field systems (Newman 1971, Vitousek *et al.* 2004). These systems were designed to work in harmony with features of the local ecosystem to optimize growing conditions for crops. For example, to provide optimal taro growing conditions in ponds of slowly circulating water, Hawaiians engineered and built foundational infrastructure such as ditches (*ʻauwai*) that fed stream water into staggered terraces, or *loʻi*. While irrigated wetland agricultural systems were primarily found on older islands and in the alluvial valleys of the younger islands, rain-fed dryland systems suitable to local growing conditions were often found on the younger volcanoes of Maui and Hawaiʻi (Vitousek *et al.* 2004). This approach to infrastructure design ultimately allowed taro cultivation in Hawaiʻi to reach intensive levels, with hundreds of varieties developed for particular terrains or for specific traits, all derived from roughly twelve original varieties brought to Hawaiʻi by the early Polynesian settlers (Hawaiian Encyclopedia 2015). As the Hawaiians' staple crop, taro (or *kalo*) was imbued with cultural significance, providing spiritual and physical sustenance simultaneously.[2]

Hawaiians continued building their local food system by developing the *ahupuaʻa* land management system, which incorporated key principles of ecology and environmental management. The ahupuaʻa system organized natural resource use and access around self-sustaining land divisions that follow watershed contours from the tips of the mountains (*mauka*) to the near-shore fisheries (*makai*). These wedge-shaped pieces of land encompass a range of microclimates and natural habitats, each section uniquely suited to cultivating crops, hunting, fishing, and foraging. This arrangement allowed for maximizing the use of biodiversity over short distances and acknowl-

[1]The canoe plants include ʻape (elephant's ear), ʻawa (kawa), ʻawapuhi kuahiwi (shampoo ginger), hau ipu (gourd), kalo (taro), kamani (Alexandrian laurel), kī (ti), kō (sugar cane), kou, kukui (candlenut), maiʻa (banana), milo (portia tree), niu (coconut), noni (Indian mulberry), ʻohe (bamboo), ōhiʻaʻai (mountain apple), ōlena (turmeric), olonā, pia (Polynesian arrowroot), ʻuala (sweet potato), uhi (yam), ʻulu (breadfruit), and wauke (paper mulberry).

[2]For Native Hawaiians, taro is not simply a traditional food, but a relative, an older brother of the Hawaiian people deserving of great respect. "The first child of Wākea and Hoʻohōkūkalani was an unformed fetus, born prematurely they named him Hāloa-naka (quivering long stalk). They buried Hāloa-naka in the earth, and from that spot grew the first *kalo* plant. The second child, named Hāloa in honor of his elder brother, was the first Hawaiian *aliʻi nui* and became the ancestor of all the Hawaiian people" (Kameʻeleihiwa 1992).

The ahupuaʻa land management style preserved ecosystem services and provided advanced agricultural options that worked with the natural world.

edged the interactive influences of biological resources and production zones. This land management style preserved ecosystem services and provided advanced agricultural options that worked with the natural world (Mueller-Dombois 2007).

An ahupuaʻa contained all the resources a community would need to sustain itself, while allowing for high productivity; historically it is reported that this system sustained a population of one million (Stannard 1989). The community living within an ahupuaʻa was responsible for managing its land and water resources. This community-based management of natural resources underpinned social and political belonging: "Rather than being residents of a village, a family belonged to an ahupuaʻa…The ahupuaʻa assured that its residents had access to the resources of both land and sea" (Corum 2000). Further, as a set of practices that shaped land and relationships, it also pointed to a "way of seeing" the world and the relationships therein, as the ahupuaʻa "governed people's survival and their capacity to secure ready access to necessary resources" (Andrade 2001). Weaving together the cultural and social identity with the place where one resides, the Hawaiian worldview further understood *ʻāina* not as simply land or property, but as *that which feeds*, signaling the inextricable relationship between land, people, and food. The values governing land and natural resources in Hawaiʻi ensured that the present generation would subsist totally from locally sourced food, and that the integrity of natural resources would be preserved so future generations could thrive. The fact that the residents of the Hawaiian Islands never relied on imported food well into the eighteenth century is a direct result of this integrated approach to the food system, land management and socio-cultural belonging.

2.2 PLANTATION AGRICULTURE

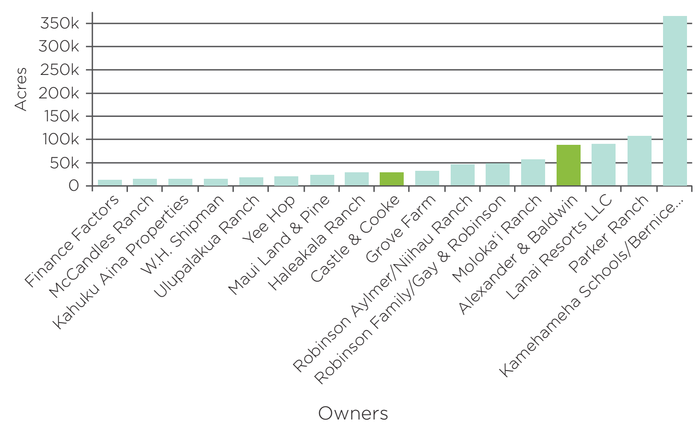
With the arrival of Captain Cook in 1778, a new era in Hawaiʻi's agriculture began – one dominated by foreign agricultural interests that would gradually alienate native Hawaiians from their land and natural resources, and utilize these resources for pesticide-intensive plantation crop agriculture that undermined Hawaiʻi's food security and impacted the health of Hawaiʻi's people and its environment as well.

In the mid-nineteenth century, the transfer of land into the hands of Americans and Europeans became known as *the Mahele*,[3] whereby the foreign concept of private property, a concept antithetical to the communal land model of *kānaka maoli*, was introduced as a legal mechanism to displace most Hawaiians from the land they had historically managed. This resulted in the concentration of land among a small group of foreign merchants and sugar planters, who came to be known as the Big Five (Castle & Cooke, C. Brewer & Co., Alexander & Baldwin, Theo Davies & Co., and Amer-

[3]The Mahele was an act for land redistribution proposed by King Kamehameha III in 1830, enacted in 1845, and amended in 1850 that allowed foreigners to buy and lease land (Bartholomew *et al.* 2012).

ican Factors) (Suryanata 2002). Indeed, the Mahele laid the foundation for the export-orientated "cash crop" plantation agriculture that would define Hawai'i until the late 1970s, and significantly increase the Islands' dependence on imported foods.

Figure 1: Top Private Landowners in Hawai'i 2013



Source: State of Hawai'i Data Book (2013).

The sugar and pineapple industries dominated Hawai'i's society, economy and agriculture for nearly two centuries, and former Big Five firms Castle & Cooke and Alexander & Baldwin remain among the largest landholders in the state today (Figure 1). In addition to land they own, large landholders have extended their control by taking advantage of the State's policy of leasing large parcels of public land at extremely low cost, available at rents as low as just $.02 an acre (Kent 1983). These large, multinational agricultural companies transformed both the environmental and political landscapes, as their increasing control over Hawai'i's land and water was inextricably tied to their increasing political power. The traditional irrigation systems supporting Hawaiian taro and fish pond production were disrupted by water diversion projects initiated by the booming sugar and pineapple plantations, which accessed the water resources free of charge (Kent 1983).

Because of their control over Hawai'i's natural resources, the production of sugar doubled in the four years after the Reciprocity Treaty.[4] After 15 years, the production and exportation of sugar had grown ten times (Kent 1983). To meet the needs of these expanding plantations, Korean, Japanese, Chinese, Filipinos, Portuguese, Puerto Ricans, and Russian contract laborers were brought to work on the Islands (Hawaiian Encyclopedia 2015). By the beginning of the 1900s, Commercial and Sugar Company had 25,000 acres of land, housed 3,200 workers and returned a 20% profit to its stockholders (Kent 1983). At their peak in 1936, pineapple plantations occupied 89,000 acres across the Islands (Bartholomew *et al.* 2012), while sugarcane occupied over 200,000 acres as late as 1982 (Figure 5). Land used for production of export commodities was of course no longer available to supply Hawai'i's needs: as early as 1934-1936, Hawai'i produced only 37% of its food, importing the rest (Loke and Leung 2013).

The sugar and pineapple plantations utilized industrial production methods to meet rising demand and increase their yields (Kent 1983). These included increasing reliance on synthetic chemical inputs (pesticides and fertilizers) and shorter crop ro-

[4]The Reciprocity Treaty was an agreement between the Kingdom of Hawai'i and U.S. starting in 1876, whereby free access to the U.S. market for sugar and other products grown in Hawai'i was granted in exchange for land, that later became Pearl Harbor naval base.

Obstacles for small farmers include the high cost and scarcity of land for sale, and the preference of landowners to lease large parcels of land in long-term leases.

tations, resulting in accelerated depletion of soil and pollution of the environment. Some extremely toxic plantation pesticides infiltrated the groundwater, posing human health risks (Allen *et al.* 1997).

Hawai'i became a state in 1959. Despite heavy pressure to develop and urbanize agricultural land in the state, both the Hawai'i State Constitution (Article 11)[5] and the 1961 Hawai'i State Land Use Law offered protections for agricultural land, which resulted in a system of controls and incentives, including tax provisions, that encouraged property owners to dedicate their land to agricultural uses. However, these land use provisions have not translated into increased access to land for small farmers, nor have they halted the decline in food self-sufficiency. Obstacles for small farmers include the high cost and scarcity of land for sale, and the preference of landowners to lease large parcels of land in long-term leases (Suryanata 2002).

Thus, Hawai'i retained a high concentration of land ownership in the post-statehood period, with the majority still dedicated to export-oriented commodity production (Kent 1983). Today, the majority of land in Hawai'i is still controlled by an exclusive group of private entities, including two firms formerly belonging to the Big Five. After the State of Hawai'i (#1) and the federal government (#2), the top six major landowners in Hawai'i are Kamehameha Schools, Parker Ranch, Lanai Resorts LLC, Alexander & Baldwin, Moloka'i Ranch, and the Robinson Family (see Figure 1). Privately owned land represents 2.4 million acres, or 57% of total land in Hawai'i (Suryanata 2002).

The plantations that once defined Hawai'i's agriculture have almost disappeared, as major producers of sugarcane and pineapple, such as Dole and Del Monte, shut down operations in Hawai'i and sought lower-cost production in developing countries (Goldberg 1996), for instance in the Philippines and Taiwan, where agricultural wages were less than 10% those of Hawai'i in the early 1970s (Bartholomew *et al.* 2012). Today, all that remains of the once dominant plantations are one sugarcane operation on Maui and a single major pineapple producer on O'ahu (HC Sugar 2015, Paiva 2009). However, the plantation era legacy of land concentration, intensive use of toxic pesticides, and agriculture for export lives on with the genetically engineered seed crop industry, to which we now turn.

2.3 THE RISE OF THE SEED CROP INDUSTRY IN HAWAI'I

Hawai'i has become a major center for production of seed crops, which are crops grown for breeding purposes or for farmers' planting stock rather than for food, feed

[5]Article XI of the Hawai'i State Constitution demands the state protect agricultural lands and support food self-sufficiency: "The state shall conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency and assure the availability of agriculturally suitable lands."

DIVERSIFIED AGRICULTURE – AN OPPORTUNITY MISSED

Diversified agriculture is an amorphous concept, a buzzword of sorts, that has come to represent the hopes for a revitalization of Hawai‘i agriculture following the demise of the plantation era and the release of many thousands of acres for alternative uses (Suryanata 2002). For some, it means developing new export crops – such as macadamia nuts, papaya and tropical flowers – to replace pineapples and sugarcane. While this strategy has enjoyed some success (e.g. high-quality Kona coffee), it has often fallen victim to the same forces that undermined plantation-era export crops: falling prices as global corporations source cheaper supplies in developing countries. For instance, producers in Mexico, Brazil and the Philippines have largely supplanted Hawai‘i's growers in major papaya markets such as the mainland U.S., Japan and the European Union. Likewise, the rapidly increasing demand for cut flowers on the mainland since the 1970s has been met largely by producers in South and Central America rather than Hawai‘i. Sadly, even the flowers for traditional Hawaiian leis are increasingly imported (Suryanata 2002).

In the 1990s, state officials showed passing interest in fostering diversified agriculture of another sort: small-scale farming for local food production. According to University of Hawai‘i (UH) agricultural scientist Hector Valenzuela, 200 novice farmers were given two acres each to cultivate, "but they weren't given full support. We didn't show them how to farm. So after a few years they gave up" (as quoted in Mitra 2014). Valenzuela acknowledges that the farming life is tough, but sees that as still more reason to help those who take the plunge to succeed. What explains the state's failure? For Valenzuela, part of the problem was that UH agricultural scientists turned to genetic engineering (GE), and "shut themselves up in labs when they should have been in the fields, showing farmers how to grow food" (*Ibid.*). Veteran Moloka‘i activist Walter Ritte had a similar experience. Agricultural extension agents never followed through on promises to provide training and support for aspiring farmers. He notes that then-Governor Ben Cayetano encouraged further expansion of the GE seed industry, instead: "[a]ll of a sudden the best lands were being given to these big chemical companies and we were back to industrial [agriculture] again" (as quoted in Mitra 2014). As a result, Hawai‘i has become less food self-sufficient than ever before; by 2010, it is estimated that the state imported over 88% of its food (Loke and Leung 2013).

BLOCK ROSEBERY

How large of an opportunity did Hawai‘i miss with its misguided promotion of the GE seed corn industry? Hawai‘i agricultural experts estimate that replacing 100% of imports of selected food products with local production would generate $303 million in earnings, $39 million in state taxes, and create 14,629 jobs (Leung and Loke 2008, Table 5), over 10 times the number currently provided by the pesticide-seed industry. A much more modest goal – replacing just 10% of imported foods overall with local production – would keep $313 million now spent overseas in the local economy; and through ripple effects generate $188 million more in sales, $37 million more in earnings, and $6 million more in state tax revenues throughout the economy. It would also create 2,300 new jobs, 65% more than currently provided by the pesticide-seed industry (Leung and Loke 2008, Hawai‘i Food Security 2012).

Even the more modest goal presents challenges. Farming is hard work that not everyone is suited to; land prices are high; low-cost competition from off-island producers lowers profit margins; and some are put off by agriculture because of its association with plantation-era abuses and pollution. Even so, the obstacles are far from insurmountable. They could be overcome if the state and university were willing to make a vigorous and sustained commitment. This might involve hiring more agricultural extension agents who know how to farm rather than genetic engineers who do not; training novice farmers; enacting policies to make agricultural land more affordable; and encouraging consumers to "Buy Hawaiian," among other measures (Leung and Loke 2008, Hawai‘i Food Security 2012).

Hawaiʻi's chief attraction to seed crop firms was and is that its year-round growing season allows for multiple plantings per year.

or biofuels production. The history of seed operations in Hawaiʻi began in 1966 with a five-acre test planting of corn on Molokaʻi by several mainland seed firms, leading to establishment of the Molokaʻi Seed Service. Winter seed corn operations expanded quickly, and by 1969 totaled about 500 acres on the islands of Molokaʻi, Maui, and Kauaʻi. University of Hawaiʻi initiated year round breeding nurseries as early as 1970, and the widespread transition from winter to year-round nurseries occurred in the 1990s. Major firms with seed corn operations on Hawaiʻi at that time included Pioneer Hi-Bred International, Northrup King, and Illinois Foundation Seeds, among others (Brewbaker 2003). The seed industry transitioned rapidly from conventional to GE crops beginning in the 1990s, and today the vast majority of seeds produced on Hawaiʻi are genetically engineered (see "Biotechnology = Pesticides + Patented Seeds").

Hawaiʻi's chief attraction to seed crop firms was and is that its year-round growing season allows for multiple plantings per year, permitting more rapid breeding of new varieties than is possible on the mainland, where the climate permits only one crop per season. Most seed crop operations are situated on the drier leeward (south and west) side of the islands, on former sugarcane land with irrigation systems, to protect the plants from damaging trade winds and excessive winter rainfall (Brewbaker 2003).

As plantation agriculture declined, prime farmland and associated irrigation systems were freed up for other uses. The State of Hawaiʻi promoted expansion of the seed crop industry onto this irrigated farmland in several ways. In addition to leasing state lands directly to agrochemical companies (discussed further below), the state legislature created an agency called the Agribusiness Development Corporation (ADC), which as part of the Hawaiʻi Department of Agriculture is charged with promoting diversified agriculture on former plantation lands. In 2007, the ADC gave exclusive license to use, manage, operate, maintain, and control the infrastructure of the former Kauaʻi sugar cane lands to a private entity called the Kekaha Agriculture Association (KAA). As part of this arrangement, KAA gained control of two critical ditch systems that represent much of west Kauaʻi's agricultural water resources. KAA is primarily financed and run by its largest corporate leaseholders, which include Pioneer Hi-Bred (now owned by DuPont), Syngenta, and BASF; but it also receives sizeable annual management and project fees that are funded by taxpayers. In contrast to its promotion of agrochemical company interests, KAA has made no noticeable efforts to train Kauaʻi's aspiring farmers in food production (Eng 2012).

Has the state's promotion of the seed crop industry been good for Hawaiʻi's agriculture and economy? Or has it foreclosed other options, incurring what economists call "opportunity costs," that would have provided more benefits? Below, we explore these questions with respect to employment, economic impact, land use, and food security.

BIOTECHNOLOGY = PESTICIDES + PATENTED SEEDS

There has been enormous consolidation in the seed industry over the past three decades. The world's six major multinational agrochemical companies – Monsanto, DuPont-Pioneer, Syngenta, Dow Chemical, Bayer, and BASF – have acquired a huge number of seed firms. These include behemoths like Pioneer Hi-Bred, DeKalb, Northrup-King and Holden's Foundation Seeds, as well as hundreds of smaller firms (Howard 2009). By 2009, the "Big Six" agrochemical companies, as they're known, accounted for fully 58% of the world's commercial seed sales (Table 1). Five of these six multinationals (all but Bayer) have seed operations on Hawai'i.

This acquisition spree was spurred by two major factors. First, the advent of plant patents in the 1980s and 1990s made the traditionally low-profit seed industry a potentially lucrative market by giving seed owners the legal "right" to prohibit farmer seed-saving, and thereby increase seed sales and prices. Second, the development of genetic engineering techniques enabled introduction of new "traits" into corn and other crops. Seed firms incorporate large "technology fees" for these traits into the price of the seed, another reason for skyrocketing seed prices in the era of genetic engineering. These new "biotechnology" (i.e., consolidated agrochemical & seed) firms have made it a top priority to use genetic engineering to make their newly acquired plant varieties resistant to herbicides (i.e., weed-killers), thereby dramatically increasing sales of these profitable products as well (Freese 2014). Table 1 illustrates the strong nexus between agrochemicals and seeds: the "Big Six" account for two-thirds (67%) of combined seed and agrichemical sales revenue worldwide.

From the mid-1990s to the present, genetically engineered varieties of corn, soybeans, and cotton have almost entirely replaced conventional varieties in both farmers' fields and in Hawai'i's seed crop operations.

Table 1: Top 6 Companies in Agrichemicals & Seeds
(2009 sales, in billions of dollars)

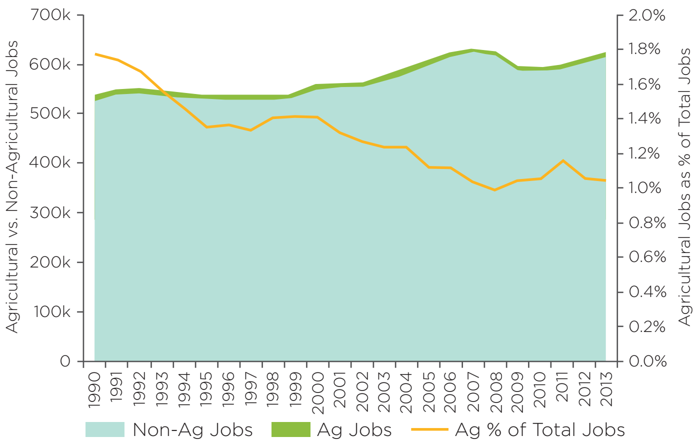
	Company	Seeds + Agrichemicals		Seeds		Agrichemicals	
		Sales	Market Share	Sales	Market Share	Sales	Market Share
1	Monsanto (USA)	11.724	16%	7.297	27%	4.427	10%
2	Syngenta (Switzerland)	11.055	15%	2.564	9%	8.491	19%
3	Bayer (Germany)	8.244	12%	0.700	3%	7.544	17%
4	DuPont-Pioneer (USA)	7.044	10%	4.641	17%	2.403	5%
5	BASF (Germany)	5.007	7%	NR	NR	5.007	11%
6	Dow Chemical (USA)	4.537	6%	0.635	2%	3.902	9%
Top Six Companies		47.611	67%	15.837	58%	31.774	71%
Total Market		71.400		27.400		44.000	

Source: Based on ETC Group (2011).

2.3.1 Employment

The agricultural sector as a whole provides extremely few jobs in Hawai'i, and its contribution to state employment has declined sharply over the past quarter century (Figure 2). Agriculture accounted for 9,550 jobs in 1990, declining 32% to just 6,500 jobs by 2013. Because this decline in agricultural employment coincided with a 16% rise in total jobs, agricultural jobs fell from 1.8% to just 1.0% of the state's work force (Figure 2). While agricultural employment is also declining nationally, Hawai'i is disproportionately job-poor in this critical sector. In 2012, for instance, agriculture

Figure 2: Agricultural vs. Non-Agricultural Jobs in Hawai'i: 1990-2013



Sources: Data for 1990 to 2010 (HDBEDT 2015a) and data for 2011 to 2013 (State of Hawai'i Data Book 2013).

accounted for 1.45% of U.S. jobs (US Department of Labor 2013, Table 1), 40% higher than the agricultural share of Hawai'i's employment in that year (1.06%).

To our knowledge, there is no independently published data regarding seed industry employment in Hawai'i; however, according to a report by industry contractors, the Hawai'i seed crop industry employed 1,397 workers in 2012 (Loudat and Kasturi 2013). This represents just 0.23% of total Hawai'i jobs (612,800) in that year. In other words, the seed industry accounted for just 1 of every 439 jobs in Hawai'i in 2012. The number of seed industry jobs has declined sharply (by 25%) since 2008, when 1,863 individuals were employed (Loudat and Kasturi 2009). Moreover, nearly half (43%) of seed industry jobs are part-time (*Ibid.*), and hence presumably provide too little income to support a family.

2.3.2 Economic Impact

Contrary to popular belief, Hawai'i's seed industry makes a marginal contribution to the state's economy, as measured by gross domestic product (GDP).[7] As with employment, we first examine the agriculture sector as a whole, of which the seed industry is a part.

The "agriculture, forestry, fishing and hunting" sector (AgFFH) ranks second to last (19th) among 20 sectors in GDP by industry, behind "arts, entertainment & recreation" and surpassing only "mining" (Figure 3). From 1997 to 2013, AgFFH comprised just 0.48% to 0.75% of Hawai'i's "all industry" GDP (Figure 4).[8] In 2012, for instance, Hawai'i's AgFFH sector had a GDP of $335 million, just 0.52% of the state's GDP of $68.8 billion (both in constant 2009 dollars).

While there are no GDP figures for the seed industry subsector in particular, annual agricultural statistics for the state indicate that seed crops represent about one-third (34%) of the overall value of agricultural production (HASB 2011, p. 7). By applying this 34% factor to total agricultural GDP ($355 million for 2012), it may be

[7]According to the U.S. Bureau of Economic Affairs, the "GDP by industry" statistic "provides the basis for comparing the performance of each industry relative to other industries and to the economy as a whole and for identifying each industry's contribution to economic growth" (BEA Consumer Guide 2015).
[8]If one excludes forestry, fishing and hunting to focus solely on the "farms" subsector that encompasses the seed industry, the GDP contribution is smaller still: from 0.40% to 0.64% of "all industry" GDP over this period.

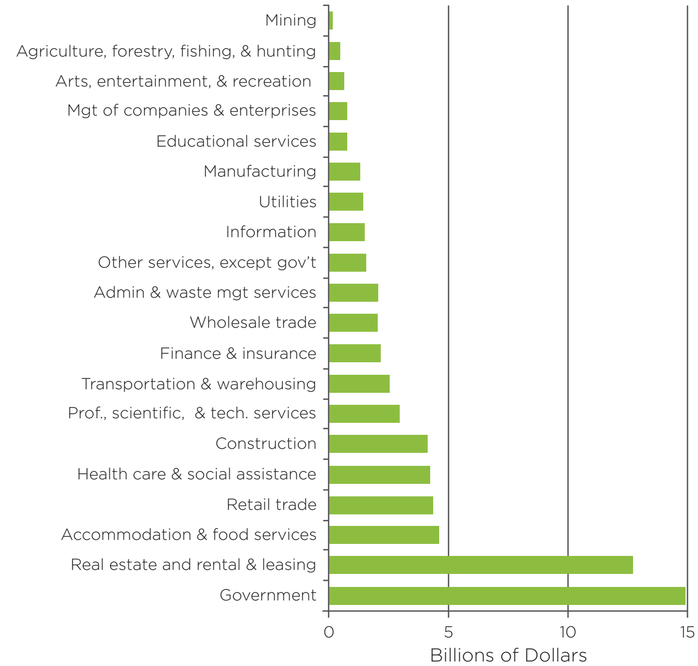
estimated that the seed industry yielded an annual GDP of roughly $121 million in 2012, representing just a small fraction (0.18%) of the state's GDP. Industry proponents have proposed a variety of economic "ripple effects" that would roughly double the industry's impact (Loudat and Kasturi 2013). However, even if these estimates are accepted at face value, **the seed industry is still an extremely minor player in Hawai'i's economy, with less than 0.5% shares of jobs and state GDP**. Moreover, it is quite clear that seed crops have much lesser ripple effects than growing food for consumption in Hawai'i (Leung and Loke 2008).

Seed industry contractors (Loudat and Kasturi 2009, 2013) have made much of the rapid growth in "value" of the Hawai'i seed industry. However, this high growth rate primarily reflects the astronomical rise in the price of genetically engineered seeds that the agrochemical/seed giants are charging American farmers, who have ever fewer affordable seed options as these companies continue to buy up smaller seed firms (Freese 2007a, Hubbard 2009). The pesticide-seed industry's increasing "value" is thus nothing to celebrate, except perhaps in the boardrooms of the companies themselves. (See Appendix I for further discussion of methods used to artificially inflate the importance of the seed industry to Hawai'i's economy).

2.3.3 Land Use and Food Security

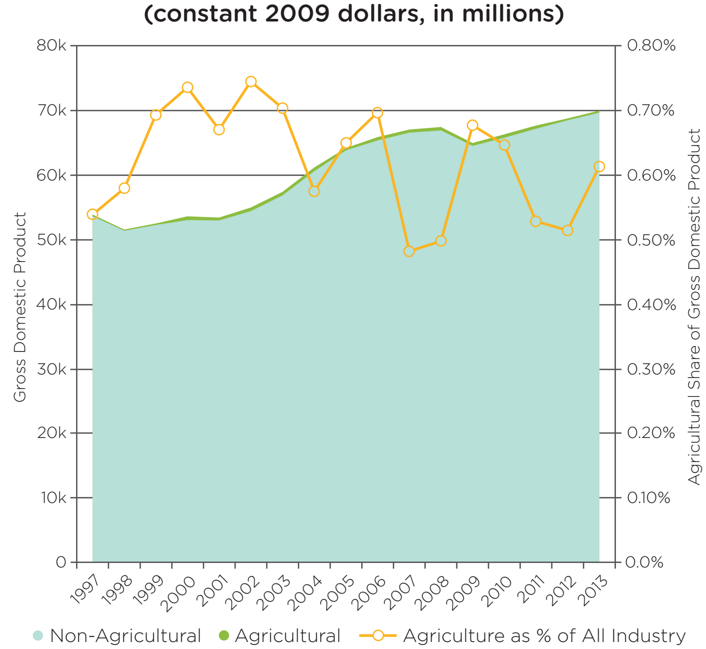
The decline of plantation agriculture freed up huge amounts of land, which opened up enormous opportunities for more local food production. Despite official rhetoric on the importance of increasing food self-sufficiency, however, the state chose not to embrace these opportunities (see "Diversified Agriculture – An Opportunity Missed"). As a result, even the non-plantation component of Hawaiian agriculture is stagnant and in some respects in steep decline.

Figure 3: GDP of Agriculture vs. Other Industries in Hawai'i: 2009



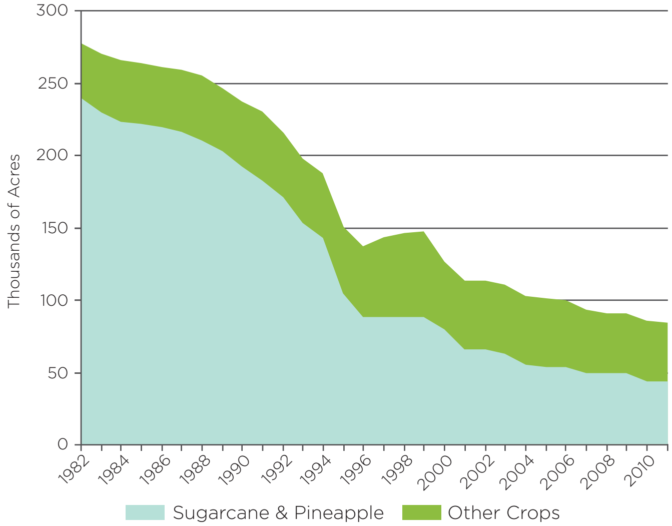
Source: HDBEDT (2015b).

