Economic Effects of Solano County Agriculture:

Baseline Assessment and Cache Slough Case Study

June 2017

Agricultural Impact Associates LLC

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TO: The Honorable Board of Supervisors, County of Solano, California

I am pleased to share **Economic Effects of Solano County Agriculture: Baseline Assessment and Cache Slough Case Study**. This report takes an important step beyond the annual *Crop and Livestock Report* we have published over the past 66 years. Instead of stopping at production values and acreage, it quantifies agriculture's total economic contribution through food production, local processing, employment, and economic "multiplier effects." The study also examines economic diversity and provides an in-depth analysis of Cache Slough agriculture.

Section 2279 of the California Food and Agriculture Code requires all county agricultural commissioners to report the annual "value" of agriculture. This typically occurs via our yearly *Crop and Livestock Report*. Using twenty-first century economic tools, we can now fulfill this mandate better than ever. We can also explore additional topics that clarify agriculture's role in sustaining a healthy local economy.

Agriculture has a long tradition in Solano County. For more than 160 years, it has been a pillar of our economy and culture. With this report, we renew our commitment to sustaining that tradition well into the future.

Respectfully submitted,

Jim Allan,
Agricultural Commissioner / Sealer of Weights & Measures

Economic Effects of Solano County Agriculture: Baseline Assessment and Cache Slough Case Study

Executive Summary

For more than a century and a half, agriculture has provided a vital link between Solano County's cultural past and economic future. Despite this long history and ongoing prominence, serious information gaps exist regarding agriculture's larger economic role. Drawing from multiple methods, this report helps fill parts of those gaps by examining the county's agricultural economy in detail. Part 1 provides a countywide, baseline economic assessment of agriculture's economic contributions. Part 2 provides in-depth economic analysis of Cache Slough agriculture. The ten items below summarize key findings:

PART 1: Countywide Baseline Assessment

1. **An ongoing growth story**. Over the past decade, farm production values rose 51.5%, from $233.5 million in 2006 to $353.9 million in 2015. This more than doubles the 19.5% inflation that occurred during this period.

2. **Farm production.** For 2015, agricultural production created $531.0 million in total economic output within Solano County. Multiplier effects, which reflect spending by agricultural companies and their employees, accounted for $144.0 million of this total. Agriculture provided 4,454 jobs, including 1,466 attributable to multiplier effects.

3. **Local food processing**. Locally sourced, value-added food processing produced an estimated $86.5 million in direct output for 2015, including $14.5 million in multiplier effects. Local food processing supported an estimated 255 jobs, 96 of them from multiplier effects.

4. **Combined, total effect**. Including farm production and locally sourced, value-added food processing, agriculture's combined economic contribution to the Solano County economy was $617.6 million. This consisted of $459.1 million in direct output from production and processing plus $158.5 million in multiplier effects. Total employment was 4,709, including 3,147 jobs directly in agriculture and another 1,562 attributable to multiplier effects.

5. **Economic diversity.** With an economic diversity index score of 3.00, Solano County has one of California's most economically diverse agricultural industries, which helps insulate it from economic shocks. Unlike many other counties, the economic diversity score has not declined over time.

PART 2: Cache Slough Case Study

6. **Crop production overview**. Cache Slough crop production created $42.9 million in total economic output and 171 jobs across Solano County. Of these totals, multiplier effects accounted for $13.9 million and 98 jobs, respectively. This represents 8.1% of Solano County's total farm production value of $531.0 million and 3.8% of the county's 4,454 jobs attributable to agriculture.

7. **Crop production details.** For 2016, Cache Slough agriculture consisted of 15 different crops grown on 38,133 acres. Alfalfa was especially impactful, accounting for 39% of agriculture's total direct value with only 24% of the total acreage. Walnuts had the highest value per acre ($36,000).

8. **Cache Slough recreational activities**. Per 5,000 acres, Cache Slough recreational activities (mostly hunting) produced an estimated $1.3 million in economic output and 13 jobs. Economic output attributable to recreation was $261 per acre, compared to $1,125 per acre from crop production.

