PESTICIDES IN PARADISE

HAWAIʻI'S HEALTH & ENVIRONMENT AT RISK

HAWAIʻI
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.

ACKNOWLEDGEMENTS

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Second Edition. This abridged summary highlights the key points of a comprehensive, fully documented report of the same title by Center for Food Safety, available at: **www.centerforfoodsafety.org/reports**

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SUMMARY OF KEY FINDINGS

On O'ahu, Kaua'i, Maui, and Moloka'i, chemical and biotechnology companies Monsanto, Syngenta, DuPont-Pioneer, Dow Chemical, and BASF have purchased prime agricultural land, taking advantage of Hawai'i's isolation and year-round growing season, in order to field test crops that have been genetically engineered (GE) to withstand greater applications of pesticides.

As the report details, the onslaught of pesticide-promoting GE crops on the Hawaiian Islands raises three main areas of concern: ***the impacts of pesticide exposure on public health, the threat to native biodiversity, and food independence for the people of Hawai'i.***

Our in-depth analysis of pesticide risks and impacts to the communities and environment of Hawai'i revealed the following findings.

SEED INDUSTRY FOOTPRINT IN HAWAI'I

- Since 1987 Hawai'i has hosted more cumulative field trials (3,243) than any other state. In 2014 alone, 178 different GE field tests were conducted on over 1,381 sites in Hawai'i (vs. only 175 sites in California).
- Due to Hawai'i's small size, it has a much higher density of field tests than other states. As a result, more people in Hawai'i live in closer proximity to field test sites than residents of any other state and run a higher risk of experiencing pesticide drift.
- The seed industry's footprint (24,700 acres) is 72% of the total area planted to crops other than sugarcane or pineapple (34,400 acres).
- The majority (91%) of the plants being tested are corn and soy—not niche crops such as papaya or banana.
- Herbicide-resistance was the most frequently tested trait in GE crop field tests in Hawai'i over the past five years. This means that plants genetically engineered in Hawai'i, by and large, are engineered to resist ever greater application of herbicides.
- Despite claims that the seed industry is a pillar of Hawai'i's economy, it only employed 1,397 workers in 2012, representing just 0.23% of total Hawai'i jobs.

PESTICIDE USE

- DuPont-Pioneer applied 90 different pesticide formulations containing 63 different active ingredients on Kaua'i from 2007 to 2012. The company sprayed on two-thirds (65%) of the days over this period and made from 8.3 to 16 applications per application day on average.
- The third-most frequently applied class of pesticides is also among the most toxic: organophosphate insecticides such as *chlorpyrifos* were sprayed an average of 91 days each year.
- Restricted Use Pesticides (RUP) sales data for Kaua'i show that 22 RUPs containing 18 active ingredients were applied in agriculture from 2010 to 2012.

- 81% of RUP active ingredients by weight were applied to corn and 19% to coffee, with negligible amounts used on ornamentals, soybeans, sugarcane, tomatoes, and turf.

PESTICIDE EXPOSURE RAISES SERIOUS HEALTH CONCERNS

- In general farmers, farmworkers, pregnant women, and children are at greatest risk: farmers are more highly exposed than the general population; and children are more susceptible to the harmful effects of pesticides than adults.
- The American Academy of Pediatrics recently published a major report entitled "Pesticide Exposure in Children" that reviewed 195 medical studies; their chief concerns were that pesticides are linked to ***childhood cancers, neurobehavioral and cognitive deficits, adverse birth outcomes, and asthma.***
- In adult populations, pesticide exposure has been linked to Non-Hodgkin's lymphoma, bladder and colon cancers, Parkinson's disease, depression, and disrupting our hormonal or endocrine systems.

REGULATION NEEDED TO ADDRESS PUBLIC HEALTH RISKS

We would all like to believe that the Environmental Protection Agency (EPA) protects us from pesticide harms, but this is often not the case.

- EPA requires safety testing only on the pesticide product's active ingredient, even though "inert ingredients" in pesticide formulations can be toxic in their own right, or increase the active ingredient's toxicity.
- In a failed attempt to better protect human health and the environment from pesticide drift, EPA proposed improved pesticide labeling in 2001, but has yet to finalize and enact the policy.
- EPA began to phase-out residential use of the toxic insecticide chlorpyrifos in 2000, specifically to protect children. Yet, rural children remain at risk, as ambient air levels of chlorpyrifos have been found to exceed health standards in agricultural areas.
- As of 2014, at least nine states had established no-spray buffer zones around sensitive areas such as schools, hospitals, and public parks, and while eleven states have established notification requirements for pesticide applications near schools. These policy actions evince growing awareness of the serious health threats posed by pesticide drift.
- Residents of three Hawai'i counties have demanded that their local governments take action, under the counties' authority to regulate agriculture, ensure the welfare of its residents, and fulfill its duty to protect public resources.

Despite making miniscule contributions to employment and the economy, Hawai'i's pesticide/seed industry occupies significant prime farmland, even as Hawai'i supplies ever less of its food needs. GE seed corn experimentation and production involves heavy, frequent, year-round use of toxic agrochemicals. Pesticide drift threatens both public health and Hawai'i's incredible biodiversity. Hawai'i's state officials must protect citizens from the irresponsible practices of agrochemical-seed firms by enacting sensible, prudent restrictions, such as no-spray buffer zones around schools. In the longer term, the state's agricultural policy must be re-directed from supporting continued expansion of GE seed corn operations towards increasing sustainable local food production, the only realistic means to reverse Hawai'i's steadily declining food security.

PART ONE:
PESTICIDES & GE SEEDS IN HAWAI‘I

JUSTIN ZERN

In November 2013, thousands of people took to the streets of Kaua‘i in support of a proposed ordinance that would require chemical-seed 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.

INTRODUCTION

In November 2013, thousands of people took to the streets of Kaua‘i in support of a proposed ordinance that would require chemical-seed 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 Hawai‘i Island, the County Council passed Ordinance 13-121, providing farmers and residents of Hawai‘i, their property, and the environment important protections from the impacts of genetically engineered (GE) crops and associated pesticide drift, while also banning the planting and outdoor testing of new GE crops. In 2014, the county of Maui passed a temporary moratorium on GE crop operations pending a company-funded 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 chemical-seed companies that operate across the state of Hawai‘i.

Despite these policy and electoral victories, some policy-makers are still confused as to why so many residents in our state would demand greater regulation of the GE

Polynesians first settled in Hawai'i from 500 to 700 AD. Over the next millennium, Hawaiians developed a sophisticated set of agricultural systems and practices to meet the daunting challenge posed by the Islands' isolation: producing all of the food required by a rapidly growing population.

HAWAI'I STATE ARCHIVES & HAWAI'I TOURIST BUREAU

seed corn industry. This report intends to resolve this confusion. It begins by briefly describing the historical and economic context of the rise of the seed industry, its role in Hawai'i's agriculture and economy, and how the rapid expansion of the industry contributed to the state missing critical 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 Hawai'i. We then report pesticide poisoning episodes in Hawai'i, and more broadly 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. The scientific research discussed in this report clearly demonstrates that intensive use of pesticides in Hawai'i's seed corn industry threatens human health and the environment. Our hope is to build support for measures to protect Hawai'i's citizens, particularly children, from harmful pesticide exposure and for measures to increase Hawai'i's local food production and food security.

TRANSITION FROM SUSTAINABLE AGRICULTURE TO PLANTATION AGRICULTURE

Polynesians first settled in Hawai'i from 500 to 700 AD. Over the next millennium, Hawaiians developed a sophisticated set of agricultural systems and practices to meet the daunting challenge posed by the Islands' isolation: producing all of the food required by a rapidly growing population. From aquaculture fish ponds *(loko i'a)* to

irrigated taro patches *(lo'i kalo),* Hawaiian agriculture was ***sustainably*** productive for over 1,000 years, and thrived entirely from local resources. The communal *ahupua'a* land management system—which fairly apportioned land, water, and fishery resources among communities—ensured that Hawaiian agriculture was socially sustainable as well. In this era of self-sufficiency, hundreds of thousands to as many as one million Hawaiians supplied virtually all of their food, clothing, shelter, and medicines (Bushnell 1993, Dye 1994).

The arrival of Captain Cook in 1778 inaugurated a new era. In 1848, the communal land system gave way to a private property regime, largely transferring lands from Hawaiians to Americans and Europeans, many of whom were part of the expanding sugar industry. This land transfer radically transformed Hawai'i's agriculture from production of food for local consumption to vast fields of sugarcane and pineapples for export. Land used for production of export commodities was of course no longer available to supply Hawai'i's needs, leading to an enormous rise in food imports. By 1934-1936, Hawai'i produced only 37% of its food. By 2010, this had plummeted to what is likely an historical low of just 11.6% (Loke and Leung 2013).

In 1848, the communal land system gave way to a private property regime, largely transferring lands from Hawaiians to Americans and Europeans, many of whom were part of the expanding sugar industry.

RISE OF THE SEED CROP INDUSTRY AND DECLINE OF HAWAI'I'S FOOD SECURITY

Hawai'i has become a major center for production of seed crops, especially corn. Seed crops are grown for breeding purposes or for farmers' planting stock rather than for food, feed, or biofuels production. From a five-acre plot of corn on Moloka'i in 1966, the seed industry has grown to occupy roughly 25,000 acres of prime farmland, which is 72% of the total area planted to crops other than sugarcane or pineapple, 34,400 acres (Table 1). Hawai'i's chief attraction to seed companies is that its year-round growing season allows for multiple plantings per year.