Figure 4: Agriculture as Share of Hawai'i's Real GDP (constant 2009 dollars, in millions)



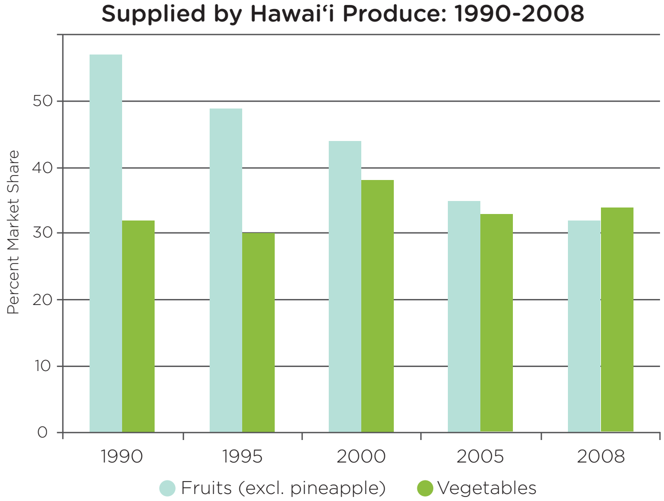
Source: HDBEDT (2015b).

Figure 5: Area Planted to Plantation vs. Other Crops in Hawai'i: 1982-2011



Sources: HASB (various years), see table entitled "SUMMARY: Acreage in crop and total farm acreage, by county" in respective annual bulletins. Note: Beginning in 2007, HASB stopped listing pineapple acreage separately, but instead folded it into the "All other crops" category (see HASB 2007, p. 79, footnote 7). In this figure, estimated pineapple acreage is added to "Sugarcane and Pineapple" and subtracted from "Other Crops" for 2007-2011.

Figure 6: Share of Fresh Fruit and Vegetable Markets Supplied by Hawai'i Produce: 1990-2008



Sources: HASB (various years). See tables entitled "Market Supply: Fresh market fruits, State of Hawai'i" and "MARKET SUPPLY: Fresh market vegetables, State of Hawai'i" in respective annual bulletins.

One clear sign of this is that the land area planted to crops other than sugarcane and pineapple (including seed crops) has not increased at all from plantation days to the present. Consider this simple fact: despite the freeing up of 200,000 acres of prime plantation land, much of it irrigated, since 1982, **there has been no net increase in land planted to other crops, which stands at roughly 40,000 acres today as it did three decades ago** (Figure 5).

A second indicator of the state's diminishing agricultural sector is the declining market share for locally grown fresh produce in Hawai'i's market. Over the past two decades, Hawai'i has made zero progress in producing a greater share of the fresh vegetables its citizens consume. In 2008, only one-third of vegetables were home-grown, while two-thirds were imported, the same split as in 1990 when plantations still claimed much of the best land (Figure 6). Incredibly, Hawai'i has become nearly twice as dependent on imports of fresh fruits: the home-grown share declined from 57% in 1990 to just 32% by 2008 (Figure 6). That a state with ideal conditions for fruit production should import two-thirds of its fresh fruit must be counted a major failure of state agricultural policy, particularly in a state supposedly committed to greater food self-sufficiency.[9] The import shares of fruits and vegetables have likely increased still further since 2008; however, these statistics are not available because the Hawai'i Department of Agriculture defunded the agency that records these data in 2009.[10]

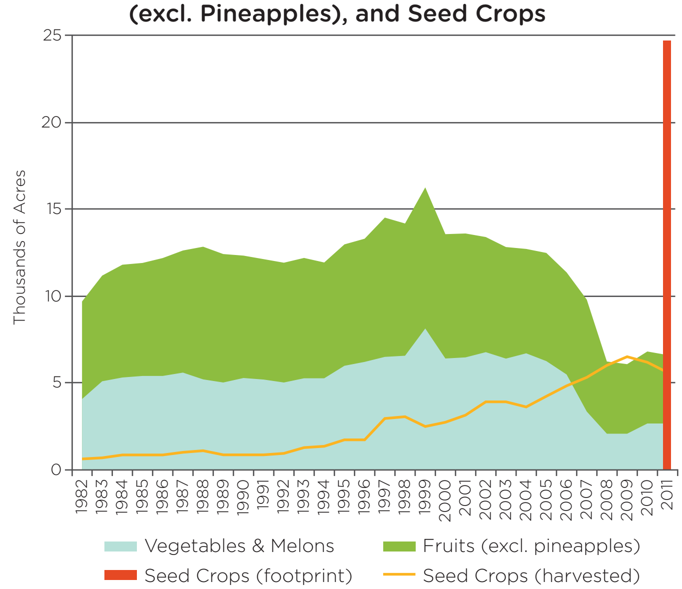
[9]The steep rise in the import share of fresh fruits is not explained by increased consumption of fruits not readily grown in Hawai'i. For instance, comparison of figures for 1990 and 2011 shows only slight increases in apple and pear imports (by weight).

[10]Because these data are of course vital for assessing Hawai'i's progress (or lack thereof) toward food self-sufficiency, the state's defunding of this agency speaks volumes about its lack of true commitment to this rhetorically supported goal. The data no longer available since 2009 are "in-shipment" or import figures for fruits and vegetables: "data was provided by the Market Analysis and News Branch of the Hawai'i Department of Agriculture. Data for 2009 is not available due to reduction-in-force eliminating all Market Analysis and News Branch positions" (HASB 2009, p. 38, footnote 2). The data are also missing for 2010 and 2011.

In the face of this failed agricultural policy (and perhaps to obscure it), state officials miss no opportunity to herald the growth of the seed crop industry. Indeed, harvested seed crop acreage has increased about 10-fold since 1982 (Figure 7). This rising acreage in seed crops has coincided with a more than 50% decline in the already minimal acreage planted to fruit and vegetable crops: from a peak of over 14,000 acres in the late 1990s to just 6,000 acres today. **In 2009, Hawai‘i for the first time had more acres planted to seed crops than to fruit (excluding pineapples) and vegetables combined** (Figure 7). As more land is devoted to inedible seed crops, less is available to farmers growing food crops for local consumption, meaning an overall decline in food security.

However, the seed industry has a much larger "footprint" than even these figures suggest. Based on real property tax records, the five agrochemical/seed firms active in Hawai‘i own or lease over 25,000 acres for their operations (Table 2). This is over four times the seed crop acres harvested in 2011, and four times the total area planted to vegetables and fruits (excluding pineapple) (Figure 7). **The seed industry's footprint (25,034 acres) is two-thirds the size of the total area planted to crops other than sugarcane or pineapple (37,600 acres).** This high-quality land, most or all of it irrigated, would be extremely well-suited to local food production, but the seed industry's control ensures that it cannot be used for this purpose. Interestingly, the great majority of this land (20,823 acres) is leased by the companies from Hawai‘i's large landowners or from the state itself (Table 3). Thus, both state officials and Hawai‘i's prominent landowners are actively ceding valuable agricultural land to pesticide-intensive seed crop operations that make zero contribution to Hawai‘i's food supply, even as the state becomes ever less food self-sufficient.

Figure 7: Area Planted to Vegetables, Fruits (excl. Pineapples), and Seed Crops



Sources: HASB (various years). See tables entitled "SUMMARY: Acreage in crop and total farm acres, by County," and "SEED CROPS: Number of farms, acreage, out-shipments, and value, State of Hawai'i" in various annual bulletins. See text for "seed crops (footprint)."

Table 2: Land Used for Seed Crop Operations in Hawai‘i

Company	Acreage Owned or Leased	Islands
Monsanto	8,480	Moloka'i, Maui, O'ahu
DuPont-Pioneer	7,644	Kaua'i, O'ahu
Dow Chemical	4,060	Moloka'i, Kaua'i
Syngenta	3,675	Kaua'i, O'ahu
BASF	1,175	Kaua'i
Total	25,034 acres	

Source: Honolulu, Kaua'i, and Maui Real Property Assessment Division, 2015.

2.3.4 Summing Up

Hawai‘i's seed crop industry provides few jobs and contributes little to the state's economy, but nevertheless claims a large amount of prime cropland. Despite a rhetorical

Table 3: Major Lessors of Land to the Seed Industry on Hawaiʻi

Landholder	Acreage Leased	Islands
Gay & Robinson, Inc.	8,835	Kauaʻi
State of Hawaiʻi DoA-ADC	5,882	Kauaʻi
Island Palm Communities	2,400	Oʻahu
Molokai Properties Limited	2,113	Molokaʻi
Kamehameha Schools	1,000	Oʻahu
Hawaiʻi Agricultural Research Center	390	Oʻahu
State of Hawaiʻi – Hawaiʻi Homelands	149	Molokaʻi
State of Hawaiʻi – Other	45	Molokaʻi
Alexander & Baldwin LLC	9	Maui
Total	20,823	

Source: Honolulu, Kauaʻi, and Maui Real Property Assessment Division, 2015.

commitment to food self-sufficiency, the state has done little or nothing to actually promote it. As a result, cropland devoted to production of fruit and vegetables is in steep decline, and Hawaiʻi imports ever more of its produce - and over 88% of its food overall (Loke and Leung 2013). Rather than continuing to facilitate the expansion of the seed crop industry, the state and major landowners must change course and make a serious, sustained effort to reinvigorate the state's agriculture for increased local food production. The health and environmental impacts of pesticide-intensive genetically engineered seed crop production make this course correction all the more urgent.

PART THREE: GENETICALLY ENGINEERED CROPS IN HAWAI‘I

Although genetically engineered (GE) crops were not grown commercially until the early to mid-1990s, outdoor experimental plantings began in 1987. Hawai‘i was one of the very first states to host a GE crop field trial in 1988. Early tests involved tomatoes, cotton, and corn engineered primarily for herbicide-resistance and/or insect-resistance (ISB Release 2015).

Genetic engineering endows crops with new "traits" by introducing genes derived from other organisms, mostly from bacteria. Insect-resistant crops incorporate one to seven bacteria-derived genes that cause the plant to generate an equivalent number of insect-killing toxins in all of its tissues. Herbicide resistance[11] is the ability of

[11]Also incorrectly called "herbicide tolerance" by the agrochemical-seed firms and those who follow their faulty naming convention. The Weed Science Society of America clearly defined such GE crops as "herbicide-resistant" in 1998 (WSSA 1998).

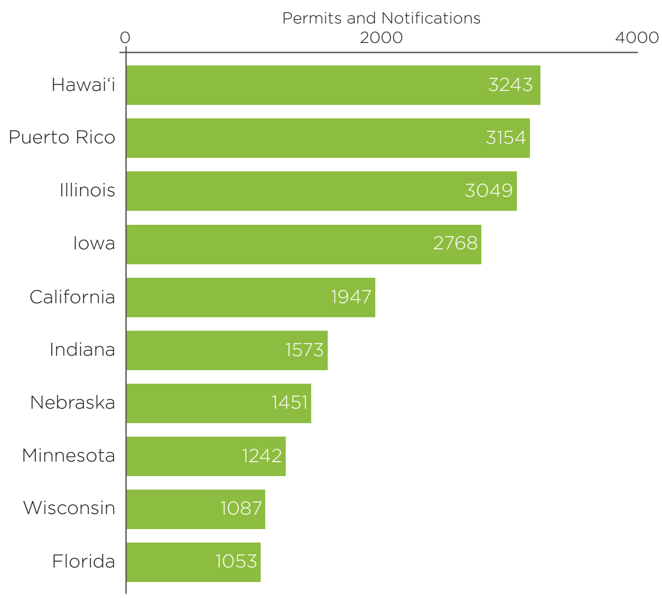
a plant to withstand an herbicide application that would otherwise kill it, to enable more convenient weed control. This trait is generated by inserting into the crop genome the "resistance" gene from a soil bacterium that has evolved immunity to the herbicide through frequent exposure to it (e.g. Adler 2011). As discussed further below, herbicide-resistant crops are by far the dominant type of GE crop grown today, and they lead to much increased use of and dependence on toxic herbicides.

Field releases of GE crops are carried out under perfunctory permits issued by United States Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS). Obtaining a permit is a simple affair that involves providing minimal information, for instance the crop species, the intended trait(s), and the field test location(s). While USDA once carried out environmental assessments under the National Environmental Policy Act (NEPA) prior to issuing permits, this is rarely done today. In fact, the last full environmental assessment of a GE crop field release in Hawai'i was conducted in 1994 (ISB EA 2015).

3.1 TRENDS IN NUMBER OF GE CROP FIELD TESTS IN HAWAI'I

Hawai'i is ground zero for experimentation with GE crops. According to a USDA-sponsored database maintained by Virginia Tech, **more permits have been issued for GE crop field tests in Hawai'i (3,243) than in any other state in the nation since field tests began in 1987 (Figure 8).** Because Hawai'i is much smaller than other states where GE crops are also frequently tested, it has a much higher *density* of field releases. For instance, Hawai'i has had 9.2 times more GE crop field releases per unit land area than Illinois. This suggests that more people in Hawai'i live in close proximity to field test sites than residents of Midwestern states, such as Illinois.

Figure 8: Top Ten Most Frequent Locations for Crop Release



Source: ISB Locations (2015). Cumulative number of GE crop field releases in leading states, from 1987 to present. Each release often involves tests on several different sites.

A permit covers just one GE crop species (e.g., corn), but may involve the testing of dozens of different GE traits. An individual permit may authorize testing in one or multiple states; on one or many sites in each of those states; and on anywhere from fractions of an acre to many thousands of acres (Figure 9). As shown in Figure 10, annual permit numbers for Hawai'i have fluctuated in a narrow range of 100-200 since the year 2000, but the number of field test sites authorized by those permits has increased nearly three-fold, from 425 to 1141, over the same period. USDA does not break down field test acreage data by state (Figure 9);

however, the dramatic rise in the number of field test sites, and the increasing acreage planted to seed crops as a whole (Figures 7 and 10), suggests strongly that ever more Hawai'i residents live in proximity to heavily sprayed GE seed crop fields.

3.2 TYPES OF GE CROPS TESTED IN HAWAI'I

Hawai'i's pesticide firms test out new GE crops under permit, as discussed above, and these experimental varieties may not be sold to farmers. They may also grow some approved GE crops to produce seed for farmers, but such "seed increase" plantings occur primarily on the mainland (Gomes 2015). In both cases, the ultimate goal is producing GE seed as planting stock. Thus, it is not surprising that the types of GE crops grown in Hawai'i reflect the types that are grown on the mainland.

GE corn and soybeans comprise the majority (about 90%) of GE crop acreage in the U.S. The remaining 10% is comprised primarily of GE cotton, alfalfa, canola, and sugar beets. Virtually all of these GE crops incorporate only one or both of two traits: insect-resistance (IR) and herbicide-resistance (HR). All GE soybeans, alfalfa, canola, and sugar beets are HR only; while most GE corn and cotton incorporate both HR and IR traits. GE crops with HR and/or IR traits are so dominant that USDA does not even bother to record the miniscule acreage planted to other types of GE crops (Figure 11). Thus, although virus-resistant GE papaya looms large in Hawai'i, neither the crop nor its trait is significant enough to register in the larger scheme of biotech agriculture. In fact, GE papaya represents less than 0.001% of U.S. acreage planted to GE crops.

Over 90% of GE crop field releases in Hawai'i involve corn or soybeans, reflecting the dominance of these crops on the mainland; all other crops combined comprise less than 9% of field releases. Corn is tested

Figure 9: Permit for Typical GE Corn Field Release in Hawai'i and Puerto Rico

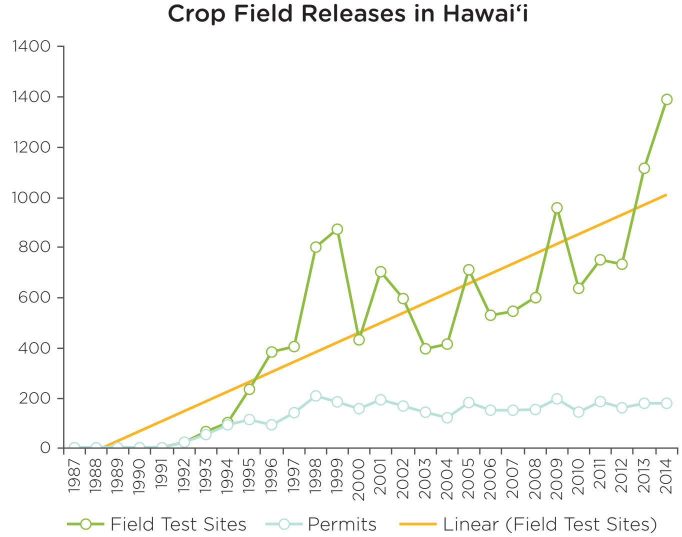
BP_Number	14-302-112rm
Institution	Monsanto
Acres	970
CBI	CBI
Receive	10/29/2014
Issued Date	02/25/2015
Effective Date	03/01/2015
Expire Date	03/01/2016
Status	Issued
Regulated Article	Corn
Locations	Hawai'i, Puerto Rico
Phenotypes	AP-Altered Nitrogen Metabolism, AP-Drought Tolerant, AP-Yield Increased, HT-2,4-D Tolerant, HT-CBI, HT-Dicamba Tolerant, HT-Glufosinate Tolerant, HT-Glyphosate Tolerant, HT-Quizalofop Tolerance, IR-CBI, MG-Method Development, NR-CBI, OO-Method Development
Genes	CBI
Sort Date	03/01/2015
In Effect	
Pet_test	
Type	rel
Petition EA & Determination	N/A
Petition for Deregulation	N/A
Associated Field Tests	N/A
Release Environmental Assessment	N/A

Confidential Business Information

No Environmental Assessment

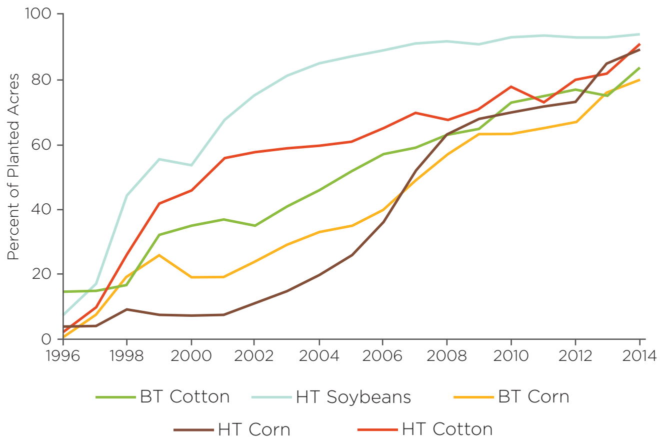
Source: ISB Release Record Detail (2015). Total maximum area of field tests in Hawai'i (HI) and Puerto Rico (PR) combined is 970 acres. Phenotypes (i.e. traits) being tested include resistance to six different herbicides (see herbicides listed after "HT" under "Phenotypes"). Several "phenotypes" and all "genes" are kept secret as "CBI" (confidential business information).

Figure 10: Permits and Field Test Sites for GE Crop Field Releases in Hawai'i



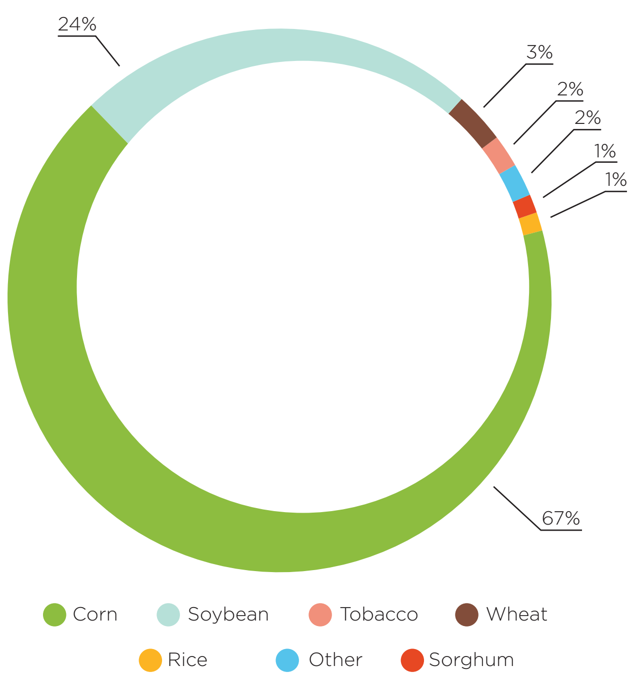
Source: ISB Locations & Sites (2015).

Figure 11: Adoption of Genetically Engineered Crops in the United States, 1996-2014



Source: USDA ERS (2015). Note that "HT" = herbicide-tolerant, which is equivalent to "HR" = herbicide-resistant. "Bt" stands for *Bacillus thuringiensis*, the bacterium from which genes are derived to make corn and cotton insect-resistant.

Figure 12: GE Crop Field Tests in Hawai'i: 2010-2014



Source: ISB Release (2010-2014). Corn and soybeans together accounted for 91% of field test permits in Hawai'i in the five years from 2010 to 2014.

nearly three times more frequently than soybeans and represented 67% of total GE crop field releases from 2010 to 2014 (Figure 12). The dominance of GE corn is also shown by the fact that seed corn comprised 95.6% of the value of the state's seed crop industry in 2011 (Loudat and Kasturi 2013).

GE crops with a broad range of traits have been intensively tested in Hawai'i (and elsewhere) for nearly three decades (Table 4), but aside from herbicide- and insect-resistant crops, virtually none have entered the marketplace. The industry's failure in this regard has several explanations. First, serious technical obstacles result in an extremely high failure rate for genetic engineering, particularly for complex traits that involve multiple genes. Second, the biotech industry's concentration of its research and development (R&D) resources on herbicide-resistant crops has occurred at the expense of developing other traits. Third, some GE crops have been rejected in the marketplace.

Herbicide-resistance was the most frequently tested trait in GE crop field tests on Hawai'i over the past five years (Figure 13). Herbicide-resistant (HR) crops were grown in over two-thirds (68%) of GE field releases over this period (542 of 802), and were even more prevalent over the past two years (82% of field releases in both 2013 and 2014).[12] The predominance of herbicide resistance in agrochemical-seed company R&D is also demonstrated by the numerous HR crops that have recently been approved by USDA for commercial use (Table 5).

In contrast, extremely few GE crops with improved nutritional quality[13] were tested: just 18 over the entire five-year period, or 2.2% of field releases (Figure 13).

[12]As noted above, a single permit often authorizes testing of a variety of different traits (see Figure 9). The average field release in Hawai'i over the past five years involved traits from 2.7 trait categories (Table 4).

[13]Based on GE crops with the phenotype designated "nutritional quality improved." Some GE crops with other compositional alterations (e.g. altered oil content, protein levels altered) are not included in this count.

This fact shows clearly that the agrochemical companies have little or no interest in improving nutrition, as they sometimes claim. Another much-touted goal of genetic engineering is disease-resistance. Here too, R&D efforts fall far short of what would be needed to successfully develop a crop with resistance to certain fungal, viral, or bacterial plant pathogens (Figure 13).

3.3 COMPANIES WITHHOLD INFORMATION ON GE CROP FIELD TESTS

As shown in Figure 9, companies routinely withhold key facts about their GE crop field tests as "confidential business information" (CBI). In fact, 81% of Hawai'i permits (in 2014) hid the identity of one or more traits as CBI. The usual rationale for CBI is that disclosing such information would give competitors valuable clues about the types of GE crops it is developing. However, facts are often deemed CBI even when they are well-known to competitors. For instance, Dow Chemical publicized its development of 2,4-D-resistant corn and soybeans to the world no later than August of 2007 (Dow Chemical 2007). Yet not a single one of the hundreds of permits issued to Dow Chemical for field tests of GE herbicide-resistant crops identifies 2,4-D-resistance as the trait, in Hawai'i or in any other state. It is hard to avoid the conclusion that companies often abuse CBI in order to hide from the public unpleasant facts about their GE crops – in this case, that they are being heavily sprayed with the toxic herbicide 2,4-D.

3.4 HERBICIDAL ONSLAUGHT WITH GE HERBICIDE-RESISTANT CROPS

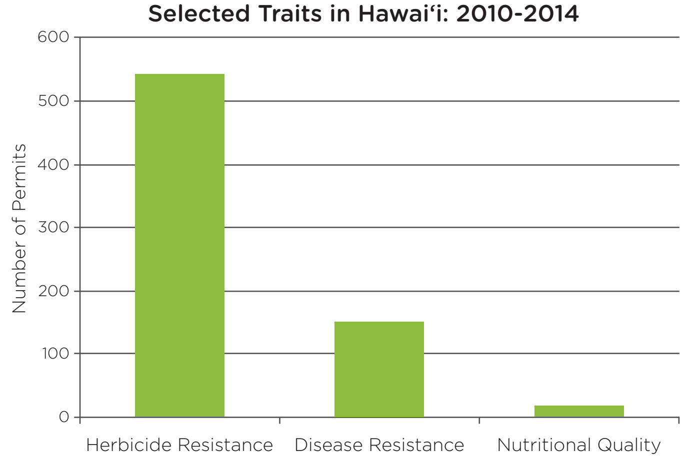
As shown in Figure 14, five agrochemical-seed firms were responsible for 97% of GE crop field releases in Hawai'i over the past five years, while various public sector institutions were responsible for just over 1%. The remainder represents testing of GE tobac-

Table 4: Types of Genetically Engineered Crops Tested in Hawai'i

Trait Category	Example	Comments
Herbicide Resistance	Corn, soybeans, cotton that survive direct application of one or more herbicides (e.g. 2,4-D, dicamba, glyphosate, glufosinate)	Most widely grown type of GE crop (-170 million acres in U.S.). Fosters rapid evolution of herbicide-resistant weeds, more herbicide use, environmental harm and crop damage from herbicide drift, and increasing farm size.
Agronomic Properties	Alterations in fertility (e.g. sterile pollen or seed), maturity or plant development	Corn w/ sterile pollen is used for breeding purposes; sterility of 2nd generation (harvested) seed is sought to prevent farmers from saving seed.
Insect Resistance	Bt corn that contains up to 7 toxins derived a from a soil bacterium (Bacillus thuringiensis, "Bt")	Various "Bt" toxins kill different pests; some reduction in chemical insecticide use; Bt-resistant corn rootworm (a serious root pest of corn) is an increasing problem.
Product Quality	Alterations in composition of grain or fruit, including nutritional changes	Corn w/ increased starch content is sought for use in biofuels production.
Marker Gene	Genes for antibiotic or herbicide resistance	Antibiotic or herbicide is applied early in development process to kill off GE plant cells that fail to express the intended trait.
Disease Resistance	Resistance to fungal, viral or bacterial plant pathogens	Little R&D for these traits; GE papaya & squash are the only commercially grown crops in this category.
Nematode Resistance	Resistance to nematodes, tiny worm-like pests in the soil	Little R&D; no commercially grown GE crops in this category.
Other	Altering "sex" of plant (female to male or hermaphrodite); pharma crops	Pharma crops are intended as "biofactories" for pharmaceutical production; drug is extracted (e.g. from corn kernels). Contamination & food safety concerns.

Source: Information in ISB Release (2010-2014).

Figure 13: GE Crop Field Trial Permits for Selected Traits in Hawai'i: 2010-2014



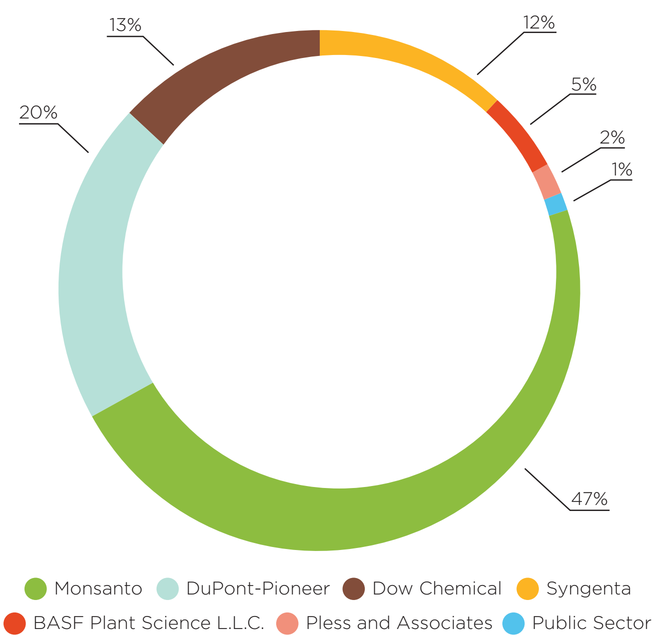
Source: ISB Release (2010-2014). Disease resistance comprises three distinct types of trait: fungal resistance, virus resistance and bacterial resistance.

Table 5: "Next Generation" GE Herbicide-Resistant Crops

Petition #	Company	Crop	Herbicides	Status
13-262-01p	Dow Chemical	Cotton	2,4-D, glufosinate, glyphosate*	Pending Approval
12-215-01p	Bayer/ Syngenta	Soybeans	HPPD inhibitors, glufosinate, glyphosate*	Approved 2014
12-185-01p	Monsanto	Cotton	Dicamba, glufosinate, glyphosate*	Approved 2015
11-234-01p	Dow Chemical	Soybean	2,4-D, glufosinate, glyphosate	Approved 2014
10-188-01p	Monsanto	Soybean	Dicamba, glyphosate*	Approved 2015
09-349-01p	Dow Chemical	Soybean	2,4-D, glufosinate, glyphosate*	Approved 2014
09-328-01p	Bayer	Soybean	Isoxaflutole, glyphosate	Approved 2013
09-233-01p	Dow Chemical	Corn	2,4-D, ACCase inhibitors, glyphosate*	Approved 2014
09-015-01p	BASF	Soybean	Imidazolinones	Approved 2014
07-152-01p	DuPont-Pioneer	Corn	Imidazolinones, glyphosate	Approved 2009

Source: USDA APHIS (2015). GE herbicide-resistant crops approved for commercial use over the past few years. Where glyphosate appears in italics and boldface, the GE crop was approved without glyphosate resistance but the pertinent company has announced plans to introduce it via cross-breeding.

Figure 14: GE Crop Field Releases in Hawai'i by Institution: 2010-2014



Source: Information in ISB Release (2010-2014).

co with some unknown product quality trait by Pless and Associates. The fact that agrochemical firms are overwhelmingly dominant explains why herbicide resistance is the most frequently tested trait in Hawai'i (Figure 14). These firms are the major producers of herbicides, which comprise 65% of all pesticide use in American agriculture (EPA 2011, Table 3.4). By engineering crops for resistance to herbicides they also sell, the agrochemical companies profit twice: from expensive GE seeds, and from vastly increased sales of the herbicides that are used with them. In fact, over the 16 years from 1996-2011, herbicide-resistant corn, soybeans, and cotton increased herbicide use by a massive 527 million lbs. over what would have been applied in their absence (Benbrook 2012). USDA confirms that herbicide use has more than doubled on soybeans from 1996 to 2012: from 61 to 133 million lbs. per year (USDA NASS 2014).