9. **Linkages to the county economy**. Any reduction of Cache Slough Area agriculture would create economic ripples in diverse industries across Solano County. For example, a 75% reduction in the value of Cache Slough agriculture would generate countywide losses estimated at $30.9 million in economic output, 121 jobs, and $2.3 million in uncollected tax revenues.

10. **Priority information gaps to fill.** Limited information exists on potential, additional impacts of reducing or eliminating Cache Slough agriculture. Future research should examine possible "tipping points" in agriculture, as well as the potential for increased operating expenses due to wildlife predation on livestock, compliance with environmental regulations, and other factors.

Overall, the study delivers the most in-depth analysis to date of agriculture's economic role in Solano County. The findings provide information useful on multiple levels. Individual producers, suppliers, and other private sector entities can use the results to put their efforts into larger economic perspective. Public agencies and non-profit organizations can better understand agriculture's role in the local economy, today and into the future.

Acknowledgments

Agricultural Impact Associates LLC produced this report under contract to the Solano County Department of Agriculture, Weights & Measures (www.ag-impact.com). Lead authors were Dr. Jeff Langholz (jeff@ag-impact.com) and Dr. Fernando DePaolis (fernando@ag-impact.com). Jim Allan and Roberta Goulart supervised the project on behalf of Solano County. Numerous local agricultural experts provided input. These included farmers, ranchers, hunters, agronomists, agency personnel, and others. This study forms part of a larger project funded by a grant from the Sacramento-San Joaquin Delta Conservancy (www.deltaconservancy.ca.gov). Cover photo credit: compiled from SolanoGrown.com

Agricultural Impact Associates

"Quantifying the value of California agriculture"

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PART 1:

Countywide Baseline Assessment

Introduction

Residents and visitors alike know and value the contributions agriculture makes to Solano County. Farmers' markets overflow with locally grown produce and community spirit. Livestock and vineyards dot the hillsides. Tomatoes, walnuts, almonds, alfalfa, and dozens of other crops grow in fertile soils and a moderate climate. Clearly, agriculture plays a vital role in sustaining a healthy local economy. The true size of that role, however, is not so clear. How much money does agriculture pump into the local economy? How many jobs does agriculture support? In other words, just how important is agriculture as a driver of Solano County's economic health?

Part 1 sheds light on these and related questions. Using multiple data sources and advanced economic modeling techniques, it analyzes agriculture's total contribution to the Solano County economy. It also examines agricultural diversity and its role in supporting economic resiliency, including a first-ever quantitative measure. The findings offer important, baseline information for policy makers, the public, and anyone who values a vibrant local economy.

Methods

When it comes to economic analysis, it is important to examine the fullest possible range of economic contributions. This report does that by focusing not just on *direct* economic effect such as farm production and employment, but also on *multiplier effects*. *Multiplier effects* are ripples through the economy. These ripples include inter-industry "business to business" supplier purchases as well as "consumption spending" by employees. The **Multiplier Effects** section on page 7 explains this further.

It is appropriate to calculate *multiplier effects* when analyzing what economists call a *basic industry*. A *basic industry* is one that sells most of its products beyond the local area and thus brings outside money into local communities. Agriculture qualifies as a basic industry in Solano County, so this report includes *multiplier effects* when describing agriculture's total economic contribution.

Our analysis only examines agriculture's economic contributions. To understand agriculture's full economic impact, one would also need to assess agricultural-related costs to society, for example net impacts on water and other natural resources. While important, these impacts lie beyond the scope of this study.

Our calculations draw from local and national data sources. Local sources include industry experts and the annual *Crop and Livestock Report* produced by the county Agriculture Department. The main national data source is IMPLAN, a widely used economic modeling program (see www.implan.com). IMPLAN uses econometric modeling to convert data from more than a dozen federal government sources into local values for every U.S. county and zip code, across 536 industry sectors. Except where otherwise noted, all figures are for the year 2015, the most recent IMPLAN dataset available. Please contact the authors for additional details on the methods.

