

The Future of Agricultural Work in Santa Cruz County and Implications for Employee Training and Development*

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Executive Summary: The Future of Agricultural Work in Santa Cruz County and Implications for Employee Training and Development

Agriculture in Santa Cruz County is highly labor intensive. Continued economic contributions of agriculture to the county economy depends on productivity of agricultural labor. Likewise, continued employment of thousands of Santa Cruz County residents depends on an economically successful agriculture.

Local agriculture is tailored to the climate, topography and nearby markets in the Central Coast of California. Santa Cruz County has long had a vibrant agricultural economy comprised primarily of berries, fresh vegetables, nursery crops, tree fruit and winegrapes. All these crops use substantial labor per acre of land and per dollar of output value. The nature of agriculture in the county has been steady and since 1988 fruit, vegetable and nursery crops accounted for about 97% of the value of farm output in the county.

The Santa Cruz County value of farm output in 2018 was \$683 million. In the 2017-2018 period berry production accounted for about 64% and strawberries alone accounted for one-third of farm value of production. Santa Cruz County grows a great variety of fresh vegetables, including Brussels sprouts, lettuce and many more. The value of vegetable production is up more than 20 percent since 2007-08 to 15% of county farm production value, about equal to nursery crops, which declined over this period.

Agriculture is an important part of the overall Santa Cruz County economy and is linked to the other industries through inputs that farms and other agricultural firms buy from the rest of the economy and through purchases of local goods and services by farmers and hired workers. Overall, agriculture contributes about 17,500 jobs to the Santa Cruz County economy when we include the impacts of agricultural production, processing and support activities.

Farm workers often have several jobs for several farm employers throughout the year. However, in 2016, about 62% of workers on strawberry farms had a single employer, compared to 59% of workers on vegetable and melon farms, and 53% of workers on other berry farms. These workers tend to work fewer than 2000 hours per year in agriculture, even though farm work is their primary occupation. Most farm wages are relatively low, but are higher than

average in Santa Cruz County and grew rapidly from 2016 through 2019. Higher wages reflect the higher cost of living in coastal California and higher productivity of workers.

Most hired farm workers are immigrants, about half with a lack of legal status for employment in the United States. They tend to speak Spanish and have relatively few years of formal schooling. Santa Cruz County farm workers are seldom migrants and most work on farms with 10 or more employees. Others, less than 10% in Santa Cruz County, work for farm labor contractors.

Labor-saving technologies and practices include reduced bending for harvesters of strawberries, high yield three-season practices for raspberries and blackberries, field packing, and electronic scanners that trace produce to individual harvesters and provide worker incentives. Robotic carts as harvest assistants, developed at UC Davis, have been used in fields in experimental trials but are not yet in commercial use. They are relatively cheap, sturdy, durable, and reliable. Our preliminary economic analysis indicates that a 25-person crew could increase harvest quantity amount by about 20%, with an added cost of only about 10% or less. Thus, this technology seems promising on economic grounds.

Two important challenges for “replacement” of harvest workers are (a) technology must “see” which of the produce are ripe and (b) technology must delicately “pick” the ripe fruit product without damaging the harvested produce, while leaving unripe produce undisturbed. Such machines have been developed, but their economic feasibility in the field has not been publicly documented.

For the next few years, despite the Covid-19 pandemic and the economic turmoil, agriculture in Santa Cruz County is likely to remain on its path of increased productivity and growth. Year-to-year flux is part of agriculture, but the resilience of the local industry has been well demonstrated.

For farm employee development and training, the key lesson seems to be the value to workers and employers of practical basic skills of literacy and numeracy. That is, as work becomes more complex, workers need to be able to keep up with demands to gather information, make calculations and generally keep up. As to specific skills, those are not yet determined.

1. Introduction

Santa Cruz County, California has long had a vibrant agricultural economy comprised primarily of berries, fresh vegetables, nursery crops, tree fruit and winegrapes. Agriculture in Santa Cruz County is highly labor intensive per acre of land and per dollar of output value. Continued economic contributions of agriculture to the county economy depends on productivity of agricultural labor. Likewise, continued employment of thousands of Santa Cruz County residents depends on an economically successful agriculture.

This report looks to the future for agriculture in Santa Cruz while rooted in the recent agricultural history and current situation. There are many drivers of change in labor intensive crop agriculture in the central coast of California. These include demand-side forces affecting what customers want and are willing to pay for. At the same time, supply-side forces affect costs of production and opportunities presented by innovations, including those in management and crop farm practice and technology can reduce costs. Technological advances in particular have garnered much attention in recent years.

This report describes and measures the role of agricultural production and processing in the economy of Santa Cruz County and surrounding areas. The descriptions and measurements establish a factual baseline to help understand and project how innovations in farming, processing and distribution are likely to affect employment and other economic contributions of agriculture in Santa Cruz County. A main objective is to help identify future workforce needs and solutions, given that enhanced productivity is required to allow wage rates to rise, and industries to thrive and continue to provide employment.