TABLE 1: LAND USED FOR SEED CROP OPERATIONS ON 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	

Source: Honolulu, Kaua'i, and Maui Real Property Assessment Division websites, 2015. Available at: http://qpublic9.qpublic.net/hi_maui_search.php; http://qpublic9.qpublic.net/ga_search_dw.php?county=hi_kauai; http://www.qpublic.net/hi/honolulu/search.html

The State of Hawai'i actively promoted expansion of the seed industry onto land abandoned by the pineapple and sugar industries. For instance, the Agribusiness Development Corporation has helped the agrochemical multinationals gain control of former sugarcane lands on Kaua'i.

As the world's seed firms were acquired by agrochemical companies in the 1980s and 1990s, there was a rapid transition of Hawai'i's seed industry from conventional to genetically engineered seeds. Today, five of the Big Six pesticide-seed conglomerates[1] grow primarily GE seed corn on Kaua'i, O'ahu, Maui, and Moloka'i, much of it engineered for resistance to herbicides.[2]

The State of Hawai'i actively promoted expansion of the seed industry onto land abandoned by the pineapple and sugar industries. For instance, the Agribusiness Development Corporation, created in 1994 as an agency of the Hawai'i Department of Agriculture, has helped the agrochemical multinationals gain control of former sugarcane lands on Kaua'i (Eng 2012). This raises an important question. Has the state's promotion of the seed crop industry been good for Hawai'i's agriculture and economy? Or has it foreclosed other options that would have provided more benefits? Below, we explore these questions with respect to employment, economic contribution, land use, and food security.

Employment and Economic Contribution

Agricultural employment in Hawai'i has declined by 32% since 1990, and today comprises only 1.06% of Hawai'i's jobs, 27% less than the national average. The seed industry employs just 1,397 workers, or 0.23% of Hawai'i's work force, which comes to just one of every 435 jobs (Loudat and Kasturi 2013, HDBEDT 2013). Nearly half (43%) of these positions are part-time and so presumably provide too little income to support a family (Loudat and Kasturi 2009). What about economic impact? There is increasing emphasis on the seed industry's rapid growth in "value" (Loudat and Kasturi 2009, 2013), yet this increasing value merely reflects the astronomical rise in GE seed prices these firms are charging U.S. farmers (Hubbard 2009), which is certainly no cause for celebration. And despite its growth, the Hawai'i seed industry's share of the state's overall gross domestic product (GDP) is estimated at just 0.18% (HDBEDT 2015).

Land Use and Food Security

The seed industry arrogates rich farmland that would generate more employment, contribute more to the economy, and increase Hawai'i's food security if it were instead devoted to local food production. In fact, the area planted to seed crops has grown ten-fold since 1982, while land growing vegetables and fruits (excluding pineapples) has declined more than 50% since the late 1990s (Figure 1). As a result, Hawai'i grows only one-third, and imports two-thirds, of the fresh produce consumed

on the Islands. That a tropical paradise like Hawai'i should be so dependent on imported fruit must be counted a major failure of state agricultural policy. And the situation is getting worse rather than better: in fact, the locally produced share of the Hawaiian market in fresh fruit fell by nearly half between 1990 and 2008, from 57% to 32% (Figure 2).

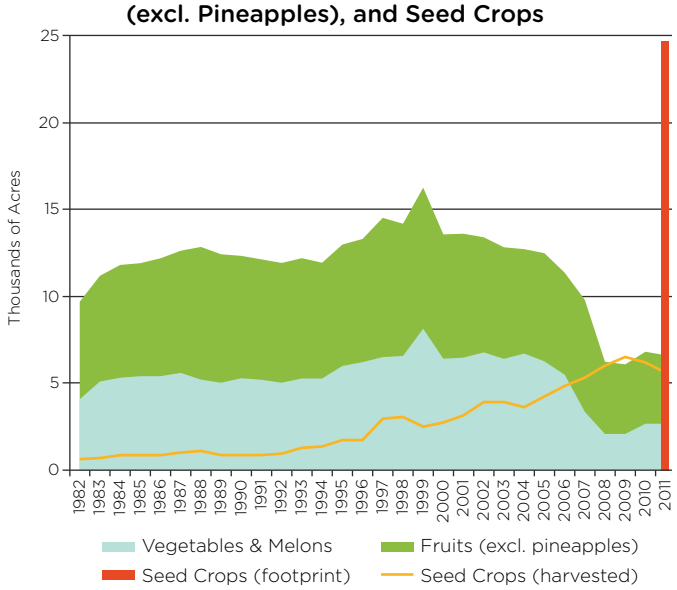
About 85% of the land occupied by the Big Five pesticide-seed firms is leased. The lessors—large landowners and the State itself—are thus actively ceding valuable farmland to pesticide-intensive seed crop operations that make zero contribution to Hawai'i's food security, and only miniscule contributions to employment and the economy.

Missed Opportunities

According to University of Hawai'i agronomist Hector Valenzuela and Moloka'i activist Walter Ritte, the State and the University of Hawai'i failed to follow through on promises to foster small-scale, diversified agriculture on former plantation lands in the 1990s (Mitra 2014). Novice farmers received little or no training and support. Instead, then-governor Ben Cayetano encouraged further expansion of the seed industry.

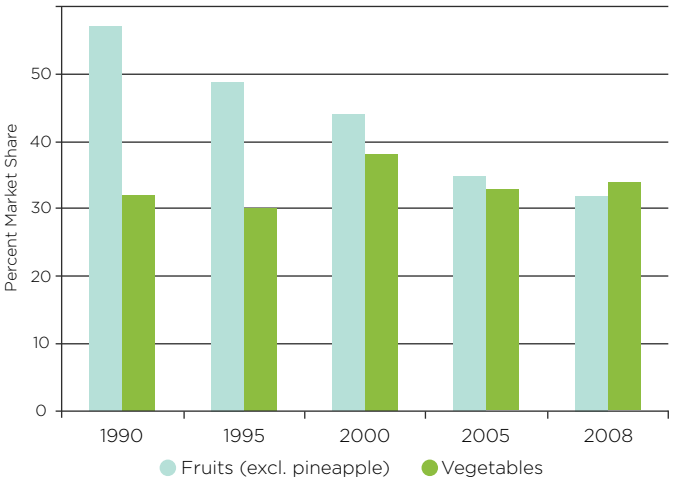
What opportunities has Hawai'i missed with these misplaced priorities? It is estimated that replacing all imports of beef, pork, eggs, fresh milk, fresh fruits, and vegetables with local production would create 14,629 jobs, over 10 times the number employed by the seed industry, and generate $303 million in earnings and $39 million in state taxes. A more modest goal of replacing just 10% of the food currently imported into the state would keep $313 million now spent overseas in the local economy. This would generate $188 million in sales, $37 million in earnings, $6 million in state taxes, and over 2,300 agricultural jobs, 65% more than the seed industry employs (Leung and Loke 2008, Hawai'i Food Security 2012). These projections show clearly that increasing Hawai'i's food security is not only the right thing to do, but also makes economic sense.

Figure 1: Area Planted to Vegetables, Fruits (excl. Pineapples), and Seed Crops



Sources: Hawai'i Agricultural Statistics (HASSa various years).

Figure 2: Share of Fresh Fruit and Vegetable Markets Supplied by Hawai'i Produce: 1990-2008



Sources: Hawai'i Agricultural Statistics (HASSb various years).

Hawai‘i is ground zero for experimentation with genetically engineered crops. The state has had more outdoor field releases of GE crops than any other state in the nation. Because Hawai‘i is much smaller than Midwestern states where GE crops are also frequently tested, it has a much higher density of field tests.

GENETICALLY ENGINEERED CROPS IN HAWAI‘I

Hawai‘i is ground zero for experimentation with genetically engineered crops. The state has had more outdoor field releases of GE crops than any other state in the nation (ISB Locations 2015). Because Hawai‘i is much smaller than Midwestern states where GE crops are also frequently tested, it has a much higher ***density*** of field tests. For instance, Hawai‘i has had 9.2 times more GE crop field releases per unit land area than Illinois, suggesting that more people in Hawai‘i live in closer proximity to field test sites than people in other states.

Field releases of experimental GE crops are carried out under perfunctory permits issued by the United States Department of Agriculture’s (USDA) Animal and Health

WHAT IS A GENETICALLY ENGINEERED CROP (A.K.A. GMO)?

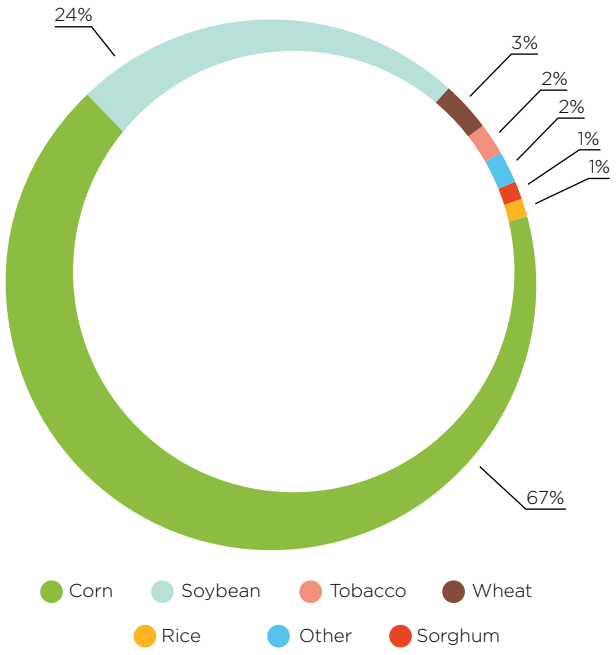
Genetic engineering involves the splicing of foreign genes, most derived from bacteria, into plants to generate new “traits.” Virtually all GE crops grown commercially today have only one or both of two traits: herbicide-resistance[3] (HR) and/or insect-resistance (IR). Insect-resistant GE crops generate up to 7 insecticidal toxins in all their tissues. HR crops survive direct application of certain herbicides that would otherwise kill them, and lead to sharply increased herbicide use. HR traits are roughly twice as common as IR traits in the world’s GE crops.