"Direct Effects" of Solano County Farm Production

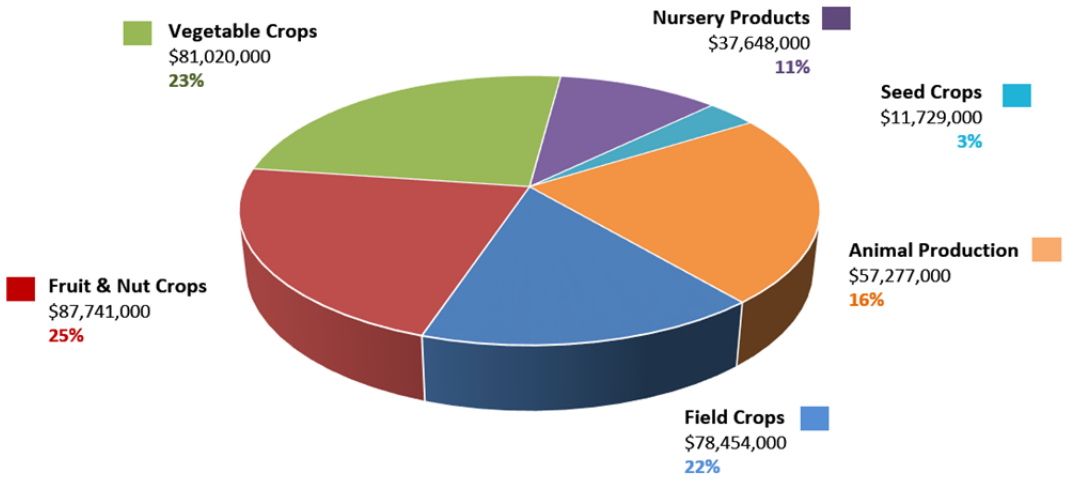
This section focuses on the simplest measures of economic activity: production and employment. It describes total farm production and the number of agriculture jobs.

Figure 1 shows the various categories that make up Solano County farm production value. For 2015, Fruit & Nut Crops was the single largest production category by dollar value ($87.7 million), comprising 25% of the county total. Three products dominated this category: Walnuts ($45.4 million), Almonds ($23.6 million), and Wine Grapes ($15.0 million). At 23%, Vegetable Crops was the second largest category ($81.0 million), consisting mostly of tomatoes. At 22% and $78.5 million, Field Crops was third largest, with alfalfa hay being the largest contributor, followed by wheat. Together, these three categories accounted for 70% of the county's direct farm production values.

The combined, total dollar value for all products rose 51.5% over the past decade, from $233.5 million in 2006 to $353.9 million in 2015. Inflation totaled 19.5% during this period, averaging just under 2% per year, making the net change positive 32.0%. Total values do not reflect net profit or loss experienced by individual growers or by the industry as a whole. Interested readers can consult the annual *Crop and Livestock Report* for additional details on specific crops and their value.

Figure 1: Distribution of Solano County Farm Production

Source: 2015 Solano County Crop and Livestock Report



Employment. How many people work in agricultural production? For 2015, agricultural production directly employed 2,699 people in Solano County. This figure encompasses a wide range of production-related jobs, including not just growing and harvesting, but also sales, marketing and many other roles. It does not include food processing jobs, which we discuss below.

"Multiplier Effects" of Solano County Farm Production

This section quantifies the economic "ripples" that farm production creates in the local economy. These ripples take two forms: *indirect effects* and *induced effects*. The first consist of "business to business" supplier purchases. For example, when a grower buys farm equipment, fertilizer, seed, insurance, banking services, and other inputs, the grower creates *indirect effects*.

The second ripple type, *induced effects*, consist of "consumption spending" by owners and employees of agriculture business and their suppliers. They buy housing, healthcare, leisure activities, and other things for their households. All of this spending creates ripples in the economy.

Although agricultural companies and their employees certainly spend money outside Solano County, this study only reflects those expenditures that occur within the county. Quantifying expenditures outside the county would be an expensive, complex effort that lies well beyond our scope here.

Table 1 shows agriculture's direct, indirect, and induced economic effects within the county, across major production categories. The numbers use IMPLAN multipliers for each sector, which are rooted in U.S. Bureau of Economic Analysis production data and other sources.