This report provides information on the following specific topics:

- (a) Direct and indirect economic impacts, recent trends, current situation and outlook;
- (b) Analysis of the current labor supply situation for Santa Cruz County agriculture;

(c) Descriptions of how technology and other potential disruptors in agriculture are likely to affect the nature of work;

(d) Analysis of how innovations in technology and practices are affecting Santa Cruz County agriculture, including future innovations in the application of information technology and engineering information agriculture;

(e) Description of challenges and opportunities affecting agriculture and the agricultural labor force, including water and resource availability, other local farm supply challenges, and labor supply availability;

(f) Projection forward of Santa Cruz County agriculture for the next few years, recognizing the unique situation of the Spring of 2020, that discusses key trends and drivers;

(g) Based on the foregoing analysis and factual basis, a description of potential opportunities for useful workforce development contributions, including skill development and training.

In short, the rest of this report responds to three questions:

1. What is the nature of agriculture and agricultural work in Santa Cruz County?

We explore how the recent history and current situation informs what we expect next. Local agriculture is tailored to the climate, topography and nearby markets in the Central Coast of California.

2. How is the quantity and nature of agriculture work likely to evolve over the next decade?

A transformation is building, but will evolve from the current situation and must maintain the County's comparative advantage. Key issues are the nature and pace of technological developments.

3. What can workforce development contribute to helping the community and industry access the appropriately trained workforce to contribute to enhanced productivity in the evolving markets?

The availability of affordable labor is central for maintaining the key crops most suitable to Santa Cruz County. Enhanced productivity is required to maintain Santa Cruz County

agriculture and demand for its labor-intensive agricultural products as wages rise; that means investments in human capital and complementary innovations.

2. Overview of Santa Cruz County Labor Intensive Agriculture

Labor intensive crop production has long comprised the large majority of farm value produced in Santa Cruz County. For example, in all three years, 1988, 2008 and 2018, fruit, vegetable and nursery crops accounted for about 97% of the value of farm output in the county (SCC Crop Reports). Field crops, pastureland with livestock and forestry cover a substantial part of the agricultural area, but account for only about 3% of the value of output. We do not include a summary of Santa Cruz County cannabis production in this report because data are not yet available. For a statewide perspective, with tentative projections and a discussion of issues see Sumner et al. 2020.

Agricultural production values vary from year to year due to prices, areas and output per area, which are driven by weather, demand conditions and other natural and market forces. Santa Cruz County value of farm output in 2018 was \$683 million. The 2018 value represented a return to the trend, compared with \$581 million in 2017, which was the lowest value since 2012 and 9% below the \$637 million in 2016.

Berry production, (strawberries, raspberries and blackberries) is most important by value of production, representing about 64% of Santa Cruz County agricultural value. For this reason, the berry industry will be a focus of attention in this report. Acreage, output per acre and price per ton of output all vary from year to year as weather and market conditions vary. None the less, the berry industry has maintained its importance in Santa Cruz County for many years as yields have grown and prices have remained strong.

Table 1 summarizes data from the Santa Cruz Country Crop Reports that are assembled each year by the Commissioner of Agriculture. Table 1 shows acreage, production and value of output for each main berry type and for total berries for the average of years 2007-2008 and years 2017-2018. Value of production is reported in terms of 2018 dollar values with earlier year prices deflated by a broad-based inflation measure—the GDP deflator.

At \$218 million, Strawberries accounted for just over half of berry value of output in the 2017-18 period and about one-third of all the value of farm output of Santa Cruz County. Strawberry acreage declined between the two periods by more than one-quarter from about 3,500 acres to about 2,600 acres. But annual production per acre rose by a greater percentage, such that total strawberry output increased by about 8%. The slightly lower prices in the later period (adjusted for inflation) caused value of strawberry output to rise by only 3.5%.

Table 1 shows that raspberry acreage, production and value of production grew substantially from 2007-08 to 2017-18, with value of output rising by about 36% despite a 10% lower price in the later period. There is evidence that the lower market price of raspberries has allowed the raspberry market to grow. With an average production value of \$141 million in 2017-18, raspberries alone represented about 22% of Santa Cruz County farm value of production.

Blackberry production has expanded by one third in acreage, risen by 138% in production per acre and grown by almost 130% in terms of value of output in the decade to 2017-2018. In 2007-08 a very small amount of other berries were included with blackberries in the Crop Report category. But in 2017-18 period, the category was reported as blackberries alone. Blackberries have grown to about 8% of Santa Cruz County value of farm output. This is larger than any other specific crop in the county, other than strawberries and raspberries.

Total berry acreage decreased by 6%, but value of production rose by 21% between 2007-08 to 2017-18. Output per acre rose substantially while market prices fell. The 2017 Census of Agriculture reported 96 berry farms and 7,415 acres of berries (USDA, NASS, 2017). The Santa Cruz County berry success story is a part of the broader pattern in the south and central coast region of California (Goodhue and Martin, 2020b). Santa Cruz County berry value of production was \$407 million on just 5,709 acres. These data imply that the Santa Cruz County industry generated gross revenue of more than \$70,000 per acre. The recent pattern is consistent with the data summarized in Tourte, Bolda and Klonsky (2016), where they review how the industry was evolving through 2016.