Most of this additional herbicide is glyphosate, the active ingredient in Monsanto's Roundup, and it is applied to the company's Roundup Ready crops. This massive use of glyphosate has triggered a raging epidemic of glyphosate-resistant weeds, just as overused antibiotics breed resistant germs. Glyphosate-resistant weeds infest upwards of 61 million acres in the U.S., and are becoming a major problem for ever more farmers (Fraser 2013).

Hawai'i is a major test ground for the pesticide companies' short-sighted response to glyphosate-resistant weeds: namely, new GE crops resistant to a host of *other* herbicides that will still kill them, at least for a time. **In 2014, 82% of GE field releases in Hawai'i involved crops resistant to one or more (class of) herbicide(s): 2,4-D, dicamba, glufosinate, ALS inhibitors, quizalofop, imidazolinones, and glyphosate.** Because 63% of Hawai'i permits had herbicide-resistance traits hidden as "CBI," GE crops resistant to unidentified chemicals are also being tested, perhaps even to restricted use herbicides such as atrazine and paraquat. Herbicides kill plants and many are toxic to human beings. By increasing herbicide use, these new GE herbicide-resistant crops pose greater risks to Hawai'i's people and environment; and they offer no real solution to mainland farmers' weed problems, because they will quickly raise a crop of even more intractable weeds resistant to multiple herbicides (Mortensen *et al.* 2012, CFS 2014b). This chemical arms race between herbicide-resistant crops and weeds will boost herbicide use to new heights, both on Hawai'i's test fields and on the mainland (Kilman 2010), putting agriculture in a "crisis situation" (Keim 2014). This may be great news for the agrochemical companies, but certainly not for the rest of us.

Glyphosate, long heralded as a relatively safe herbicide, was recently determined to be a probable human carcinogen by cancer experts at the World Health Organization.

Two of the major "next-generation" herbicide-resistant crops to be introduced in the next year or two are Dow Chemical's 2,4-D-resistant corn and soybeans and Monsanto's dicamba-resistant soybeans and cotton (Mortensen *et al.* 2012). Introduction of these crops is projected to boost agricultural use of 2,4-D by three- to seven-fold (CFS 2014a) and that of dicamba by 11-fold (CFS 2014b). Why does this matter? 2,4-D was part of Agent Orange used in the Vietnam War, and continues to be contaminated with highly toxic dioxins, contrary to industry claims (Holt *et al.* 2010). Many scientific studies link exposure to chlorophenoxy herbicides like 2,4-D to non-Hodgkin's lymphoma (Schinasi and Leon 2014), a cancer of the immune system that kills 30% of those afflicted with it. Other studies have found 2,4-D exposure linked to low sperm counts in workers and other reproductive impacts. Dicamba has also been associated with increased risk of non-Hodgkin's lymphoma, among other cancers, developmental toxicity *in vitro* and in experimental animals, and inhibition of a critical brain enzyme (CFS 2013a). BASF has experimented with corn and canola resistant to imidazolinone herbicides; at least one widely used imidazolinone herbicide (imazethapyr) has been strongly linked to bladder and colon cancer (Koutros *et al.* 2009).

Glyphosate, long heralded as a relatively safe herbicide, was recently determined to be a probable human carcinogen by cancer experts at the World Health Organization (Guyton *et al.* 2015). In a two-year rat feeding study, animals that ingested Roundup and/or Roundup Ready corn (event NK603) exhibited a higher incidence of mammary tumors, as well as adverse effects on the kidney, liver and pituitary glands, relative to an untreated control group (Seralini *et al.* 2014a). This peer-reviewed study, originally published in *Food and Chemical Toxicology* in 2012, was retracted after intense, politically charged criticism, much of it by plant biologists with no experience in toxicology (Seralini *et al.* 2014b). Over 150 scientists condemned the retraction as politically motivated (End Science Censorship 2014, Portier *et al.* 2014), leading to its re-publication in another journal in 2014.

PART FOUR: PESTICIDE AND FERTILIZER USE IN GE SEED CORN PRODUCTION

Intensive herbicide spraying is just one component of the chemical onslaught involved in growing GE seed crops in Hawai‘i. Other types of pesticides are also heavily used, especially for GE corn, the dominant seed crop in Hawai‘i.

4.1 AGROCHEMICAL USE ON MAINLAND FIELD CORN

No major crop is as chemical-intensive as corn. Field corn cultivation claims nearly half the nitrogen and phosphate fertilizer used in U.S. agriculture (USDA ERS 2013). Excessive fertilizer use is one of the biggest threats of industrial agriculture, generating toxic nitrates that pollute water supplies (Charles 2015), creating “dead zones” in water bodies such as the Gulf of Mexico (Diaz and Rosenberg 2008), and degrading soil quality (Mulvaney *et al.* 2009).

Corn is also heavily treated with pesticides, a category that includes herbicides to kill weeds, insecticides, fungicides, and other pest-killing chemicals. Corn accounted for 50% of all herbicides (by weight) applied to 21 major and minor crops in the U.S. in 2008 (USDA ERS 2014), including about 85% of the endocrine-disrupting herbicide atrazine (USGS Atrazine 2015). Unlike corn grown for seed (see below), most mainland field corn is not sprayed with insecticides or fungicides. However, at least 90% of corn seed is now treated with neonicotinoids (Douglas and Tooker 2015), a class of insecticides implicated in bee die-offs that have been severely restricted in Europe, as well as up to four fungicides (CFS 2013b).

Corn accounted for 50% of all herbicides applied to 21 major and minor crops in the U.S. in 2008, including about 85% of the endocrine-disrupting herbicide atrazine.

4.2 AGROCHEMICAL USE ON SEED CORN GROWN IN HAWAI'I

Cultivation of seed corn involves still more intensive use of agrochemicals. This is because the inbred varieties grown for breeding purposes are less vigorous and more vulnerable to environmental stress and pests than the more robust hybrids that mainland farmers grow (Thomison undated). Because inbreds have smaller root systems than hybrids, some seed growers "over fertilize to ensure against fertility deficiencies" (*Ibid.*). Because inbreds are less able than hybrids to compete with weeds, "seed growers rely heavily on herbicide applications…." (*Ibid.*). A seed growers' guide lists groups of 10 to 18 insecticides to control various insect pests of corn (Rinehold 2011). All told, it is not unusual for seed corn growers to make 12 trips across the field per crop for agrochemical applications and other tasks (Thomison undated).

Agrochemical use is especially intensive on seed corn in Hawai'i, as described by Hawai'i's premier corn breeder, Dr. James L. Brewbaker. Because Hawai'i's soils are not well-suited to corn, they require heavy applications of nitrogen fertilizer, which creates "[t]he potential for leached nitrate to pollute groundwater …. a serious environmental concern" (Brewbaker 2003). Hawai'i's subtropical climate also fosters greater disease and insect threats than are found on the mainland – threats that the mainland varieties grown by the seed firms on Hawai'i have not been bred to withstand. This explains why "Hawai'i's corn seed industry … is compelled to use pesticides heavily" (Brewbaker 2003). According to Brewbaker, the "[u]nique pesticide regimes … imposed by the seed industry" on Hawai'i kill off beneficial insect predators that would otherwise control the pests:

> "Seeds are treated before planting, and preemergence insecticide is usually incorporated at the time of planting for control of leafhoppers and thrips. **Subsequent insecticide and fungicide treatments are applied on a 5-7 day regime**…. One result of this insecticide regime is that many predators and parasites of corn pests are also eliminated or reduced in population. These insects serve to greatly reduce the severity of damage from thrips, leafhoppers, aphids, and mites in pesticide-free fields to levels of insignificance, as is

> the case at CTAHR's Waimanalo Research Station" (Brewbaker 2003, p. 69, emphasis added).

Dr. Brewbaker followed an entirely different path in his own breeding work, demonstrating that Hawai'i can produce food crops to supply local needs while also dramatically reducing toxic pesticide use (see "Breeding for Resistance … and Food").

4.3 PESTICIDE USE ON HAWAI'I'S SEED CORN: BY THE NUMBERS

These authoritative accounts of intensive pesticide use on seed corn are borne out by hard numbers. The following discussion is based on limited pesticide sales and usage information reported by the agrochemical-seed firms on Hawai'i. Some of these data have been released as part of a vigorous effort to defeat legislative initiatives requiring greater transparency and protective measures (i.e., no-spray buffer-zones around schools). Other data have been released in the context of a lawsuit brought against DuPont-Pioneer by Kaua'i citizens sickened by dust and pesticide drift from the company's seed crop operations (Jervis and Smith 2013).

Only the latter data cover all pesticides: general use as well as restricted use (see below). Records obtained from DuPont-Pioneer show that this single company applied 90 different pesticide formulations containing 63 different active ingredients[14] on Kaua'i from 2007 to 2012 (Jervis and Smith 2013). Consistent with Dr. Brewbaker's description above, the frequency of use is extremely high. **DuPont-Pioneer sprayed on two-thirds (65%) of the days over this nearly six-year period;** and **8.3 to 16 applications were made per application day, on average**, in various years of this period (Jervis and Smith 2013). Figure 15 shows the frequency of use by class of pesticide. The third-most frequently applied class is also among the most toxic: organophosphate insecticides such as chlorpyrifos (discussed below), which were sprayed on average 91 days each year (see Figure 15 and Table 6). If one considers the additional pesticide use by Dow Chemical, Syngenta, and BASF, which presumably use similar practices, **there are likely an average of 30 or more spray operations most days of the year on Kaua'i**. Even if one accounts for the fact that applications are made to only portions of the companies' overall seed fields, this still represents extremely intensive pesticide use.

The other available data applies only to "restricted use pesticides" (RUPs), an EPA designation for pesticides whose "toxicity exceeds one or more … specific hazard

[14] An "active ingredient" (a.i.) is the pest-killing-component of a pesticide formulation that contains many other ingredients (some kept hidden as trade secrets) as well. Some formulations contain the same a.i. While the a.i. is normally the most toxic component, other components of the formulation (e.g. surfactants) can in some cases be harmful as well.

BREEDING FOR RESISTANCE... AND FOOD

It is ironic that Hawai'i, a leading center of pesticide-intensive, GE seed corn production, is at the same time the breeding ground for the world's leading "pesticide-free"[15] conventional corn varieties. Dr. James L. Brewbaker, known in Hawai'i as the King of Corn, has bred a multitude of sweet corn varieties with excellent resistance to diseases and insect pests. These varieties – bred over half a century at the University of Hawai'i's Waimanalo Research Station on O'ahu – are credited with saving Hawai'i's sweet corn industry, and are also widely grown in Thailand, Australia, and many other countries (Salkever 2003). The University of Hawai'i has developed field corn varieties with similarly broad-spectrum resistance. The key to Dr. Brewbaker's success is breeding without insecticides and fungicides:

> "Using no pesticides, a continuing evolution occurred between diseases, pests, and Hawai'i's home-bred corn. Today, Waimanalo-bred corns effectively can be grown without pesticides, having high levels of resistance to a host of diseases, pests, and stresses peculiar to the Hawaiian Islands" (Brewbaker 2003, p. 4).

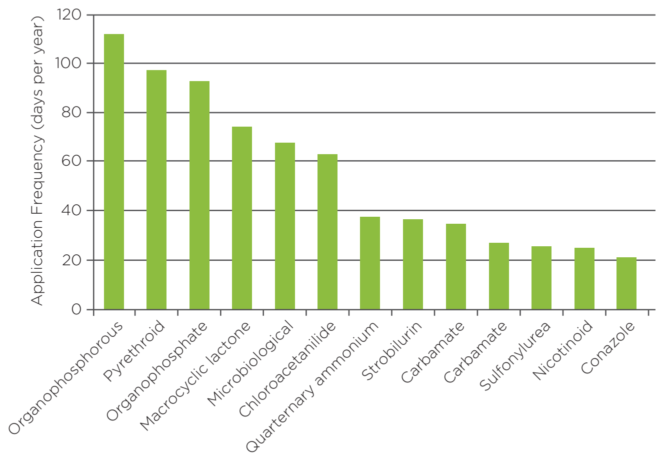
The concept is simple. By foregoing pesticide use, those strains that have natural resistance to ubiquitous pests and diseases are less infested, and so can be selected for further breeding to enhance resistance still more. In contrast, the intensive use of pesticides in most conventional breeding operations eliminates pest and disease "pressure," making it impossible to identify and thus select for varieties that have natural resistance. Lacking resistance, these defenseless plants are sprayed heavily, as described above.

While the concept is simple, the execution involves hard work and many years of breeding. Even so, this approach has had demonstrably superior results to genetic engineering. While Hawai'i's local corn varieties have broad-based resistance to all of the state's major insect pests and diseases, nearly three decades of genetic engineering have only succeeded in endowing corn with resistance to a few key mainland insect pests, and entirely failed on the disease front. Even this narrow GE-endowed resistance is proving fragile, as the devastating corn rootworm is rapidly evolving resistance to the Bt toxin in Monsanto's GE corn (Philpott 2011).

If corn can be bred for resistance to Hawai'i's pests and diseases, so can other food crops. In fact, University of Hawai'i scientist James C. Gilbert has employed similar techniques to breed resistant tropical varieties of tomatoes, eggplant, edamame soybeans, and other crops (Brewbaker 2010). Indeed, it is well-known that breeding without pesticides is an effective means to develop pest- and disease-resistant strains of most crops (Robinson 1996). By slashing insecticide and fungicide use, such crops would be cheaper to produce, which in turn would help make Hawai'i produce more cost-competitive with offshore production. Every acre of pesticide-intensive seed corn replaced by a resistant food crop would thus have multiple benefits – reducing the human health and environmental impacts of pesticides while increasing local food production. The work of Dr. Brewbaker and others shows that this is not only a desirable, but also a feasible path, if only Hawai'i's government and large landowners would commit to plant breeding in the public interest, provide proper financial and technical support to aspiring farmers, and withdraw subsidies and leases to the agrochemical-seed industry.

[15]In this informal usage, pesticide refers only to insecticides and fungicides, not herbicides.

Figure 15: DuPont-Pioneer Pesticide Use on Kaua'i: 2007-2012



Source: Jervis and Smith (2013). Chart based on data released by DuPont-Pioneer regarding its pesticide use practices on its seed corn and GE crop test fields near the town of Waimea, Kaua'i. See Table 6 below for key.

Table 6: Key to DuPont-Pioneer Pesticides Used on Kaua'i

Pesticide Class	Pesticide Type	Examples of Active Ingredients
Organophosphorous	Herbicide	Glyphosate, glufosinate
Pyrethroid*	Insecticide	Permethrin*, zeta-cypermethrin*
Organophosphate*	Insecticide	Chlorpyrifos*
Macrocyclic lactone	Insecticide	Avermectin
Microbiological	Insecticide	Bacillus thuringiensis
Chloroacetanilide*	Herbicide	S-metolachlor*, alachlor*
Quaternary ammonium*	Herbicide	Paraquat dichloride*
Strobilurin	Fungicide	Azoxystrobin
Carbamate*	Insecticide	Methomyl*
Sulfonylurea	Herbicide	Chlorimuron
Triazine*	Herbicide	Atrazine*
Nicotinoid	Insecticide	Imidacloprid
Conazole	Fungicide	Propiconazole

Note: Entries with * are classes with one or more members in the restricted use pesticide (RUP) category. All active ingredients with * in the "Examples" column are RUPs used on Kaua'i.

criteria."[16] While RUPs are generally more toxic, it should be noted that many general use pesticides are also harmful.

RUP sales data for Kauaʻi show that 22 RUPs representing 18 active ingredients were applied in agriculture from 2010 to 2012. Assuming that sales are roughly equivalent to usage, an average of 20,801 lbs. of agricultural RUPs (weight of active ingredients only) were applied annually over this period (Figure 16). Eighty-one percent (81%) of RUP active ingredients by weight were applied to corn, 19% to coffee, and negligible amounts used on ornamentals, soybeans, sugarcane, tomatoes, and turf. The major users of agricultural RUPs were Dow Chemical, Syngenta, DuPont-Pioneer, Terminix International,[17] and Kauaʻi Coffee Company.

Total pesticide use is likely four times greater than RUP use, or over 80,000 lbs. of active ingredients annually. This is based on the fact that DuPont-Pioneer applies over four times as many general use pesticide products (90) as RUP products applied by all major RUP users (22). All other things being equal, total pesticide use would be 90/22 or 4 times greater than RUP use. Estimation is our only recourse in the absence of Kauaʻi County's Ordinance 960, which would have required all major RUP users to report their use of all pesticides.

4.4 RESTRICTED USE PESTICIDES: HAWAIʻI VS. MAINLAND CORN

More nuanced information about monthly RUP use for Kauaʻi has been provided by the Hawaiʻi Department of Agriculture, based on industry reporting, beginning in December 2013 (HDOA 2015c).[18] Below, we first compare use of restricted use (RU) insecticides

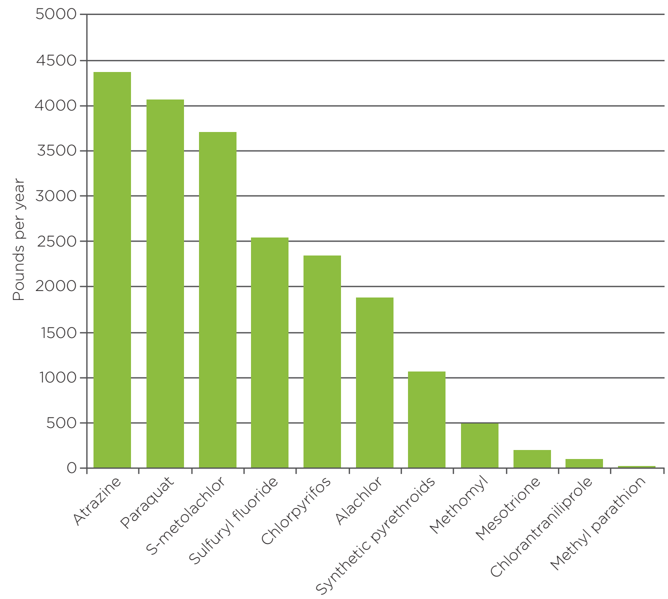
[16]See 40 CFR Part 152.170: Criteria for restriction to use by certified applicators.

[17]Terminix is known for use of sulfuryl fluoride, a toxic fumigant, for residential pest control (e.g. termites), but also supplies (or supplied) large amounts of this compound to the pesticide companies on Hawaiʻi to treat their stored seed corn. Interestingly, EPA instituted a phase-out of food uses of sulfuryl fluoride on human health grounds in 2011 (EPA Sulfuryl Fluoride 2011).

in Kaua'i seed corn operations to the use of the same RU insecticides on mainland corn (see Table 7). For this comparison, we assume that 25% of land leased by pesticide companies on Kaua'i (12,500 acres) is planted to seed or GE test corn in a given year, and that all of it is sprayed with RU insecticides.[19]

We focus first on restricted use insecticides, for several reasons. First, RU insecticides are extremely toxic; for instance, the nervous system toxin chlorpyrifos has been strongly linked to cognitive disorders in children, as discussed later in this report. Second, many are quite potent, meaning they are **harmful at extremely low doses**; for example, beta-cyfluthrin (the active ingredient of Baythroid XL) kills insects at the vanishingly low rate of 0.01 lb. per acre (1/100th of a pound). Third, RU insecticides are used quite frequently and throughout the year (Figure 17). Finally, many are **drift-prone**, and thus may pose risks to residents near seed corn fields where they are used.

Figure 16: Average Annual Sales of Restricted Use Pesticides on Kaua'i: 2010-2012 (lbs. a.i.)



Source: Based on "Restricted Use Pesticides Sold on Kaua'i: 2010-2012," a spreadsheet obtained from Kaua'i County Council member Gary Hooser. RUPs converted to pounds active ingredient based on EPA-approved labels for the respective pesticides. "Synthetic pyrethroids" are restricted use insecticides that include permethrin, tefluthrin, esfenvalerate, lambda-cyhalothrin, zeta-cypermethrin, beta-cyfluthrin and bifenthrin. Because some pesticides are much more potent than others (applied at much lower rates), lesser use does not necessarily mean less concern for human health or environmental impacts. For instance, methomyl is a carbamate insecticide with high acute toxicity to humans.

The annual per acre rate of RU insecticides is 7.84 times greater on Kaua'i than on those acres of mainland corn that are treated at all: 0.750 versus just 0.096 lbs/acre (see Table 7 for following discussion). The proportion of pesticide company land that is used to grow seed corn in a given year (25%) is over twice (2.17 times) the proportion of mainland corn that receives any RU insecticide at all (just 11.52%). When these two factors are considered together, **use of Hawai'i RU insecticides is 17 times more intense (7.84 x 2.17) on Kaua'i than use of the same insecticides on mainland corn: 0.188 versus 0.011 lbs./acre/year.** Finally, the average acre of Kaua'i seed corn is treated with RU insecticides more than 3.5 times per year, versus barely more than 1 time per year on the minority of mainland corn that is sprayed with these insecticides.

[18]The Kaua'i Good Neighbor Program. We find it unfortunate that the Hawai'i Dept. of Agriculture chose a clearly biased euphemism for this program ("Good Neighbor") rather than giving it a neutral name.

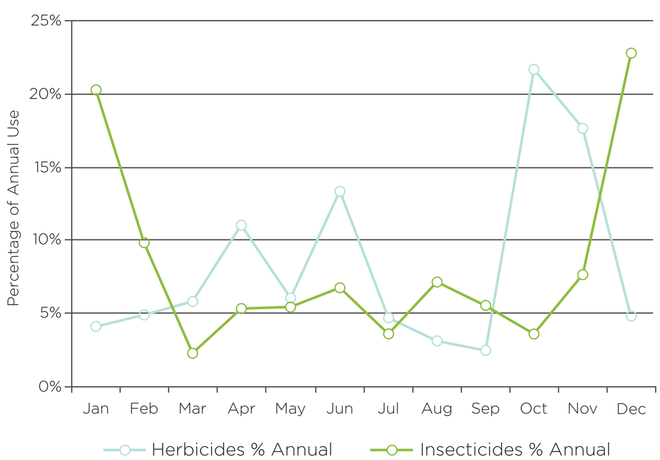
[19]The 25% figure is the proportion of pesticide company land on Hawai'i (25,034 acres, see Table 2) that is used to grow seed or test corn in a given year (6,110 acres, the average number of seed crop acres grown over the 2009-2010 to 2011-2012 crop years (see Figure 7). Applying the same 25% figure to the 12,500 acres leased by pesticide companies on Kaua'i (*Syngenta Seeds vs. County of Kaua'i 2014*) yields 3,125 acres of seed corn grown and sprayed with RU insecticides on Kaua'i in a given year.

Table 7: Restricted Use Insecticide Use on Kaua'i Seed Corn vs. Mainland Field Corn

Parameter	Kaua'i	Mainland	Factor
RUI Use Pounds Total	2,345	903,000	
Seed/field corn acres treated	3,125	9,434,821	
Total land in corn	12,500	81,875,000	
Avg. lbs. RUI/Treated Acre	0.750	0.096	7.84
% Total Area Treated w/ RUI	25.00%	11.52%	2.17
Avg. lbs. RUI/All Acres	**0.188**	**0.011**	**17.01**
RUI Total Acre Treatments	11,116	9,575,720	
Acre Treatments (total)	3.557	1.015	3.50

Source: CFS analysis of RUP use on Kaua'i in 2014, accessed 2/17/15 (HDOA 2015c). Pounds and gallons of RUP products converted to pounds active ingredient according to EPA labels for the respective RUPs. Figures for mainland corn based on 2010 pesticide use data from USDA NASS (2011).

Figure 17: Pounds of Restricted Use Pesticides (a.i.) Applied on Kaua'i by Month: 2014



Source: CFS analysis of RUP use on Kaua'i in 2014 (HDOA, 2015c). Pounds and gallons of RUP products converted to pounds active ingredient according to EPA labels for the respective RUPs.

Figure 17 shows that RUPs are sprayed throughout the year, meaning that there are many more opportunities for harmful drift episodes to occur than in the Midwest, where spraying on corn is limited primarily to narrow windows in the spring and early summer. In general, RU herbicides are applied more heavily in the spring and especially in the fall. RU insecticides are applied more consistently throughout the year, though with a very strong spike in the winter months (December to February). It is likely no accident that two of the higher-profile pesticide drift poisoning episodes on Kaua'i occurred in November (Gregg 2006) and January (Leone 2008), when spraying of RU herbicides and insecticides, respectively, were likely near peak levels based on these 2014 data.

4.5 COMPARISON TO PESTICIDE USE IN CALIFORNIA

There have been a number of misinformed comparisons between pesticide use on Kaua'i and California. While it is true that pesticides are heavily used in vegetable and fruit production in California, these comparisons are fatally flawed and hence highly misleading. First, some have compared *overall* pesticide use in California to *RUP* use on Kaua'i, which is entirely illegitimate because the total amount of pesticides used on Hawai'i is estimated to be four-fold higher than RUPs alone (see Section 4.3).

Second, crude comparisons of "pounds per acre" are not very informative if they make no distinction between extremely toxic and relatively benign compounds. For example, the most heavily used pesticide in California (25% by weight) is sulfur, a comparatively safe fungicide that is far less concerning than nerve-toxin insecticides, like chlorpyrifos, even though the latter are used in much lesser quantities (CA Pesticides 2012).

Finally, the most important comparison that can be made between the two states is that at least 14 California counties have responded to the rampant pesticide drift that afflicts the state's children by establishing no-spray buffer zones around schools (CPR

2010, Khokha 2010), while the single such measure enacted by voters in Hawai'i – Kaua'i's Ordinance 960 – was defeated in court by the pesticide companies whose toxic products are implicated in sickening the state's children.

4.6 PESTICIDE USE BY AGROCHEMICAL FIRMS VS. SMALL FARMERS

Pesticide industry representatives have tried to argue that Kaua'i's Ordinance 960 would be detrimental to small-scale farmers, but nothing could be further from the truth. Ordinance 960 applies only to "commercial agricultural entities" that use more than 5 pounds or 15 gallons of any single restricted use pesticide per year, and thus would exempt the vast majority of small farmers. This is demonstrated in Table 8, which shows that small agricultural RUP users account for just 0.17% of agricultural RUP sales statewide, versus the 99.83% share of large RUP users. Even those few small farmers who might be subject to Ordinance 960 could continue their sparing use of RUPs, as long as they comply with the law's buffer zone restrictions and reporting requirements, which are designed to protect public health and increase transparency.

The pesticide companies have also argued that Ordinance 960 unfairly singles them out. This allegation not only contradicts their notion that small farmers would be harmed by the law, it is also patently untrue. The Ordinance applies not only to seed crop operations, but to *all* large RUP users, including for instance some coffee operations. The exemption of small RUP users is also entirely reasonable, since the impacts of their minor use of RUPs pales in comparison to the harms from large-scale RUP use. In like manner, the federal Food Safety Modernization Act exempted many small farms selling locally from regulations designed to prevent large-scale outbreaks of food illness associated with industrial operations that market their products regionally or nationally (CFS 2010). Like other community members, small farmers would in fact benefit from the public health provisions of Ordinance 960.

Table 8: Sales of Restricted Use Pesticides for Agricultural Use in Hawai'i: 2013

RUP Users	Pounds Product	Gallons Product	Pounds Active Ingredient	Percent of Total
Agricultural Use - Large Users*	123,133.05	59,189.81	422,478.84	99.83%
Agricultural Use - Small Users**	27.64	793.43	720.66	0.17%
Totals	1,020,419.03	60,948.72	1,310,780.53	

*5 lbs./15 gallons and greater
**Less than 5 lbs./15 gallons

Source: HDOA (2015b)

PART FIVE: ADVERSE IMPACTS OF PESTICIDES REPORTED IN HAWAIʻI

5.1 LESSONS FROM HISTORY

Many Hawaiʻi residents can recall incidents when public health was threatened by exposure to agricultural pesticides. For example, in 1980 drinking water wells in the Oʻahu town of Kunia were closed due to contamination with hazardous levels of several pesticides, including ethylene dibromide (EDB) and dibromochloropropane (DBCP), the latter a Dow Chemical nematicide infamous for causing sterility or impaired fertility in tens of thousands of farmworkers worldwide (Gonzalez and Loewenberg 2003). The contamination of Kunia wells was so serious that EPA designated the area a Superfund site (EPA 1995). In 1982, milk on Oʻahu was found to be contaminated with hazardous levels of the pesticide heptachlor, and elevated levels were also found in human breast milk[20] (Smith 1982). Researchers found that exposure to DBCP and heptachlor

[20]Heptachlor-contaminated pineapple leaves were fed to dairy cows.

was one likely factor driving increased breast cancer rates in Hawaiʻi (Allen *et al.* 1997). All three pesticides were long used in pineapple production, and are today banned for food uses as probable human carcinogens (EPA 2014a, 2014b, 2014c) and other health risks.

These episodes teach us important lessons. First, pesticides initially approved and used for many years as "safe" are found to be hazardous based on further scientific study. Second, powerful agricultural interests often continue to use hazardous pesticides even after their toxicity is well understood. For instance, even though EPA banned the sale, distribution and shipment of heptachlor in 1988 (EPA 2014c), existing stocks continued to be used as late as 1993 in Del Monte pineapple fields on Oʻahu (Allen *et al.* 1997); and while EPA banned DBCP in 1979, an exemption was granted for continued use on pineapples in Hawaiʻi until at least 1985 (EPA 2014b). Most disturbing, perhaps, is how Hawaiʻi state and university officials have covered up pesticide contamination and denied clear health risks to citizens so as to protect agricultural interests (Smith 1982).

These lessons are still relevant today because hazardous pesticides continue to be applied today on GE corn fields. These GE seed corn operations are run by some of the very firms that produced the plantation-era pesticides and long assured us of their supposed safety. While the crops and chemical names have changed, Hawaiʻi residents continue to be threatened by pesticides – not only in the water, but in the very air we breathe.