For example, the IMPLAN sector called “Grain farming” has an *indirect effects* multiplier of .3469 in Solano County and an *induced effects* multiplier of .1026. This means that each dollar’s worth of direct output generates and extra 34 cents in supplier purchases, plus approximately 10 cents extra in consumption spending by agriculture owners and employees. Individual sectors all have different multipliers for *induced* and *indirect* output as well as for employment.

Agricultural production created $531.0 million in total economic output within Solano County, of which $144..0 million were multiplier effects. Indirect and induced spending supported an additional 1,466 jobs within the county, bringing agriculture-related production’s total employment to 4,454.

Table 1: Economic Effects of Solano County Farm Production

FARM PRODUCTION SECTOR	DIRECT	INDIRECT	INDUCED	TOTAL
	Output Effect ($ Millions)			
Animals and animal products	$93.5	$14.6	$10.4	$118.5
Tree nut farming	$70.7	$12.8	$18.9	$102.4
Vegetable farming	$74.2	$10.5	$16.6	$101.4
All other crop farming	$43.0	$10.8	$9.9	$63.7
Support activities for agriculture	$33.6	$1.0	$10.2	$44.9
Fruit farming	$30.4	$5.2	$7.7	$43.2
Greenhouse, nursery & floriculture	$30.5	$3.5	$6.8	$40.9
Grain farming	$6.7	$2.3	$0.7	$9.7
Oilseed farming	$4.0	$1.1	$0.6	$5.6
Forestry & forest products	$0.4	$0.2	$0.2	$0.8
TOTAL ECONOMIC OUTPUT:	**$387.0**	**$62.0**	**$82.0**	**$531.0**
Employment Effect (# Jobs)				
TOTAL EMPLOYMENT:	**2,988**	**762**	**704**	**4,454**

Dollar values are in $ millions. Figures are for 2015 and come from IMPLAN, annual Crop and Livestock Reports, and U.S. Bureau of Economic Analysis. Not all columns and rows add due to rounding.

Locally Sourced, Value-added Food Processing

Farm production tells only part of the story. Solano County agriculture also includes value-added activities that contribute to the local economy. This section captures the economic value of local, value-added food processing. It makes four key points: 1) the county has a thriving food manufacturing industry but nearly all of its raw materials come from elsewhere; 2) most raw agricultural products leave the county for processing; 3) several examples of small-scale food processing exist; and 4) locally-sourced, valued added processing occurs on a significant scale for tomatoes, alfalfa, grapes, sheep, and lambs.

The discussion is neither an exact science nor a full assessment but rather gives the reader a basic overview of the topic. A full assessment would require significant additional research that includes collecting detailed financial information from individual companies. To avoid overstating the numbers, we only include food processing sectors that fit two strict criteria: 1) they rely heavily on local agricultural inputs; and 2) they are unlikely to exist here without the presence of the associated agricultural sector. These strict criteria rule out most food processing within the county.

Local Food Manufacturing. With $1.9 billion in 2015 production, local food and beverage manufacturing is one of the county's largest industries. For 2015, the county produced significant quantities of beer ($518.2 million), snack foods ($143.4 million), bread and bakery items ($39.6 million), and many other products.

Nearly all of this food manufacturing relied on raw products imported from outside the county. Manufacturers source most of their flour, yeast, flavorings, and other materials from elsewhere. The $39.6 million tobacco products industry, for example, imports all its tobacco leaves from other states. Likewise, the $71.3 million coffee and tea manufacturing sector depends on coffee beans and tea leaves grown overseas.

Given its massive size, beer brewing warrants a closer look. Large producers such as the Anheuser-Busch plant in Fairfield account for most of the beer brewing and rely on externally sourced raw materials. That said, several small and medium sized breweries exist and the "craft" beer niche is growing fast. Local brewers need various raw products, including hops. They import most hops from the Pacific Northwest and Germany where the required cold temperatures occur. Interesting examples of local sourcing have recently emerged. For example, a brewery and seven-acre farm near Dixon is testing several hops varieties for potential suitability in California. Also, a Montezuma Hills malting facility should come online soon, which may drive demand for local barley production and perhaps triticale and other grains for special blends.