Table 2 shows the patterns of tree fruit and winegrape production. Tree and vine fruit acreage decreased by 9% percent, but total value of production rose by 60% increase from 2007-08 to

2017-18. Apples had a 73% increase in value of production and wine grapes a 25% increase in value of production. Total production value was \$24 million on 2,924 acres for about \$8,200 per acre in revenue.

Santa Cruz County grows a great variety of fresh vegetables, including Brussels sprouts, lettuce and many more. Table 3 shows that vegetable acreage is down a bit over the past decade, but inflation adjusted value of production is up more than 20 percent since 2007-08. Lettuce acreage has grown slightly, while value of production has almost doubled to \$27 million. Overall the vegetable production value of \$93 million represents about 15% of Santa Cruz County value of farm production (Table 3). The fresh vegetable produce industry is important throughout the Central Coast of California and has remained a vibrant and productive industry (Goodhue and Martin, 2020a). With 7,344 acres, vegetables generate production value of about \$12,700 per acre in Santa Cruz County.

Nursery crop production value declined substantially from 2007-08 to 2017-18 to \$97 million using 767 acres. Table 4 shows that the decline in value was most prominent in cut flower and cut greens from \$64 million to \$34 million. Cut flowers and cut greens acreage fell by 32% and production value fell by 46%. Nursery stock acreage fell by 32 percent, but production value fell by only 6%. Overall the farm value of nursery crop production fell by about 37%. For the 2017-2018 years, the average revenue for nursey crops was \$121,000 per acre. Despite the reduction in farm value associated especially with cut flowers and cut greens, nursery crops continue to produce about one-quarter of farm value in Santa Cruz County. Carmen (2020) documents similar declines of segments of the nursery crop industry in California more generally and discussed challenges of higher energy costs and global competition for cut flowers among other crops.

All the main crops important in Santa Cruz County are labor intensive. They generate high value per acre because they use substantial labor per acre and the farm labor share of farm cost is high as well. The next section explores costs of production for some of these crops.

Table 1. Patterns of Santa Cruz County Berry Production

Berry Crops	2007-2008	2017-2018
Strawberries		
Acres	3,483	2,590
Production (tons)	109,362	118,430
Total value (\$2018)	\$211 million	\$218 million
Raspberries		
Acres	1,958	2,275
Production (tons)	16,501	19,965
Total value (\$2018)	\$104 million	\$141 million
Misc. Berries (Blackberries)		
Acres	662	844
Production (tons)	3,267	7,761
Total value (\$2018)	\$21 million	\$48 million
Total Berries		
Acres	6,102	5,709
Total value (\$2018)	\$337 million	\$407 million

Source: Santa Cruz County Commissioner of Agriculture. (2008). *2008 Crop Report. 2018 Crop Report.*

Table 2. Patterns of Santa Cruz County Tree Fruit and Winegrape Production

Fruit crops	2007-2008	2007-2018
Apples		
Acres	2,317	2,027
Production (tons)	40,528	52,732
Total value (\$2018)	\$11 million	\$19 million
Wine Grapes		
Acres	605	634
Production (tons per acre)	1,228	1,466
Total value (\$2018)	\$4 million	\$5 million
Total Apple, Wine Grapes, and Misc. Fruit		
Acres	3,216	2,924
Total value (\$2018)	\$15 million	\$24 million

Source: Santa Cruz County Commissioner of Agriculture. (2008). *2008 Crop Report. 2018 Crop Report.*

Table 3. Patterns of Santa Cruz County Vegetable Crop Production

Vegetable Crops	2007-2008	2017-2018
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Brussels Sprouts		
Acres	1,234	1,079
Total value (\$2018)	\$9 million	\$16 million
Lettuce		
Acres	3,186	3,251
Total value (\$2018)	\$14 million	\$27 million
Miscellaneous Vegetables*		
Acres	3,354	3,015
Total value (\$2018)	\$56 million	\$50 million
Total Vegetables		
Acres	7,630	7,344
Total value (\$2018)	\$76 million	\$93 million

* Miscellaneous Vegetables includes artichokes, beans, beets, broccoli, cabbage, cauliflower, celery, chicory, collards, cucumbers, herbs, kale, leeks, mushrooms, mustard, peas, pumpkins, radicchio, spinach, squash, vegetable seed, and other vegetables.

Source: Santa Cruz County Commissioner of Agriculture. (2008). *2008 Crop Report. 2018 Crop Report.*

Table 4. Patterns of Santa Cruz County Nursery Crop Production

Nursery Crops	2007-2008	2017-2018
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Cut Flowers & Cut Greens		
Acres	468	317
Total value (\$2018)	\$64 million	\$34 million
Nursery stock		
Acres	664	451
Total value (\$2018)	\$69 million	\$65 million
Total Nursery		
Acres	1,132	767
Total value (\$2018)	\$133 million	\$99 million

Source: Santa Cruz County Commissioner of Agriculture. (2008). *2008 Crop Report. 2018 Crop Report.*

3. Farm Costs and Returns for Major Crops in Santa Cruz County

The University of California has prepared sample costs and returns for a variety of California crops for many years. These sample costs apply to a typical farm of the specifications detailed in each study for crops that are important in each part of the state. The series of cost studies include many recent studies that assess costs and returns for typical operations growing the major crops in Santa Cruz County.

