Santa Cruz, California • USA

Turning strawberry monocultures into sustainable food and farming systems through a 30-year farmer-researcher partnership.
In the early 1980s, after years of farming with agro-chemicals, Jim Cochran of Swanton Berry Farm in Santa Cruz, California, decided to try farming strawberries organically. At the same time, at the University of California at Santa Cruz (UCSC), agroecologist Steve Gliessman founded the UCSC Agroecology Program with a focus on researching alternative farming systems. The collaborative, multifaceted research project that followed over the next 30 years demonstrated that organic strawberries could be grown successfully, ultimately providing impetus for the strawberry industry to shift a significant portion of its production to organic management.

The transition occurred on the central coast of California, where the Mediterranean climate has made it a key world region for strawberry production. Like in many settings, the region’s conventional strawberry production is highly dependent on expensive, energy-intensive, and environmentally harmful synthetic inputs. In the early 1980s, farmers started responding to rising market interest in organic food, and growing attention to the issues of pesticide safety and environmental protection. Yet the idea of departing from the conventional model was considered radical, and when Cochran and Gliessman teamed up, many people in their immediate environment thought that the research would only show why the conversion would not work, and why it was impossible to grow organic strawberries commercially.

The project was rooted in redesigning strawberry production systems into more sustainable agroecosystems in which fumigation is no longer required. A series of stepwise changes in production practices were introduced, evolving from simple input substitution to comprehensive, system-wide redesign, based around sophisticated crop rotations and ‘push-pull’ pest management techniques. These steps reflected the evolution of the project as a farmer-researcher partnership, with research questions emerging out of the changes on Cochran’s farm.

A series of increasingly ambitious innovations have also occurred on the social front and played an essential role in sustaining and advancing the transition. An alternative direct sales network has emerged around the farm, while an increasing focus on workers’ rights has culminated in Swanton Berry Farm’s attainment of the Food Justice Certification.

With organic now occupying a substantial foothold in the market, the California strawberry industry stands at a crossroads. A national ban on the use of the key fumigant (methyl bromide – MeBr) was originally proposed in 2005, and finally came into effect in 2017. This has stimulated research on alternatives, from organic management systems to other acutely toxic chemicals. Market developments have also proven double-edged. As more growers have learned how to substitute organic for synthetic inputs, competition has increased, and the sector has consolidated into the hands of fewer and larger players, with problematic implications for sustainability.

### Changes in Production Practices

Monterey and Santa Cruz counties account for about half of the total California strawberry crop, producing more than $953 million worth of strawberries on 13,063 acres in 2016 (Monterey County Agricultural Commissioner, 2016; Santa Cruz County Agricultural Commissioner, 2016).

The system of industrial/conventional strawberry production in California can be traced back to the early 1960s, when MeBr was intro-
duced (Wilhelm and Paulus, 1980). Until that time, growers treated strawberries as a perennial crop, with each field requiring rotation out of strawberries for several years. The use of MeBr allowed growers to manage strawberries as an annual crop by planting the berry plants year after year on the same piece of land, removing them at the end of the growing season in late summer or early fall, and then cultivating and fumigating the soil before replanting them for the next season. Intensive systems of drip irrigation, plastic mulch, and soil manipulation were required.

The first efforts at improving input use efficiency and safety on Swanton Berry Farm, carried out before the involvement of the Agroecology Research Group, were focused as much on increasing yields and profitability as on changing the nature of the production system. In parallel, extensive research was being carried out by researchers in the UC Land Grant system (i.e. UC Davis and UC Berkeley) to find more effective ways of controlling common pests (such as the two-spotted spider mite) and diseases that kept evolving resistance to synthetic chemicals, as well as reducing the environmental impacts of those treatments.

It was in this context that researchers at UC Santa Cruz, headed by Steve Gliessman, formed a partnership for organic conversion of strawberry production with Jim Cochran. The farmer-researcher collaboration was underpinned by a clear vision of agroecological transition. The changes implemented on Swanton Berry Farm evolved over time from simple input substitution to more comprehensive and systematic innovations.