Most Raw Product Leaves the County. Raw product moves not only into Solano County, but also out of it. For example, ranchers produced $27.6 million in cattle & calves for 2015 but no commercial beef processing occurs within the county. Ranchers sell livestock at auction, from where it goes to diverse locations in California and nationwide, including meat processing facilities in Sonoma and Fresno Counties. The only exception we found was a family-run, custom meat processing facility north of Vacaville. The county's remaining two dairies, both near Dixon, ship fluid milk to facilities outside the county for pasteurizing and packaging.

All of the county's $23.6 million almond crop leaves the county, as does its $5.6 million in dried prunes. Local processing may become cost effective in the future as the county's almond trees mature. A sizable walnut processing facility exists in Dixon, drawing from several dozen walnut growers in Solano County and far beyond. Of the county's $37.9 million walnut crop, only an estimated 2.5% goes to this processing facility.

At $631,000 in value, the county's olive industry is boutique level and makes use of mobile olive processors operating within the county. An exception is a Fairfield facility we visited, which offers on-site processing to growers who bring product there. On the regional level, large-scale olive processing occurs mostly in Lodi, from where olive oil ships to locations nationwide.

Small-scale processing. Consultations with local experts revealed examples of small-scale, valued-added food processing. For example, a dried fruit company in Winters sources significant, raw ingredients from local sources, then combines them into trail mix blends with imported ingredients such as Brazil nuts and Turkish apricots. A few growers process fruit into jams and jellies for sale at farmers' markets. This provides a value-added option for lower quality fruit unfit for the fresh market.

Vegetable processors include a company in Dixon that specializes in growing and processing several kinds of sprouts, especially daikon and mung bean. A state of the art facility in Rio Vista is North America's largest grower and packager of endives. A Vacaville farm is a leading supplier of mushrooms, including shiitakes, oysters, and eryngii.

Among animal production, a boutique goat farm north of Vacaville produces a wide range of cosmetics made from goat milk. Starting with goat milk soap, the product line has grown to include other goat milk products such as bath powders, body butters, salves, and lotions. In another animal example, at least two ranches north of Vacaville now produce and sell their own fiber, yard, roving, and related products from alpacas.

Other examples include fruit and nut gift baskets, walnut oil, pies, popsicles, dog treats, and salsas. Interested readers can find many examples of specific farms and their products at the Solano Grown website: www.solanogrown.org.

Noteworthy Exceptions. Significant food processing does occur, especially for sheep, lambs, alfalfa, tomatoes, and wine grapes. The following paragraphs describe these in turn.

Unlike cattle and calves, all of the county's $6.7 million in sheep and lamb production stays within the county for processing. Sheep and lambs go to a facility near Dixon that is North America's largest processor and marketer of lambs. The facility handles product from Solano County and across the West. It makes use of several local feedlots that help pace the flow of product into the facility. The county's *2015 Crop and Livestock Report* profiles the lamb and sheep industry from its early beginnings in the 1850's to its modern state, including the annual Lambtown Festival in Dixon, now in its 30th year.

At $42.2 million for 2015, processing tomatoes were Solano County's single largest crop category. An estimated 29.7% of this crop went to a Dixon-based processing facility. That facility produces soups, juices, and related products, drawing from Solano County and beyond.

Among field crops, growers process an increasing portion of the county's $34.8 million alfalfa crop into small, dense squares rather sell for direct consumption. Three alfalfa compressing facilities operate within the county. These companies have significant foreign ownership and ship to the United Arab Emirates, Japan, and other Asian markets. In contrast, a local ranching family that has produced hay continuously since the 1850's now owns a pressing facility in Dixon. This family operation grows and presses its own hay then, like the others, ships most of it to Asian markets. An estimated 50% of the county's alfalfa hay now goes for processing.