Inspection Service (APHIS). 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).

The GE crops grown in Hawai'i mirror those grown on the mainland. GE corn and soybeans dominate mainland fields, and comprise 91% of field releases in Hawai'i, with corn tested nearly three times more frequently than soybeans (Figure 3). Herbicide-resistance is the trait that characterizes the most widely grown type of mainland GE crop, and it is also the most commonly tested type in Hawai'i. Over two-thirds (68%) of GE field releases over the past five years, and 82% over the past two years, involved herbicide-resistant crops (ISB Release 2010-2014).[4] Despite rhetoric about nutritional enhancement and disease resistance, the pesticide-seed firms have conducted extremely few field trials of such GE crops, and there are hardly any such GE crops grown commercially (Figure 4).

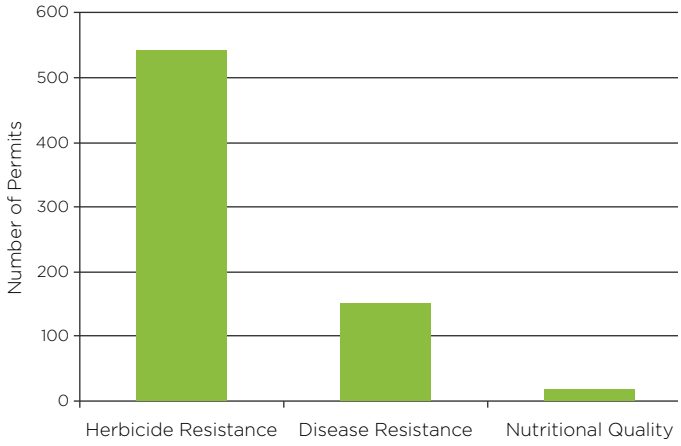
The Big Five pesticide-seed firms conducted 97% of GE field tests in Hawai'i over the past five years, while public sector institutions were responsible for only 1% (ISB Release 2010-2014). The dominance of pesticide firms explains why herbicide-resistance is the most frequently tested trait in GE crop development. Because these firms are the major producers of herbicides, and genetically engineered crops with HR traits dramatically increase herbicide use, these companies profit twice: first from the sale of expensive GE seeds, and then again from the vastly increased sales of the herbicide(s) used in conjunction with them. Herbicide-resistant corn, soybeans, and cotton alone have increased overall herbicide use by a massive 527 million lbs. in the 16 years from 1996 to 2011 (Benbrook 2012). The USDA confirms that herbicide use has more than doubled on soybeans over same the period, when GE soybeans became dominant (USDA NASS 2014). Most of this additional herbicide is glyphosate, the active ingredient in Monsanto's Roundup, and is applied to the company's GE Roundup Ready crops.

Figure 3: GE Crop Field Tests in Hawai'i: 2010-2014



Source: ISB Release (2010-2014).

Figure 4: GE Crop Field Trial Permits for Selected Traits in Hawai'i: 2010-2014



Source: ISB Release (2010-2014). Nutritional quality refers to permits for GE crop field trials involving the phenotype (trait) "nutritional quality improved." Disease resistance comprises three distinct trait categories: fungal resistance, virus resistance, and bacterial resistance.

Hawai'i is a major test ground for the pesticide companies' short-sighted response to these resistant weeds: namely, "next-generation" GE crops resistant to a host of toxic herbicides that will still kill them, at least for a time.

This massive use of glyphosate has triggered a raging epidemic of glyphosate-resistant weeds, just as overused antibiotics breed resistant bacteria. Hawai'i is a major test ground for the pesticide companies' short-sighted response to these resistant weeds: namely, "next-generation" GE crops resistant to a host of toxic herbicides that will still kill them, at least for a time (Kilman 2010). As noted above, 82% of GE field releases in Hawai'i over the past two years have involved crops resistant to one or more herbicide(s). Because 63% of Hawai'i permits had herbicide-resistance traits hidden as "confidential business information" (CBI),[5] GE crops resistant to unidentified chemicals are also being tested. The major "next-generation" HR crops are resistant to 2,4-D (Dow Chemical) and dicamba (Monsanto), and will come stacked with resistance to glyphosate as well (Mortensen et al. 2012). USDA has issued multiple permits allowing field testing of corn and soybeans resistant to 2,4-D and/or dicamba in Hawai'i (ISB Release 2010-2014). Widespread adoption of these HR crops is expected to boost agricultural use of 2,4-D by three- to seven-fold (CFS 2014a); and that of dicamba by 11-fold (CFS 2014b). These crops will generate still more intractable weeds resistant to multiple herbicides, driving herbicide use to new heights, both on Hawai'i's test fields and on the mainland, putting agriculture in a "crisis situation" (Keim 2014).

However, intensive use of herbicides on herbicide-resistant GE crops is just one component of the chemical onslaught involved in growing GE seed crops in Hawai'i.

PESTICIDE AND FERTILIZER USE IN GE SEED CORN PRODUCTION

The vast majority of Hawai'i's seed crops are GE corn, as indicated by the following two facts: seed corn comprised 95.6% of the "value" of the state's seed crop industry in 2011 (Loudat and Kasturi 2013); and 93% of U.S. corn is genetically engineered. GE field corn grown on the mainland involves intensive use of chemicals: half of the herbicide and nearly half of the nitrogen and phosphorous fertilizer applied in all of U.S. agriculture is used on corn (USDA ERS 2013, 2014). Growing seed corn is still more chemical-intensive because the inbred varieties grown for breeding purposes are less vigorous and more vulnerable to pests and disease than the more robust hybrids that mainland farmers grow (Thomison undated). To compensate for these vulnerabilities, seed corn growers make heavier applications of fertilizer and pesticides (Ibid, Rinehold 2011). Hawai'i corn breeder James L. Brewbaker describes the chemical-intensive practices employed by the seed corn firms. Fertilizer is applied heavily to compensate for Hawai'i's soils, which are not well-suited to corn. This creates

"[t]he potential for leached nitrate to pollute groundwater …. a serious environmental concern" (Brewbaker 2003). Pesticides are also used intensively because the temperate varieties grown by the pesticide companies have no resistance to local pests and diseases. Dr. Brewbaker, famous for breeding pest- and disease-resistant Hawaiʻi sweet corn varieties (see inset), is diametrically opposed to the seed industry in this respect: "There is no thought of trying to grow such valuable but unadapted germplasm pesticide-free!"[6] The "[u]nique pesticide regimes … imposed by the seed industry" on Hawaiʻi kill off beneficial insect predators that would otherwise control the pests (Brewbaker 2003, p. 69). Corn seeds are treated with pesticides; insecticides are applied to the soil during planting; and as the corn grows, insecticides and fungicides are applied every 5 to 7 days.

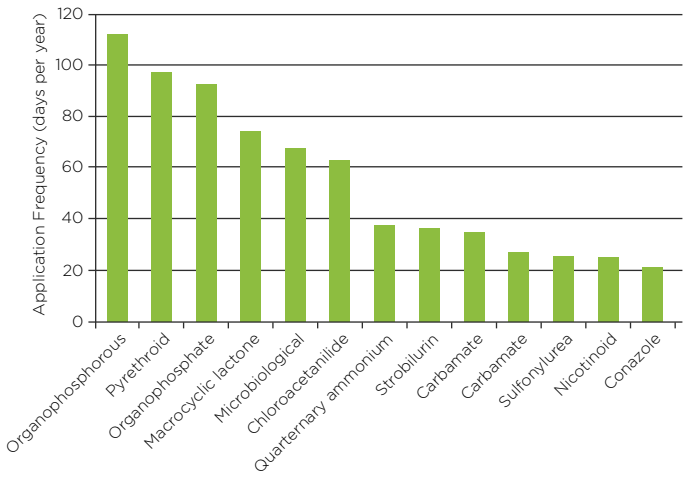
BREEDING FOR RESISTANCE . . . AND FOOD

It is ironic that Hawaiʻi, 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"[5] conventional corn. Dr. James Brewbaker, known in Hawaiʻi as the King of Corn, has bred a multitude of sweet corn varieties with excellent resistance to diseases and insect pests. These varieties are credited with saving Hawaiʻi's sweet corn industry, and are also widely grown in Thailand, Australia, and many other countries (Salkever 2003). The University of Hawaiʻi has developed field corn varieties with similarly broad-spectrum resistance. The key to Dr. Brewbaker's success is breeding without insecticides and fungicides, the precise opposite of pesticide company practice:

> "Using no pesticides, a continuing evolution occurred between diseases, pests, and Hawaiʻi'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).

University of Hawaiʻi breeder James C. Gilbert has employed similar techniques to breed resistant tropical varieties of tomatoes, eggplant, edamame soybeans, and other crops (Brewbaker 2010), and breeding without pesticides is known to be an effective means to develop pest- and disease-resistant strains of most crops (e.g. see Robinson 1996). By slashing insecticide and fungicide use, such crops would be cheaper to produce, which in turn would help make Hawaiʻi 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 path, but also a feasible one, if only Hawaiʻi'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.