In 1987, this partnership became a comparative strawberry conversion research project. For three years, strawberries were grown in plots using conventional inputs and management alongside strawberries grown under organic management. In the organic plots, each

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12. In particular the first three levels of Gliessman’s Five Levels Transition framework (see Annex).
conventional input or practice was substituted with an organic equivalent – for instance, synthetic miticides were replaced with beneficial predator mites, and ideal release rates were established (Gliessman et al., 1996).\textsuperscript{13}

After the three-year comparison study, researchers continued to observe changes and the farmer continued to make adjustments in input uses and practices. Soil-borne diseases producing root rot were particularly problematic, and triggered a number of experimental innovations.\textsuperscript{14}

Even as input substitution approaches were refined, it became clear that the system of monoculture itself was the root cause of some of the most intractable problems. It was at this stage that a whole-system approach was adopted. This meant returning to the crop rotations that had been used before the appearance of MeBr.

The researchers used their knowledge of ecological interactions to redesign the strawberry agroecosystem in a way that nurtured diversity and complexity. Rotations needed to become more effective, and in some cases, shorter (Shennan et al., 2016). And rather than rely on biopesticides, which still had to be purchased outside the system, redesign approaches were focused on incorporating natural control agents into the system and keeping them active on a continuous basis.

For example, mustard cover crops were used to reduce weeds and diseases by releasing toxic natural compounds.\textsuperscript{15} ‘Push-pull’ techniques were also applied, based around the intercropping of alfalfa rows to draw harmful pests away from strawberry plants and facilitate targeted treatments.\textsuperscript{16}

Changes in production practices therefore occurred through a step-by-step process, moving from the substitution of conventional inputs with more efficient and less noxious ones, to substitution with organic inputs and alternative practices such as Anaerobic Soil Disinfestation, and finally to a reorganization of cropping patterns to allow for agroecological push-pull pest management.

\textsuperscript{13} Different miticides for control of the common pest two-spotted spider mite (Tetranychus urticae) were tested with the goal of overcoming the problems of evolving mite resistance to pesticides, negative impacts on non-target organisms, pollution of ground water, persistent residues on harvested berries, and health impacts for farmworkers (Sances et al., 1982). Rather than control the two-spotted spider mite with a miticide, beneficial predator mites (Phytoseiulus persimilis) were released into the organic plots. Over the three-year conversion period, population levels of the two-spot were monitored, releases of the predator carried out, and responses quantified. By the end of the third year of the study, ideal rates and release amounts for the predator—now the norm for the industry—had been worked out (Gliessman et al., 1996).

\textsuperscript{14} Further research to substitute for MeBr fumigation is still underway with a practice called Anaerobic Soil Disinfestation (ASD). This approach incorporates different sources of organic matter, from broccoli crop residue to mustard seed cake, into the soil, floods the soil with water, then covers the soil with an impermeable plastic tarp. The combination of anaerobic conditions and breakdown products of the organic matter fulfil the same function as MeBr, but with materials accepted by organic certification standards (Shennan et al., 2010).

\textsuperscript{15} Mustard cover crops were tested for their ability to allelopathically reduce weeds and diseases through the release of toxic natural compounds. Broccoli has been shown to be very important as a rotation crop since it is not a host for the Verticillium disease organism, and broccoli residues incorporated into the soil release biofumigants that reduce the presence of disease organisms (Muramoto et al., 2014). Other crops that are not hosts for the disease have also been successfully used in rotation with strawberries, such as spinach, peas, and artichokes.

\textsuperscript{16} Because the western tarnished plant bug (Lygus Hesperus) is a generalist pest, it is very difficult to control through input substitution. By replacing every 25th row in a strawberry field with a row of alfalfa (approximately 3% of the field), and then concentrating control strategies on that row (such as vacuuming or biopesticide application), it was possible to reduce Lygus damage to acceptable levels (Swezey et al., 2013). Alfalfa rows have also proved effective as reservoirs of beneficial insects for better natural pest control.
New environmental challenges may need to be addressed in the coming years, as growing conditions across the region are threatened. Soil erosion and nutrient leaching have been observed in large organic strawberry monocultures (Derouin and Hiolski, 2017; RCD Monterey, 2015), while groundwater depletion and saltwater intrusion into aquifers in strawberry growing regions is occurring (Hanson, 2003; Walton, 2015).