5.2 PESTICIDE DRIFT IN HAWAIʻI

Any pesticide can drift beyond the field where is it applied. Spray drift occurs during application, and is favored by windy conditions. Volatile pesticides like 2,4-D and dicamba are subject to vapor drift, which occurs when previously applied pesticides evaporate from plant and soil surfaces days to months after application (USGS 2003), and is more likely in hot, still conditions. Finally, pesticides can be carried in the wind as pesticide-laden dust. State pesticide officials receive over 2,000 complaints of pesticide drift each year, many involving crop damage (AAPCO 1999, 2005), but all agree this vastly underestimates the true scope of the problem.

Pesticide drift occurs quite frequently in Hawaiʻi. A cursory search of Hawaiʻi media revealed numerous episodes in which pesticides drifted to schools, affecting the health of hundreds of students and their teachers (e.g. Clark 2001, Vorsino 2006, Shikina 2007, Da Silva 2007, Fujimori 2008, Kakesako 2010, KITV 2013, Wong 2013, Yager 2014, Wong 2014). Some of these incidents involved residential use of malathion, an organophosphate insecticide recently determined to be a probable human carcinogen by the World Health Organization's International Agency for Research

Pesticide drift occurs quite frequently in Hawaiʻi. A cursory search of Hawaiʻi media revealed numerous episodes in which pesticides drifted to schools, affecting the health of hundreds of students and their teachers.

Hawai'i does not have a "pesticide poisoning surveillance program" of the sort established in 11 other states.

on Cancer (Guyton *et al.* 2015). Because malathion products are not restricted use pesticides, data are lacking on their use in seed crop operations, though we know that pesticide firms use considerable quantities of related insecticides such as chlorpyrifos (Figures 15 & 16). Many of these incidents necessitated emergency medical care, decontamination showers, and/or school evacuations and closures.

Teachers and schoolchildren in Waimea on Kaua'i have reported becoming sick on at least three separate occasions following chemical applications to a nearby seed corn plot (Leone 2008). In a 2008 episode, 60 children and at least two teachers experienced headache, dizziness, nausea, and/or vomiting; 10 or more children were treated at an emergency room; several were put on a nebulizer to relieve respiratory distress; and one was given an anti-vomiting medication intravenously. A teacher who was also affected firmly rejected the explanation given by Hawai'i officials and Syngenta that "stinkweed" was the culprit, saying that she was familiar with stinkweed's odor and that this was not the cause (Leone 2008, Hillyer 2008).

Many similar episodes have been reported on O'ahu. In 2007, 15 students were sickened by pesticide drift at Kahuku Intermediate and High Schools, forcing closure of the school for three days, while other students reported ill effects from the use of the insecticide malathion at St. Joseph School in Waipahu in 2008 (Hillyer 2008, Leone 2008). In 2014, 31 students and staff at Kahalu'u Elementary School experienced nausea, burning eyes, shortness of breath, dizziness, sore throat, and coughing, and 26 were evacuated to and treated at nearby hospitals, due to a strong chemical odor that the Fire Department linked to reports of pesticide spraying in the area (Kalani and Fujimori 2014). These symptoms are all commonly reported effects of exposure to pesticides (AAP 2012: Table 2). Even when victims appear to fully recover from short-term or "acute" pesticide exposures of this sort, they can sometimes have serious long-term health consequences, as discussed further in Section 6.

These media reports likely represent a small fraction of actual pesticide poisoning cases, for several reasons. First, as acknowledged by the EPA, "many [pesticide drift] incidents are unreported" (EPA 2001). Second, even when victims of pesticide poisoning do seek medical attention, California officials have found that "[p]hysicians often do not report potential pesticide illnesses" (CA PISP Fact Sheet undated), often because they are ignorant of the effects of pesticide poisoning (AAP 2012). Finally, Hawai'i does not have a "pesticide poisoning surveillance program" of the sort established in 11 other states – California, Florida, Iowa, Louisiana, Michigan, Nebraska, New York, North Carolina, Oregon, Texas, and Washington (CDC 2014). Such a program, if established in Hawai'i, would likely capture many more pesticide-induced illnesses.

Evidence from other states also suggests that pesticide drift is a frequent occurrence. A study of pesticide exposure at schools in eight states from 1998 to 2002 identified 2,593 individuals who had experienced acute pesticide-related illnesses. Of the 406 cases for which more detailed information was available, nearly one third (31%) involved pesticide drift from farmland while the others involved pesticide use at the school (Alarcon *et al.* 2005). In a single year, seven pesticide drift cases involving school buses were reported in California's San Joaquin Valley (Khokha 2010). According to Teresa de Anda of Californians for Pesticide Reform, who has visited many rural communities in her state, drift has become "so commonplace that people don't report it" (as quoted in Khokha 2010).

Physicians concerned about pesticide drift in west Kaua'i encounter "almost daily reports of respiratory symptoms in patients that have no history of these respiratory illnesses."

Physicians concerned about pesticide drift in west Kaua'i encounter "almost daily reports of respiratory symptoms in patients that have no history of these respiratory illnesses…," many of whom do not recover despite healthy lifestyle changes or pharmacological interventions. They also report recurring nose bleeds in children, recurring dermatitis, patients who experience a "metallic taste" in their mouths, as well as high levels of infertility and gout (Kaua'i Physicians 2013). Waimea residents are frequently afflicted with "fugitive dust" blowing into their town, which is downwind of a 1,000-acre DuPont-Pioneer seed corn operation (Jervis and Smith 2013). The dust comes so frequently and in such quantity that continual laborious cleaning is required, disrupting residents' lives. Windblown dust is also frequently a problem on Moloka'i. Extremely fine dust can penetrate into the lungs and cause bronchitis (CCOHS 2012). As the U.S. Geological Survey has observed, "pesticides can become airborne attached to wind-blown dust" (USGS 2003). Thus, pesticide-laden dust must be considered together with spray drift as well as water and food contamination when considering the health threats of pesticides near GE test fields.

Pesticides may also be a factor in still more serious health threats. Dr. James Raelson and his colleague Dr. Chatkupt, practicing pediatricians on Kaua'i, have noted an unusually high incidence of rare birth defects involving malformations of the heart in Kaua'i over the past seven years, at roughly ten times the national rate (Raelson 2013). They note that Hawai'i has not had surveillance for birth defects since 2005, and have called for unbiased epidemiology studies by the U.S. Centers for Disease Control and Hawai'i's Department of Health to better understand the causes. Kaua'i physicians and residents have also noted a "cancer cluster" in Waimea – 37 cases in a neighborhood of just 800 – which is said to be 10 times the statewide cancer rate. Although a one-page report by the Hawai'i Department of Health disputes the existence of a cancer cluster on Kaua'i, the author conceded that her analysis was inconclusive, and reportedly said: "If I lived there, it would concern me" (Skolnick 2013).

To our knowledge, there have been no official medical investigations of the episodes reported above. To be successful, investigations of this sort must be conducted

The pesticide poisoning episodes reported in the media are likely a small fraction of actual cases.

promptly after the episode occurs, be led by epidemiologists and other medical personnel, and involve detailed examination of victims and thorough assessments of possible causes. Chemists with the University of Hawai'i conducted an "air sampling" study at the Waimea school where the 2008 episode recounted above occurred (Li *et al.* 2013). However, this investigation began more than two years after the incident occurred; was conducted by chemists rather than physicians; involved no questioning or examination of victims; and perversely focused on stinkweed as the possible cause despite eyewitness testimony to the contrary. Some of the 24 pesticides measured in the study are no longer in use; and conversely, no testing was conducted for the great majority of the 63 pesticide active ingredients known to be used on Kaua'i by DuPont-Pioneer (Jervis and Smith 2013). Thus, it is unsurprising that the results were inconclusive.

However, the testing did detect the insecticide chlorpyrifos in the ambient air inside and outside the school, and exposure to organophosphate insecticides like chlorpyrifos is known to cause nausea, dizziness, respiratory distress, and the other reported symptoms (AAP 2012: Table 2). Other pesticides detected in the ambient air inside and outside the school included bifenthrin, benzene hexachloride (BHC), and dichlorodiphenyltrichloroethanes (DDT). While the concentrations of these pesticides detected more than two years after the incident were thought to be below health concern limits, their presence demonstrates a troubling history of pesticide drift, and together with eyewitness evidence supports pesticides as the likely cause of the poisoning episodes on Kaua'i.

In Part 4, we discussed the extremely intensive use of pesticides by the agrochemical firms on Kaua'i; similar practices are used to grow seed corn on Moloka'i, O'ahu, and Maui (refer to Appendix II for RUP use maps). Given the heavy and frequent application of toxic pesticides, and the proximity of many seed fields to rural towns and dwellings, the pesticide poisoning episodes reported in the media are likely a small fraction of actual cases. Next, we discuss some of the medical literature on the health impacts of pesticide exposure.

PART SIX: HEALTH IMPACTS OF PESTICIDE EXPOSURE

PESTICIDES HAVE A LONG HISTORY of negative, often unforeseen, impacts on human health. People are exposed to certain pesticides in their food and water; farmworkers take in pesticides via dermal contact and inhalation of spray. Pesticide drift represents an important additional exposure pathway (Goldman *et al.* 2009). In general, farmers, farmworkers, pregnant women, and children are at greatest risk: farmers are more highly exposed than the general population; while fetuses and children are more susceptible to the harmful effects of pesticides than adults. Pesticides cause acute health problems such as nausea, dizziness, vomiting, headaches, abdominal pain, muscle aches, and skin or eye irritation (AAP 2012, Owens and Feldman 2004), and can also have longer-term impacts as discussed below (see Table 9 for a summary of findings).

6.1 FARMERS AND PESTICIDE APPLICATORS

Age-adjusted cancer rates in the U.S. population nearly doubled (85% rise) from 1950 to 2001, corresponding to the period of rapid growth in use of pesticides and other

In general, farmers, farmworkers, pregnant women, and children are at greatest risk of pesticide poisoning.

industrial chemicals (Clapp *et al.* 2006). Significant associations between agricultural chemical use and cancer deaths have been found in 1,497 rural U.S. counties (Steingraber 2010). National Cancer Institute scientists have found that farmers in the U.S. and elsewhere suffer from higher rates of certain cancers – including leukemia, non-Hodgkin's lymphoma, multiple myeloma, and brain cancer – than the general population, even though they have fewer cancers and are healthier overall (Blair and Zahm 1995).

These findings drove considerable research into potential causes, particularly pesticide exposure. Non-Hodgkin's lymphoma (NHL) is a terrible cancer of the immune system that kills 30% of those who contract it. A large number of studies have associated NHL with exposure to chlorophenoxy herbicides like 2,4-D (Zahm *et al.* 1990, Cantor *et al.* 1992, Blair and Zahm 1995, Mills *et al.* 2005); dicamba herbicides (Cantor *et al.* 1992, McDuffie *et al.*, 2001); glyphosate (Hardell *et al.* 2002, De Roos *et al.* 2003, Schinasi and Leon 2014, Guyton *et al.* 2015); atrazine (De Roos *et al.* 2003); and organophosphate insecticides (Schinasi and Leon 2014).

The findings involving glyphosate, 2,4-D and dicamba are especially concerning because GE crops resistant to these herbicides have been developed by Dow Chemical (2,4-D and glyphosate) and Monsanto (dicamba and glyphosate) (see Section 3.4). These crops involve heavier and more frequent applications than are otherwise used (Mortensen *et al.* 2012), and have been field-tested in Hawai'i (ISB Release 2010-2014). In addition, these three herbicides are among the most drift-prone herbicides in use today, as evidenced by the large number of drift-related crop damage complaints attributable to them (AAPCO 1999, 2005). If drift is damaging crops, people may be exposed as well.

Exposure to imidazolinone herbicides has been strongly associated with bladder and colon cancer in the Agricultural Health Study (Koutros *et al.* 2009), and BASF has field-tested imidazolinone-resistant corn and soybeans in Hawai'i (ISB Release 2010-2014). Exposure to chlorpyrifos, a restricted use pesticide heavily used in Hawai'i (see Figures 15 and 16, Table 6), has been linked to lung cancer (Lee *et al.* 2004) and rectal cancer (Lee *et al.* 2007).

Many pesticides affect the nervous system. Thus, it is not surprising that a large body of research finds that pesticide exposure can trigger neurological disorders. Several major meta-analyses[21] have demonstrated a strong association between pesticides and Parkinson's disease. For instance, Priyadarshi *et al.* (2000) assessed 19 studies published between 1989 and 1999, and found that the majority reported that pesticide

[21] A meta-analysis is a "study of studies." By assessing the findings of multiple studies for a particular disease outcome, more definitive conclusions can be reached than is possible with individual studies.

exposure elevated the risk of Parkinson's disease. Brown *et al.* (2006) made similar findings, which were "strongest for exposure to herbicides and insecticides, and for long durations of exposure." A review by van den Mark *et al.* (2012) came to the same conclusions. Particular (classes of) pesticides implicated in Parkinson's disease include paraquat and rotenone (Tanner *et al.* 2011), chlorophenoxy herbicides (Brighina *et al.* 2008, Elbaz *et al.* 2009), and 2,4-D (Tanner *et al.* 2009).

Table 9: Health Impacts of Pesticides

Impacts	Pesticides Implicated	Selected Studies
Non-Hodgkin's Lymphoma	Chlorophenoxy herbicides & 2,4-D Dicamba herbicide Glyphosate Organophosphate insecticides Atrazine	Zahm et al. 1990, Cantor et al. 1992, Blair and Zahm 1995, McDuffie et al., 2001, Hardell et al. 2002, De Roos et al. 2003, Mills et al. 2005, Schinasi and Leon 2014
Bladder and Colon Cancer	Imidazolinone herbicides	Koutros et al. 2009
Lung Cancer	Chlorpyrifos	Lee et al. 2004
Rectal Cancer	Chlorpyrifos	Lee et al. 2007
Parkinson's Disease	Pesticides Generally Paraquat Rotenone Chlorophenoxy herbicides & 2,4-D	Brown et al. 2006, Priyadarshi et al. 2000, Brighina et al. 2008, Elbaz et al. 2009, Tanner et al. 2009 & 2011, van den Mark et al. 2012
Depression, Mental Health, Neurotoxic effects	Organophosphates Herbicides Chlorophenoxy herbicides & 2,4-D	Beseler et al. 2008, Beseler and Stallones, 2008, Bjorling-Poulsen et al. 2008, Weisskopf et al. 2013, Beard et al. 2014; see Bienkowski 2014 for review
Hormone disruption (reproductive impacts)	Atrazine Alachlor Diazinon	Swan et al. 2003a & 2003b, Hayes et al. 2010 & 2011

Paraquat is one of the most heavily used RUPs on Kaua'i (Figure 16). Besides the association with Parkinson's disease, it is also one of the most acutely toxic herbicides in use, and is banned in 32 countries, including the European Union and Switzerland, home of Syngenta, its major producer (Watts 2011). It is responsible for thousands of deaths, both accidental poisonings and suicides (*Ibid.*). While ingestion of as little as a teaspoon of concentrate is fatal, paraquat is 1,000-fold more toxic when inhaled (Ames *et al.* 1993) due to its extreme toxicity to lung tissue (McDonald *et al.* 1992). Paraquat also frequently causes topical injuries and may be associated with skin cancer (Wesseling *et al.* 2001). Kentucky agricultural extension agent Gordon Johnson reports that paraquat can drift for miles (Johnson 2008). Paraquat drift sickened dozens of people in a small California agricultural community, inducing respiratory distress, nausea, and diarrhea, among other symptoms (Ames *et al.* 1993).

Several studies have also found a positive relationship between pesticide exposure and depression (reviewed in Bienkowski 2014, see also Beard *et al.* 2014). Higher rates of clinically diagnosed depression were found in both farmers with high cumulative exposure and those who reported pesticide poisoning (Beseler *et al.* 2008, Beseler and Stallones 2008). A study of agricultural workers in France found nearly double the rate of depression in those exposed to herbicides, with higher rates associated with longer-term exposure (Weisskopf *et al.* 2013). Bjorling-Poulsen *et al.* (2008) provide further information on the neurotoxicity of pesticides. The troubling implication of many of these studies is that acute poisoning episodes can in certain cases have chronic, long-term consequences for mental health.

Pesticides can also disrupt our hormonal systems, including the production and activity of sex hormones such as testosterone. The evidence is particularly strong for at-

Exposure of pregnant mothers to pesticides is particularly hazardous, since pesticides can be potent disruptors of fetal development.

razine, the most heavily used RUP on Kaua'i (Figure 16) and most common pesticide contaminant of water. Numerous studies show that low-level exposure to atrazine has demasculinizing effects – such as reduced sperm production and testes size – on male fish, amphibians, reptiles and mammals (e.g. Hayes *et al.* 2011). Low concentrations of atrazine have been shown to completely feminize male frogs (Hayes *et al.* 2010). The Study for Future Families, sponsored by the U.S. National Institutes of Health, provides evidence of impacts on humans. Men in Columbia, Missouri, which is situated in a predominantly agricultural part of the state, were found to have significantly lower sperm counts and fewer motile sperm than men in New York, Minneapolis and Los Angeles (Swan *et al.* 2003a). A follow-up study found that Missouri men more highly exposed to atrazine, alachlor or diazinon (as measured by the levels of pesticide metabolites in their urine) were much more likely to have lower sperm counts, as well as more abnormal and less motile sperm, than those with lesser exposure (Swan *et al.* 2003b). Taken together, this evidence strongly suggests that atrazine and perhaps other pesticides pose a real threat to human reproductive health. The environmental effects of atrazine are discussed below (see Section 7).

6.2 OUR KEIKI AT RISK

It is well established that the young are more susceptible to the harmful effects of pesticides than adults (National Research Council 1993, Roberts and Karr 2012), for several reasons. First, infants and children are more highly exposed to pesticides because they consume more food and water on a body-weight basis and have a higher breathing rate than adults. Secondly, children have greater hand-to-mouth activity, increasing opportunities for exposure to pesticide residues in dirt and dust. Finally, the immature, developing physiological systems of children are more susceptible to disease-causing disruption. This applies particularly to neurological impacts and cancer (NRDC 1997). Exposure of pregnant mothers to pesticides is particularly hazardous, since pesticides can be potent disruptors of fetal development.

The American Academy of Pediatrics (AAP) recently published a major report entitled "Pesticide Exposure in Children" that comprehensively reviewed 195 medical studies on the subject (Roberts and Karr 2012). Among other impacts, their chief concerns were as follows:

1. **Childhood cancers**, especially leukemia and brain tumors;
2. **Neurobehavioral and cognitive deficits**, such as reduced IQ and attention deficit/hyperactivity disorder;
3. **Adverse birth outcomes**, including preterm birth, low birth weight, and congenital anomalies; and
4. **Asthma.**

We briefly discuss each of these impacts below with reference to the AAP's comprehensive review (see Table 10 for a summary of findings).

A spate of recent studies is building an irrefutable case that long-term, low-level exposure to organophosphate insecticides in early life has profoundly negative impacts on children's neurological development.

6.2.1 Childhood Cancers

Five of six recent case-control studies found a statistically significant relationship between pesticide exposure and leukemia (Roberts and Karr 2012). Two of the studies offered the most detailed exposure assessment conducted to date, and link increasing risk with rising exposure, a strong indication that the observed associations are real. **Maternal exposure to pesticides** between the periods of preconception through pregnancy was identified as the primary risk factor. Maternal use of either herbicides or insecticides was associated with nearly double the risk of childhood leukemia (Infante-Rivard *et al.* 1999). A meta-analysis provided additional support, also showing double the risk of leukemia in children of mothers occupationally exposed to pesticides while pregnant (Wigle *et al.* 2009). Monge *et al.* (2007) also finds increased risk of leukemia in children borne to parents exposed occupationally to pesticides in Costa Rica.

Nine of the ten studies examining pesticides and brain cancer that have been conducted since 1998 demonstrated an increased risk estimate of brain tumors with maternal and/or paternal exposure to pesticides, though not all achieved statistical significance. Among the better quality studies, one that involved 321 cases demonstrated that maternal exposure to insecticides before or during pregnancy was associated with a 90% greater risk of astrocytoma (a type of brain cancer) in the child, as well as a trend to higher risk when fathers were exposed (van Wijngaarden *et al.* 2003).

6.2.2 Neurobehavioral and Cognitive Deficits

Exposure to many pesticides causes acute neurological symptoms, such as headaches and dizziness. However, a spate of recent studies is building an irrefutable case that long-term, low-level exposure to organophosphate insecticides (OPs) in early life (particularly *in utero*) has profoundly negative impacts on children's neurological development. The National Institutes of Health and the EPA are sponsoring three large-scale studies on this subject, two in urban settings and one in a rural community (Roberts and Karr 2012). Women were enrolled during pregnancy, and their exposure to OPs carefully measured. Their children were tested for neurological development in the following years. What do the studies show? At two to four years of age, higher prenatal OP exposure was associated with "significantly poorer mental development," "pervasive developmental disorder," and in one group "increased scores for attention-deficit/hyperactivity disorder" (Rauh *et al.* 2006, Eskenazi *et al.* 2007). At seven years of age, kids more highly exposed to OPs in the womb had

Records released by DuPont-Pioneer show that the company sprays organophosphate insecticides on Kaua'i quite frequently: once every four days (91 days/year).

lower IQ scores in all three groups (Bouchard *et al.* 2011, Engel *et al.* 2011, Rauh *et al.* 2011). Bouchard *et al.* (2010) similarly found increased rates of attention-deficit/hyperactivity disorder in eight to fifteen-year olds whose urine had higher levels of OP breakdown products, a sign of greater exposure.

These findings are even more concerning when one considers the intensive use of chlorpyrifos in Hawai'i's seed corn operations, coupled with its propensity to drift. Records released by DuPont-Pioneer show that the company sprays OPs on Kaua'i quite frequently: once every four days (91 days/year) (Figure 15). The OP insecticide chlorpyrifos is also one of the most heavily used restricted use pesticides on Kaua'i, with on average 2,350 lbs. applied each year (Figure 16). Air monitoring in California and Washington has found levels of chlorpyrifos exceeding health limits on several occasions (Goldman *et al.* 2009). An examination of California's Pesticide Illness Surveillance Program found that chlorpyrifos was among the most frequently cited culprits in drift-related pesticide illnesses over the past two decades (CA PISP 1992-2011). As noted above, air sampling at Waimea School consistently detected chlorpyrifos. Based on these multiple lines of evidence, there is every reason to expect that chlorpyrifos drift is adversely affecting the health of residents living near GE seed corn fields.

6.2.3 Adverse Birth Outcomes

The American Academy of Pediatrics is also concerned about the possible role of pesticides in triggering adverse birth outcomes (Roberts and Karr 2012). Two studies in Minnesota have revealed a higher rate of birth defects in children fathered by male pesticide applicators in areas of the state where chlorophenoxy herbicides (e.g. 2,4-D) and fungicides are most heavily applied. These studies also found a seasonal effect, with children conceived in the spring, when herbicide use is heaviest, exhibiting the highest birth defect rates (Garry *et al.* 1996, Garry *et al.* 2002). Six additional studies described by Roberts and Karr (2012) found higher risk ratios for birth defects in mothers exposed to pesticides, with three of them showing statistically significant effects. A study of expectant mothers carried out in New York demonstrated an association between exposure to chlorpyrifos and reduced birth weight and length (Perera *et al.* 2003). Wolff *et al.* (2007) also found reduced birth weight in infants born to mothers exposed to OPs during pregnancy, but only in those children with a mutation that reduces their ability to detoxify OPs, demonstrating the important principle that genetic makeup can increase susceptibility to pesticidal harms. Another study concluded that in utero exposure to OPs is associated with reduced gestation time (Eskenazi *et al.* 2004). Prenatal atrazine exposure has been associated with suppression of fetal growth (Chevrier *et al.* 2011) and exposure to chlorophenoxy herbicides and certain other classes of herbicide, such as triazines (e.g. atrazine), with increased risk of spontaneous abortion (Arbuckle *et al.* 1999, 2001).

6.2.4 Asthma

Asthma is the most common, chronic noninfectious disease of childhood, and is estimated to affect 300 million people worldwide, causing a quarter of a million deaths each year (Strina *et al.* 2014). Asthma is characterized by intermittent breathing difficulty, including chest tightness, wheezing, cough, and shortness of breath. There have been few studies of pesticides and asthma in children, but those conducted raise serious concerns. For instance, in a study carried out in Southern California, exposure to either herbicides or insecticides in the first year of life was strongly linked to a diagnosis of asthma before the age of five – an over four-fold higher risk from herbicides and more than two-fold greater risk from insecticide exposure (Salam *et al.* 2004).

Studies of adults provide similar evidence. Farmers are at high risk of asthma and other respiratory diseases (Hoppin *et al.* 2002), and exposure to organophosphate and carbamate insecticides has been linked to asthma in Canadian farmers (Senthilselvan *et al.* 1992). Two studies in the U.S. have associated exposure to a number of pesticides with wheezing, one of the major symptoms of asthma. Hoppin *et al.* (2002) found a higher incidence of wheezing in farmers exposed to the herbicides atrazine, alachlor, and paraquat as well as the OP insecticides chlorpyrifos, parathion, and malathion. Five of these pesticides are known to be used in Hawai'i, with atrazine, alachlor, and chlorpyrifos at particularly high levels (Figure 16). Slager *et al.* (2009) found that recent exposure to 2,4-D and glyphosate was associated with greater risk of rhinitis, and increasing scientific evidence suggests that rhinitis and asthma are a single disorder with clinical manifestations in the upper and lower respiratory tracts, respectively (Moscato *et al.* 2009). These findings take on added weight when one considers the testimony of Kaua'i physicians that Westside residents are very frequently afflicted with symptoms of respiratory distress.

Children may be harmed by pesticides even from second-hand exposure. For example, farmworkers exposed to pesticides may accumulate residues on their skin and clothing, and thereby inadvertently expose their families (Thompson *et al.* 2003). Similarly, rural homes have much higher levels of pesticide residues in dust than non-rural residences (Simcox *et al.* 1995, 1999; Rull *et al.* 2009). These take-home pathways can contribute to children's exposure to pesticides in agricultural communities (Lu *et al.* 2000).

Children may be harmed by pesticides even from second-hand exposure.

Table 10: Pesticide Impacts on Children

Categories	Specific Impacts	Selected Studies
Childhood Cancers	Leukemia, Brain tumors, astrocytoma (a type of brain cancer)	Infante-Rivard et al. 1999, van Wijngaarden et al. 2003, Monge et al. 2007, Wigle et al. 2009
Neurobehavioral & Cognitive deficits	Poor mental development & developmental disorder, increased rates of attention-deficit & hyperactivity disorder, lower IQ scores	Rauh et al. 2006, Roberts et al. 2007, Eskenazi et al. 2007, Rauh et al. 2011, Bouchard et al. 2011, Engel et al. 2011, Shelton et al. 2014
Adverse birth outcomes	Preterm birth, low birth weight, lower birth length, higher risk rates for birth defects, reduced gestation time, congenital anomalies, suppression of fetal growth, higher risk of spontaneous abortion	Garry et al. 1996, Arbuckle et al. 1999, 2001, Garry et al. 2002, Perera et al. 2003, Eskenazi et al. 2004, Wolff et al. 2007, Chevrier et al. 2011, Roberts and Karr 2012
Asthma	Higher risk of asthma, other respiratory diseases, breathing difficulty, chest tightness, wheezing, cough, shortness of breath	Senthilselvan et al. 1992, Hoppin 2002, Salam et al. 2004, Strina et al. 2014

6.3 HEALTH HARMS SPECIFICALLY LINKED TO PESTICIDE DRIFT

The medical studies discussed above address the harms of pesticides from a variety of exposure pathways: food, water, dermal contact, inhalation and/or drift. Below, we discuss studies that specifically address health outcomes where drift is the presumed exposure pathway.

A growing body of research supports the proposition that living near pesticide-sprayed fields increases the risks of a number of serious diseases, and exposure via pesticide drift is the most likely explanation. Many of these studies have been conducted in California, which has an extremely fine-grained pesticide reporting system that provides precise information on which pesticides are sprayed near any given community, when, and in what amounts.

Expectant mothers residing within 500 meters of fields sprayed with organochlorine insecticides during early pregnancy have a six-fold higher risk of bearing children with autism spectrum disorder than mothers not living near such fields.

Epidemiological studies based on this information have made some troubling findings. For instance, Costello (2009) found that exposure to paraquat and maneb within 500 meters of the home increased the risk of Parkinson's disease by 75%, with those under 60 years of age at higher risk. Roberts *et al.* (2007) conducted a similar analysis, and concluded that expectant mothers residing within 500 meters of fields sprayed with organochlorine insecticides (e.g. dicofol and endosulfan) during early pregnancy have a six-fold higher risk of bearing children with autism spectrum disorder than mothers not living near such fields; this ASD risk declined with increasing distance from field sites and increased with rising application amounts.

Shelton *et al.* (2014) reported a 60% increased risk of ASD in children of mothers who lived near fields sprayed with organophosphate insecticides at some point during their pregnancies, with much higher risk when exposure occurred in the second trimester of their pregnancies. Similarly increased risk – for both ASD and developmental delay – was found for children of mothers near fields treated with pyrethroid insecticides just prior to conception or during their third trimester. Proximity to carbamate-treated fields was also linked to higher risk of developmental delay. These findings take on added significance when one considers that most of the insecticides at issue in this California study are used on Kaua'i and likely on other Islands as well: one of the three organophosphates (chlorpyrifos); four of the five pyrethroid insecticides – permethrin, lambda-cyhalothrin, cypermethrin, and esfenvalerate; and one of the two carbamates (methomyl) (see Figures 15, 16 and Table 6).