Figure 5: 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 2 below for key.

These authoritative accounts of intensive pesticide use associated with GE seed corn production in Hawai'i are borne out by hard numbers. Records obtained from DuPont-Pioneer in a lawsuit show that this single company applied 90 different pesticide formulations containing 63 different active ingredients[7] on Kaua'i from 2007 to 2012 (Jervis and Smith 2013). Consistent with Dr. Brewbaker's description above, these pesticides are used quite frequently. The company sprayed on two-thirds (65%) of the days over this six-year period; and made from 8.3 to 16 applications per application day, on average, in various years of this period (Jervis and Smith 2013). 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 5 and Table 2). If one considers the additional pesticide use by Dow Chemical, Syngenta, and BASF, there are likely 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 represents extremely intensive pesticide use.

TABLE 2: 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

Growing seed corn is still more chemical-intensive, because the inbred varieties grown for breeding purposes are less vigorous and more vulnerable to pests and disease than the more robust hybrids that mainland farmers grow. To compensate for these vulnerabilities, seed corn growers make heavier applications of fertilizer and pesticides.

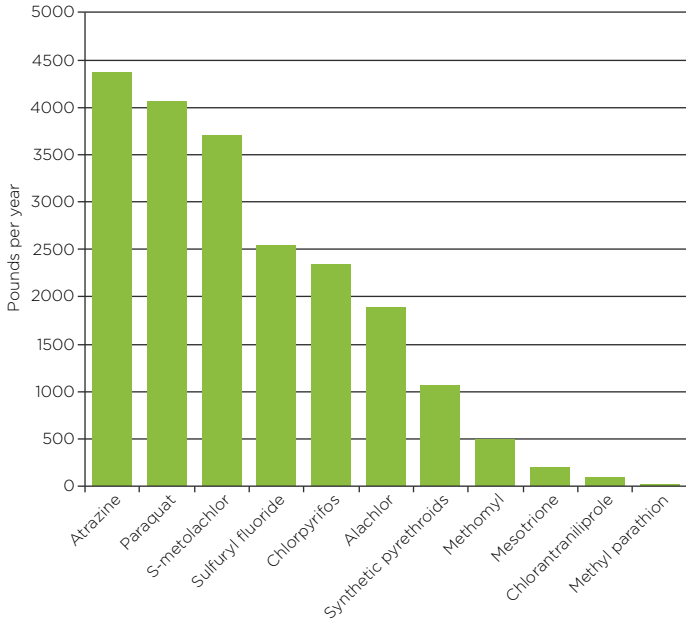
The only other available data on pesticide use on Kaua'i applies only to "restricted use pesticides" (RUPs), an Environmental Protection Agency (EPA) designation for pesticides whose "toxicity exceeds one or more … specific hazard criteria."[8]

RUP sales data for Kaua'i 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 6). Eighty-one percent (81%) of RUP active ingredients by weight were applied to corn, 19% to coffee, with negligible amounts used on ornamentals, soybeans, sugarcane, tomatoes, and turf. Major users of agricultural RUPs were Dow Chemical (and its subsidiary Agrigenetics), Syngenta, DuPont-Pioneer, BASF, and Kaua'i Coffee Company.

Total pesticide use is likely four times greater, or over 80,000 lbs. annually. This is based on the fact that DuPont-Pioneer applies over four times as many 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 Kaua'i Ordinance 960, which would have required all major RUP users to report their use of all pesticides, not just RUPs.

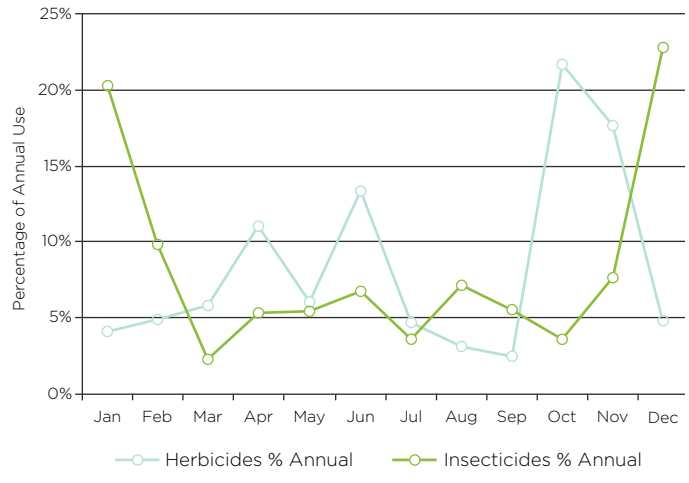
Because of Kaua'i citizens' demand for more transparency concerning pesticide use associated with GE seed corn operations, some additional data have become available since December 2013. After the mayor of Kaua'i vetoed Bill 2491 (subsequently passed as Ordinance 960), a program was brokered where the five largest users of RUPs (Dow Chemical, DuPont-Pioneer, Syngenta, BASF, and Kaua'i Coffee Company) now voluntarily disclose their RUP use in Kaua'i to the Hawai'i Department.

Figure 6: 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.

Figure 7: Pounds of Restricted Use Pesticides (a.i.) Applied on Kaua'i by Month: 2014



Source: Kaua'i Good Neighbor Program RUP data for 2014.

of Agriculture, who then release it to the public under the Orwellian name of "Kaua'i Good Neighbor Program."This program provides the only data on use (vs. sales) of RUPs in the state, although specifics on locations where the pesticides are applied are not provided. The data discussed below are for the 12 months of 2014.

We first compare the use intensity of the ten restricted use insecticides (RUIs) applied to Kaua'i seed corn to that of the same RUIs on mainland corn (USDA NASS 2011). When one considers both the proportion of acres treated and the amounts applied, ***Kaua'i seed corn fields receive 17 times more RUIs than mainland corn: 0.188 versus 0.011 lbs./acre/year.*** While 0.188 lb./acre may not sound like much, one must consider how potent some of these RUIs are. For instance, beta-cyfluthrin and lambda-cyhalothrin are applied at the vanishingly low rates of 0.01 to 0.02 pound (about 1 to 2 teaspoons) of active ingredient ***per acre***. According to their labels, these insecticides may be fatal if swallowed; are harmful when inhaled or absorbed through the skin; and are also extremely toxic to aquatic organisms and bees. The nerve toxin chlorpyrifos comprises two-thirds of RUI use. Health and environmental impacts of RUPs and other pesticides are discussed further below.

Figure 7 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 confined 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 (discussed below) 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.

PART TWO: IMPACTS ON HUMAN HEALTH + THE ENVIRONMENT

AARON SCHMIDT

The industrial food system externalizes much of its true costs by passing them on to society and the environment. These costs stem from the system's reliance on temporary chemical "fixes," and include adverse public health impacts, contamination of ground and surface water, soil degradation and erosion, and biodiversity loss.

REPORTED HEALTH HARMS FROM PESTICIDE USE IN HAWAI'I

Lessons from History

HAWAI'I'S PLANTATION HISTORY has given its citizens ample exposure to toxic pesticides, and more than enough reason to doubt industry and government assurances of safety. EPA shut down drinking water wells in the O'ahu town of Kunia in 1980, and later designated the area a Superfund site, due to hazardous levels of several pesticides used in pineapple production. These included a Dow Chemical nematicide (DBCP) infamous for causing sterility or impaired fertility in tens of thousands of farmworkers around the world (Gonzalez and Loewenberg 2003). In 1982, milk on O'ahu was found to be contaminated with hazardous levels of the pesticide heptachlor,[9] and elevated levels were also found in human breast milk (Smith 1982). These toxic pesticides, which have also been linked to breast cancer (Allen et al. 1997), continued to be used in Hawai'i pineapple production 5-6 years after EPA had otherwise banned them.

Star Advisor—September 18, 2014
Pesticide Odor Closes Big Isle Schools, Sends 50 to Hospitals

Honolulu Advisor–October 13, 2001
PECTICIDE SICKENS PAHOA STUDENTS

HAWAI'I NEWS NOW—2008
School Samples Test Positive for Pesticide

Star Bulletin–March 7, 2008
Smell From Pesticide Spill Sickens Pearl City Kids

KPUA, Hawai'i News—April 13, 2006
Pesticide Forces School Evacuation

These episodes teach important lessons. First, pesticides initially approved as "safe" are found to be hazardous only after years of use and thousands are harmed. Second, powerful agricultural interests often succeed in keeping hazardous pesticides on the market even after their toxicity is well-understood. Third, Hawai'i state officials have a history of covering up pesticide contamination and denying clear health risks to citizens in order to protect agricultural interests (e.g. heptachlor contamination, see Smith 1982).

These lessons are still relevant today because hazardous pesticides continue to be applied today on the GE corn fields that have largely replaced the plantations. And these operations are run by some of the very firms that produced the plantation-era pesticides and long assured us of their supposed safety, for instance Dow Chemical. While the crops and chemical names have changed, Hawai'i residents continue to be threatened by pesticides—not only in the water, but in the very air we breathe.

Pesticide Drift in Hawai'i

Many pesticide drift incidents go unreported. Hawai'i does not have a "pesticide poisoning surveillance program" of the sort established in eleven other states.

Communities in Hawai'i are rightly concerned about pesticide drift that occurs from open-air GE seed corn operations. Teachers and schoolchildren in Waimea on Kaua'i became 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 headaches, 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).

At least three 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

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 …," and report that many do not recover despite healthy lifestyle changes or pharmaco-logical interventions.