In recent years, the University has generated studies of strawberries, raspberries, blackberries, and organic strawberries (Bolda et al. 2016, 2017, 2018, and 2019). These berry studies document two important points. First, the net revenue of berry operations depends crucially on operational efficiency and market prices. Some seasons and years may be profitable and others not. Each of the studies applies to a specific crop and set of practices, say organic strawberries in the central coast, and to a specific year and thus an expected price. In some cases, the studies show a positive net return to invested capital and management. In other cases, they show a negative return. As the studies stress, the costs and return are considered typical, but every operation is different.

Second, whereas investment in equipment, capital in fields, such as irrigation systems, and farm input materials are expensive, by far the largest input cost for berry farm operations is hired labor. Moreover, the bulk of the hired labor cost is for harvest. Harvest costs account for the majority of all costs. Hired labor is more important than all the other cultural production costs, cash overhead and costs for land rent and capital costs put together. And, although supplies, cooling and equipment for harvest are expensive, by far the largest harvest cost is hired labor. For strawberries, for example, harvest costs are 70% of annual costs and hired labor is about 70% of harvest costs (Bolda et al. 2016 and 2019). Multiplying these shares indicates that hired harvest labor represents half of all costs of production for strawberries in the University of California cost studies. Moreover, since hired labor is also a large share of the other costs, overall, hired labor represents about 60% of all costs.

The berry labor use implications of these costs studies may be summarized briefly. For organic strawberries in 2019, operating labor use is about 460 hours per acre. Harvest uses about 1700

hours of labor per acre for a total of about 2,160 per acre. Raspberries and blackberries have higher revenue per acre and proportionally higher labor use per acre. The modern production method spreads costs and output over three seasons, which makes summarizing the labor data more complex. Nonetheless, we estimate that, in total, raspberries use almost 3,000 hours per acre, including growing operations and harvest. Unlike many crops that are harvested once or perhaps twice per year, berry harvest continues every few days throughout the season. That also means that berry workers often have a much more steady employment than many other farm workers.

The vegetable costs studies (Tourte et al. 2015, 2017a, 2017b, 2019) each document a different specific situation, but with a consistent methodology and similar approach. For example, the 2019 study for organic romaine lettuce hearts indicates revenue of \$11,250 per acre for the median price and yield assumptions. In that study, operating costs are about \$11,500 per acre with \$826 per acre in production labor and about \$5,400 in harvest labor cost per acre. Total cost including overhead is \$13,864 per acre, which implies a substantial loss at the assumed prices, crop yields and costs.

The iceberg lettuce study (2017) has lower costs of \$12,400 per acre, of which about \$2,450 is overhead costs, about \$3,000 per acre is cultural costs and about \$7,000 per acre is harvest costs. Overall labor costs are about \$6,000 per acre about 90% of which is harvest costs. At a price of \$13/carton, for 900 cartons per acre, this example also has a net loss.

Broccoli costs in the 2017 study resemble the iceberg lettuce cost pattern. Harvest costs are more than half the total, and most of the harvest costs are for hired labor. For 2017 prices and assumed yields the grower returns were negative and losses ranged across most of the assumed prices and yields that were likely for 2017.

We estimate from the lettuce studies that cultural labor use is about 40 hours per acre and harvest labor is about 250 hours per acre based on \$5,000 at about \$20 per hour in labor cost for harvesting operations.

The organic spinach study (2015) has much lower reported cultural costs overall and much smaller harvest costs than the organic lettuce romaine lettuce crop. For lettuce, total operating

costs are \$5,682 per acre with \$722 per acre of labor expenses. Harvest cost is \$1,300 per acre and only about half of that is assumed to be labor. Total cost per acre is \$7,131 and total revenue assumed at median prices and yields is \$6,500 per acre. At median assume prices of \$1.00 per pound, positive profits require lower than assumed costs or higher than assumed yield per acre.

Finally, the 2014 cost study for organic processing apples in Santa Cruz Country represents an orchard with 20 acres of mature apple trees. Total cost per acre is about \$4,700, about \$1,500 of which is cash overhead and amortized capital costs. Labor costs are about \$1,273 for cultural activity. Harvest is \$900 per acre, most of which is for labor. The amount of labor is about 150 hours per acre, including harvest. Under the assumed prices and yields, the orchard returns a small positive net revenue of about \$184 per acre.

These cost studies illustrate the challenges all crops face in generating farm profits. In general farms need to do better than the typical costs per acre in the cost studies to generate positive profits. The cost studies also illustrate the importance of hired labor in all the major crops in Santa Cruz County.