6.4 PESTICIDE POISONING CAN CAUSE LASTING HARM

All of the symptoms reported above involving Hawai'i's schoolchildren are among those typically caused by pesticide drift, which include headaches, dizziness, difficulty breathing, nausea, vomiting, weakness, chest pain, fatigue, rashes, and eye ailments (Owens and Feldman 2004, CA PISP 1992-2011). It is often assumed that people suffer no permanent harm from pesticide poisoning episodes, but research is demonstrating that this is sometimes not the case. For instance, several studies of Colorado farmers and their spouses have demonstrated that pesticide poisoning is significantly associated with depression up to three years after the self-reported acute poisoning episode (e.g. Stallones and Beseler 2002, Beseler and Stallones 2008). In a study of Nicaraguan agricultural workers, those who had been hospitalized for organophosphate pesticide poisoning, and experienced standard symptoms such as nausea, vomiting, lightheadedness and heachaches, performed much more poorly on neuropsychological tests conducted roughly two years after the episode than an unpoisoned control group (Rosenstock *et al.* 1991). Kofman *et al.* (2006) conducted a neuropsychological assessment of children 6 to 12 years of age who had been hospitalized for organophosphate poisoning in infancy (< 3 years of age). These children had more difficulty restraining and controlling their motor behavior, a hallmark of attention deficit hyperactivity disorder (ADHD), than a matched control group (see also Section 6.2.2). The pathways and intensity of exposure were generally not reported in these studies, making it difficult to draw conclusions about the impacts of poisoning by pesticide drift. However, this research clearly indicates that children and others exposed just a single time to a pesticide may in certain cases go on to develop chronic neurological conditions, even if they appear to fully recover.

Children and others exposed just a single time to a pesticide may in certain cases go on to develop chronic neurological conditions, even if they appear to fully recover.

6.5 EXPOSURE TO PESTICIDES IN WATER

Exposure to pesticides via drift must be considered together with other pathways, especially water and food. Both surface water (e.g. streams, rivers, lakes) and groundwater (e.g. source of well water) are regularly polluted with agrochemicals. As noted above, heavy nitrogen fertilizer use on corn can contaminate drinking water supplies with toxic nitrates (Brewbaker 2003, Charles 2015). The U.S. Geological Survey has conducted extensive investigations into the presence of various pesticides in U.S. water bodies, the atmosphere, and groundwater as part of the National Water-Quality Assessment Program (NAWQA). In the 1990s, NAWQA investigations revealed that one or more pesticides or breakdown products were detected more than 90% of the time during the year in streams draining watersheds with agricultural, urban and mixed land uses. Annual mean concentrations of one or more pesticides exceeded a human health benchmark in about 10% of the 83 agricultural streams that were sampled. Pesticide concentrations in groundwater (wells) also sometimes exceeded health standards (Gilliom *et al.* 2006).

Atrazine is among the most commonly detected pesticide contaminants in our waters. Monitoring of twenty Midwest and Southern watersheds revealed atrazine in all of them, with 16 having average concentrations above 1 part per billion – the

Atrazine was the most commonly found pesticide in the study, with 80% of test sites contaminated by this restricted use pesticide.

level that has been shown to harm plants and wildlife (Wu *et al.* 2010). Atrazine easily leaches into groundwater, and has been detected in 80% of raw (untreated) and ready-for-consumption water samples taken from 153 drinking water systems across the country (*Ibid.*). A *New York Times* exposé based on these monitoring data revealed that an estimated 33 million Americans are exposed to atrazine in tap water (Duhigg 2008).

The European Union banned atrazine in 2003 on the basis of its persistence (Sass and Colangelo 2006). Atrazine's maker, Syngenta, has conducted a dirty tricks campaign in an attempt to discredit atrazine critics, and heavily lobbied EPA to keep the herbicide registered in the U.S. (Duhigg 2008, Howard 2013). EPA has acknowledged concerns about the potential risk of atrazine exposure to children (EPA 2006), but it remains the second most-heavily used agricultural pesticide in the U.S. (EPA 2011).

While the Hawaiʻi Department of Health does not routinely monitor surface water for pesticides, it recently teamed up with the Hawaiʻi Department of Agriculture to conduct a statewide pesticide sampling project of 24 watersheds and streams. Results showed at least one pesticide was detected at all locations (Grange 2014). Atrazine was the most commonly found pesticide in the study, with 80% of test sites contaminated by this restricted use pesticide. Atrazine was also the most common pesticide contaminating water samples in the earlier study based on a NAWQA investigation of Oʻahu, which found trace levels of atrazine in 90% of base flow samples (Anthony *et al.* 2004).

These researchers interpreted pesticide patterns in water samples as reflecting historic land uses, meaning that pesticides used on pineapple and sugar cane fields still impacted water resources years after their use on those lands ended. Agricultural herbicides were generally detected in water originating from groundwater, which is particularly significant given that nearly all of Hawaiʻi's drinking water is from groundwater sources. Four public supply wells exceeded the state's water quality standards for fumigants (DBCP and TCP), and Hawaiʻi was ranked first in the percentage of water wells in which fumigants were detected out of more than 80 NAWQA studies across the nation (Anthony *et al.* 2004). It is important to note that monitoring programs test for breakdown products of some but not all pesticides, thus some could escape detection. Some of these breakdown products persist longer in the environment and may have greater toxicity than their parent compounds.

6.6 EXPOSURE TO PESTICIDES IN FOOD

Pesticide residues are often found on food crops that have been directly or indirectly sprayed, a major exposure pathway. Organically grown foods have substantially lower residue levels than conventionally grown foods (Baker *et al.* 2002). Lu *et al.*

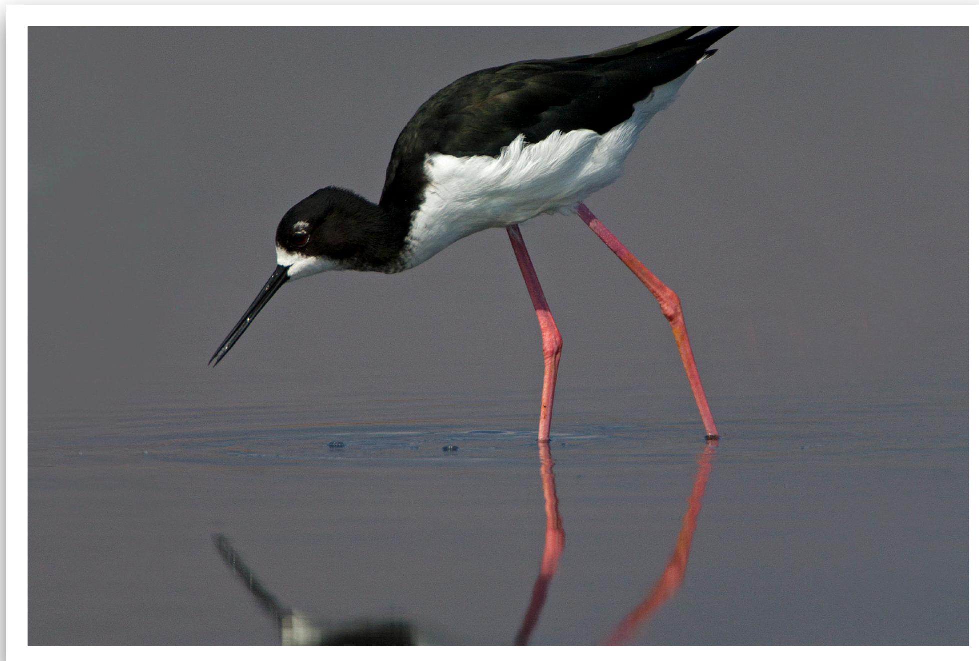
(2008) demonstrated that breakdown products of organophosphate insecticides (OPs) practically disappeared in the urine of urban and suburban children after they were switched from a diet of conventional fresh fruit and vegetables to their organic counterparts. This shows that for (sub)urban children, diet is the major exposure pathway for OPs, which as discussed above are associated with a range of cognitive and neurobehavioral disorders in children. Children exposed to OPs via spray drift as well as their diets will have higher cumulative exposure and thus a still greater risk of health impacts.

A recent Government Accountability Office (GAO) study determined that the U.S. Food and Drug Administration (FDA) and USDA should strengthen pesticide monitoring programs and further disclose monitoring limitations (US GAO 2014). FDA is responsible for monitoring fruits and vegetables for pesticides. According to the GAO study, FDA is testing an ever smaller proportion of produce for pesticide residues. Less than 0.1% of imported fruits and vegetables, and even fewer domestic food samples, are being tested (US GAO 2014). GAO also found that FDA's residue testing program does not give a statistically representative picture of either the frequency or magnitude of pesticide residue violations in the U.S. food supply. FDA's annual reports did not disclose that the agency failed to test produce for 6 of the 25 most commonly used pesticides with set tolerances, including glyphosate, 2,4-D, methyl bromide, and paraquat. The GAO report reveals that Americans cannot rely on our nation's food safety agency to protect us from excessive pesticide residues in the U.S. food supply.

Children and others exposed just a single time to a pesticide may in certain cases go on to develop chronic neurological conditions, even if they appear to fully recover.

PART SEVEN: ENVIRONMENTAL IMPACTS OF PESTICIDES IN HAWAI‘I

DANIEL CLARK



BEYOND THE CONSIDERABLE THREATS that pesticides pose to the health of Hawai‘i residents, these chemicals also threaten Hawai‘i's unique and biodiverse environment.

7.1 HAWAI‘I – BIODIVERSITY HOTSPOT AND "ENDANGERED SPECIES CAPITAL OF THE WORLD"

The Hawaiian Islands are the most isolated group of islands on the planet, about 2,400 miles from the nearest continental shore. As a result of this isolation, very few plants and animals have colonized the islands, lending to a large number of endemic species—in fact, about 9,500 species are found nowhere else on the planet (Evenhuis and Eldredge 2002). Further, the microclimates of each island vary greatly, ranging from tropical rainforest to even alpine conditions. These microclimates, coupled with volcanic activity, have also created diverse soils; ten of the twelve soil orders of the world have been identified on the Islands (Deenik and McClellan 2007). This wide range of environmental conditions has led to about 24,000 distinct species calling Hawai'i home (Scheuer and Clark 2001).

Yet, while Hawai'i is identified as a biodiversity hotspot, it has also been named the "endangered species capital of the world" (Scheuer and Clark 2001). **The Islands represent just 0.2% of land area in the United States, and yet they are home to over one-third of the nation's federally endangered species** (Holt 2001). Roughly 75% of documented species extinctions in the U.S. have occurred in Hawai'i (Allison and Miller 2000), and 437 species on the Islands are listed as either threatened or endangered (US Fish and Wildlife Service 2012).

Chemical pesticide run-off is associated with a wide range of habitat damage, including direct species harm and soil and watershed degradation.

7.2 THREATS POSED BY AGROCHEMICALS

The intensive use of agrochemicals in seed corn operations, described above, cannot fail to harm the environment as well as human health. Much of the fertilizers and pesticides applied to fields are washed off to enter streams and bays, or percolate downwards to contaminate groundwater resources. Streams laden with nitrogen fertilizer – which is heavily used in seed corn operations (Brewbaker 2003) – cause eutrophication in the bays that receive them (Diaz and Rosenberg 2008). In this process, the excess nitrogen stimulates excessive growth of aquatic plants, which upon dying are decomposed by organisms that deplete the water of oxygen, killing off fish and other aquatic animals.

Chemical pesticide run-off is associated with a wide range of habitat damage, including direct species harm and soil and watershed degradation. Studies have found that benthic, or bottom-living, organisms in tropical bays such as Hawai'i had higher concentrations of contaminants than bays in comparable temperate regions (Hunter *et al.* 1995). In a study performed in 1995, oysters in Kaneohe Bay contained levels of the pesticides dieldrin and chlordane high enough to be classified as a threat to human health by EPA (*Ibid.*).

Below, we discuss the environmental harms associated with several (classes of) pesticide heavily used in Hawai'i's seed corn operations. Where available, we discuss studies and information specific to the Hawai'i context.

7.2.1 Atrazine

Atrazine is the number one restricted use pesticide applied in Kaua'i's seed corn operations (Figure 16), and is also applied to a handful of other crops, such as sugarcane and macadamia nuts. As discussed in Section 6.5, atrazine is the most commonly detected pesticide in Hawai'i's waters (Grange 2014). In this study, however, agricultural locations where a perennial water source is not available were not tested, so much of

The ubiquitous presence of atrazine in water is concerning because of its ability to disrupt hormonal systems, including sex hormones. Atrazine demasculinizes male fish, amphibians, reptiles and mammals at extremely low levels.

Maui's agricultural regions as well as Kunia (Del Monte pineapple plantation), Moloka'i, and Wai'anae were not sampled. Further, the majority of samples were taken from flowing water rather than lakes and ponds, where pesticide concentrations can be 2.5-10 times higher than those found in flowing water. Amphibians often mate in standing water and ephemeral agricultural ponds or irrigation ditches, where they may be exposed to higher concentrations than found in this study.

The ubiquitous presence of atrazine in water is concerning because of its ability to disrupt hormonal systems, including sex hormones. Atrazine demasculinizes male fish, amphibians, reptiles and mammals at extremely low levels (Hayes *et al.* 2011). Male tadpoles exposed to atrazine at concentrations as low as 0.1 parts per billion (ppb) developed hermaphroditic characteristics (multiple male and female gonads), while as little as 1 ppb atrazine reduced larynx size, which could affect fitness in the wild (Hayes *et al.* 2002).

Atrazine is also linked to immunosuppression in amphibians, making them more susceptible to pests and disease. Tree frog tadpoles exposed to an environmentally realistic concentration of atrazine experienced increased mortality as adults from infection with a chytrid fungus that is implicated in global amphibian declines (Rohr *et al.* 2013). A meta-analysis of the effects of atrazine on fish and amphibians found still broader evidence for atrazine's suppression of immunity, namely, increased risk of infection by a host of pathogens, including trematodes, nematodes, viruses, and bacteria (Rohr and McCoy 2010).

Atrazine may also indirectly harm aquatic organisms by degrading their habitats. The EPA has reported that the effects of atrazine on aquatic ecosystems "may be severe due to the loss of up to 60 to 95% of the vegetative cover, which provides habitat to conceal young fish and aquatic invertebrates from predators," and that "numerous studies have described the ability of atrazine to inhibit photosynthesis, change community structure," and kill aquatic plants at concentrations between 20 and 500 parts per million (ppm) (EPA 2006).

Marine and coral environments are at increased risk due to groundwater and runoff contamination (Cesar and van Beukering 2004). Several essential watersheds throughout the state have been classified as impaired water bodies due to pollutants found exceeding the total maximum daily load limits (TMDLs) by the Hawai'i Department of Health (HDOH 2009). Atrazine is also toxic to coral (Jones *et al.* 2003), and while the causes of the epidemic disease killing Kaua'i's North Shore coral reefs have not been fully ascertained, atrazine in runoff water has been suggested as one possible factor (D'Angelo 2013). Atrazine may also harm coral by slowing the growth rates of symbiotic phytoplankton, which could also reduce the availability of food throughout higher trophic levels in the oceanic food web (Weiner 2007).

7.2.2 Paraquat

Paraquat is highly toxic to a wide range of animals by all routes of exposure.

Paraquat is one of the leading restricted use pesticides applied on Kauaʻi (see Figure 16), and is used primarily in coffee but also in seed crop operations. Paraquat is a highly toxic and fast-acting non-selective herbicide that acts by inhibiting photosynthesis. Paraquat has been found to persist in soils because it easily binds to both clay and organic materials, and is extremely resistant to breakdown by both sunlight and soil microbes. Thus, paraquat residues accumulate with repeated applications (EPA 2009b).

Paraquat is highly toxic to a wide range of animals by all routes of exposure (Extoxnet 1993). In 2014, five family pets (four dogs and one cat) were killed in a small neighborhood in Kalaheo, Kauaʻi due to paraquat poisoning (D'Angelo 2014). The fitness of male parasitic wasps, an important beneficial predator often used in integrated pest management strategies, is decreased when exposed to paraquat (Lacoume *et al.* 2009).

Paraquat also poses risks to aquatic organisms. Paraquat reduced the growth rate of a freshwater microalgal species, among other adverse impacts, which could have negative effects on organisms at higher levels of the food web (Prado *et al.* 2009). Certain types of freshwater fish may experience gill, liver, and kidney alterations when exposed to paraquat (Parvez and Raisuddin 2006). Paraquat in water is rapidly absorbed by aquatic plants, reaching high concentrations in plant tissue. In one study, tadpoles feeding on paraquat-contaminated plants had shorter tails, exhibited abnormal swimming behavior, and died at higher rates than unexposed tadpoles (Bauer Dial and Dial 1995). Another study co-authored by two EPA scientists found that paraquat was "highly toxic" to tadpoles of the Northern leopard frog. Exposure to just 0.1 part per million (ppm) paraquat for as little as four days caused significant reductions in weight and length relative to unexposed controls. Some tadpoles had gross skeletal abnormalities, dying after the four-day exposure (Linder *et al.* 1990).

In response to a lawsuit, EPA conducted an assessment of the risks posed by paraquat and other pesticides to the federally threatened California red-legged frog (CRLF), finding that paraquat is "likely to adversely affect" the CRLF, and potentially affect the frog's designated critical habitat (EPA 2009b). However, the ensuing efforts to restore CRLF populations in California leave the vast majority of amphibians, including those in Hawaiʻi, vulnerable to continued harm from paraquat, atrazine and other pesticides.

7.2.3 Chlorpyrifos

Chlorpyrifos is a restricted use, organophosphate insecticide that is heavily and frequently used on Kauaʻi (Figures 15 and 16). Organophosphates are a class of nerve

Chlorpyrifos is very highly toxic to birds, aquatic invertebrates, freshwater fish, other estuarine and marine organisms, and bees.

toxin insecticides that inhibit the enzyme that breaks down the neurotransmitter acetylcholine. Insects are killed by unnatural accumulation of the neurotransmitter, which overstimulates neuronal cells. Because forms of this enzyme are present not only in insects but in many animals, chlorpyrifos is very highly toxic to birds, aquatic invertebrates, freshwater fish, other estuarine and marine organisms, and bees (NPIC 2009). The cognitive and neurobehavioral impacts of chlorpyrifos on children are discussed in Section 6.2.

Chlorpyrifos binds readily to soils and is a fairly persistent chemical with a half-life ranging from 7-120 days, but has been detected in fields as long as a year after application (NPIC 2009). Like other pesticides, chlorpyrifos is washed out of the atmosphere in rainfall events to contaminate bodies of water. In 2001, the U.S. Geological Survey found chlorpyrifos in "toxic rainfall" at levels exceeding the proposed state guidelines for protection of aquatic life in most samples, and at excessive levels in some river samples as well (USGS 2003). Chlorpyrifos is also a terrestrial threat, and has been shown to kill substantial numbers of both adult and larval bees at levels that are found in the environment (Zhu *et al.* 2014). When it does not kill, chlorpyrifos can alter honeybees' behavior in ways that reduce their fitness, such as increased time grooming, abdominal spasms, and disrupted gut functioning (Williamson *et al.* 2013).

In 2004, the State of New York sued Dow Chemical, the manufacturer of chlorpyrifos, for illegally marketing the chemical as "safe." Chlorpyrifos is one of five pesticides currently being assessed by the U.S. Fish and Wildlife Service for their impacts on endangered species (CBD 2014).

7.2.4 Synthetic Pyrethroids

Synthetic pyrethroids are another class of neutrotoxic pesticide. They are among the restricted use insecticides used 17 times more intensively in Hawai'i's seed corn operations than in mainland corn (see Section 4.4, Table 7), and include permethrin, tefluthrin, esfenvalerate, lambda-cyhalothrin, zeta-cypermethrin, beta-cyfluthrin, and bifenthrin. They are also the second-most frequently used class of RUPs, sprayed on 96 days per year by DuPont-Pioneer on Kaua'i (Figure 15). Pyrethroids are derived from an extract (pyrethrum) of the chrysanthemum, but they have been chemically altered to be both more potent and more persistent in the environment. They are also often formulated with additional ingredients (synergists) that increase their potency by inhibiting enzymes that detoxify the pyrethroid (BP Pyrethroids undated).

Although generally less acutely toxic to human beings than organophosphate insecticides, several pyrethroid formulations (i.e. those containing bifenthrin, esfenvalerate and lambda cyhalothrin) carry label statements warning of possible death upon ingestion as well as harm from inhalation. EPA regards permethrin, zeta-cypermethrin and bifenthrin as possible human carcinogens (BP Pyrethroids undated). Infants are more susceptible to pyrethroids because they lack the ability to efficiently detoxify them. Pyrethroids also cause respiratory and dermal allergies in sensitive individuals (BP Pyrethroids undated).

Pyrethroids are extremely toxic to fish, aquatic invertebrates, lobsters, oysters, shrimp, zooplankton and bees (BP Pyrethroids undated). Shrimp, the amphipod *Hyalella azteca*, and the midge larva *Chaoborus obscuripes* can be killed by pyrethroids at the vanishingly low concentrations of 2 to 5 parts per *trillion* (Weston and Lydy 2010). Some fish (bluegill and lake trout) are killed at levels below 1 part per billion (BP Pyrethroids undated). Permethrin, the most heavily applied of the restricted use pyrethroids on Kaua'i, can enter water via erosion of soil particles to which it binds, or through drift. EPA classifies it as "very highly toxic" to fish and invertebrates in both freshwater and marine environments (EPA 2009a).

Permethrin, the most heavily applied of the restricted use pyrethroids on Kaua'i, is classified by EPA as "very highly toxic" to fish and invertebrates in both freshwater and marine environments.

Pyrethroids are also extremely toxic to bees, which according to product labels can be killed not only by direct exposure to spray, but also at the much lower concentrations found in spray drift. Pyrethroids are so toxic that EPA warns of harm to bees that visit blooming crops or weeds that have previously been sprayed (EPA 2009a). Permethrin also has sub-lethal effects. Bees exposed to low doses spend less time foraging and more time engaging in self-cleaning behaviors and trembling (Cox and Wilson 1984). In its registration of permethrin, EPA acknowledges that it is "likely to reduce the numbers and possibly eliminate populations of beneficial insects" (EPA 2009a).

7.2.5 Neonicotinoids

Neonicotinoids are a class of neuroactive insecticides that are often applied to seeds as a seed treatment; they are absorbed by the growing seedling and distributed throughout its tissues. Thus, foraging pollinators such as bees and birds can be exposed to neonicotinoids when collecting pollen or nectar.

Neonicotinoids are highly toxic and have lethal or sublethal effects on a wide variety of species. In 2013, over 50,000 bees were killed in a Target Store's parking lot in Oregon when a direct application of the neonicotinoid formulation Safari, containing the active ingredient dinotefuran, was sprayed on flowering linden trees to control aphids (Case 2013). Studies also show that neonicotinoids can make native and managed bees more susceptible to viral pathogens and the varroa mite (Nazzi *et al.* 2012, Di Prisco *et al.* 2013). Neonicotinoids also affect bee behavior and inhibit their ability to efficiently forage or return to the hive. In Hawai'i, there have recently been dramatic losses of both domesticated and feral bees (Edwards-Hunt 2011).

Neonicotinoids are soluble, persistent compounds that are frequently found in surface waters across the U.S., where they are known to affect aquatic species (Morrissey

Neonicotinoids have long half-lives and may persist in field sites for several years, where they can accumulate due to repeated use.

et al. 2015). An EPA report concluded that imidacloprid, a widely used neonicotinoid, "is categorized as very highly toxic (0.069 - 0.115 ppm) to freshwater invertebrates on an acute basis" (EPA 2007). Neonicotinoids have long half-lives and may persist in field sites for several years, where they can accumulate due to repeated use (van der Sluijs *et al.* 2013).

Birds may also be poisoned by neonicotinoid exposure. A single kernel of corn coated in neonicotinoids can kill a songbird (Mineau and Palmer 2013), and birds may be adversely affected by lack of invertebrate prey as neonicotinoids reduce insect populations (Hallmann *et al.* 2014). Birds are among the most endangered animal groups. Currently, 34 bird species, including many species of Hawaiian honeycreeper, are listed as endangered (US Fish and Wildlife Service 2015).

Clearly, neonicotinoids have serious and pervasive environmental impacts. But because they are not restricted use pesticides, they are exempt from the voluntary RUP reporting system on Kauaʻi, and data on their use is not available either in Kauaʻi or on the other Islands. However, we know that roughly 90% of corn seeds planted by mainland farmers are coated with the neonicotinoids clothinanidin or thiomethoxam (Douglas and Tooker 2015, Stokstad 2013), and that Hawaiʻi seed corn is almost certainly treated as well (Brewbaker 2003). Thus, neonicotinoids very likely persist in Hawaiʻi's environment in and around seed corn fields. In a draft report assessing findings from Hawaiʻi's pilot program to monitor pesticide contamination in surface waters, the most common seed-applied neonicotinoids were not tested. Testing for these compounds is absolutely essential to make a realistic assessment of environmental impacts from seed corn and other crops.

7.3 IMPACTS OF MULTIPLE PESTICIDES

Humans and other organisms are often exposed to numerous pesticides, which can have additive effects or interact in various ways that make them more toxic than exposure to one of them alone. Several studies have shown that organophosphate insecticides like chlorpyrifos are more toxic to aquatic invertebrates and frogs when low levels of atrazine are also present (Belden and Lydy 2000). Bumblebee colonies exposed to both a neonicotinoid and a pyrethroid suffered higher losses of worker bees than colonies exposed to either chemical alone (Gill *et al.* 2012). Synthetic pyrethroids are often formulated with a substance (piperonyl butoxide) that inhibits enzymes that would otherwise break down the pyrethroids, thus making them more toxic (BP Pyrethroids undated). Some fungicides likewise suppress detoxifying enzymes (Stokstad 2013). The intensive and frequent use of many different pesticides in seed corn fields increases the opportunities for additive and synergistic interactions that potentiate their toxic effects on Hawaiʻi's wildlife.

PART EIGHT: DEFICIENCIES IN REGULATION

FLICKR USER JETSANDZEPPELINS

The responsibilities for regulation of GE crops and pesticides in the United States are shared by three agencies. USDA is responsible for field trials and commercial approval of GE crops. EPA has jurisdiction over pesticides, including those that are produced in or applied to GE crops. FDA conducts voluntary consultations regarding GE foods with companies that choose to consult with it under the Federal Food, Drug, and Cosmetic Act. This compartmentalization of review means that significant impacts and harms are not addressed holistically, if at all. A prime example of regulatory breakdown is the failure of either USDA or EPA to address the significant harms caused by GE herbicide-resistant crop systems, which include a dramatic increase in toxic herbicide use and an epidemic of herbicide-resistant weeds. At the state level, there is nothing in Hawai'i's pesticide law that requires buffer zones, mandatory disclosure, or notification of the public regarding use of toxic pesticides. There is also no Hawai'i statute that specifically addresses GE crops. At both state and federal levels, government officials are failing to protect Hawai'i's citizens and environment from the deleterious effects of GE crops and their associated pesticide use.

EPA assesses risks from exposure to only one active ingredient in isolation, even though in the real world people are exposed to multiple pesticides that can in some cases have additive or synergistic effects.

8.1 PESTICIDE REGULATION

8.1.1 Flaws in EPA regulation

EPA regulates pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act and the Federal Food, Drug, and Cosmetic Act. Its regulatory authority encompasses the insecticidal toxins produced in insect-resistant GE crops and the weed-killers applied to crops engineered for resistance to herbicides. We have described numerous examples of EPA-approved pesticides that are harmful. Below, we discuss several weaknesses in EPA's assessment process that lead to the approval of hazardous products (Jacobs and Clapp 2008).

First, EPA normally requires tests only on the pesticide product's active ingredient, even though it is well-known that so-called "inert ingredients"[22] in pesticide formulations can be toxic in their own right, or increase the active ingredients' toxicity. Similarly, EPA assesses risks from exposure to only one active ingredient in isolation, even though in the real world people are exposed to multiple pesticides that can in some cases have additive or synergistic effects. Importantly, EPA relies almost entirely on experiments conducted by the financially interested pesticide company, and virtually ignores more relevant human epidemiological studies, such as those discussed in this report, that are carried out by independent medical scientists (e.g. Sears *et al.* 2006). In addition, EPA approves hazardous pesticides based on the assumption that farmers and pesticide applicators will comply perfectly with exposure reduction measures (e.g., rubber gloves, goggles, and long-sleeve shirt), despite clear evidence that such measures are unrealistic and often not followed. Of course, schoolchildren and others exposed to drift have no way of implementing such protective measures.

As deficient as EPA regulation is generally, it provides still less protection in the case of pesticide drift. Though EPA has long required pesticide labels to include admonitions to applicators to avoid spray drift, as documented in this report it is a very frequent occurrence, both on Hawaiʻi and the mainland. Despite rules that ostensibly prohibit application in windy conditions, the Association of American Pesticide Control Officials (AAPCO), an organization of state pesticide officials, "has experience that supports that there are numerous pesticide applications made when it is too windy" (AAPCO 2002). EPA proposed labeling changes with the aim of mitigating pesticide drift in 2001, but the proposal was never finalized (Goldman *et al.* 2009). Finally, EPA's very definition of drift is deficient, in that it leaves out vapor drift and pesticide-laden dust, applying only to the type of drift that occurs during application.[23]

[22]In this context, "inert" means non-toxic to the target pest, and says nothing about the ingredient's toxicity to people or the environment.

One stark example of EPA's deficient regulation is chlorpyrifos (see Sections 6.2.2 and 6.6). EPA is quite aware that chlorpyrifos is toxic, which explains why it phased out residential uses of the insecticide beginning in the year 2000, specifically to protect children (Goldman *et al.* 2009). Yet chlorpyrifos remains the most heavily used insecticide in U.S. agriculture (EPA 2011), meaning that residues on produce remain a major exposure pathway. Rural kids subject to drift are still more highly exposed. In Hawai'i, GE crop field test sites are often so close to populated areas that people in both rural areas and towns are at risk of drift exposure.

Hawai'i's Pesticide Law does not comprehensively address the significant potential harms associated with pesticide use and pesticide drift, particularly as these practices relate to the cultivation and testing of GE crops.