**CHANGES IN KNOWLEDGE GENERATION AND DISSEMINATION**

The innovations described above were underpinned by a novel form of farmer-researcher knowledge generation enabled by the UCSC Agroecology Program. From the beginning of the partnership, research questions arose directly from challenges in the field, while the hypotheses, methods, and implementation were established in collaboration.

Knowledge was treated, *de facto*, as something that needed to be regularly adapted to ecological and economic conditions, with the partners taking stock of progress and outstanding problems at the end of the three-year conversion period.

As weeds, pests, beneficial insects, soil organisms, soil chemical and physical conditions changed through the diversification process, it became evident that production systems would need to be further redesigned to include crop rotations and trap crops. This observation came not only from agroecological research, but also from ‘re-learning’ practices (e.g. traditional crop rotations) used before the advent of MeBr.

The dissemination of new knowledge – e.g. on the ideal rates and release amounts of beneficial predator mites, or on intercropping alfalfa as a trap crop for the western tarnished plant bug – occurred both through traditional scientific journals and through informal interactions with other strawberry growers in the region. Following discussions with Cochran and UCSC researchers, and as the commercial viability of organic strawberry farming became apparent (see below), many farmers adopted the input substitution changes pioneered at Swanton Berry Farm.

The emergence of a local market for organic strawberries was also contingent on disseminating knowledge and building relationships with consumers. Visitors to Swanton Berry Farm, including school groups, can now follow a self-guided tour that tells the full story of the strawberries from field to market.

**CHANGES IN SOCIAL AND ECONOMIC RELATIONS**

The new production model described above had to be made economically viable. During the first two years of conversion, non-renewable input costs associated with pesticides, fertilizers, and fuel were lower than for conventional production systems, although the organic system required more hours of mechanical weeding by tractor and longer picking time per unit of production, leading to higher labour costs (Gliessman et al., 1996).

Cochran started selling organic berries at about a 50% price premium to local markets: this price differential permitted a positive profit margin, despite lower production levels. By the third year, leaving the plants in the ground saved approximately $288/acre of cultural labour costs in the conventional production system, and $1,717/acre in the organic system. Mulching the beds with black plastic immediately after pruning eliminated the need to hand weed the organic plots, which accounted for most of the savings. Leaving the plants for a second year also saved money in field ma-
Acreage may tend to be an over-estimate since it may also include fallow or unplanted land set aside for future plantings.
terials and power – approximately $3,648/acre in the conventional system and $3,032/acre in the organic system.

Nonetheless, adaptive strategies were required to maintain economic viability over time. As more – and larger – growers began to implement input substitution practices (see Figure 4), the farm’s normal wholesale outlets became more difficult to maintain.

In response, the farm decided to sell organic strawberries directly to consumers at farmers’ markets in order to capture a larger percentage of the sales price. Additional direct marketing approaches were later adopted, including on-farm U-Pick and a farm stand for fresh strawberries and value-added products like pies and jams.

Through these channels, a committed network of consumers has emerged, made up of customers who know Cochran, know his organic system, and know how his farm values the people who work there and the land they work on.

Meanwhile, students at the UCSC campus convinced the campus dining service managers to begin integrating local, organic, and fair-trade items – including Swanton Berry Farm’s organic strawberries – into the meal service.

The relationship between the farmer and his workers has also changed dramatically over the years. Since organic strawberry production usually requires more labour, issues of worker health, safety, immigration status, and pay equity came to the fore.