4. Economywide Relationships of Agriculture and Agricultural Employment in Santa Cruz County

Farm production links to the rest of the economy through a range of market relationships whereby farm industries buy inputs from other, mostly non-farm, industries and sell to other industries. In addition, farmers and workers participate in the local economy as consumers and their earnings are spent on local goods and services. The IMPLAN data set and input-output model provides information about those linkages. Table 5 shows the direct output, value added and employment data. In the IMPLAN data “output” is measured by revenue. Farming had revenue of about \$700 million in 2017, \$462 million in fruit (mostly berries according to the more detailed and specific county data). Processing, which includes packaging, cooling and transport, is a \$1.1 billion industry so total agriculture is about \$1.8 billion in Santa Cruz County. Value added is the contributions of the labor, management and capital in an industry. This is the contribution to gross state product. Employment is all jobs including part-time jobs,

with no attempt to determine full time equivalents. Farming has almost 8,200 jobs plus the 1,016 jobs added in agricultural support. Notice that 62% of employment is in the fruit industry, almost all in the berry industry of Santa Cruz County.

Table 6 broadens the outlook to consider the contributions of agriculture to the broader Santa Cruz County economy. The total economic effects include indirect impacts that ripple out from purchases by agriculture from other sectors. In addition, total economic effects include the ripples from consumer purchases made by business owners and employees in agriculture. These impacts show how output value-added and jobs in agriculture ripple through the local economy. Overall, agriculture contributes about 17,500 jobs when we include the impacts of agricultural production, processing and support activities.

Table 5. Direct Economic Effects of Santa Cruz County’s Agricultural Production and Processing, 2018¹

	<u>Direct Effects</u>			<u>Shares of Total Agriculture Production and Processing</u>		
	Industry Output ²	Value Added ³	Employment ⁴	Output	Value Added	Employment
	Million		Jobs	Share		
Ag Production and Processing	\$1,786	\$644	11,088	1.00	1.00	1.00
Agricultural Processing ⁵	\$1,091	\$260	2,928	0.61	0.40	0.26
Farming	\$695	\$383	8,160	0.39	0.60	0.74
Fruit Farming	\$462	\$255	6,920	0.26	0.40	0.62
Greenhouse and Nursery	\$110	\$61	485	0.06	0.10	0.04
Vegetable and Melon Farming	\$92	\$53	697	0.05	0.08	0.06
All Other Agriculture	\$30	\$14	57	0.02	0.02	0.01
Ag-Support Activities ⁶	\$64	\$60	1,016			

Source: IMPLAN Model and Data.

¹ Direct effects from farming industry sectors are estimated by applying IMPLAN 2017 multipliers to 2018 output figures reported in Santa Cruz County Agricultural Commissioner’s Report. Agricultural processing and agricultural support activity figures come directly from IMPLAN dataset.

² Industry output: value of production (i.e. total sales) of the named industry.

³ Value added equals the sum of labor income, proprietary income and indirect business taxes. This is equivalent to total sales (industry output) less purchased inputs and services.

⁴ Employment: number of jobs directly employed by the corresponding industry.

⁵ This group includes animal feed, food and beverage industries.

⁶ Agricultural support activities include contract labor, fertilizer and pesticide manufacturing, soil preparation and harvesting services, packing and cooling, and animal production services.

Table 6. Total Economic Effects of Santa Cruz County’s Agricultural Production and Processing, 2018^{1,2}

	Industry Output³	Value Added⁴	Implied Economywide Employment⁵
	\$million		Jobs
Ag Production and Proc.	\$2,668	\$1,177	16,159
Agricultural Processing ⁶	\$1,595	\$552	6,384
Farming	\$1,073	\$625	9,775
Fruit Farming	\$722	\$424	7,833
Greenhouse and Nursery	\$169	\$98	998
Vegetable and Melon Farming	\$138	\$82	784
All Other Agriculture	\$45	\$22	159
Ag-Support Activities ⁷	\$101	\$83	1,282

Source: IMPLAN Model and Data.

¹ Total effects from farming industry sectors are is estimated by applying IMPLAN 2017 multipliers to 2018 output figures reported in Santa Cruz County Agricultural Commissioner’s Report. Agricultural processing and agricultural support activity figures come directly from IMPLAN dataset.

² Total effects are the summation of direct, indirect and induced effects stemming from economic activity within the listed agricultural sectors.

³ Industry output: value of production (i.e. total sales) of the named industry.

⁴ Value added equals the sum of labor income, proprietary income and indirect business taxes. This is equivalent to total sales (industry output) less purchased inputs and services.

⁵ Employment: number of jobs directly employed by the corresponding industry.

⁶ This group includes animal feed, food and beverage industries.

⁷ Agricultural support activities include contract labor, fertilizer and pesticide manufacturing, soil preparation and harvesting services, packing and cooling, and animal production services.