8.1.2 Hawai'i State Pesticide Law

The State of Hawai'i regulates pesticides under the Hawai'i Pesticide Law, H.R.S. chapter 149A. The scope of the Hawai'i Pesticide Law has been a subject of litigation since 2014, when the chemical industry challenged a county ordinance passed in the Island and County of Kaua'i that required disclosure and imposed buffer-zones on certain pesticide uses on the Island. *Syngenta Seeds v. County of Kaua'i*, No. 14-00014, 2014 WL 4216022 (D. Haw. Aug. 25, 2014), *appeal docketed*, No. 14-16833 (9th Cir. Sept. 25, 2014). Regardless of the scope of the State's pesticide authority, this much is clear: Hawai'i's Pesticide Law does not comprehensively address the significant potential harms associated with pesticide use and pesticide drift, particularly as these practices relate to the cultivation and testing of GE crops.

Hawai'i's Pesticide Law is one of only a handful of state pesticide laws that does *not* expressly preempt local pesticide authority (Porter 2013). Regardless of the outcome of the ongoing appeal, and what counties may have authority to regulate regarding pesticide use, as it currently stands, the Hawai'i Pesticide Law does not regulate the local impacts of pesticide use. The provisions of the Hawai'i Pesticide Law govern (1) pesticide *licensing*, H.R.S. §§ 149A-11, -13, -13.5, -14; (2) pesticide *labeling, id.* §§ 149A-11, -15; (3) pesticide *sales, id.* §§ 149A-11, -15.5, 17, -18, -20; (4) the *manner* of pesticide use, *id.* § 149A-31; and (5) *online posting of certain records, id.* § 149A-31.2. Hawai'i Revised Statute 149A-2 prohibits the use of pesticides in any manner that presents an unreasonable adverse effect on the environment, which includes any unreasonable risk to humans or the environment with consideration for the economic, social and environmental costs and benefits of the pesticide's use. The State law neither provides for nor prohibits mandatory warnings prior to, or after, pesticide application, nor any direct or indirect restrictions on the locations of pesticide use.

[23]EPA's definition: "Spray or dust drift is the physical movement of pesticide droplets or particles through the air at the time of pesticide application or soon thereafter from the target site to any non-, or off-target site. Spray drift shall not include movement of pesticides to non- or off-target sites caused by erosion, migration, volatility, or windblown soil particles that occurs after application or application of fumigants unless specifically addressed on the product label with respect to drift control requirements." See http://www.epa.gov/PR_Notices/prdraft-spraydrift801.htm, last visited 7/14/13.

The last full environmental assessment of a proposed GE crop field trial in Hawai'i was conducted in 1994.

8.2 REGULATION OF GENETICALLY ENGINEERED CROPS

8.2.1 United States Department of Agriculture

USDA regulates GE crops under the Plant Protection Act (PPA). Under the PPA, a GE crop is presumed to be a "plant pest" unless or until USDA determines that it does not pose plant pest risks, in which case it is formally "deregulated" for commercial use. The majority of GE crops grown in Hawai'i are presumed to be plant pests, and as such can only be grown in regulated field trials upon approval of USDA's Animal and Plant Health Inspection Service (APHIS). In most cases, however, APHIS grants perfunctory approval of such field tests under a streamlined "notification system" instituted in 1993. The GE crop developer "notifies" APHIS of its intent to conduct a field trial, providing minimal information such as the crop species, genetic modification(s), and field trial location(s). APHIS responds with an "acknowledgement" within 30 days (Freese 2007b). While APHIS once conducted environmental assessments under the National Environmental Policy Act prior to granting approval, this is rarely done today. In fact, the last full environmental assessment of a proposed GE crop field trial in Hawai'i was conducted in 1994 (ISB EA 2015).

APHIS is supposed to tightly regulate GE crops grown in field trials to ensure that they do not persist in the environment, become admixed with neighboring crops, or cause environmental harm. However, USDA's own Inspector General and a National Research Council committee have harshly criticized APHIS for its poor performance in this arena (USDA OIG 2005, National Research Council 2002). APHIS's failure to properly regulate GE crops is also demonstrated by several federal court decisions. *See, e.g., Center for Food Safety v. Johanns*, 451 F. Supp. 2d 1165 (D. Haw. 2006) (*Hawai'i Biopharm*); *International Center for Technology Assessment v. Johanns*, 473 F. Supp. 2d 9 (D.D.C. 2007) *motion to dismiss appeal granted*, No. 07-5238, (D.C. Cir. Mar. 17, 2008) (*GE Grasses*); *Geertson Seed Farms v. Johanns*, 2007 WL 518624 (N.D. Cal. Feb. 13, 2007), *affirmed*, 541 F.3d 938 (9th Cir. 2008) (*GE Alfalfa*); *Monsanto Company v. Geertson Seed Farms*,130 S.Ct. 2743 (2010).

In the *Hawai'i Biopharm* case, the federal district court in Hawai'i ruled that the government had, in fact, violated the National Environmental Protection Act (NEPA) and acted in "utter disregard" of the Endangered Species Act by failing to perform the required analysis before issuing field trial permits for GE crops engineered to be "biofactories" for production of potent pharmaceutical compounds (*Hawai'i Biopharm*, 451 F. Supp. 2d at 1182). In the *GE Alfalfa* case, the federal district courts found for the first time that USDA's commercialization approval of a GE crop (Monsanto's Roundup Ready alfalfa) without preparing a full Environmental Impact Statement (EIS) was illegal. Prior to the *GE Alfalfa* decision, USDA had never before undertaken an EIS for any GE crop in over 15 years (Achitoff and Kimbrell 2013). As a direct result of the *GE Alfalfa* decision, USDA now regularly prepares the requisite NEPA documentations prior to commercial approval of new GE crops.

8.2.2 Hawai'i State GE regulatory framework

The State's authority to regulate GE crops is similarly a question that is currently pending before the Ninth Circuit Court of Appeals. *See Hawai'i Floriculture & Nursery Ass'n v. Cnty. of Hawai'i*, No. 14 CV-00267-BMK, 2014 WL 6685817 (D. Haw. Nov. 26, 2014), appeal docketed, *sub nom. Hawai'i Papaya Industry Ass'n v. Cnty. of Hawai'i* (9th Cir. Jan 6, 2015). In that case, the federal district court found that an assortment of state laws relating to plant quarantine, plant pests, and noxious weeds, *could* apply to GE crops and thereby preempt local county action. Whether or not such laws may be amended or applied in such a way, the statutes have *never* been applied to GE crop regulation. In fact, none of the statutes relied upon by the court even mentions GE crops. As with the Hawai'i Pesticide Law, Hawai'i statute does not expressly prohibit or address the issue of disclosing production of GE plants, nor regulate GE organisms in any way. The State has no statute that specifically addresses the impacts of cultivating and testing GE crops. There is currently no comprehensive state statutory scheme occupying the field of GE organism regulation.

Lacking protection from state and federal agencies, residents of different counties have demanded that their local governments take action, under the counties' authority to regulate agriculture, ensure the welfare of its residents, and protect public resources.

8.3 ATTEMPTS AT LOCAL REGULATION – LITIGATION UPDATE

Lacking protection from state and federal agencies, whose regulatory mechanisms fail to account for the impacts of pesticides and GE crops on Hawai'i, residents of different counties have demanded that their local governments take action, under the counties' authority to regulate agriculture, ensure the welfare of its residents, and protect public resources. *See* HRS § 205-43; HRS § 46 1.5(13); *Syngenta Seeds, Inc. v. Cnty. of Kaua'i*, No. 14-CV-00014-BMK, 2014 WL 4216022, at *4 (D. Haw. Aug. 23, 2014). As the federal district court observed in *Syngenta Seeds v. County of Kaua'i*, No. 14-00014, 2014 WL 4216022 (D. Haw. Aug. 25, 2014), the legislature has "expressly recognized that the counties have some role to play in enacting regulations that affect the field of agriculture," citing state law expressly granting the counties authority that includes "formulating 'agricultural policies, tax policies, land use plans, ordinances, and rules'" (citing HRS § 205–43).

8.3.1 Kaua'i County

In November 2013, the County of Kaua'i approved a groundbreaking new ordinance to protect the public from pesticide exposure. Ordinance 960 required notification and disclosure of pesticide applications to help residents avoid pesticide drift and to ensure better medical treatment for those exposed to pesticides, and also created buffer zones around sensitive locations, including schools, hospitals, and waterways. Unwilling to comply with these prudent restrictions to safeguard the health of Hawai'i

On November 5, 2014, Maui voters made history by passing a Maui County ballot initiative, which was unprecedented given that chemical companies raised over $8 million to fight the initiative – the most money raised on any local ballot initiative in U.S. history.

residents, the chemical corporations filed a lawsuit, alleging every claim of which they could conceive, rather than simply comply with the County's urgently-needed, reasonable, and limited ordinance. Unfortunately, in September 2014, the court ruled that the county ordinance was preempted by state law.

However, the decision had some positive aspects. The court denied the chemical companies' claim that County Ordinance 960 law was also contrary to or prohibited by federal law. Thus, federal pesticide law and the federal plant law applied to GE crops did not prohibit county regulation. Thus, the decision supported the conclusion that, in other states, federal law would not prohibit counties from protecting themselves the way Kaua'i did, by regulating pesticides and GE crops via disclosures and buffer zones. The Kaua'i decision is currently under appeal before the Ninth Circuit Court of Appeals.

8.3.2 Hawai'i County (Big Island)

In December of 2013, Hawai'i County enacted Ordinance 13-121, which prohibited the open-air cultivation of GE crops with certain limited exemptions, for instance GE papaya registered with the County. The Ordinance provided farmers and residents of the Big Island, their property, and the environment important protection from the impacts of GE crops, such as transgenic contamination and associated pesticide drift. In June 2014, Hawai'i County was sued by the Biotechnology Industry Organization, which represents the Islands' chemical corporations, among other plaintiffs, and Ordinance 13-121 was determined to be invalid. The ruling, issued by the same judge as in the Kaua'i case, again concluded that GE crops must be regulated at the state level, despite the fact no state statute even mentions GE crops or was intended to regulate them. However, the Court's decision was not without its silver lining, in that it rejected the plaintiffs' arguments that county and state regulation of commercialized GE crops was prohibited by federal law, though it did hold that federal law prohibited county regulation of some, but not all, experimental plantings. CFS is representing the County *pro bono* to appeal the lower court's ruling before the Ninth Circuit Court of Appeals.

8.3.3 Maui County

On November 5, 2014, Maui voters made history by passing a Maui County ballot initiative that would have placed a temporary moratorium on the testing and planting of GE crops in Maui unless or until an environmental and public health study demonstrated that they were safe. This victory was unprecedented, given that chemical companies like Monsanto and Dow Chemical raised over $8 million to fight the initiative – the most money raised on any local ballot initiative in U.S. history.

Monsanto and Dow Chemical challenged the ballot initiative in federal court. The litigation is being adjudicated before a different federal judge than the one who presided over the Kauaʻi and Hawaiʻi Island decisions. In light of the two erroneous rulings on the other Islands' ordinances by Magistrate Judge Kurren, the road to victory at the district court level is admittedly difficult.

An increasing number of states and counties have recognized the health threats posed by pesticide drift and the serious deficiencies in EPA regulation.

8.4 MOMENTUM BUILDING TO PROTECT KIDS FROM PESTICIDE DRIFT

In a failed attempt to better protect human health and the environment from pesticide drift, EPA proposed improved pesticide labeling in 2001 (EPA 2001), but this proposal was never finalized and is not in effect. In an important sign of the times, however, public interest and farmworker groups formally challenged EPA for its inaction, and petitioned the Agency to establish regulations to protect children from pesticide drift. This petition, entitled *Pesticides in the Air – Kids at Risk*, provides further information documenting the harms from this neglected health threat (Goldman *et al.* 2009). In Section 6, we discussed a seminal review of the medical literature on the threat of pesticides to children's health by the premier organization representing our nation's pediatricians, the American Academy of Pediatrics (Roberts and Karr 2012). AAP has also released an official policy statement based on this review that makes specific recommendations to mitigate health threats from pesticides (AAP 2012). Among the local policy approaches listed by AAP are the establishment of no-spray buffer zones around schools, posting warning signs of pesticide use, and restricting specific types of pesticides at schools. Medical scientists from the federal and state governments, writing in the prestigious *Journal of the American Medical Association*, also support "adoption of pesticide spray buffer zones around schools" (Alarcon *et al.* 2005).

An increasing number of states and counties have recognized the health threats posed by pesticide drift and the serious deficiencies in EPA regulation. Momentum is building to protect kids from pesticide drift, including measures such as those found in Ordinance 960 (Feitshans 1999). As of 2004, at least seven states had established no-spray buffer zones around schools, hospitals, nursing homes, public parks, and playgrounds (Owens and Feldman 2004). More recent information shows that nine states (Hurley *et al.* 2014) and fourteen counties in California (CPR 2010) have established similar no-spray zones. States with notification requirements for pesticide applications near schools have increased in number from eight in 2004 to eleven today (Owens and Feldman 2004, Hurley *et al.* 2014). These policy actions evince growing awareness of the serious health threats posed by pesticide drift.

How much more important is it to protect people, and especially vulnerable children, from the hazards of pesticide drift?

8.5 OTHER STATE AND COUNTY PESTICIDE PROGRAMS AND REGULATIONS

As noted in Section 5.2, eleven states have established pesticide poisoning surveillance programs: California, Florida, Iowa, Louisiana, Michigan, Nebraska, New York, North Carolina, Oregon, Texas, and Washington (CDC 2014). Such a program, if established in Hawai‘i, would likely capture many more pesticide-induced illnesses.

Washington State tracks pesticide-induced illnesses and publishes annual pesticide incident reports to provide a sound empirical basis for measures to mitigate these harms. Pesticide drift is consistently the leading cause of pesticide-induced illness (WA PIRT 2010). In California, counties play a leading role in pesticide regulation (CA DPR 2011). The County Agricultural Commissioners (CACs) generally have enforcement authority for state pesticide law, especially with respect to more hazardous pesticides, which are designated “restricted materials.” Anyone who wishes to use a restricted material must petition the CAC for a permit. The CAC can conduct on-site monitoring to assess risk, and then deny the permit, or issue it with restrictions based on local conditions. Because a permit is the functional equivalent of an environmental impact report, it is up to the county to decide if the proposed use of a restricted material will cause a substantial adverse health or environment impact. In addition, growers must file a “notice of intent” with the CAC at least 24 hours before a scheduled application to give county staff time to evaluate the site before or during the application.

In many states, one finds county- or even township-specific drift regulations that are tailored to the particular types of crops that are grown and pesticides used in the area. Some of these regulations target certain drift-prone pesticides; some restrict usage during part of the year. The intent of most such regulations is to prevent drift-related crop damage (Feitshans 1999, CPR 2010, MI DoA 2011). How much more important is it to protect people, and especially vulnerable children, from the hazards of pesticide drift?

PART NINE: CONCLUSION

Hawai'i is at a crossroads in its economic and agricultural development. Over a century of plantation agriculture, producing commodities for export, has steadily diminished Hawai'i's ability to feed itself, and today the state imports 88% of its food. Plantation-era pesticides have exacted a heavy toll on the health of Hawai'i's citizens and its environment. This legacy of food insecurity and pollution has been perpetuated by the agrochemical firms that test genetically engineered seed crops on a large and growing share of Hawai'i's prime farmland. Like sugarcane and pineapple, GE seeds are shipped offshore; and like the plantation crops, they involve intensive use of pesticides.

As communities across the state have become more aware of the hazards, they have pushed back, demanding greater transparency and prudent restrictions. Their chief concern is not whether GE foods are safe to eat, as some would have it, but rather the health and environmental effects of the toxic pesticides that are so heavily used in the expanding GE seed crop operations.

As our knowledge of the many risks posed by pesticides grows, policymakers will be in a better position to develop regulations that adequately protect public and environmental health.

As this report shows, there is ample reason for concern. Growing GE seed corn in Hawai'i involves much more frequent and intensive use of insecticides and fungicides than mainland corn. Because so much of it is genetically engineered for resistance to herbicides, weed-killers are also heavily applied. Hawai'i's media have reported numerous episodes of pesticide drift sickening schoolchildren. Residents of the Kaua'i town of Waimea, downwind of DuPont-Pioneer test fields, have been especially hard hit.

The medical literature discussed in this report leaves little doubt that many of the pesticides used in Hawai'i can cause serious harm to human health. In adult populations, pesticide exposure has been strongly linked to various cancers, Parkinson's disease, depression, and disruption of our hormonal systems. Still more concerning are the impacts on children, whose developing systems are more vulnerable to pesticidal harms. Exposure of pregnant women is particularly threatening, since pesticides can cause lasting damage by interfering with fetal development. The neurobehavioral impacts of pesticides are perhaps most frightening. A spate of recent studies is building an irrefutable case that long-term, low-level exposure to nerve toxin insecticides in early life (particularly *in utero*) can result in autism, attention-deficit/hyperactivity disorder, and reduced intelligence. Other pesticidal impacts indicated by a growing number of studies include childhood cancers, adverse birth outcomes, and asthma. Pesticides also threaten native biodiversity and ecological services by polluting water and harming aquatic organisms, and killing beneficial insects and pollinators.

Lacking protection from federal regulators, three Hawai'i counties have taken action. The State of Hawai'i must follow suit. Greater transparency and modest protections are urgently needed. The public has the right to know which pesticides are being used, and in what quantities, particularly because they are often applied near places of work and play. Scientists and physicians require this information to better assess pesticidal threats and make informed medical decisions for their patients. As our knowledge of the many risks posed by pesticides grows, policymakers will be in a better position to develop regulations that adequately protect public and environmental health. However, enough is known already for Hawai'i lawmakers to follow the lead of numerous other states and counties and establish modest, no-spray buffer zones around homes, schools and hospitals. Such buffer zones represent a prudent first step towards better protecting Hawai'i's residents, particularly vulnerable children, from pesticide drift.

Together, we can ensure that Hawai'i's agriculture takes a new path, one that promotes the health, well-being, and food self-sufficiency of our Islands, now and for future generations.

REFERENCES

AAP (2012) Pesticide Exposure in Children. Policy Statement, Council on Environmental Health of the American Academy of Pediatrics. Pediatrics 130(6): e1757-e1763. http://pediatrics.aappublications.org/content/130/6/e1757.full.html

AAPCO (2002) Letter from Donnie Dippel, President of Association of American Pesticide Control Officials, to Jay Ellenberger of EPA, March 25, 2002.

AAPCO (1999, 2005) 1999 and 2005 Pesticide Drift Enforcement Surveys, Association of American Pesticide Control Officials, 2005. http://www.aapco.org/documents/surveys/drift99.html; http://www.aapco.org/documents/surveys/DriftEnforce05Rpt.html

Achitoff PH, Kimbrell GA (2013) Gaining ground in the courts. In: Facing Hawai'i's Future, Hawai'i SEED pp. 28-38.

Adler J (2011) The growing menace from superweeds. Scientific American, May 2011, pp 74-79.

Alarcon WA, Calvert GM, Blondell JM, Mehler LN, Sievert BS, Propeck M, Tibbetts DS, Becker A, Lackovic M, Soileau SB, Das R, Beckman J, Dorilee PM, Thomsen CL, Stanbury M (2005) Acute illnesses associated with pesticide exposure at schools. Journal of the American Medical Association 294(4): 455-465.

Allen RH, Gottlieb M, Clute E, Pongsiri MJ, Sherman J, Obrams GI (1997) Breast cancer and pesticides in Hawai'i: The need for further study. Environmental Health Perspectives 105(Suppl. 3): 679-683.

Allison A, Miller SE (2000). Hawai'i Biological Survey: museum resources in support of conservation. In: Raven PH Williams T (eds) Nature and human society. The quest for a sustainable world. National Academy Press, Washington, D.C., pp 281-290.

Ames RG, Howd RA, Doherty L (1993) Community exposure to a paraquat drift. Environmental Health Perspectives 48(1): 47-52.

Andrade C (2001) Ha'ena, Ahupua'a: Towards a Hawaiian geography. Dissertation, University of Hawai'i at Manoa, 2001.

Anthony SS, Hunt CD Jr, Brasher AMD, Miller LD, Tomlinson MS (2004) Water quality on the island of O'ahu, Hawai'i, 1999-2001. Report by U.S. Geological Survey Circular 1239, pp 41. http://pubs.water.usgs.gov/cir1239.

Arbuckle TE, Lin Z, Mery LS (2001) An exploratory analysis of the effect of pesticide exposure on the risk of spontaneous abortion in an Ontario farm population. Environmental Health Perspectives 109(8): 851-857.

Arbuckle TE, Savitz DA, Mery LS, Curtis KM (1999) Exposure to phenoxy herbicides and the risk of spontaneous abortion. Epidemiology 10(6): 752–760.

Baker BP, Benbrook CM, Groth III E, Benbrook KL (2002) Pesticide residues in conventional, integrated pest management (IPM)-grown and organic foods: Insights from three US data sets. Food Additives and Contaminants 19(5): 427-446.

Bartholomew DP, Hawkins RA, Lopez JA (2012) Hawai'i Pineapple: The rise and fall of an industry. HortScience 47(10): 1390-1398.

Bauer Dial CA, Dial NA (1995) Lethal effects of the consumption of field levels of paraquat-contaminated plants on frog tadpoles. Bulletin of environmental contamination and toxicology 55(6): 870-877.

BEA Consumer Guide (2015) Measuring the Nation's Economy. Bureau of Economic Analysis. U.S. Department of Commerce, accessed 2015. http://www.bea.gov/agency/pdf/BEA_Customer_Guide.pdf.

Beard JD, Umabach DM, Hoppin JA, Richards M, Alavanja MCR, Blair A, Sandler DP, Kamel F (2014) Pesticide exposure and depression among male private pesticide applicators in the Agricultural Health Study. Environmental Health Perspectives 122(9): 984-991.

Belden JB, Lydy (2000) Impact of atrazine on organophosphate insecticide toxicity. Environmental Toxicology and Chemistry 19(9): 2266-2274.

Benbrook CM (2012) Impacts of genetically engineered crops on pesticide use in the U.S. – the first sixteen years. Environmental Sciences Europe 24(1): 24.

Beseler CL, Stallones L, Hoppin JA, Alavanja MC, Blair A, Keefe T, Kamel F (2008) Depression and pesticide exposures among private pesticide applicators enrolled in the Agricultural Health Study. Environmental Health Perspectives 116(12): 1713-1719.

Beseler CL, Stallones L (2008). A cohort study of pesticide poisoning and depression in Colorado farm residents. Annals Epidemiology 18:768–774.

Bienkowski, B (2014) Pesticide use by farmers linked to high rates of depression, suicides. Environmental Health News, October 6, 2014. http://www.environmentalhealthnews.org/ehs/news/2014/oct/pesticides-depression/.

Bjorling-Poulsen M, Andersen HR, Grandjean P (2008) Potential developmental toxicity of pesticides used in Europe. Environmental Health 7:50.

Blair A, Zahm SH (1995) Agricultural exposures and cancer. Environmental Health Perspective 103(supplement 8): 205–208.

Bouchard MF, Chevrier J, Harley KG, Kogut K, Vedar M, Calderon N, Trujilo C, Johnson C, Bradman A, Barr DB, Eskenazi B (2011) Prenatal exposure to organophosphate pesticides and IQ in 7-year-old children. Environmental Health Perspective 119(8): 1189–1195.

Bouchard MF, Bellinger DC, Wright RO, Weisskopf MG (2010) Attention-deficit/hyperactivity disorder and urinary metabolites of organophosphate pesticides. Pediatrics 125(6): e1270-e1277. www.pediatrics.org/cgi/content/full/125/6/e1270

BP Pyrethroids (undated) Fact Sheet on Pyrethroids/Pyrethrins. Beyond Pesticides. http://www.beyondpesticides.org/infoservices/pesticidefactsheets/toxic/pyrethroid.php.

Brewbaker JL (2010) Breeding crops for sustainable pesticide-free production in Hawaii. Hanai'Ai/The Food Provider, Dec. 2009/Jan.-Feb. 2010. http://www.ctahr.hawaii.edu/sustainag/news/articles/V2-Brewbaker-Breeding.pdf.

Brewbaker JL (2003) Corn production in the tropics: The Hawai'i experience. University of Hawai'i, Manoa. College of Tropical Agriculture and Human Resources. Department of Tropical Plant and Soil Science.

Brighina L, Frigerio R, Schneider NK, Lesnick TG, de Andrade M, Cunningham JM, Farrer MJ, Lincoln SJ, Checkoway H, Rocca WA, Maraganore DM (2008) Alpha-synuclein, pesticides, and Parkinson disease: A case–control study. Neurology 70(16 pt 2): 1461–1469.

Brown TP, Rumsby PC, Capleton AC, Rushton L, Levy LS (2006) Pesticides and Parkinson's Disease – Is There a Link?. Environmental Health Perspectives 114(2): 156-164.

CA DPR (2011). A Guide to Pesticide Regulation in California. California Department of Pesticide Regulation. December 2011 pp. 56-63.

CA PISP (1992-2011) Records obtained from a search of agricultural drift episodes in California from 1992-2011. CA Pesticide Illness Surveillance Program Illness Query database, search conducted 7/12/14. http://www.cdpr.ca.gov/docs/whs/pisp.htm.

CA PISP Fact Sheet (undated). Preventing pesticide illness. California's Pesticide Illness Surveillance Program. CA Department of Pesticide Regulation.

CA Pesticides (2012) Summary of Pesticide Use Report Data 2012: Indexed by Commodity. California Dept. of Pesticide Regulation, February 2014, p. 15. http://www.cdpr.ca.gov/docs/pur/pur12rep/comrpt12.pdf

Cantor KP, Blair A, Everett G, Gibson R, Burmeister LF, Brown LM, Schuman L, Dick FR (1992) Pesticides and other agricultural risk factors for non-Hodgkin's lymphoma among men in Iowa and Minnesota. Cancer Research 52: 2447–2455.

Case E (2013) Bee deaths a result of pesticide Safari; count upped to 50,000 dead insects. The Oregonian, June 21, 2013 (updated April 22, 2014).

CBD (2014) Settlement will help safeguard nation's endangered wildlife from 5 dangerous pesticides. Center for Biological Diversity. July 28, 2014. http://www.biologicaldiversity.org/news/press_releases/2014/pesticides-07-28-2014.html.

CCOHS (2012) What are the effects of dust on the lungs?. Canadian Centre for Occupational Health and Safety, October 1, 2012.

CDC (2014) Center for Disease Control and Prevention. Pesticide Illness & Injury Surveillance – State-Based Pesticide Poisoning Surveillance Programs. Last visited 11/12/14. http://www.cdc.gov/niosh/topics/pesticides/Statebase.html

Center for Food Safety v. Johanns, 451 F. Supp. 2d 1165 (D. Haw. 2006) (Hawai'i Biopharm).

Cesar HSJ, van Beukering PJH (2004) Economic valuation of the coral reefs of Hawai'i. Pacific Science 58(2): 231-242.

CFS (2014a) Comments to USDA APHIS on Draft Environmental Impact Statement for Determination of Nonregulated Status of Herbicide Resistant Corn and Soybeans: Science Comments I, Docket APHIS-2013-0042. http://www.centerforfoodsafety.org/files/cfs-enlist-draft-eis-science-comments-i_77655.pdf.

CFS (2014b) Comments to USDA's Animal and Plant Health Inspection Service on the Agency's draft Environmental Impact Statement on Monsanto Petitions (10-188-01p and 12- 185-01p) for Determinations of Nonregulated Status for Dicamba-Resistant Soybean and Cotton Varieties, Science Comments I, Center for Food Safety, October 10, 2014. http://www.centerforfoodsafety.org/files/cfs-dicamba-cotton-and-soy-deis-science-comments-i_21022.pdf.

CFS (2013a) Comments to EPA on Application to Register New Use of Dicamba on Dicamba and Glufosinate Resistant MON 87701 Cotton, and to Establish Tolerances for Residues of Dicamba in Cottonseed and Cotton Gin Byproducts. Center for Food Safety, January 18, 2013. http://www.centerforfoodsafety.org/files/cfs-science-comments-on-dicamba-use-registration-for-cotton-date-corrected_45293.pdf.

CFS (2013b) Comments to USDA APHIS on Draft Environmental Assessment and Draft Plant Pest Risk Assessment for DuPont-Pioneer's Petition (11-244-01p) for Determination of Nonregulated Status of Insect-Resistant and Herbicide-Resistant Pioneer 4414 Maize: Event DP-004114-3. Center for Food Safety, April 29, 2013: 3-5. http://www.centerforfoodsafety.org/files/cfs-comments-dupont-pioneer-4114-maize--final_43107.pdf.

CFS (2010) Center for Food Safety applauds new power for the FDA. Press Release, Center for Food Safety, Nov. 30, 2010. http://www.centerforfoodsafety.org/issues/976/ge-food-labeling/press-releases/815/senate-passes-landmark-food-safety-legislation.

Charles D (2015) Iowa's largest city sues over farm fertilizer runoff in rives. The Salt, National Public Radio, January 12, 2015. http://www.npr.org/blogs/thesalt/2015/01/12/376139473/iowas-largest-city-sues-over-farm-fertilizer-runoff-in-rivers

Chevrier C, Limon G, Monfort C, Rouget F, Garlantezec R, Petit C, Durand G, Cordier A (2011) Urinary biomarkers of prenatal atrazine exposure and adverse birth outcomes in the PELAGIE birth cohort. Environmental Health Perspectives 119(7): 1034-1041.

Clapp RW, Howe GK, Jacob M (2006) Environmental and occupational causes of cancer revisited. Journal of Public Health Policy 27(1): 61-76.

Clark H (2001). Insecticide sickens Pahoa students. Honolulu Advertiser, October 13, 2001.

Corum AK (2000) Ethnic Foods of Hawai'i. Bess Press, Honolulu: HI.

Costello S (2009) Parkinson's disease and residential exposure to maneb and paraquat from agricultural applications in the central valley of California. American Journal of Epidemiology 169(8): 919-926.

Cox RL, Wilson WT (1984) Effects of permethrin on the behavior of individually tagged honey bees Apis mellifera L. (Hymenoptera: Apidae). Environmental entomology 13(2): 375-378.

CPR (2010) Pesticide Protection Zones: Keeping Kids Safe at School. Californians for Pesticide Reform, Pesticide Watch, Center for Environmental Health, March 2010.