In 1998, Swanton Berry Farm was pioneering in its willingness to sign a contract with the United Farm Workers (UFW) union, guaranteeing wage, health, and vacation benefits. Going well beyond the average relationship between growers and workers, the contract was established with a view to allowing workers to see themselves as professionals rather than as ‘cogs’ in a system. In 2014, Swanton Berry Farm was one of the first two farms to achieve the ‘Food Justice Certification’.¹⁷

Over time, the profitability of organic strawberry production has drawn in bigger players such as Driscoll’s, and led to increasing farm size in the area. In 2016, the total farmgate revenue from organic farming in California’s two strawberry-producing central coast counties was more than $480 million (Monterey County Agricultural Commissioner, 2016; Santa Cruz County Agricultural Commissioner, 2016). By 2016, organic-certified acreage was more than eight times higher than in 1997 in these two counties, compared to a threefold nation-wide average increase of organic acres over the same period (USDA, 2018).

Recent ballooning of the organic strawberry supply has led to market saturation and price crashes. These changes have only deepened the incentives for small growers to focus on local and direct marketing strategies, and to diversify their production, as many have been shut out of mainstream markets. As described above, environmental threats are also arising from large-scale strawberry production, and may also threaten yields and profits across the sector in the coming years.

¹⁷. The Food Justice Certification protects workers’ rights under the farm certification (including transparent contract specifications, clear conflict resolution processes, rights to freedom of association and collective bargaining, preference for direct hiring of farm workers, safe and adequate housing, health and safety protections, regular and timely payments, sick leave and parental leave, and compensation sufficient to pay for childcare) and farmers’ rights under the buyer certification (including fair, transparent and equitable negotiations and pricing with minimum price fairness protection, timely payments, profit sharing, long term relationships with farmers, and the prohibition of the termination of contracts without just cause). For more information see: www.agriculturaljusticeproject.org
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FIGURE 5 - ORGANIC STRAWBERRY PRODUCTION IN CALIFORNIA
(Data source: California Department of Food and Agriculture, 2018; California Strawberry Commission, 2018)

CHANGES IN INSTITUTIONAL FRAMEWORK

Funding for the initial three-year conversion project between Swanton Berry Farm and UCSC’s Agroecology Program came from the UC Sustainable Agriculture Research and Education Fund (SAREP). This Fund was established in 1985 under new state legislation, mandating the University of California system to develop a grants program in support of small farm systems and farm labour. Institutional incentives from the state legislation and public education infrastructure therefore opened up space for the intensive co-learning process to evolve.

A second significant change in the institutional conditions was the regulatory ban of MeBr, which reduced farmers’ conventional management options and raised their interest in seeking alternatives. The time that elapsed from the proposal to ban MeBr in 2005 to its implementation in 2017 allowed for substantial experimentation to occur, paving the way for alternative models to be calibrated and substitution costs to fall.

Institutional changes of relevance also occurred in regard to organic certification, with double-edged implications for agroecological innovation. The demand for organic food in the US has steadily risen, alongside formalization of organic certification following the 1990 Organic Food Production Act.

18. The UC Sustainable Agriculture Research and Education Fund (UCSAREP). For more information see: asi.ucdavis.edu/programs/sarep
On the one hand, the rise of the USDA organic label is seen to have improved the quality assurances offered to consumers, protecting them against the (possibly fraudulent) proliferation of private organic labels (Vos, 2000). On the other, authors have argued that certification and labelling has paved the way for the ‘conventionalization’ of organic production and a gradual watering down of standards, with ever more non-organic input substances permitted for organic production (Arcuri, 2014; Guthman, 2004; Jaffee and Howard, 2010).

Given the difficulties smaller growers are now confronting in the face of multinational competitors, it would appear that current institutional frameworks and policies – including the organic certification process – are not doing enough to support those seeking to fundamentally redesign their production systems.

Jim Cochran, farmer and owner of Swanton Berry farm, openly provided information on his farm and reviewed an early draft of this case study. Steve Gliessman was his research partner while on the faculty at UCSC’s Department of Environmental Studies where he began the UCSC Agroecology Program. Joji Muramoto, a researcher in agroecology at UCSC, provided much of the recent data on strawberry production in California and information on new lines of research, some of which is being carried out in partnership with Jim Cochran.