(Kalani and Fujimori 2014). These symptoms are all commonly reported effects of exposure to pesticides (AAP 2012: Table 2).

These media reports likely represent a small fraction of actual pesticide poisoning cases, for several reasons. Many pesticide drift incidents go unreported (EPA 2001). Hawai'i does not have a "pesticide poisoning surveillance program" of the sort established in eleven other states (CDC 2014). And even when drift victims do seek medical attention, many physicians lack the training to recognize the effects of pesticide poisoning, and so do not report it (CA PISP Fact Sheet, AAP 2012).

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…," and report that many do not recover despite healthy lifestyle changes or pharmacological interventions. They also report recurring nose bleeds in children and recurring dermatitis, among other symptoms (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 (see photo above) (Jervis and Smith 2013). Fine dust can penetrate the lungs and cause bronchitis (CCOHS 2012), and is still more harmful if the dust is laden with pesticides (USGS 2003).

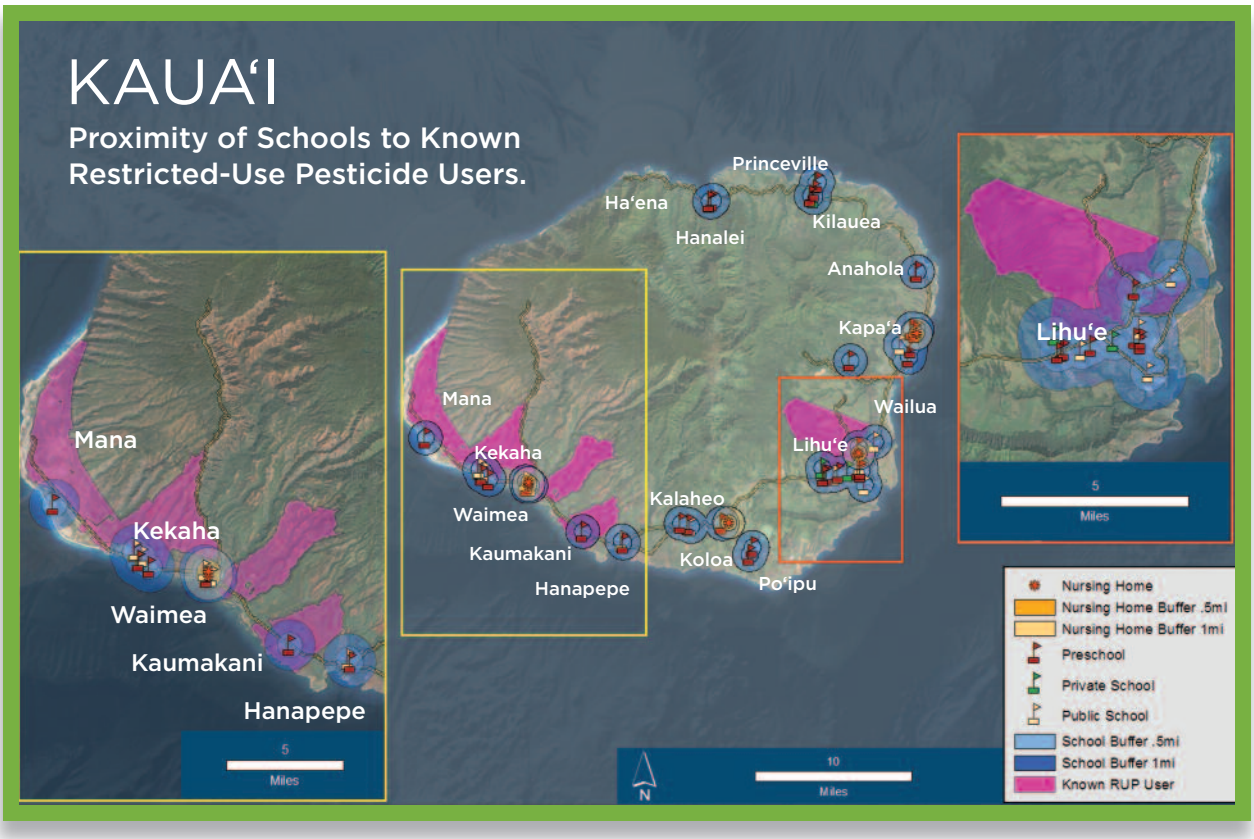
Evidence from other states also suggests that pesticide drift is a frequent occurrence. A study of pesticide exposure at schools in eight states from 1998 to 2002 identified 2,593 individuals who had experienced acute pesticide-related illnesses. Of the 406 cases for which more detailed information was available, nearly one third (31%)

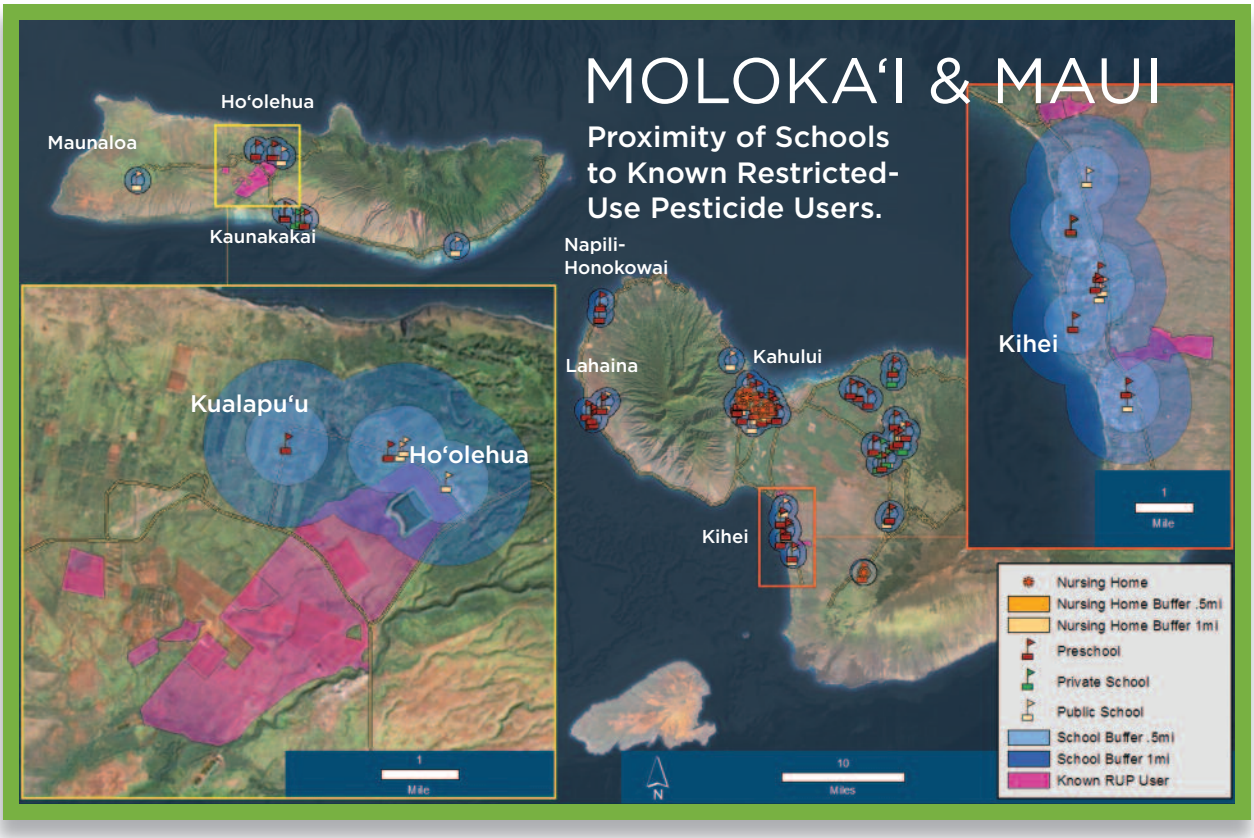
Kaua'i physicians and residents have noted a "cancer cluster" in Waimea—37 cases in a neighborhood of just 800—which is said to be 10 times the statewide cancer rate.