D'Angelo C (2014) Animals poisoned in Kalaheo. The Garden Island, February 9, 2014.

D'Angelo C (2013) Lilley: Reef has 'coral AIDS.' The Garden Island, March 25, 2013.

Da Silva A (2007). Farm faces fine for school pesticide fumes. Honolulu Star-Bulletin, May 24, 2007.

Deenik J, McClellan AT (2007) Soils of Hawai'i. Soil and Crop Management, SCM-20. College of Tropical Agriculture and Human Resources, University of Hawai'i at Manoa, Honolulu: HI.

De Roos AJ, Zahm SH, Cantor KP, Weisendburger DD, Holmes FF, Burmeister LF Blair A (2003) Integrative assessment of multiple pesticides as risk factors for non-Hodgkin's lymphoma among men. Journal of Occupational Medicine 60(11): e11. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1740618/ .

Diaz RJ, Rosenberg R (2008) Spreading dead zones and consequences for marine ecosystems. Science 321: 926-929.

Di Prisco G, Cavaliere V, Annoscia D, Varricchio P, Caprio E, Nazzi F, Gargiulo G, Pennacchio F (2013) Neonicotinoid clothianidin adversely affects insect immunity and promotes replication of a viral pathogen in honey bees. Proceedings of the National Academy of Sciences, 110(46): 18466-18471.

Douglas M, Tooker JF (2015) Large-scale deployment of seed treatments has driven rapid increase in use of neonicotinoid insecticides and preemptive pest management in

U.S. field crops. Environmental Science Technology 49(8): 5088-97.

Dow Chemical (2007) Dow AgroSciences Reveals Progress on New Herbicide Tolerance Trait. Decatur, IL. http://www.seedtoday.com/articles/dow_agrosciences_reveals_progress_on_new_herbicide_tolerance_trait-47836.html

Duhigg C (2008) Debating how much weed killer is safe in your water glass. The New York Times, August 8, 2008.http://www.nytimes.com/2009/08/23/us/23water.html?_r=1andpagewanted=print

Edwards-Hunt T (2011) Hawai'i Beekeepers Overwhelmed By Three Pests. Hawai'i Business, September 2011.

Elbaz A, Clavel J, Rathouz PJ, Moisan F, Galanaud JP, Delemotte B, Alperovitch A, Tzourio C (2009) Professional exposure to pesticides and Parkinson disease. Annals of Neurology 66(4): 494–504.

End Science Censorship (2014). 150 scientists condemn retraction of Seralini study as bow to commercial interests, March 4, 2014. http://www.endsciencecensorship.org/en/page/press-release#.VWOe9TrKdrC.

Eng P (2012) Facing Hawai'i's future: Essential information about GMO's: In: Plantations to GMO's: The struggles for the farming future of west Kaua'i. Hawai'i SEED.

Engel SM, Wetmur J, Chen J, Zhu C, Barr DB, Canefield RL, Wolff MS (2011) Prenatal exposure to organophosphates, paraoxonase 1, and cognitive development in childhood. Environmental Health Perspectives 119(8): 1182–1188.

EPA (2014a) 1,2-Dibromo-3-Chloropropane (DBCP) Hazard Summary – Created in April 1992; Revised in January 2000. Last visited 11/12/14. http://www.epa.gov/ttnatw01/hlthef/dibromo-.html

EPA (2014b) Ethylene Dibromide (Dibromoethane) Hazard Summary – Created in April 1992; Revised in January 2000. Last visited 11/12/14. http://www.epa.gov/ttnatw01/hlthef/ethyl-di.html

EPA (2014c) Heptachlor Hazard Summary – Created in April 1992; Revised in January 2000. Last visited 11/12/14. http://www.epa.gov/ttnatw01/hlthef/heptachl.html

EPA (2011) Pesticide Industry Sales and Usage: 2006 and 2007 Market Estimates. http://www.epa.gov/opp00001/pestsales/07pestsales/market_estimates2007.pdf.

EPA Sulfuryl Fluoride (2011) Sulfuryl Fluoride; proposed order granting objections to tolerances and denying request for a stay. Federal Register 76(12): 3422-3449.

EPA (2009a) Reregistration Eligibility Decision (RED) for Permethrin.

EPA (2009b) Risk of Paraquat Use to Federally Threatened California Red-legged Frog (Rana aurora draytonii) - Pesticide Effects Determination, EPA, June 10, 2009. http://www.epa.gov/espp/litstatus/effects/redleg-frog/paraquat/analysis.pdf.

EPA (2007) EFED Section 3 and IR-4 risk assessment for imidacloprid for use on soybeans, peanuts, kava, millet, oats, artichoke, wild raspberry, and caneberry subgroup 13A. PC code 129099, pp.72.

EPA (2006) Atrazine: Finalization of Interim Reregistration Eligibility Decision and Completion of Tolerance Reassessment and Reregistration Eligibility Process. http://www.epa.gov/pesticides/reregistration/REDs/atrazine_combined_docs.pdf

EPA (2001) Pesticide Registration (PR) Notice 2001-X Draft: Spray and Dust Drift Label Statements for Pesticide Products. Office of Pesticide Programs, Environmental Protection Agency, 2001.

EPA (1995) Del Monte Corporation (Oahu Plantation). Designated a Superfund site on Sept. 1, 1995. Last visited 11/12/14. http://www.jdsupra.com/legalnews/dpr-proposal-for-right-to-know-notificat-11530/

Eskenazi B, Marks AR, Bradman A, Harley K, Barr DB, Johnson C, Morga N, Jewell NP(2007) Organophosphate pesticide exposure and neurodevelopment in young Mexican-American children. Environmental Health Perspectives 115(5): 792–798.

Eskenazi B, Harley K, Bradman A, Weltzien E, Jewell NP, Barr DB, Furlong CE, Holland NT (2004) Association of in utero organophosphate pesticide exposure and fetal growth and length of gestation in an agricultural population. Environmental Health Perspectives 112(10): 1116–1124.

ETC Group (2011) Who will control the Green Economy?. ETC Group, November 2011.

Evenhuis NL, Eldredge LG (eds) Records of the Hawai'i Biological Survey for 2000. Bishop Museum Occasional Papers, Numbers 68, 69. Honolulu: Bishop Museum, March 25, 2002.

Extoxnet (1993) Paraquat. Pesticide Information Profile, Extension Toxicology Network. Sept. 1993. http://pmep.cce.cornell.edu/profiles/extoxnet/metiram-propoxur/paraquat-ext.html#6.

Feitshans TA (1999) An analysis of state pesticide drift laws. 20 San Joaquin Agricultural Law Review. 269: 2010 -2011.

Fraser K (2013) Glyphosate-resistant weeds – intensifying. Stratus Research, January 25,

2013. http://stratusresearch.com/blog/glyphosate-resistant-weeds-intensifying.

Freese B (2014) Why GM crops will not feed the world. In: Krimsky S, Gruber J (eds). The GMO Deception, Skyhorse Publishing New York: NY.

Freese B (2007a) Cotton Concentration Report: An Assessment of Monsanto's Proposed Acquisition of Delta and Pine Land. Center for Food Safety, February 2007.

Freese W (2007b) Regulating transgenic crops: Is the government up to the task?. Biotechnology, 1: 14-17.

Fujimori L (2008). Smell from pesticide spill sickens Pearl City kids. Honolulu Star-Bulletin, March 7, 2008.

Garry VF, Harkins ME, Erickson LL, Long-Simpons LK, Holland SE, Burroughs BL (2002) Birth defects, season of conception, and sex of children born to pesticide applicators living in the Red River Valley of Minnesota, USA. Environmental Health Perspectives 110 (Suppl. 3): 441-449.

Garry VF, Schreinemachers D, Harkins ME, Griffith J (1996) Pesticide appliers, biocides, and birth defects in rural Minnesota. Environmental Health Perspective 104 (4): 394-399.

Geertson Seed Farms v. Johanns, 2007 WL 518624 (N.D. Cal. Feb. 13, 2007), affirmed, 541 F.3d 938 (9th Cir. 2008) (GE Alfalfa).

Gill RJ, Ramos-Rodriguez O, Raine NE (2012) Combined pesticide exposure severely affects individual- and colony-level traits in bees. Nature, 21 October 2012. http://www.nature.com/nature/journal/vaop/ncurrent/pdf/nature11585.pdf#close.

Gilliom RJ, Barbash JE, Crawford CG, Hamilton PA, Martin JD, Nakagaki N, Nowell LH, Scott JC, Stackelberg PE, Thelin GP, Wolock DM (2006) The Quality of Our Nation's Waters—Pesticides in the Nation's Streams and Ground Water 1992–2001. U.S. Geological Survey Circular 1291: 172.

Goldberg C (1996) As sugar fades, Hawaii seeks a new cash crop. New York Times, August 9, 1996.

Goldman P, Brimmer JK, Ruiz V (2009) Pesticides in the air – kids at risk: Petition to EPA to protect children from pesticide drift. Earth Justice and Farmworker Justice

October 2009.

Gomes A (2015) Seed crop value falls for second year in a row. Honolulu Star-Advertiser May 6, 2015.

Gonzalez D, Loewenberg S (2003) Banana workers get day in court. New York Times, January 18, 2003.

Grange F (2014) 2013-1014 State Wide Pesticide Sampling Pilot Project Water Quality Findings. Prepared by the State of Hawai'i Department of Health Hazard Evaluation and Emergency Response Office. http://eha-web.doh.hawaii.gov/eha-cma/documents/7fb9412b-9b2f-401e-992a-92bf729b3159.

Gregg AC (2006) Odor closes Waimea elementary school. The Garden Island, November 17, 2006.

Guyton KZ, Loomis D, Grosse Y, El Ghissassi F, Benbrahim-Tallaa L, Guha N, Scoccianti C, Mattock H, Straif K (2015) Carcinogenicity of tetrachlorvinphos, parathion, malathion, diazinon, and glyphosate. Lancet Oncology online 3/20/15. http://dx.doi.org/10.1016/S1470-2045(15):70134-70138.

Hallmann CA, Foppen RPB, van Turnhout CSM, de Kroon H, Jongejans E (2014) Declines in insectivorous birds are associated with high neonicotinoid concentrations. Nature 511: 341-343.

Hardell L, Eriksson M, Nordstrom M (2002) Exposure to pesticides as risk factor for non-Hodgkin's lymphoma and hairy cell leukemia: Pooled analysis of two Swedish case-control studies. Leukemia Lymphoma 43: 1043–1049.

HASB (various years) Hawai'i Agricultural Statistics Bulletins. Hawai'i Department of Agriculture and US Dept. of Agriculture National Agricultural Statistics Service. Based on data from various annual bulletins. http://www.nass.usda.gov/Statistics_by_State/Hawaii/Publications/Annual_Statistical_Bulletin/.

Hawaiian Encyclopedia (2015) Polynesian-Introduced Plants, Taro. Retrieved on 2/18/2015. http://www.hawaiianencyclopedia.com/.

Hawaii Ag Stats (2011) Statistics of Hawaii Agriculture. Hawaii Department of Agriculture & US Department of Agriculture NASS.

Hawai'i Food Security (2012) Increased food security and food self-sufficiency strategy. Department of Business Economic Development and Tourism and Dept. of Agriculture, State of Hawai'i, October 2012. http://files.hawaii.gov/dbedt/op/spb/INCREASED_FOOD_SECURITY_AND_FOOD_SELF_SUFFICIENCY_STRATEGY.pdf.

Hawai'i Floriculture & Nursery Ass'n v. Cnty. of Hawai'i, No. 14 CV-00267-BMK, 2014 WL 6685817 (D. Haw. Nov. 26, 2014), appeal docketed, sub nom.

Hawai'i Papaya Industry Ass'n v. Cnty. of Hawai'i (9th Cir. Jan 6, 2015).

Hayes T, Anderson LL, Beasley VR, de Solla SR, Iguchi T, Ingraham H, Kestemont P et al. (2011) Demasculinization and feminization of male gonads by atrazine: Consistent effects across vertebrate classes. Journal of Steroid Biochemistry and Molecular Biology 127: 64-73.

Hayes TB, Khoury V, Narayan A, Nazir, M, Park A, Brown T, Adame L, Chan E, Buchholz D, Stueve T, Gallipeau S (2010). Atrazine induces complete feminization and chemical castration in male African clawed frogs (Xenopus laevis). Proceedings of the National Academy of Sciences 107(10): 4612-4617.

Hayes TB, Collins A, Lee M, Mendoza M, Noriega N, Stuart AA, Vonk A (2002) Hermaphroditic, demasculinized frogs after exposure to the herbicide atrazine at low ecological relevant doses. Proceedings of the National Academy of Sciences 99(8): 5476-5480. http://www.pnas.org/content/99/8/5476.full.pdf

HDBEDT (2015a): Hawai'i Department of Business, Economic Development and Tourism, Research & Economic Analysis. Data for 1990 to 2010 downloaded 2/6/15 from http://www.hawaiieconomicdata.com.

HDBEDT (2015b): Hawai'i Department of Business, Economic Development and Tourism, Research and Economic Analysis. Select GDP, Income, and Prices; then GDP; then Real GDP. Data downloaded 2/7/15 from http://www.hawaiieconomicdata.com.

HDOA (2015a) History of Agriculture in Hawaii. Hawaii Department of Agriculture. Last viewed 2/28/15 at: http://hdoa.hawaii.gov/wpcontent/uploads/2013/01/HISTORY-OF-AGRICULTURE-IN-HAWAII.pdf.

HDOA (2015b) Sales of restricted use pesticides - 2013. Hawai'i Department of Agriculture. Email correspondence to Senator Josh Green M.D., January 2015.

HDOA (2015c) Kaua'i Good Neighbor Program, Hawai'i Department of Agriculture. Database. Last viewed 2/17/15 at: http://hdoa.hawaii.gov/pi/good-neighbor-data/

HDOH (2009) Total maximum daily loads (TMDLs) for total suspended soils, nitrogen, and phosphorus in Kaneohe stream Kaneohe, Hawaii. Hawai'i Department of Health http://health.hawaii.gov/cwb/files/2013/05/Integrated_KaneoheStream.pdf

HC Sugar (2015). Hawaiian Commercial and Sugar Company. What We Do. http://hcsugar.com/what-we-do/, last accessed 5/4/15.

Hillyer B (2008) Lawmakers concerned about pesticide spraying. Hawai'i News Now, February 5, 2008. http://www.hawaiinewsnow.com/story/7822628/lawmakers-concerned-about-pesticide-spraying.

Holt A (2001) An alliance of biodiversity, agriculture, health, and business interests for improved alien species management in Hawai'i. In: Sandlund OT, Schei PJ, Viken AS (eds). Kluwer Academic Publishers: Dordrecht, The Netherlands, pp. 65-75.

Holt E, Weber R, Stevenson G, Gaus C (2010) Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) impurities in pesticides: a neglected source of contemporary relevance. Environmental Science Technology 44: 5409-5415.

Honolulu Real Property Assessment Division (2015) Search by map. Retrieved on 2/9/2015. http://qpublic9.qpublic.net/hi_honolulu_search.php.

Hoppin JA, Umbach DM, London SJ, Alavanja MCR, Sandler DP (2002) Chemical predictors of wheeze among farmer pesticide applicators in the Agricultural Health Study. American Journal of Respiratory and Critical Care Medicine 165: 683-689.

Howard P (2009) Visualizing consolidation in the global seed industry: 1996-2008. Sustainability 1(4): 1266-1287.

Howard C (2013) Syngenta's campaign to protect atrazine, discredit critics. Environmental Health News June 17, 2013. http://www.environmentalhealthnews.org/ehs/news/2013/atrazine.

Hubbard C (2009) Out of Hand: Farmers face the consequences of a consolidated seed industry. National Family Farm Coalition, December 2009. http://farmertofarmercampaign.com/Out%20of%20Hand.FullReport.pdf

Hunter CL, Stephenson MD, Tjeerdema RS, Crosby DG, Ichikawa GS, Goetzl JD, Newman JW (1995) Contaminants in oysters in Kaneohe Bay, Hawai'i. Marine Pollution Bulletin 30(10): 646-654.

Hurley JA, Green TA, Gouge DH, Bruns ZT, Stock T, Braband L, Murray K, Westinghouse C, Ratcliffe ST, Pehlman D, Crane L (2014) Regulating pesticide use in United States Schools. American Entomologist 60(2): 105-114.

Infante-Rivard C, Labuda D, Krajinovic M, Sinnett D (1999) Risk of childhood leukemia associated with exposure to pesticides and with gene polymorphisms. Epidemiology 10(5): 481-487.

International Center for Technology Assessment v. Johanns, 473 F. Supp. 2d 9 (D.D.C. 2007) motion to dismiss ap¬peal granted, No. 07-5238, (D.C. Cir. Mar. 17, 2008) (GE Grasses).

ISB EA (2015) Information Systems for Biotechnology, a USDA-sponsored, searchable database of GE crop field releases. Search for releases in "Location" Hawai'i and "Show only results with Release Environmental Assessment." http://www.isb.vt.edu/search-release-data.aspx.

ISB Locations (2015) Information Systems for Biotechnology. Downloaded 2/14/15 See chart at: http://www.isb.vt.edu/release-summary-data.aspx.

ISB Locations & Sites (2015) Information Systems for Biotechnology. Select Locations and Sites for all years at http://www.isb.vt.edu/locations-by-years.aspx. Last accessed 5/13/15. Note that the number of "sites" in Hawai'i stood at 1,381 on 2/14/15, but was reduced to 1,141 sometime after that.

ISB Release (2015) Information Systems for Biotechnology, a USDA-sponsored, searchable database of GE crop field releases. Search for releases in "Location" Hawai'i. Viewed 2/12/15. http://www.isb.vt.edu/search-release-data.aspx.

ISB Release Record Detail (2015) Information Systems for Biotechnology, a USDA-sponsored, searchable database of GE crop field releases. Viewed 2/14/15. http://www.isb.vt.edu/getRelDetail.aspx?bp=14-302-112rm.

ISB Release (2010-2014) Information Systems for Biotechnology, a USDA-sponsored, searchable database of GE crop field releases. Searches for releases in "Location" Hawai'i and "Date Ranges" 1/1/14 to 12/31/14 (2014) and similarly for the years 2010 to 2013. Search conducted on 2/12/15.

Jacobs M, Clapp S (2008) Agriculture and Cancer: A Need For Action. October 2008. http://www.sustainableproduction.org/downloads/AgricultureandCancer_001.pdf

Jervis G, Smith K (2013) Presentation by plaintiffs' attorneys in lawsuit by Waimea, Kaua'i residents against Pioneer, DuPont. July 13, 2013. http://vimeo.com/70580803.

Johnson G (2008) Watch spray drift. Kent County Agriculture Cooperative Extension, University of Delaware, May 4, 2008. http://extension.udel.edu/kentagextension/tag/paraquat/.

Jones RJ, Muller J, Haynes D, Schreiber U (2003) Effects of herbicides diuron and atrazine on corals of the Great Barrier Reef, Australia. Marine Ecology Progress Series 251: 153-167.

Kakesako GK (2010). Insecticide odor sickens 14 students and 3 adults. Honolulu Star-Advertiser, Sept. 28, 2010.

Kalani N, Fujimori L (2014) Dozens of Kahaluu students sickened by fumes at campus. Honolulu Star-Advertiser April 4, 2014. http://www.staradvertiser.com/s?action=login&f=y&id=253867411&id=253867411

Kame'eleihiwa L (1992) Native land and foreign desires = ko Hawai'i 'āina a me nā koi pu'umake a ka po'e hale: How shall we live in harmony? [A history of land tenure change in Hawai'i from traditional times until the 1848 Māhele including an analysis of Hawaiian Ali'i Nui and American Calvinists]. Honolulu: Bishop Museum Press.

Kaua'i Physicians (2013) Letters from Kaua'i physicians to Kaua'i Mayor Carvalho, October 2013. http://www.stoppoisoningparadise.org/#!doctors-and-nurses-letters-to-mayor/cs1m.

Kaua'i Real Property Assessment Division (2015) Search by map. Retrieved on 2/9/2015. http://qpublic9.qpublic.net/ga_search_dw.php?county=hi_kauai.

Keim B (2014) New generation of GM crops puts agriculture in 'crisis situation. Wired, September 25, 2014. http://www.wired.com/2014/09/new-gm-crops/.

Kent NJ (1983) Hawai'i, Islands under the influence. University of Hawai'i Press, Honolulu: HI.

Khokha S (2010) Pesticide drift eluding efforts to combat it. NPR, February 28, 2010. http://www.npr.org/templates/story/story.php?storyId=123817702.

Kilman S (2010) Superweed outbreak triggers arms race. Wall Street Journal, June 4, 2010.

KITV (2013) 3 Ewa Beach schools report strong odors from pesticide. KITV4, November 25, 2013.

Kofman O, Berger A, Massarwa A, Friedman A, Jaffar AA (2006) Motor inhibition and learning impairments in school-aged children following exposure to organophosphate pesticides in infancy. Pediatric Research 60(1): 88–92.

Koutros S, Lynch CF, Ma X, Lee W J, Hoppin JA, Christensen CH, Andreotti G, Freeman LB, Rusiecki JA, Hou L, Sandler DP, Alavanja MCR (2009) Heterocyclic aromatic amine pesticide use and human cancer risk: Results from the U.S. Agricultural Health Study. International Journal of Cancer 124(5): 1206-1212.

Lacoume S, Bressac C, Chevier C (2009) Male hypofertility induced by Paraquat consumption in the non-target parasitoid Anisopteromalus calandrae (Hymenoptera: Pteromalidae). Biological Control 49(3): 214-218.

Lee WJ, Sandler DP, Blair A, Samanic C, Cross AJ, Alavanja MC (2007) Pesticide use and colorectal cancer risk in the Agricultural Health Study. International Journal of Cancer 121(2): 339-46.

Lee WJ, Blair A, Hoppin JA, Lubin JH, Rusiecki JA, Sandler DP, Dosemeci M, Alavanja MC (2004) Cancer incidence among pesticide applicators exposed to chlorpyrifos in the Agricultural Health Study. Journal of the National Cancer Institute 96(23): 1781-1789.

Leone D (2008) Odor that got kids sick debated. Honolulu Advertiser, February 24, 2008. http://the.honoluluadvertiser.com/article/2008/Feb/24/ln/hawaii802240350.html.

Leung P, Loke M (2008) Economic impacts of increasing Hawai'i's food self-sufficiency. Economic Issues, EI-16, College of Tropical Agriculture and Human Resources, University of Hawai'i at Manoa, December 2008. http://www.ctahr.hawaii.edu/oc/freepubs/pdf/EI-16.pdf.

Li QX, Wang J, Boesh R (2013) Final Project Report for Kaua'i Air Sampling Study. University of Hawai'i Department of Molecular Bioscience and Bioengineering.

Linder G, Barbitta J, Kwaiser T (1990) Short-term amphibian toxicity tests and paraquat toxicity assessment. Aquatic Toxicology and Risk Assessment: Thirteenth Volume, ASTM STP 1096, W.G. Landis and W.H. van der Schalie, Eds., American Society for Testing and Materials, Philadelphia, 1990, pp. 189-198.

Loke MK, Leung PS (2013) Competing food concepts – implications for Hawai'i, USA.

Association of Applied Biologist, Food and Energy Security. http://onlinelibrary.wiley.com/doi/10.1002/fes3.33/full.

Longnecker MP, Klebanoff MA, Zhou H, Brock JW (2001). Association between maternal serum concentration of the DDT metabolite DDE and preterm and small-for-gestational-age babies at birth. Lancet 358(9276): 110–114.

Loudat T, Kasturi P (2013) Hawaii's Seed Crop Industry: Current and potential economic and fiscal contributions. http://www.nass.usda.gov/Statistics_by_State/

Hawaii/Publications/Sugarcane_and_Specialty_Crops/SeedEcon.pdf

Loudat T, Kasturi P (2009) Hawaii's Seed Crop Industry: Current and potential economic and fiscal contributions. http://www.nass.usda.gov/Statistics_by_State/Hawaii/Publications/Miscellaneous/SeedEcon.pdf

Lu C, Barr DB, Pearson MA, Waller LA (2008) Dietary intake and its contribution to longitudinal organophosphate pesticide exposure in urban/suburban children. Environmental Health Perspectives 116(4): 537-542.

Lu C, Fenske RA, Simcox NJ, Kalman D (2000) Pesticide exposure of children in an agricultural community: evidence of household proximity to farmland and take home exposure pathways. Environmental Research 84: 290–302.

Maui Real Property Assessment Division (2015) Search by owner name. Retrieved on 2/9/2015. http://qpublic9.qpublic.net/hi_maui_search.php.

McDonald SA, Wamsley MA, Victor JK, Hoffelt M, Funt RC (1992) Applying Pesticides Correctly – A guide or private and commercial applicators. Ohio State University: Columbus, OH.

McDuffie HH, Pahwa P, McLaughlin JR, Spinelli JJ, Fincham S, Dosman JA, Robson D, Skinnider LF, Choi NW (2001) Non-Hodgkin's lymphoma and specific pesticide exposures in men: cross-Canada study of pesticides and health. Cancer Epidemiology Biomarkers and Prevention 10: 1155-1163.

MI DoA (2011) Restriction on use of 2,4-D or MCPA in grape growing areas. Michigan Department of Agriculture and Rural Development, April 13, 2011.

Mills PK, Yang R, Riordan D (2005) Lymphohematopoietic cancers in the United FarmWorkers of America (UFW), 1988-2001. Cancer Causes & Control 16(7): 823-830.

Mineau P, Palmer C (2013) The Impact of the Nation's Most Widely Used Insecticides on Birds. American Bird Conservancy, March 2013.

Mitra MN (2014) Could small, biodiverse farms help Hawai'i grow enough food to feed itself? Grist, June 19, 2014. http://grist.org/author/maureen-nandini-mitra/

Monge P, Wesseling C, Guardado J, Lundberg I, Ahlbom A, Cantor KP, Weiderpass E, Partanen T (2007) Parental occupational exposure to pesticides and the risk of childhood leukemia in Costa Rica. Scandinavian Journal Work Environmental Health 33(4): 293-303.

Morrissey CA, Mineau P, Devries JH, Sanchez-Bayo F, Liess M, Cavallaro MC, Liber K (2015) Neonicotinoid contamination of global surface waters and associated risk to aquatic invertebrates: A review. Environment International, 74: 291-303.

Mortensen DA, Egan JF, Maxwell BD, Ryan MR, Smith RG (2012) Navigating a Critical

Juncture for Sustainable Weed Management. Bioscience 62(1): 75-84.

Monsanto Company v. Geertson Seed Farms,130 S.Ct. 2743 (2010).

Moscato G, Vandenplas O, Van Wijk RG, Malo, JL, Perfetti L, Quirce S, Walusiak J, Castano R, Pala G, Gautrin D, De Groot H, Folletti I, Yacoub MR, Siracusa A (2009) EAACI position paper on occupational rhinitis. Respiratory Research 10:16.

Mueller-Dombois D (2007) The Hawaiian ahupua'a land use system: Its biological resource zones and the challenge for silvicultural restoration. Bishop Museum Bulletin - Cultural and Environmental Studies, 3: 23-33.

Mulvaney RL, Khan SA, Ellsworth TR (2009) Synthetic nitrogen fertilizers deplete soil nitrogen: A global dilemma for sustainable cereal production. Journal of Environmental Quality 38: 2295–2314.

National Research Council (2002) "Environmental Effects of Transgenic Plants; The Scope and Adequacy of Regulation," National Academy of Science, The National Academies Press, Washington, D.C., 2002.

National Research Council (1993) Pesticides in the Diets of Infants and Children. National Academy Press: Washington D.C.

Nazzi F, Brown SP, Annoscia D, Del Piccolo F, Di Prisco G, Varricchio P, Vedova GD, Cattonaro F, Caprio E, Pennacchio F (2012) Synergistic parasite-pathogen interactions mediated by host immunity can drive the collapse of honeybee colonies. PLoS Pathogens, 8(6): e1002735.

Newman TS (1971) Hawai'i Island Agricultural Zones, Circa A.D. 1823: An ethnohistorical Study. Ethnohistory 18(4): 335-351.

NPIC (2009) Chlorpyrifos Technical Fact Sheet. National Pesticide Information Center, last reviewed August 2009.

NRDC (1997) Chapter 5 Pesticides. In: Our Children At Risk: The Five Worst Environmental Threats to Their Health. November 1997.

Owens K, Feldman J (2004) Getting the drift on chemical trespass: Pesticide drift hits homes, schools, and other sensitive sites throughout communities. Pesticides and You 24(2): 16-21.

Paiva D (2009) End of an era: Maui Land & Pineapple closing its pineapple operations. Hawaii Magazine, November 4, 2009.

Parvez S, Raisuddin S (2006) Effects of paraquat on the freshwater fish Channa punctata (Bloch): non-enzymatic antioxidants as biomarkers of exposure. Archives of environmental contamination and toxicology, 50(3): 392-397.

Perera FP, Rauh VA, Tsai WY, Kinney P, Camann D, Barr D, Bernert T, Garfinkel R, Tu YH, Diaz D, Dietrich J, Whyatt RM (2003) Effects of transplacental exposure to environmental pollutants on birth outcomes in a multiethnic population. Environmental Health Perspectives 111(2): 201–205.

Philpott T (2011) Monsanto (still) denies superinsect problem, despite evidence. Mother Jones, December 8, 2011. http://motherjones.com/tom-philpott/2011/12/superinsects-monsanto-corn-epa.

Porter M (2013) State Preemption Law: The battle for local control of democracy. Pesticides and You 33(3). Last viewed 12/22/2014. http://www.beyondpesticides.org/lawn/activist/documents/StatePreemption.pdf

Portier CJ, Goldman LR, Goldstein BD (2014) Inconclusive findings: now you see them, now you don't! Editorial, Environmental Health Perspectives 122(2): A36. http://ehp.niehs.nih.gov/1408106/,

Prado R, Rioboo C, Herrero C, Cid A (2009) The herbicide paraquat induces alterations in the elemental and biochemical composition of non-target microalgal species. Chemosphere 76(10): 1440-1444.