5. Agricultural Labor Market Conditions, Employment, Wages and Worker Characteristics

Most California hired farm workers do not work full time, but earn their primary income from farm work (Martin 2020). Many farm workers, about 40% on average, have more than one employer, but in many cases the single employer is a farm labor contractor (FLC) and the employee works on, but is not employed by, more than one farm. Many workers who have more than one employer are employed part of the year by FLCs and part of the year by one or more individual farms. In 2016, about 62% of workers on strawberry farms had a single employer, compared to 59% of workers on vegetable and melon farms, and 53% of workers on other berry farms (Martin, Hooker and Stockton, 2019). Given the intermittent nature of the work, which would seem to encourage filing for unemployment benefits, relatively few farm workers receive unemployment insurance benefits, perhaps because of immigration status or other eligibility concerns. The share of workers receiving unemployment benefits in 2016 by crop activity was: 33% vegetable and melon, 28% harvesting, 23% berry (except strawberries), 19% FLC, and 15% strawberries (Martin, Hooker and Stockton, 2019).

The 2017 Census of Agriculture reports 320 farms in Santa Cruz County with hired farm labor (USDA, NASS, 2017). Of these farms, 115 farms, about 30%, hire 10 or more workers. The farms hiring 10 or more workers hire 96% of the workers, which is more than 15,000 workers. The California Employment Development Department (EDD) reported 16,400 workers with at least one farm job in Santa Cruz County in 2016 (Martin, Hooker and Stockton, 2019). The Census also reports that 57% of the farms with 10 or more workers, employ workers 150 days or more per year. A slightly different measure is that, for those workers employed on farms with 10 or more workers, 72% are employed for 150 days or more per year. The Census also reports that relatively few farms (less than 5%) report using labor that is migrant in the sense that their employment causes them to spend the night away from home.

Hired farm work in Santa Cruz County follows the pattern of berry, vegetable and nursery crop workers in California more generally. Most workers are immigrants, about half have problems with immigration documentation, most speak Spanish as their native language, many have relatively little English literacy, have less than a high school education, and most are relatively

young. The average age has been rising and agricultural employment tenure has risen as replacement immigration has slowed over the past 15 years or so (Martin 2020). Many farm workers leave the industry when they have opportunities in other industries with higher wages, more regular employment throughout the year, or what they consider more favorable working conditions. In the past few years, before the Covid-19 pandemic, wage rates rose and unemployment declined for non-farm jobs. That caused farm wages to rise and farms attempted to improve the attractiveness of farm employment to retain workers (Martin, 2020).

Wage rates were rising in Santa Cruz County agriculture in recent years, mainly reflecting competitive conditions and the demand for labor. At the same time, California has been implementing increases in minimum wages and mandatory overtime wages for farm workers at lower hours per day and per week than had prevailed. The minimum wage increases may have some impact in relatively low wage counties but, given higher prevailing wages the state increase in the minimum wage to \$15 per hour is likely to have a relatively minor impact in Santa Cruz County and the surrounding area. Higher wages reflect the higher cost of living in coastal California and the demand for workers in places where the climate allows production of berries, fresh vegetables and nursery crops.

Several other strategies are being applied to meeting the derived demand for farm labor as demand for fruit and vegetable products have risen. First, farms have attempted to raise worker productivity by creating incentives for more output. Carefully designed piece rate wage arrangements can be a part of this strategy, as can providing safe and healthy working conditions. For example, encouraging exercise and stretching can reduce absenteeism. Second, investing more in biological or physical capital can also allow more output per input of labor. Planting berries with higher planting beds relative to the rows between the plants allows harvest with less bending. Harvesting aids for moving down the row can allow less walking and carrying for the harvest worker.

Two other strategies result in replacement of local farm workers. One is the use of immigrant guest workers who are only temporary residents in the community and who return to their home in Mexico or another country at the end of each employment season. The H-2A program has generally been too cumbersome, expensive and complicated to apply much in California,

but its use grew from 2015 to 2019. The other replacement strategy is to apply machines not just to make workers more productive, but to replace many or most hired farm workers. Machine harvesting is standard practice for most crops, such as grain or hay, that was harvested by hand a century ago, but for which very little hired labor has been used in recent decades. Berries and vegetables are much more complex in applying mechanical harvest or other operations.

Of course, such machine harvesting is possible, but remains cost prohibitive. The next section considers progress and future application of mechanical operations that may replace many farm workers or enhance productivity such that few workers are used for berries, vegetables and nursery crops.

6. Farm Practices and Technology to Reduce the Amount of Farm labor and Affect Characteristics of Farm Workers

The previous sections have documented the high use of farm labor per acre and per dollar of farm output in Santa Cruz County. High wage rates and high cost of living for workers also encourage development of innovations that increase worker productivity. Clearly, if the cost of labor exceeds the revenue that can be derived from the work, less labor will be demanded by employers.

The labor-saving technologies and practices that have gained ground in the last decade mainly deal with innovation on the farm. These include reduced bending for harvesters of strawberries and high-yield three-season cropping practices for raspberries and blackberries (Bolda et al, 2018). Older innovations include field packing and using electronic scanners to trace harvested produce to individual workers and rows, and use of technology to provide worker incentives. These all encourage productivity and have allowed berry production to expand while berry prices have declined in inflation adjusted terms.