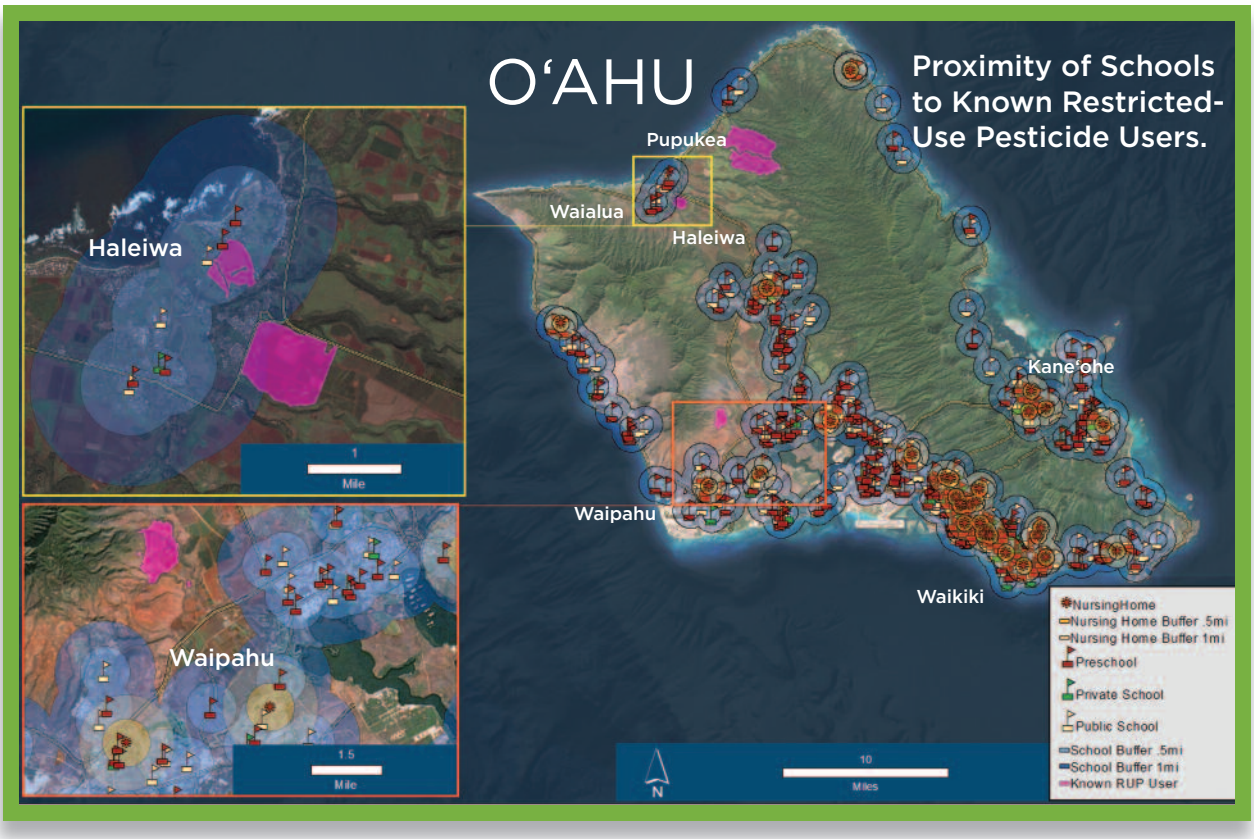
involved pesticide drift from farmland while the others involved pesticide use at the school (Alarcon et al. 2005).

Pesticides may also be a factor in still more serious health threats. Dr. James Raelson and his colleague Dr. Chatkupt, practicing pediatricians in 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).

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.
Haleiwa
Pupukea
Waialua
Haleiwa
Kane'ohe
Waipahu
Waikiki
Waipahu
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

In a 2008 episode, 60 children and at least two teachers experienced headaches, 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.

HEALTH IMPACTS OF PESTICIDE EXPOSURE

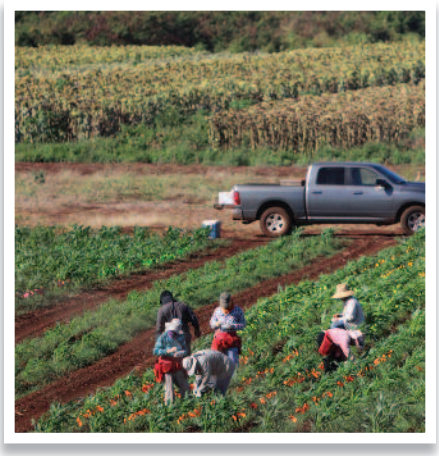
Pesticides have a long history of having negative, often unforeseen, impacts on human health. People are exposed to certain pesticides in their food and water; farmworkers take in pesticides via dermal contact and inhalation of spray. Pesticide drift represents an important additional exposure pathway (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; and pregnant women 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 long-term impacts, as discussed below.

Farmers and Farmworkers at Risk

CANCER: Cancer rates in the U.S. have nearly doubled since 1950, corresponding to the period of rapid growth in use of pesticides and other 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 famers 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 herbicide (Cantor et al. 1992, McDuffie et al. 2001); glyphosate (Hardell et al. 2002, De Roos et al. 2003, Schinasi and Leon 2014); and to organophosphate insecticides (reviewed in Schinasi and Leon 2014). In a landmark ruling, the World Health Organization's International Agency for Research on Cancer recently determined glyphosate to be a probable human carcinogen (Guyton et al. 2015). This is the major organophosphorous herbicide, the most frequently applied class on Kaua'i (Figure 5).



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.

These findings are especially concerning when one considers the intensive use of these toxic herbicides on GE crops resistant to them (see above), and the fact that they are prone to drift (AAPCO 1999, 2005). 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. Exposure to the organophosphate insecticide chlorpyrifos has been linked to lung cancer (Lee et al. 2004), colorectal cancer (Lee et al. 2007), and non-Hodgkin's lymphoma (Schinasi and Leon 2014).

PARKINSON'S DISEASE: Several major meta-analyses[10] 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 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 pesticide 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).

Paraquat is one of the most heavily used RUPs on Kaua'i (Figure 6). 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 (Watts 2011). While ingestion of as little as a teaspoon of concentrate is fatal, paraquat is 1,000-fold more toxic when inhaled due to its extreme toxicity to lung tissue (Ames et al. 1993). Kentucky agricultural extension agent Gordon Johnson reports that paraquat can drift for miles (Johnson

While exposure to many pesticides causes acute neurological symptoms, such as headaches and dizziness, a spate of recent studies builds an irrefutable case that long-term, low-level exposure to organophosphate insecticides in early life (particularly in utero) has profoundly negative impacts on children's neurological development.

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).

DEPRESSION: 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 in France found nearly double the rate of depression in agricultural workers exposed to herbicides, with greater risk from longer-term exposure (Weisskopf et al. 2013). The troubling implication of many of these studies is that acute poisoning episodes can have chronic, long-term consequences for mental health.

ENDOCRINE DISRUPTION: Pesticides can also disrupt our hormonal or endocrine systems. Extremely low levels of atrazine, a restricted use herbicide applied heavily in Hawai'i (Figure 6), have been shown to cause feminization of male frogs —a process described as chemical castration (Hayes et al. 2011). Because human hormonal systems are similar to those of amphibians, these animal findings suggest that atrazine may be hazardous to human health as well. Atrazine is discussed further below.

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). 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, particularly neurological impacts and cancer (NRDC 1997). Exposure of pregnant women to pesticides is particularly hazardous, since pesticides can be potent disruptors of fetal development, meaning our future generations will face a lifetime of impacts due to exposure in the womb.

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 (see Roberts and Karr 2012). They found that pesticide exposure was strongly linked to four types of disease:

1) ***Childhood cancers***, especially leukemia and brain tumors;
2) ***Neurobehavioral and cognitive deficits***, such as reduced IQ and attention deficit/hyperactivity disorder;

Chlorpyrifos is the most heavily sprayed Restricted Use insecticide on Kaua'i, and DuPont-Pioneer alone sprays OPs on Kaua'i once every four days. Air sampling at Waimea School consistently detected chlorpyrifos.

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.

Childhood Cancers

Five of six recent case-control studies found a statistically significant relationship between pesticide exposure and leukemia (Roberts and Karr 2012). ***Maternal exposure to pesticides between the periods of preconception through pregnancy was 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 (Wigle et al. 2009) and a study of parents exposed to pesticides in Costa Rica (Monge et al. 2007) arrived at similar results.

A high-quality study entitled "Parental Occupational Exposure to Pesticides and Childhood Brain Cancer, involving 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 in children of exposed fathers (van Wijngaarden et al. 2003).

Neurobehavioral and Cognitive Deficits

While exposure to many pesticides causes acute neurological symptoms, such as headaches and dizziness, a spate of recent studies builds an irrefutable case that long-term, low-level exposure to organophosphate insecticides (OPs) in early life

Chlorpyrifos is the most heavily sprayed restricted use insecticide on Kaua'i, and DuPont-Pioneer alone sprays OPs on Kaua'i once every four days. Air sampling at Waimea School consistently detected chlorpyrifos.

(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 into 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. 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 lower IQ scores in all three groups (Rauh et al. 2011, Bouchard et al. 2011, Engel 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. Chlorpyrifos is the most heavily sprayed RU insecticide on Kaua'i (Figure 6), and DuPont-Pioneer alone sprays OPs on Kaua'i once every four days (Figure 5). Air monitoring in California and Washington has found levels of chlorpyrifos exceeding health limits on several occasions (Goldman et al. 2009), and chlorpyrifos is one of the most frequently cited culprits in drift-related pesticide poisioning episodes in California (CA PISP 1992-2011). Air sampling at Waimea School consistently detected chlorpyrifos (Li et al. 2013). Based on these multiple lines of evidence, there is every reason to expect that chlorpyrifos drift is adversely affecting the mental health of Hawai'i residents living near GE seed corn fields.

Adverse Birth Outcomes

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 children of 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. Another study found that *in utero* exposure to OPs was 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). ***All of these pesticides are heavily used in Hawai'i seed corn operations.***

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

Asthma

Asthma is estimated to affect 300 million people worldwide and cause a quarter of a million deaths each year (Strina et al. 2014). Asthma is characterized by intermittent breathing difficulty, including chest tightness, wheezing, and cough. There have been few studies of pesticides and asthma in children, but those conducted raise serious concerns. For instance, 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 in a study carried out in southern California—an over four-fold higher risk from herbicide 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 2002), and exposure to organophosphate and carbamate insecticides has been linked to asthma in Canadian farmers (Senthilselvan et al. 1992). 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. 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.

HEALTH HARMS SPECIFICALLY LINKED TO PESTICIDE DRIFT

A growing body of research finds increased risk of disease in those living near pesticide-sprayed agricultural fields. Costello et al. (2009) have 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) found that expectant mothers residing within 500 meters of fields sprayed with organochlorine insecticides during early pregnancy had a six-fold higher risk of bear-

It is often assumed that people suffer no permanent harm from a single (acute) pesticide exposure, but research is proving this to be untrue.

ing children with autism spectrum disorder than mothers not living near such fields. Shelton et al. (2014) found ***a 60% increased risk of autism spectrum disorder*** (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. Most of the insecticides at issue in this California study are used on Kaua'i and likely on other islands as well: chlorpyrifos; the pyrethroids permethrin, lambda-cyhalothrin, cypermethrin, and esfenvalerate; and methomyl (Figures 5 & 6 and Table 2).