Priyadarshi A, Khuder SA, Schaub EA, Shrivastavas S (2000) A meta-analysis of Parkinson's disease and exposure to pesticides. Neurotoxicology 21(4): 435-40.

Raelson J (2013) Subject: Birth Defects West Side Babies. Email testimony to Kaua'i County Council for Bill 2491, September 12, 2013.

Rauh V, Arunajadai S, Horton M, Perera F, Hoepner L, Barr DB, Whyatt R (2011) Seven-year neurodevelopmental scores and prenatal exposure to chlorpyrifos, a common agricultural pesticide. Environmental Health Perspectives 119(8): 1196–1201.

Rauh VA, Garfinkel R, Perera FP, Andrews HF, Hoepner L, Barr DB, Whitehead R, Tang D, Whyatt R (2006) Impact of prenatal chlorpyrifos exposure on neurodevelopment in the first 3 years of life among inner-city children. Pediatric 118(6): e1845-e1859. www.pediatrics. org/cgi/content/full/118/6/e1845.

Restricted Use Pesticides Sold on Kaua'i: 2010-2012. A spreadsheet obtained from Kaua'i County Council member Gary Hooser.

Rinehold (2011) Pests of corn grown for seed. In: Pacific Northwest Insect Management Handbook, Oregon State University, last revised November 2011.

Roberts EM, English PB, Grether JK, Windham GC, Somberg L, Wolf C (2007) Maternal Residence near Agricultural Pesticide Applications and Autism Spectrum Disorder among Children in the California Central Valley. Environmental Health Perspectives 115(10): 1482-1489.

Roberts JR, Karr CJ (2012) Pesticide Exposure in Children. Council on Environmental Health of the American Academy of Pediatrics. Pediatrics 130(6): e1765-e1788. http://pediatrics.aappublications.org/content/130/6/e1765.abstract/

Robinson RA (1996) Return to Resistance: Breeding crops to reduce pesticide dependency. 3rd edition 2007. Sharebooks Publishing. http://www.idrc.ca/EN/Resources/Publications/Pages/IDRCBookDetails.aspx?PublicationID=402.

Rohr JR, McCoy KA (2010) A qualitative meta-analysis reveals consistent effects of atrazine on freshwater fish and amphibians. Environmental Health Perspectives 118(1): 20-32.

Rohr JR, Raffel TR, Halstead NT, McMahon TA, Johnson SA, Boughton RK, Martin LB (2013) Early-life exposure to a herbicide has enduring effects on pathogen-induced mortality. Proceedings of the Royal Society B: Biological Sciences, 280(1772), 20131502.

Rosenstock L, Keifer M, Daniell WE, McConnell R, Claypole K (1991) Chronic central nervous system effects of acute organophosphate pesticide intoxication. Lancet 338: 223–227.

Rull RP, Gunier R, Von Behren J, Hertz A, Crouse V, Buffler PA, Reynolds P (2009) Residential proximity to agricultural pesticide applications and childhood acute lymphoblastic leukemia. Environmental Research 109(7): 891-899.

Salam MT, Li YF, Langholz B, Gilliland FD, Children's Health Study (2004) Early-life environmental risk factors for asthma: findings from the Children's Health Study. Environmental Health Perspective 112(6): 760–765.

Salkever A (2003) King of the Corn. Hawai'i Business Magazine, March 2003.

Sass JB, Colangelo A (2006) European Union bans atrazine, while the United States negotiates continued use. International Journal of Occupational Environmental Health 12(3): 260-267.

Scheuer JL, Clark TW (2001) Conserving Biodiversity in Hawai'i: What is the Policy Problem? Yale FE and S Bulletin 105: 159-83.

Schinasi L, Leon ME (2014) Non-Hodgkin lymphoma and occupational exposure to agricultural pesticide chemical groups and active ingredients: a systematic review and meta-analysis. International Journal of Environmental Public Health 11(4): 4449-4527.

Sears M, Walker CR, van der Jagt RHC, Claman P (2006). Pesticide assessment: Protecting public health on the home turf. Paediatr Child Health 11(4): 229-34.

Senthilselvan A, McDuffie HH, Dosman JA (1992) Association of asthma with use of pesticides—results of a cross-sectional survey of farmers. American Review Respiratory Disease Journal 146: 884–887.

Seralini GE, Clair E, Mesnage R., Gress S, Defarge N, Malatesta M, Hennequin D, de Vendomois JS (2014a) Republished study: long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize. Environmental Sciences Europe 26:14. http://www.enveurope.com/content/26/1/14.

Seralini GE, Mesnage R, Defarge N, de Vendomois JS (2014b). Conflicts of interests, confidentiality and censorship in health risk assessment: the example of an herbicide and a GMO. Environmental Sciences Europe 26:13. http://www.enveurope.com/content/26/1/13.

Shelton JF, Geraghty EM, Tancredi DJ, Delwiche LD, Schmidt RJ, Ritz B, Hansen RL, Hertz-Picciotto I (2014) Neurodevelopmental Disorders and Prenatal Residential Proximity to Agricultural Pesticides: The CHARGE Study. Environmental Health Perspective 122(10): 1103-1110.

Shikina R (2007) Fumes sicken Kahuku schoolchildren. Honolulu Star-Bulletin, May 4, 2007.

Simcox NJ, Camp J, Kalman D, Stebbins A, Bellamy G, Lee IC, Fenske R (1999) Farmworker exposure to organophosphorus pesticide residues during apple thinning in central Washington State. American Industrial Hygiene Association Journal 606: 752–61.

Simcox NJ, Fenske RA, Wolz SA, Lee IC, Kalman DA (1995) Pesticides in household dust and soil: exposure pathways for children of agricultural families. Environmental Health Perspective 103: 1126–34.

Skolnick A (2013) GMOs are Tearing a Tropical Paradise Apart. Salon, September 5, 2013. http://www.salon.com/2013/09/04/a_battle_in_paradise_how_gmos_are_tearing_a_tropical_utopia_apart/

Slager RE, Poole JA, LeVan TD, Sandler DP, Alavanja MC, Hoppin JA (2009) Rhinitis associated with pesticide exposure among commercial pesticide applicators in the Agricultural Health Study. Occupational and Environmental Medicine 66: 718–724.

Smith JR (1982) Hawaii Milk Contamination Creates Alarm. Science 217: 137-140.

Stallones L, Beseler C (2002) Pesticide poisoning and depressive symptoms among farm residents. Annals of Epidemology 12: 389-394.

Stannard DE (1989) Before the Horror: The population of Hawai'i on the eve of western contact. University of Hawai'i Press, Honolulu: HI.

State of Hawai'i Data Book (2013) Section 12: Labor Force, Employment and Earnings. Table 12.11: Job Count, by NAICS Industry: Annual Average, 2009 to 2013.

Steingraber S (2010) Living Downstream. Da Capo Press, 2nd edition, 2010.

Stokstad E (2013) How Big a Role Should Neonicotinoids Play in Food Security? Science 340(6133): 675.

Strina A, Barreto ML, Cooper PH, Rodrigues LC (2014) Risk factors for non-atopic asthma/wheeze in children and adolescents: a systematic review. Emerging Themes in Epidemiology 11(5). http://www.ete-online.com/content/11/1/5.

Suryanata K (2002) Diversified agriculture, land use, and agrofood networks in Hawai'i. Economic Geography 78(1): 71-86.

Swan SH, Brazil C, Drobnis EZ, Liu F, Kruse RL, Hatch M, Redmon JB, Wang C, Overstreet JM, The Study for Future Families Research Group (2003a). Geographic differences in semen quality of fertile U.S. males. Environmental Health Perspectives 111(4): 414-420.

Swan SH, Kruse RL, Liu F, Barr DB, Drobnis EZ, Redmon JB, Wang C, Brazil C, Overstreet JW, The Study for Future Families Research Group (2003b) Semen Quality in Relation to Biomarkers of Pesticide Exposure. Environmental Health Perspectives

111(12): 1478-1484.

Syngenta Seeds v. County of Kaua'i, No. 14-00014, 2014 WL 4216022 (D. Haw. Aug. 25, 2014), appeal docketed, No. 14-16833 (9th Cir. Sept. 25, 2014)

Syngenta Seeds, Inc. v. Cnty. of Kaua'i, No. 14-CV-00014-BMK, 2014 WL 4216022, at *4 (D. Haw. Aug. 23, 2014)

Tanner CM, Kamel F, Ross GW, Hoppin JA, Goldman SM, Korell M, Marras C, Bhudhikanok GS, Kasten M, Chade AR, Comyns K, Richards MB, Meng C, Priestley B, Fernandez HH, Cambi F, Umback DM, Blair A, Sandler DP, Langston JW (2011) Rotenone, paraquat and Parkinson's disease. Environmental Health Perspectives 119(6): 866-872.

Tanner CM, Ross GW, Jewell SA, Hauser RA Jankovic J, Factor SA, Bressman S, Deligtisch A, Marras C, Lyons KE, Bhudhikanok GS, Roucoux DF, Meng C, Abbott RD, Langston JW (2009) Occupation and risk of Parkinsonism: A multicenter case–control study. Archives of Neurology 66(9): 1106–1113.

Thomison PR (undated) Cultural practices for optimizing maize seed yield and quality in production fields. http://www.seedconsortium.org/PUC/pdf%20files/16-%20Cultural%20practices%20for%20optimizing%20maize%20seed....pdf

Thompson PR, Coronado GD, Grossman JE, Puschel K, Solomon CC, Islas I, Curl CL, Shirai JH, Kissel JC, Fenske RA (2003) Pesticide Take-Home Pathway among Children of Agricultural Workers: Study Design, Methods, and Baseline Findings. Journal of Occupational and Environmental Medicine 45: 42-53.

USDA APHIS (2015) Animal and Plant Health Inspection Service. Biotechnology – Petitions for Determination of Nonregulated Status. http://www.aphis.usda.gov/biotechnology/petitions_table_pending.shtml.

USDA ERS (2015) Economic Research Service: Recent trends in GE adoption. Retrieved on 1/25/15. http://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us/recent-trends-in-ge-adoption.aspx

USDA ERS (2014) Pesticide use in U.S. agriculture: 21 selected crops, 1960-2008. USDA Economic Research Service, Economic Information Bulletin No. 124, May 2014.

USDA ERS (2013) Fertilizer Use and Price, USDA's Economic Research Service, see Tables 1 and 2, http://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx#26718.

USDA NASS (2014) Agricultural Resource Management Survey: U.S. Soybean Industry. USDA National Agricultural Statistics Service, No. 2014-1, January 2014.

USDA NASS (2011) Agricultural Chemical Use Survey: Corn 2010. USDA National Agricultural Statistics Service, May 2011. http://www.nass.usda.gov/Data_and_Statistics/Pre-Defined_Queries/2010_Corn_Upland_Cotton_Fall_Potatoes/index.asp.

USDA OIG (2005) "Audit report: Animal and Plant Health Inspection Service controls over issuance of genetically engineered organism release permits," Audit 50601-8-Te, USDA, Office of Inspector General, Southwest Region, December 2005. Online at www.usda.gov/oig/webdocs/50601-08-TE.pdf.

US Department of Labor (2013) Industry employment and output projections to 2022. Monthly Labor Review, U.S. Bureau of Labor Statistics, December 2013, Table 1.

US Fish and Wildlife Service (2015) Listed species believed to or known to occur in Hawaii. Environmental Conservation Online System. Retrieved February 15, 2015 from http://ecos.fws.gov/tess_public/reports/species-listed-by-state-report?state=HI&status=listed.

US Fish and Wildlife Service (2012) Endangered Species. Pacific Islands Fish and Wildlife Office. Retrieved February 15, 2015. http://www.fws.gov/pacificislands/species.html.

US GAO (2014) FDA and USDA should strengthen pesticide residue monitoring programs and further disclose monitoring limitations. Report to the Ranking Member, Subcommittee on Environment and the Economy, Committee on Energy and Commerce, House of Representatives. US Government Accountability Office, October 2014.

USGS Atrazine (2015) Estimated Agricultural Use for Atrazine: Use by Year and Crop. US Geological Survey. https://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=2012&map=ATRAZINE&hilo=L&disp=Atrazine.

USGS (2003) USGS releases study on toxic rainfall in Joaquin Valley. US Geological Survey, August 18, 2003.

van den Mark M, Brouwer M, Kromhout H, Nijssen P, Huss A, Vermeulen R (2012) Is pesticide use related to Parkinson Disease? Some clues to heterogeneity in study results. Environmental Health Perspectives 120(3): 340-347.

van der Sluijs JP, Simon-Delso N, Goulson D, Maxim L, Bonmatin JM, Belzunces LP (2013) Neonicotinoids, bee disorders and the sustainability of pollinator services. Current opinion in environmental sustainability, 5(3): 293-305.

van Wijngaarden E, Stewart PA, Olshan AF, Savitz DA, Bunin GR (2003) Parental occupational exposure to pesticides and childhood brain cancer. American Journal of Epidemiology 157 (11): 989–997.

Vitousek PM, Ladefoged TN, Kirch PV, Hartshorn AS, Graves MW, Hotchkiss SC, Tuljapurkar S, Chadwick OA (2004) Soil, Agriculture, and Society in Precontact Hawai'i. Science 304: 1665-1668.

Vorsino M (2006). Bug spray sickens Aina Haina students. Honolulu Star-Bulletin, April 14, 2006.

WA PIRT (2010) Pesticide Incident Reporting and Tracking Review Panel: 2009 Annual Report, April 15, 2010.

Watts M (2011) Paraquat. Pesticide Action Network Asia and the Pacific, August 2010.

Weiner JA (2007) Atrazine induced species-specific alterations in the subcellular content of microalgal cells. Pesticide Biochemistry and Physiology 87(1): 47-53.

Weisskopf MG, Moisan F, Tzourio C, Rathouz PJ Elbaz A (2013) Pesticide exposure and depression among agricultural workers in France. American Journal of Epidemiology 178(7): 1051-8.

Wesseling C, van Wendel de Joode B, Ruepert C, Leon C, Monge P, Hermosillo H, Partanen T (2001) Paraquat in developing countries. International Journal Occupational and Environmental Health 7: 275-286.

Weston DP, Lydy MJ (2010) Urban and agricultural sources of pyrethroid insecticides to the Sacramento-San Joaquin Delta of California. Environmental Science and Technology 44: 1833-1840.

Wigle DT, Turner MC, Krewski D (2009) A systematic review and meta-analysis of childhood leukemia and parental occupational pesticide exposure. Environmental Health Perspectives 117(10): 1505-1513.

Williamson SM, Moffat C, Gomersall MAE, Saranzewa N, Connolly CH, Wright GA (2013) Exposure to acetylcholinesterase inhibitors alters the physiology and motor function of honeybees. Frontiers in Physiology 4, Article 13, February 2013.

Wolff MS, Engel S, Berkowitz G, Teitelbaum S, Siskind J, Barr DB, Wetmur J (2007) Prenatal pesticide and PCB exposures and birth outcomes. Pediatric Research 61(2):

243–250.

Wong A (2014). Chemical odor, nausea symptoms prompt closure of Noelani Elementary. Civil Beat, March 10, 2014.

Wong A (2013). Strange smell forces children, teachers to evacuate Hawaii Kai School. Civil Beat, November 27, 2013.

WSSA (1998) Technology Notes. Weed Technology 12(4): 789-790.

Wu M, Quirindongo M, Sass J, Wetzler A (2010) Natural Resource Defense Council, Still Poisoning the Well: Atrazine Continues to Contaminate Surface Water and Drinking Water in the United States. April 2010. http://www.nrdc.org/health/atrazine/files/atrazine10.pdf.

Yager B (2014) Insecticide spraying closes Honokaa schools. West Hawaii Today, Sept. 14, 2014.

Zahm SH, Weisenburger DD, Babbitt PA, Saal RC, Vaught JB, Cantor KP, Blair A (1990) A case-control study of non-Hodgkin's lymphoma and the herbicide 2,4-dichlorophenoxyacetic acid (2,4-D) in eastern Nebraska. Epidemiology 1: 349–356.

Zhu W, Schmehl DR, Mullin CA, Frazier JL (2014). Four common pesticides, their mixtures and a formulation solvent in the hive environment have high oral toxicity to honey bee larvae. PloS one 9(1): e77547.

APPENDIX I: CONTRIBUTION OF AGRICULTURE AND THE SEED INDUSTRY TO HAWAI'I'S ECONOMY

One source of confusion in measuring the economic contribution of Hawai'i's agriculture is the use of inappropriate statistics that inflate the "agricultural" sector by aggregating it with processed foods, beverages and tobacco. This is the approach taken by the Hawai'i Department of Agriculture, which combines "agriculture, forestry, fishing and hunting" (AgFFH) with the "food and beverage and tobacco products manufacturing" sector (FoodBTP)[24] as the basis for its assessment of the performance of Hawai'i's agriculture (HASB 2011, p. 17). Because the GDP of FoodBTP is roughly the same as that of AgFFH, this method of accounting doubles the apparent contribution of agriculture to Hawai'i's economy relative to the real GDP figures portrayed in Figures 3 and 4.

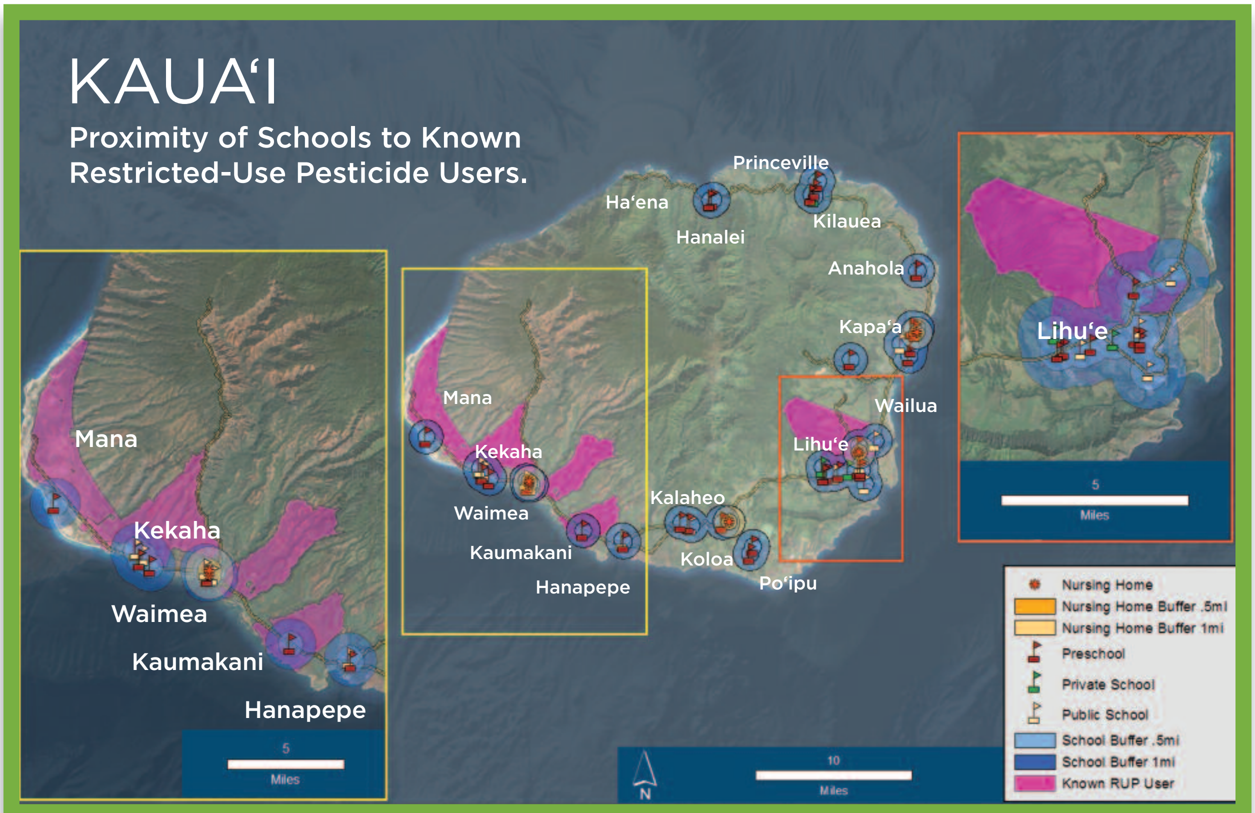
The seed industry, its contractors and the state agricultural officials use several other dubious methods to overstate the industry's contribution to Hawai'i's economy. First, they utilize the hazy metric of "value" rather than GDP. Value is variously defined as "annual operating expenses" (Loudat and Kasturi 2013, Table 2) or "sales or gross operational budgets" (HASB 2011, Seed Crops, p. 22). Whatever is meant by "value," GDP is clearly a much preferable metric because it avoids the "double-counting" inherent in the use of sales data.[25] Second, seed industry contractors Thomas Loudat and Prahlad Kasturi make misleading use of statistics to inflate the seed crop industry's economic impact. They breathlessly report an extremely large figure for the seed industry's percentage growth "since its inception" (Loudat and Kasturi 2013). As noted in the body of the report, the Hawai'i seed industry began as a 5-acre winter nursery on Moloka'i. Such a tiny "industry" can grow at a breathtaking percentage rate and still make little contribution to the economy. The misleading nature of this statistic is illustrated by a simple example. Assume an industry's "value" is just $1,000 at its inception. An increase to $1 million some years later would represent a 99,900% rise, despite the fact that a $1 million enterprise is still quite insignificant in the larger scheme of things.

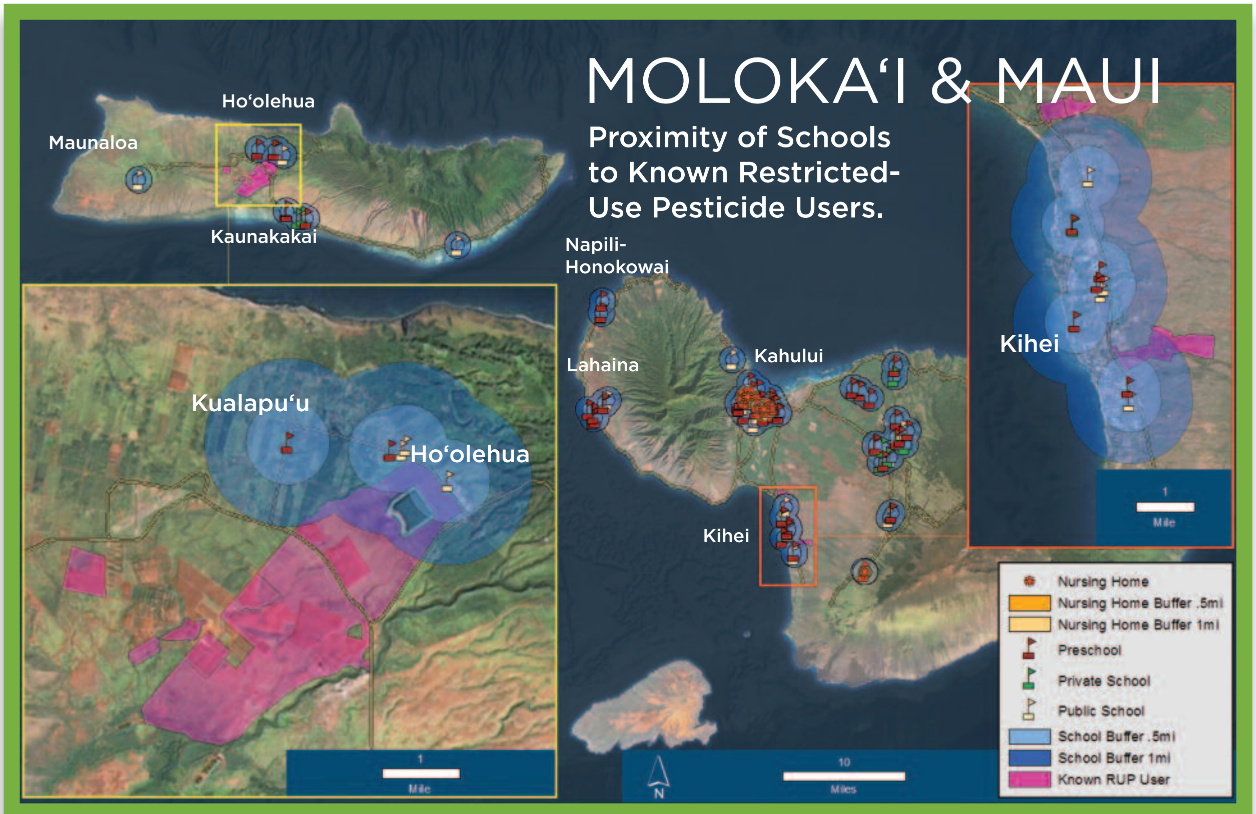
[24]FoodBTP itself combines two distinct subsectors in the North American Industry Classification System (NAICS): NAICS 311: "food manufacturing" and NAICS 312: "beverage and tobacco product manufacturing."

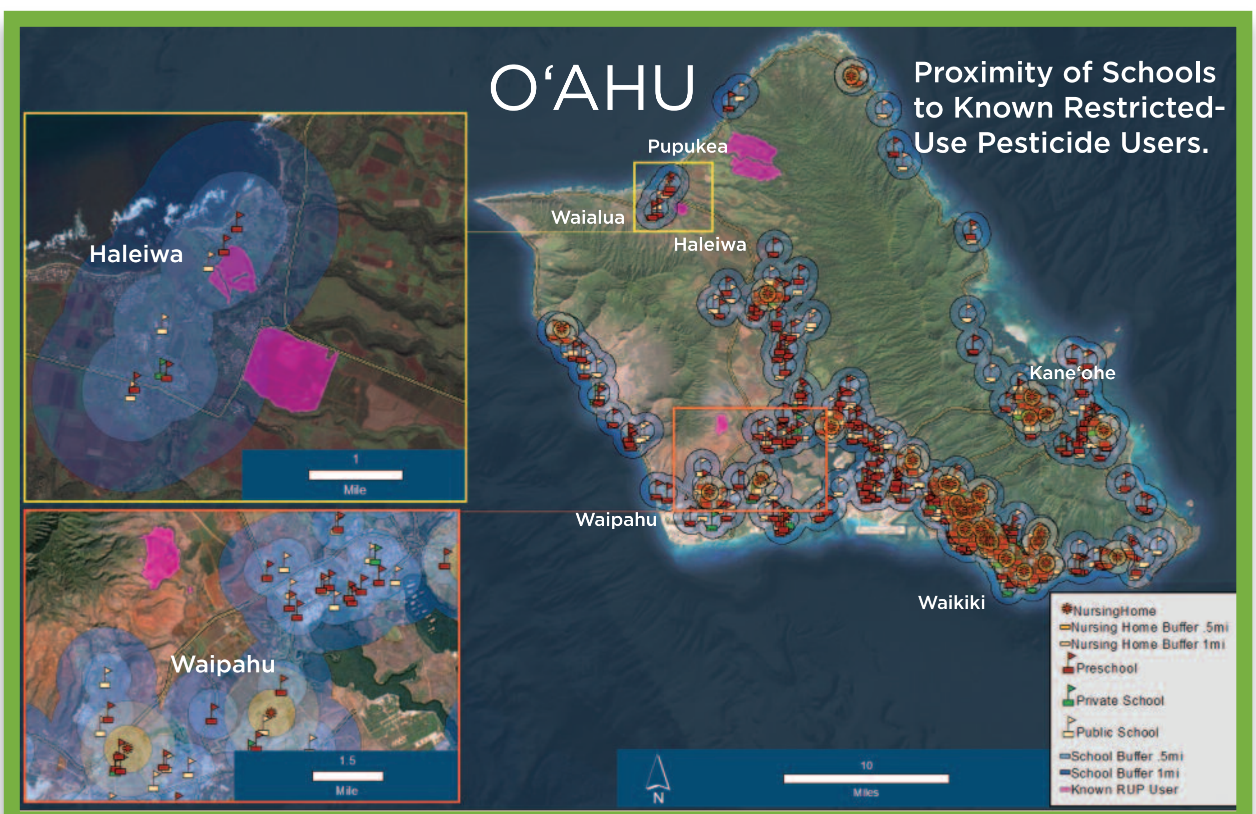
[25]An industry's GDP is its gross output (e.g. sales) minus inputs used in the production process (e.g. energy, raw materials, purchased services) (BEA Consumer Guide 2015). Subtracting inputs is necessary to avoid inflation of economic impact by "double-counting," as acknowledged by the Hawaii Dept. of Agriculture (Hawaii Ag Stats 2011, p. 17), which nevertheless continues to rely primarily on gross output as measured by sales in describing the performance of Hawai'i agriculture (*Ibid.*).

APPENDIX II: RUP USE IN KAUA'I, MOLOKA'I, MAUI, AND O'AHU

These parcels of land (identified in pink) are known RUP users confirmed through Honolulu, Maui, and Kaua'i County Real Property Assessment Division websites. Schools are marked with red, green, and yellow flags with a half mile and one mile buffer zones identified by blue circles. Nursing homes are marked by orange stars with a half mile and one mile buffer zones identified by orange circles. Schools and residential areas are in dangerous proximity to agrochemical operations. [GIS MAPS: ADRIAN RAMIREZ]




MOLOKA'I & MAUI
Proximity of Schools to Known Restricted-Use Pesticide Users.
Ho'olehua
Maunaloa
Kaunakakai
Kualapu'u
Ho'olehua
Napili-Honokowai
Lahaina
Kahului
Kihei
Kihei
1
Mile
10
Miles
N
Nursing Home
Nursing Home Buffer .5mi
Nursing Home Buffer 1mi
Preschool
Private School
Public School
School Buffer .5mi
School Buffer 1mi
Known RUP User


O'AHU
Proximity of Schools to Known Restricted-Use Pesticide Users.
Pupukea
Waialua
Haleiwa
Haleiwa
Kane'ohe
Waipahu
Waipahu
Waikiki
1
Mile
1.5
Mile
10
Miles
N
NursingHome
Nursing Home Buffer .5mi
Nursing Home Buffer 1mi
Preschool
Private School
Public School
School Buffer .5mi
School Buffer 1mi
Known RUP User

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