Wineries offer another significant example of locally sourced, value-added food processing. Solano County has a long and distinguished history of winemaking. Wineries concentrate in the Suisun Valley and neighboring Green Valley, both of which hold their own American Viticultural Area (AVA) designations. Both valleys also occur under the larger "North Coast" American Viticultural Area (AVA) that includes Napa, Sonoma, and three other counties.

A combination of factors have positioned Solano County wineries and vineyards for continued growth. Climate, water, and proximity to highways and rail lines all play a role. Among other things, the maturing wine economy now includes glass makers, cork distributors, and a new Fairfield facility owned by the world's largest screw-cap manufacturer. Considerable product also ships to out-of-state buyers as boxed grapes for small wineries and home winemaking, especially in New York and New Jersey.

This section avoids double-counting by including only the dollar values and employment that wineries add to wine grapes by producing wine. Totals in the Farm Production section above included the $15.0 million value of wine grape production. Wineries produce significant multiplier effects despite the fact that many wine grapes leave the county for bottling in Napa, Sonoma, and other locations. As with all food processing, documenting precise multiplier effects within the county would require significant further study.

Based on the preceding discussion, **Table 2** summarizes the economic contributions made by Solano County's locally sourced, value-added food processing.

Table 2: Economic Effects of Locally Sourced, Value-added Food Processing

FOOD MANUFACTURING SECTOR	DIRECT	INDIRECT	INDUCED	TOTAL
	Output Effect ($ Millions)			
Canned/bottled fruits & vegetables	$32.2	$4.7	$2.7	$39.6
Wineries	$14.2	$1.6	$1.4	$17.2
Processed meat products	$14.8	$0.9	$0.7	$16.5
Miscellaneous other products	$10.8	$1.1	$1.3	$13.2
TOTAL ECONOMIC OUTPUT:	**$72.1**	**$8.3**	**$6.2**	**$86.5**
Employment Effect (# Jobs)				
TOTAL EMPLOYMENT:	**159**	**49**	**47**	**255**

Sources: IMPLAN® and U.S. Bureau of Economic Analysis data, with input by local industry experts.
Not all columns and rows add due to rounding.

Local food processing produced an estimated $72.1 million in direct output. Multiplier effects bring the total value to $86.5 million. The sector directly employed 159 workers. These workers and their employers spent enough money in the local economy to support an additional 96 jobs, bringing Solano County's total food processing employment effect to 255.

Total Economic Effect of Solano County Agriculture

The previous sections have provided key pieces to an economic puzzle. This section combines those puzzle pieces into a final picture showing the overall economic effect of Solano County agriculture.

As **Table 3** shows, the total economic effect of Solano County agriculture was $617.6 million. This consisted of $459.1 million in direct output from production and processing, plus $158.5 million in multiplier effects. Total employment was 4,709. This included 3,147 jobs directly in agriculture and another 1,562 attributable to multiplier effects.

Table 3. Overall Economic Effects of Solano County Agriculture

TYPE OF EFFECT	DIRECT	INDIRECT	INDUCED	TOTAL
FARM PRODUCTION Sector				
Output Effect ($ Millions)	$387.0	$62.0	$82.0	$531.0
Employment Effect (# Jobs)	2,988	762	704	4,454
LOCALLY SOURCED, VALUE-ADDED PROCESSING SECTOR				
Output Effect ($ Millions)	$72.1	$8.3	$6.2	$86.5
Employment Effect (# Jobs)	159	49	47	255
TOTAL VALUE OF AGRICULTURAL SECTOR				
Output Effect ($ Millions)	$459.1	$70.3	$88.2	$617.6
Employment Effect (# Jobs)	3,147	811	751	4,709

Note that not all columns and rows add properly due to rounding.

The Value of Agricultural Diversity

Economists may disagree on some things but there's one thing they all can agree on: a diverse economy is a resilient economy. Any region that depends on a large number of economic sectors reduces risk of catastrophic shocks.

This important economic principle applies to agricultural diversity, too. For example, a county with just one or two main crops faces higher vulnerability to shocks in the form of price drops, disease outbreaks,

new regulations, new competitors, spikes in the cost of key inputs, and other unpleasant surprises. Meanwhile, a county with a diverse agricultural industry can withstand shocks to certain crops without unraveling the entire agricultural economy.