ACUTE PESTICIDE EXPOSURE CAN CAUSE LASTING HARM

All of the symptoms reported above in 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 (Owen and Feldman 2004, CA PISP 1992-2011). It is often assumed that people suffer no permanent harm from a single (acute) pesticide exposure, but research is proving this to be untrue. For instance, many studies have found increased rates of lasting depression (e.g. Stallones and Beseler 2002, Beseler and Stallones 2008), impaired cognitive functioning (Rosenstock et al. 1991), and reduced neuromuscular control (Kofman et al. 2006) in people exposed acutely to certain toxic pesticides. This means that children and adults exposed just a single time to a pesticide, even though they may appear to fully recover, in certain cases go on to develop chronic, long-term illnesses that may persist throughout their lives.

ADDITIONAL EXPOSURE TO AGROCHEMICALS IN FOOD AND 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 (USGS) monitors the nation's water bodies for pollutants. In the 1990s, USGS studies found one or more pesticides or their breakdown products in sampled streams more than 90% of year; and that the mean annual 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 (e.g. Gilliom et al. 2006). Atrazine is among the most commonly detected pesticide contaminants in our streams and drinking water (Wu et al.

2010). Monitoring data reveal that an estimated 33 million Americans are exposed to atrazine in tap water (Duhigg 2008). Atrazine was detected in 80% of the 24 watersheds and streams recently tested by Hawai‘i health and agricultural officials (Grange 2014), and in 90% of base flow samples tested in an earlier investigation by USGS on O‘ahu (Anthony et al. 2004).

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Pesticide residues from the direct or indirect spraying of food crops is another major exposure pathway. Organically grown foods have substantially lower residue levels than conventionally grown foods (Baker et al. 2002). Lu et al. (2008) showed 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. 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. As noted above, OPs have been found to cause serious neurobehavioral and cognitive deficits in infants and children.

A recent Government Accountability Office (GAO) study found that the Food and Drug Administration (FDA) is testing an ever smaller proportion of produce for pesticide residues (GAO 2014). FDA tests too few samples to estimate either the frequency or magnitude of pesticide residue violations in the U.S. food supply. FDA does not test produce for 6 of the 25 most commonly used pesticides with set tolerances,[11] 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.

ENVIRONMENTAL IMPACTS OF AGROCHEMICAL USE IN HAWAI‘I

Beyond the considerable threat that RUPs pose to the health of Hawai‘i residents, these chemicals also threaten Hawai‘i's unique and biodiverse environment, which is home to about 9,500 species found nowhere else on the planet (Evenhuis and Eldredge 2002). While Hawai‘i is considered 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 on Hawai‘i (Allison and Miller 2000), and 437 species on the islands are listed as either threatened or endangered (USFWS 2012).

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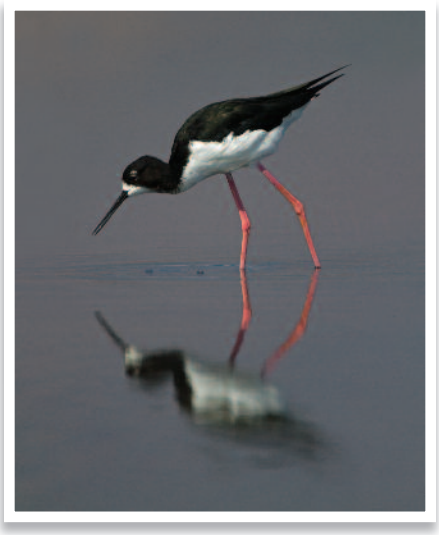
Below, we discuss the environmental harms associated with several classes of pesticide heavily used in Hawai'i's seed corn operations. Where available, we discuss studies and information specific to the Hawai'i context.

ATRAZINE As discussed above, atrazine is the most heavily used RUP on Kaua'i (Figure 6) and the most frequently detected pesticide contaminant in Hawai'i's surface waters. Atrazine is toxic to coral (Jones et al. 2003), and atrazine runoff has been proposed as one possible cause of coral reef decline on the north shore of Kaua'i (D'Angelo 2013). Atrazine is also extremely toxic to amphibians at low concentrations that are found in nature. For instance, male tadpoles exposed to atrazine concentrations as low as 0.1 part per billion (ppb) developed hermaphroditic characteristics (multiple male and female gonads); and exposure to as little as 1.0 ppb reduced larynx size, which could reduce fitness in the wild (Hayes et al. 2002). Low-dose exposure to atrazine consistently suppresses the immune systems of fish and amphibians, predisposing them to infection with pathogens and parasites (Rohr and McCoy 2010). Atrazine may also harm aquatic organisms indirectly by killing off vegetation and so degrading habitat (EPA 2006).

CHLORPYRIFOS is an organophosphate, and by far the most heavily applied restricted use insecticide on Kaua'i (Figure 6). Chlorpyrifos is very highly toxic to birds, aquatic invertebrates, freshwater fish, other estuarine and marine organisms, and bees (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" and in rivers in California at levels exceeding the proposed state guidelines for protection of aquatic life in most samples (USGS 2003).

Chlorpyrifos is also a terrestrial threat. It has been shown to kill or injure substantial numbers of both adult and larval bees at levels that are found in the environment (Williamson et al. 2013). Chlorpyrifos is currently being reassessed together with other insecticides for their impacts on endangered species (USFWS 2014).



DANIEL CLARK

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

SYNTHETIC PYRETHROIDS are a class of neurotoxic insecticides 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 (BP Pyrethroids). At least seven are used in Hawai'i's seed corn operations: permethrin, tefluthrin, esfenvalerate, lambda-cyhalothrin, zeta-cypermethrin, beta-cyfluthrin, and bifenthrin. They form the second-most frequently used class of pesticide (Figure 5). Although generally less acutely toxic to human beings than organophosphate insecticides, several pyrethroids carry label statements warning of possible death upon ingestion and harm from inhalation.

Permethrin, zeta-cypermethrin, and bifenthrin are possible human carcinogens (BP Pyrethroids). 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). Pyrethroids are extremely toxic to fish, aquatic invertebrates, oysters, lobsters, and shrimp, which can be killed at levels ranging from just 2 parts per trillion to 1 part per billion (BP Pyrethroids, Weston and Lydy 2010). Pyrethroids are also extremely toxic to bees, which are killed not only by direct exposure to spray, but also by residues on blooming crops and weeds that have been previously sprayed. The U.S. EPA in its registration of permethrin acknowledges that it is "likely to reduce the numbers and possibly eliminate populations of beneficial insects" (EPA Permethrin 2009).

NEONICOTINOIDS are a class of neuroactive insecticides that are often applied to seeds; they are absorbed by the growing seedling, making the plant itself toxic to insects. Pollinators such as bees can be exposed when collecting pollen or nectar. Nearly all corn seed in the U.S. is treated with neonicotinoids (Krupke et al. 2012). Massive bee kills have resulted upon exposure of bees to neonicotinoid-laden dust from seed corn at planting time (Krupke et al. 2012, Stokstad 2013). Bees exposed to sublethal levels of neonicotinoids experience problems with flying and navigation, reduced taste sensitivity, and slower learning of new tasks, which all impact foraging ability (Hopwood et al. 2012). Neonicotinoids also make honey bees more susceptible to parasites and pathogens, including the intestinal parasite, *Nosema*, that is one cause

Massive bee kills have resulted upon exposure of bees to neonicotinoid-laden dust from seed corn at planting time. Bees exposed to sublethal levels of neonicotinoids experience problems with flying and navigation, reduced taste sensitivity, and slower learning of new tasks, which all impact foraging ability

of colony collapse disorder (Hopwood et al. 2012, Di Prisco et al. 2013). *Nosema* is one of the major causes of the dramatic loss of both domesticated and feral bees in Hawai'i in recent years (Edwards-Hunt 2011).

Neonicotinoids are frequently found in surface waters around the world, often at levels that exceed water quality guidelines (Morrissey et al. 2015). Imidacloprid, a leading neonicotinoid, is highly toxic to freshwater invertebrates. Ground beetles are killed or impaired when they consume slugs that have been contaminated with neonicotinoids through ingestion of treated seedlings (Douglas et al. 2014). 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 neonicotinoids also appear to harm birds by reducing populations of insects they feed on (Hallemann et al. 2014). Many birds are threatened by extinction, and 34 bird species, including many species of Hawaiian honeycreeper, are listed as endangered (USFWS 2015).

Seed corn in Hawai'i is treated with pesticides (Brewbaker 2003), and this almost certainly includes neonicotinoids; but since they are not RUPs, they are exempt from Kaua'i's voluntary RUP reporting system. Hawai'i's pilot program to monitor pesticide contamination of surface waters did not include testing for neonicotinoids. Testing for these compounds is absolutely necessary to make a realistic assessment of the environmental impacts of their use in Hawai'i.

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). 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 Hawai'i's wildlife.