One intermediate alternative relates to a robotic harvest assistant developed at UC Davis, used in fields in experimental trials, but not yet in commercial use. The innovations in engineering are described in several technical publications (Khosro, Vougioukas, and Slaughter (2018); Khosro and Vougioukas, 2019; Seyyedhasani et al. 2020a and 2020b). This innovation uses

sophisticated algorithms on a computer guided small cart that moves from worker to worker, transporting berries from the picker to the loading wagon.

The computerized robotic cart works with a central computer and sensors in the workers' personal carts. This system allows approximately one relatively cheap robot to service five workers. A typical crew of 25 workers would be supplemented by one robot operator and five robots. We conducted economic calculations based on current estimates of wage rates, robot costs, technician wages and maintenance costs. Our preliminary economic analysis indicates that the crew could increase harvesting amount by about 20% for an added cost of only about 10% or less. Thus, depending on competing technology or future expectations, robotics such as that described would be a strong candidate for adoption in the berry industry.

A benefit of this sort of technology is that it may be operated by a technician with modest training. Also, it accomplishes tasks that do not require visual sensors or delicate robot "fingers." The robotic carts can be cheap, sturdy, durable and reliable. Thus, this intermediate kind of robotic technology may be applied sooner rather than later and may allow hired farm workers to be more productive which allows wages to rise while overall costs of production declines. The result is more acreage and more employment rather than the replacement of workers.

Carlton et al. (2019a and 2019b) explore whether productivity can be enhanced rapidly enough to allow California production of labor-intensive crops to compete with places that have lower wage rates. A similar kind of competition is to compete in consumer demand with fruit and vegetable crops that are less labor intensive. For example, machine harvested crops such as tree nuts, prunes, dried peas and beans, potatoes and sweet potatoes and others have faced modest cost increases. None of those compete effectively with berries and fresh produce, but high labor costs could cause the market price of these crops to become out of reach for many consumers.

Looking a bit further into the future is important to consider the magnitude and characteristics of the farm labor workforce for berries, fresh vegetable and nursery crops. More sophisticated technology for the harvest of berries and other delicate crops has been under development for decades. Recent progress has followed substantial progress in the underlying science and

engineering models. Two important challenges are the obvious ones. First, the technology must “see” which of the products are ripe and ready to be picked while leaving the other unripe products undisturbed. That is, technology must replicate the function of the human eyes to rapidly evaluate and select. Second, technology must “pick” the ripe product from the living plant without damaging the harvested product and leaving other products on the plant undisturbed.

Several systems have garnered substantial publicity, but how close they are to commercial viability that makes large and expensive machines profitable is less clear. One prominent exposition in the popular press by Seabrook (2019) describes demonstrations of equipment and quotes researchers as well. That article interviews UC Davis agricultural engineers David Slaughter and Stavous Vougioukas, who makes the point that within fruits and vegetables, strawberries and leafy greens are among the few industries with scale to support needed research and development to create specialized technology.

Paul Nolan of Driscoll’s raised the important issue that “...it’s not going to be as simple as just the robotics, let’s say, for harvest. It’s a combination of the robotics and the growing system and actually the genetics too. In that combination of all three is where you’ll really see the success.” (Quoted in Cosgrove, 2018). This issue of co-innovations in the biology and technology date from decades or centuries ago. It applies to short stature trees that can be grown in hedgerows for mechanical pruning and harvesting and processing tomatoes that ripen at one time to facilitate one pass through the field for mechanical harvesters. The same relationships between biological technology and mechanical or information engineering apply to berries and fresh vegetables.

Advances in information technology that allow robot assisted movement of fruit in a berry field also allow autonomous movement of farm equipment for cultivation, weeding and other operations. Much progress has been achieved in this as well as in other precision information about productivity of specific positions in the field to better irrigate or apply production materials (Cafiero, 2020). However, little of that technology seems particularly applicable to produce vegetables or berries, where such information is now gathered during the process of

hand harvesting. GPS technology attached to worker carts allow specific traceability and, as noted above is used in worker renumeration.

Additional relevant technologies are being developed for berry operations. These technologies use only a few highly trained machine technicians who work with complex and expensive machines that move through the field, greenhouse or indoor facility. The equipment has both sensors for color (say red to ripe raspberries or strawberries) and rapidly moving, yet delicate, robot fingers that harvest fruit one-by-one. Lessing (2020) describes the elements required for success of such equipment. He recognizes as crucial reliability, durability and ability to adapt to field conditions. Leclerc (2020) describes what is needed for investors to supply the capital needed for the further development to make such equipment practical and competitive with human harvesters. Such equipment is currently operational (Strawberryplants.org, 2020) and videos show the impressive technology. Commercial farms are among those investing in such development activities, but it remains unclear when or if use in the field will become widespread. We have not seen independent and objective economic evaluation of the technologies.