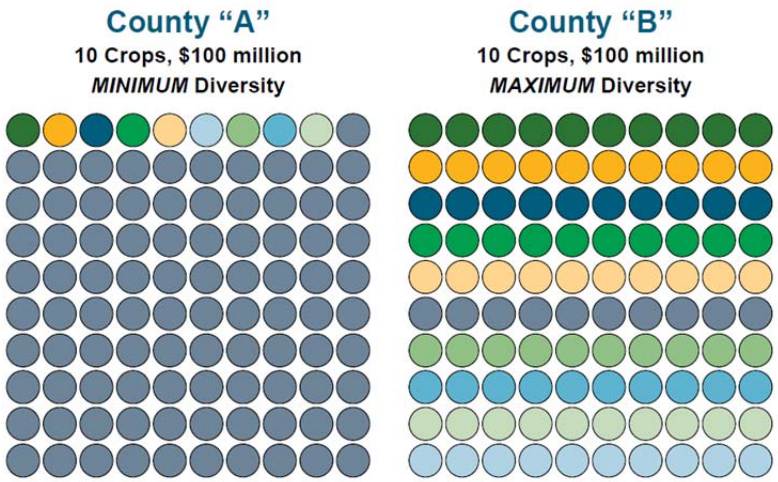
Bottom line: having "all your eggs in a single basket" is never a good idea, especially when it comes to something as economically important as agriculture.

Unfortunately, robust measures of Solano County agricultural diversity do not exist, let alone the total economic value of such diversity. People see assorted crops growing in well-tended fields. They see farmer's markets overflowing with different kinds of food and flowers. No one, however, has attempted to quantify that diversity or its economic value.

Part of the reason is that measuring diversity is a complex job. It requires more than just counting the different things for sale at the farmer's market or listed in Solano County's annual *Crop and Livestock Report.* Measuring diversity includes the number of different crops grown as well as the assessing their economic *abundance* or *evenness*.

For example, imagine two California counties where the annual farm production value is $100 million each. Both counties grow ten different kinds of crops. In County "A," a single crop contributes 91% of the revenue and the nine other crops make up 1% each (see **Figure 2** below). In County "B" the ten crop types all contribute equally, at 10% each. *Both counties have the same number of crops and total revenues, but County "B" has much higher economic diversity*. Thus, we could expect County "B" to be much more resilient to economic shocks than County "A".

Figure 2. Agricultural Economic Diversity is More Than Just the Number of Crops



Because economic diversity is so important, economists have developed sophisticated tools for measuring it. The most popular one is a summary statistic called the Shannon-Weaver Index. The index stems from the Shannon-Weaver entropy function, created in 1949 and widely used in both ecology and economics. Economists and ecologists alike use the formula to calculate the Shannon-Weaver Index, which we share here and can explain further to interested readers:

$$SW_t^k = -\sum_{n=1}^{k} p_n * \ln(p_n)$$

The lowest possible index score is 0.00. Zero represents an extreme case where all economic output occurs in only one sector. In ecology, this would be a forest with only one species. In agriculture, it would be a county with just one commercial crop. The other extreme, an open system where potential diversity is unlimited, would have a much higher score. The higher the score, the greater the diversity.

To measure agricultural diversity in Solano County, we started by creating a list of specific crops mentioned in the *Crop and Livestock Report* over the past several years. We only used crops for which production values existed for each year under consideration, even though the total number of commercial crops grown is certainly much larger. For example, we tracked alfalfa hay from its 2015 total ($34.8 million) all the way back to 2010 ($19.7 million).

Careful lumping and splitting resulted in 45 different crop categories consistently reported over the past decade. Next, we applied the list of crops and production values to the formula above. This resulted in a 2015 Shannon-Weaver Diversity Index score of 3.00.

By itself, the index score says little. Where it comes in handy is making external and internal comparisons. Internally, the agricultural community can track the score over time to ensure that overall agricultural economic diversity remains high. Maintaining high economic diversity in agriculture will minimize the risk of significant economic shocks. It's an insurance policy against economic earthquakes.