PART THREE:
TAKING CONTROL OF OUR FUTURE

REGULATION DOES NOT PREVENT HARMS

County Regulatory Initiatives Consistent with State Law

COUNTIES HAVE AUTHORITY to regulate local impacts of agriculture. Lacking protection from state and federal agencies, various counties in Hawai'i have taken action to protect the health and welfare of their people and natural environment. Kaua'i County passed Ordinance 960 to require basic transparency via disclosure, and shelter from pesticide drift and spray through the imposition of buffer zones, among other measures. In response, the chemical corporations filed a lawsuit, alleging every claim of which they could conceive, rather than simply complying with the County's urgently-needed, reasonable, and limited ordinance.

Hawai'i County Ordinance 13-121 provides farmers and residents of Hawai'i, their property, and the environment important protection from the impacts of genetically engineered crops, such as transgenic contamination and associated pesticide drift. However, Hawai'i County was also sued by chemical corporations, and Ordinance 13-121 was similarly determined as invalid, under state law, even though no Hawai'i

Counties have authority to regulate local impacts of agriculture, lacking protection from state and federal agencies, various counties in Hawai'i have taken action to protect the health and welfare of their people and natural environment.

We would all like to believe that the EPA protects us from pesticide harms, but this is often not the case. Fundamental flaws in EPA's regulatory process ensure that the Agency regularly approves pesticide products that are hazardous to human health and the environment.

law speaks to any requirements for any GE organisms. The case is also currently on appeal before the Ninth Circuit. More recently, the County of Maui passed a moratorium on genetically engineered crops, in response to which chemical companies again filed a lawsuit, leading to a temporary hold on the moratorium.

Despite these setbacks, the district court rulings make one thing clear: counties have authority to regulate agricultural activities for the protection of its residents and the environment. The legislature granted the counties the authority to protect health, life, and property in HRS § 46-1.5(13), and also the power to enact and enforce ordinances to address public nuisances. There is no Hawai'i constitutional provision or law that expressly precludes county regulation of agriculture, and no court has held that any law does so implicitly. Moreover, the district court's decision in the Kaua'i litigation makes clear that such county initiatives are not prohibited by federal law. The 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, and regulating pesticides and GE crops via disclosures and buffer zones.

Deficient Federal Pesticide Regulation

We would all like to believe that the EPA protects us from pesticide harms, but this is often not the case. Fundamental flaws in EPA's regulatory process ensure that the Agency regularly approves pesticide products that are hazardous to human health and the environment (see e.g. Jacobs and Clapp 2008). These flaws include:

1) Tests conducted on one pesticide at a time, even though in the real world we are exposed to multiple pesticides that can have additive or synergistic effects;

2) Tests conducted only on the active ingredient (a.i.), even though so-called "inert ingredients"[12] in pesticide formulations can be toxic in their own right, or increase the a.i.'s toxicity;

3) Testing is biased to acute effects and is not geared to detect most impacts from long-term exposure to lower levels of the pesticide;

4) Near exclusive reliance on animal experiments conducted by the financially interested pesticide company, with little or no attention paid to more relevant human epidemiological studies carried out by independent medical scientists;

5) Assumption of perfect compliance with a host of complicated label directions that are often unworkable and not followed.

The deficiencies in EPA's regulatory regime are demonstrated by the long history of presumably "safe" pesticides that have had to be taken off the market, but only after harming many thousands of people and the environment. These include the plantation era pesticides DBCP and heptachlor (see "Lessons from History" above), and two pesticides used on Hawai'i as recently as 2012—methyl parathion and sulfuryl

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fluoride (Figure 6). Although long known to be toxic, these pesticides are only now in the process of being phased out (EPA Methyl Parathion, EPA Sulfuryl Fluoride 2011). Even when EPA acknowledges a pesticide's toxicity, its use can continue for many years. EPA phased out all residential uses of chlorpyrifos beginning in the year 2000, specifically to protect children, yet rural kids remain unprotected (Goldman et al. 2009). Chloryprifos is the most heavily used insecticide in U.S. agriculture (EPA 2011) and the most heavily applied restricted use insecticide in Hawai'i (Figure 6).

These examples, as well as the hundreds of medical studies showing harm from approved pesticides (some discussed in this report), demonstrate clearly that EPA cannot be relied upon to protect Hawai'i residents or the environment from intensive pesticide spraying by agrochemical-seed firms.

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Momentum Building to Protect Kids from Pesticide Drift

EPA regulation is especially deficient in the area of pesticide drift. Requirements intended to mitigate drift are often not followed; for instance, applicators often violate pesticide labels by spraying pesticides when it is too windy (AAPCO 2002). Recognizing its deficient regulation of drift, EPA proposed improved pesticide labeling in 2001, but the proposal was never finalized and is not in effect (Goldman et al. 2009). Neither does EPA take drift exposure into account when it registers or re-registers individual pesticides. EPA's very definition of drift is deficient, in that it leaves out vapor drift and pesticide-laden dust, considering only the form of drift that occurs during application.

Public interest and farmworker groups formally challenged EPA for its inaction, and petitioned the Agency to establish regulations to protect children from pesticide drift (Goldman et al. 2009). An official policy statement of The American Academy of Pediatrics lists the establishment of no-spray buffer zones around schools as one of several local approaches to protect children from pesticide drift (AAP 2012). Medical scientists from the federal and state governments also support "adoption of pesticide spray buffer zones around schools" (Alarcon et al. 2005).

Because federal regulators do not protect citizens from pesticidal harms, a growing number of states and counties—including Maui, Hawai'i Island, and Kaua'i—have taken matters into their own hands by requiring environmental and public health impact assessments, banning outdoor GE field tests, establishing no-spray buffer zones around schools, and requiring notification and disclosure of pesticide use.

Momentum is building to protect kids from pesticide drift, including measures such as those found in Kaua'i County Ordinance 960. 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 such no-spray buffer 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.

CONCLUSION

Hawai'i is at a cross roads in its economic, ecological, and agricultural development. After over 150 years of export-oriented commodity production, the last 50 of which have involved the intensive use of pesticides, its land and food system are dangerously insecure. While Hawai'i imports 88% of its food, the GE seed industry's footprint is 72% of the total area planted to non-plantation crops. Much of this land is used to field test new crops that have been genetically engineered to resist one or more herbicides. These industrial agriculture practices threaten public and environmental health.

It is in the face of this tipping point that communities across the state have started to push back against the untempered expansion of GE field trials on our prime agricultural land. While questions of the safety of GE foods in the food supply have also been subject to political debate in the U.S., most popularly through the question of labeling, the debate in Hawai'i is significantly different. Given the amount of agricultural land dedicated to GE field trials in Hawai'i, combined with the integral role pesticides play in this industry, we are questioning whether the development and testing of GE seeds is safe for our communities and our environment.

This report examines the available data and literature that communities need to answer this question. Rather than turning to farmers and pesticide applicators for the answers to these questions, it has been critical for us to shed light on the medical literature that examines the impacts of pesticides on human health. In adult populations, pesticide exposure has been linked to Non-Hodgkin's lymphoma, bladder and colon cancers, Parkinson's disease, depression, and disrupting our hormonal or endocrine systems. More frightening are the links associating children and pregnant women exposed to pesticides with childhood cancers, neurobehavioral and cognitive

deficits, adverse birth outcomes, and asthma. This literature is unequivocal in its findings: pesticides threaten the long-term health of children, farmworkers, and other individuals who are exposed. Pesticides also threaten native biodiversity and ecological services by degrading soils and water, and harming insects and pollinators.

The GE seed industry warrants unprecedented public concern in Hawai'i because it is largely devoted to testing and developing seeds that have been genetically engineered to resist the application of new herbicide combinations, and uses growing methods that require frequent application of insecticides and fungicides. Because of the rapid expansion of this industry in our state, we lack the appropriate regulatory framework to protect families and environment from these potential harms. This is why our counties have stepped forward to act. The State of Hawai'i must follow suit. The public has the right to know what chemicals are applied, particularly because they are applied so closely to places of work and play; doctors need this information to make informed medical decisions for their patients; and policy makers, without a clear picture of what pesticides are being used, cannot develop regulations that adequately protect public and environmental health.

Pesticides threaten the long-term health of children, farmworkers, and other individuals who are exposed. Pesticides also threaten native biodiversity and ecological services by degrading soils, water, and killing beneficial microorganisms, insects, and pollinators.

As we gain more clarity on the amount of pesticides applied in the state, and the locations of these practices, we also need to ensure that we reduce the likelihood that children and pregnant women will be exposed. Buffer zones, around homes, schools, and hospitals are a moderate first step in mitigating exposure risk. These are the concerns of community members working on the issues of pesticides and genetic engineering in our state. Together, we can ensure that the agricultural systems of Hawai'i promote the health and well-being of our islands now and for future generations.

ENDNOTES

1 Monsanto, DuPont-Pioneer, Dow Chemical, Syngenta, and BASF.

2 These companies, which account for two-thirds of combined seed and agrochemical sales in the world today (ETC 2011), are referred to variously as agrochemical, pesticide, and seed firms in this report.

3 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).

4 It should be noted that a single permit often covers a field release in which several different types of traits are tested.

5 Note that many individual permits authorize testing of more than one herbicide-resistance trait (e.g. one with the herbicide identified and a second one hidden as CBI).

6 In this informal usage, pesticide refers only to insecticides and fungicides, not herbicides.

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

8 See 40 CFR Part 152.170: Criteria for restriction to use by certified applicators.

9 Heptachlor was used in the pineapple industry. Heptachlor-contaminated pineapple leaves were fed to dairy cows.

10 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.

11 A tolerance is a legally enforceable, maximum allowable pesticide residue.

12 In EPA usage, "inert" means non-toxic to the target pest, and says nothing about the ingredient's toxicity to people or the environment.

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