One alternative to maintain farm employment while farm wages rise would be an initiative to market crops on the basis of the treatment of hired farm workers, including wages, benefits and working conditions. A kind of “fair trade” certification and labeling arrangement might allow consumers to pay more for products that guaranteed higher wages and benefits for hired farm workers. So, for example, lettuce that was labeled as guaranteeing \$25/hour for workers may cost 10% or 20% more than other lettuce, much like organic produce is more expensive. It is unclear the market potential for such arrangements.

Indoor and greenhouse farming, by allowing for standard clean conditions is more readily suited for robotic harvesting technologies and cultivation activities using less human labor. Indoor and mixed light farming is suitable for places with low-cost electricity and relatively low-cost warehouse space. Since the outdoor climate is less important the major advantage of Santa Cruz County would be of limited value. Because of high costs building rental and high cost energy indoor production of berries and produce would likely migrate. At the same time Santa Cruz County maintains a viable, if gradually declining nursery crop industry much of

which is pursued in greenhouses, so if that format were favored Santa Cruz County may be more competitive.

7. Projection of Santa Cruz County Agriculture Over the Next Few Years

The Covid-19 pandemic of 2020 and the lockdown of the economy in many places of the world reinforces just how difficult it is to predict market conditions and economic situations reliably. That said, current estimates are that the berry and produce industries have been resilient to the economic shock, while the cut flower industry has faced one more damaging event that reduced demand substantially.

On the supply side, the Covid-19 pandemic and the economic shutdown has had relatively little impact. Farm labor has been available, farm supplies are distributed and the weather has cooperated so far in 2020. On the demand side there was initial disruption by the abrupt government policy to close most food service establishments. However, demand for meals at home rose and demand for fresh vegetables and berries has grown to compensate for much of the loss of food service. Concern about worker safety has encouraged more costly measures to keep workers healthy. The industry now faces disruption and uncertainty in the other direction, with movements to open food service. The uncertainty about business opening is a large impediment for all parts of the food industry including the produce business. Moreover, with a severe recession and high unemployment that seems likely to last for more than a year, the demand for produce including berries, fresh vegetables and nursery crops are all vulnerable.

From early March through late June, strawberry price averages are in a similar range as recent years, while raspberry and blackberry prices have been mostly lower than the range of 2017-2019. Projecting the rest of this year and into next year depends on how quickly the recession ends and how rapidly employment grows. The best estimate is for reduced demand and hence lower prices and maybe reduced production. Labor supply to agriculture is likely to be closer to adequate as hiring in other industries remains slow.

The bottom line for this next 12 months is normal supply, lower consumer incomes but much uncertainty about consumer food consumption patterns and if and when they will return to

“normal.” There is no reason to see the Santa Cruz County crop mix shift, except perhaps to more strawberries, if demand holds up better than for the other berries. If fresh vegetable demand continues to be strong we may see additional acreage and production of those crops. Nonetheless, the most likely case for Santa Cruz County agriculture is little change.

Over the next few years, we see a gradual return to a new “normal”, but increased uncertainty. Some analysts expect more pressure for reduced farm labor demand (Martin 2020b). The alternative is that a slow economic recovery will allow for additional farm labor availability and less pressure on farms to find ways to curb labor demand. These offsetting forces indicate how much is uncertain in the economic forecast.

8. Implications for Workforce Development Contributions

Santa Cruz County agriculture is heavily dependent on a capable and reliable agricultural labor force working in berries, fresh vegetable and nursery crops. There are a wide range of managerial, marketing and technical workers that provide support for farm and marketing operations. These jobs are much like any non-farm occupation and no special training or development is required. These workers are graduates of local and regional schools, colleges and universities and are attracted to employment with agricultural companies because they offer competitive opportunities and tend to be good employers. These workers have similar continuing education needs as the rest of the Santa Cruz County labor force.

Some employees at farm operations are first line managers. Others handle farm chemicals or maintain and operate complex machinery. Many of these workers have limited formal schooling and may not have completed high school. Some have limited English language proficiency and little mathematical education. For career advancement these workers would value some practical language skills such as reading (perhaps in Spanish) and training in the application of practical mathematics. These demands also apply to current students who may be entering farm work with the skills to move into higher level jobs.

The greatest numbers of workers in the agriculture industry are relatively low-wage seasonal farm workers who use little formal education in their current jobs. For the near future, the demand for thousands of these employees in Santa Cruz County seems very likely. These

workers would gain additional literacy and numeracy not so much to improve their current productivity at work as to enhance their broader participation and contribution to the local society.

The future demand for the agricultural workforce is for a gradual move to more managerial and somewhat technical jobs that demand ability to read instructions for equipment, confirm application rates for materials, or understand rules and regulations for supervising other workers. These are common skills that are not specific to farming. In that sense, the farm workforce is likely to gradually converge to become more like the workforce in other occupations.

While agricultural management, practices, and technology have steadily become more sophisticated and productivity growth has been remarkable over a horizon of decades, the changes have been gradual. There is nothing obvious on the horizon that seems likely to change the pace of innovation and adoption of technologies. Moreover, given uncertainty about the pace and direction of innovations, specific training for agricultural workers would likely miss the mark. That suggests practical skills that are applicable to many alternative futures.

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