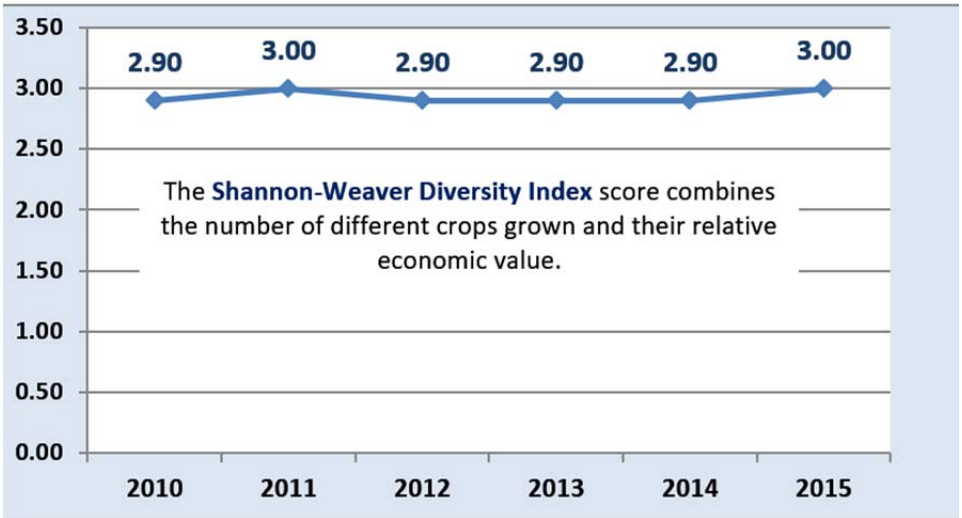
Speaking of earthquakes, note that equation above includes a logarithmic function ("ln") similar to the Richter Scale that measures earthquakes. Many Californians understand that a 7.4 earthquake releases twice the energy of a 7.2 earthquake even though the numbers are not far apart. The same principle applies to Shannon-Weaver Diversity Index scores: a tiny numeric difference represents a big change.

Figure 3 shows how the Shannon-Weaver Diversity Index score has fluctuated over time. The overall six-year change has been small, suggesting stable economic diversity within agriculture. Unlike many California counties, Solano seems to have avoided situations where one or a few crops increasingly dominate the agricultural economy, for example strawberries in certain coastal counties.

Externally, the score can allow useful comparisons to other industries within the county such as real estate, manufacturing, and tourism. It also enables comparisons between Solano County agriculture and other counties in California. Examples from years 2013 to 2015 include counties of Santa Cruz (2.01), San Diego (2.43), Santa Barbara (2.49), Contra Costa (2.67), San Luis Obispo (2.92), and Monterey (3.09).

Because Solano is an innovator when it comes to measuring agricultural economic diversity, the number of external comparisons remains limited at this time. Potential comparisons will no doubt grow over time as more counties follow Solano's example. In the meantime, Solano residents can take pride in having one of the most economically diverse agricultural industries anywhere, with numbers to prove it. They can also take comfort that diversity is holding steady over time.

Figure 3. How Economically Diverse is Solano County Agriculture?



Conclusion to Part 1

Part 1 has documented the role that Solano County agriculture plays as a local economic driver. Agriculture contributes $617.6 million to the county economy. Agriculture also plays an important role in county employment, directly or indirectly supporting 4,709 jobs. Finally, agriculture's impressive diversity provides critical economic stability to the county. The economic value of this stability is certainly high, albeit hard to quantify.

Agriculture is an important pillar of the Solano County economy and represents a vital link to both the county's cultural past and competitive future. Although this report has presented considerable detail, it has barely begun to fill key information gaps about agriculture's economic role. The process of developing this report has raised several additional questions that lie beyond the scope of this report but may warrant future research **(Box 1)**. In the meantime, the findings herein provide the clearest picture yet of Solano County agriculture's economic role.

Box 1: Additional Questions to Answer

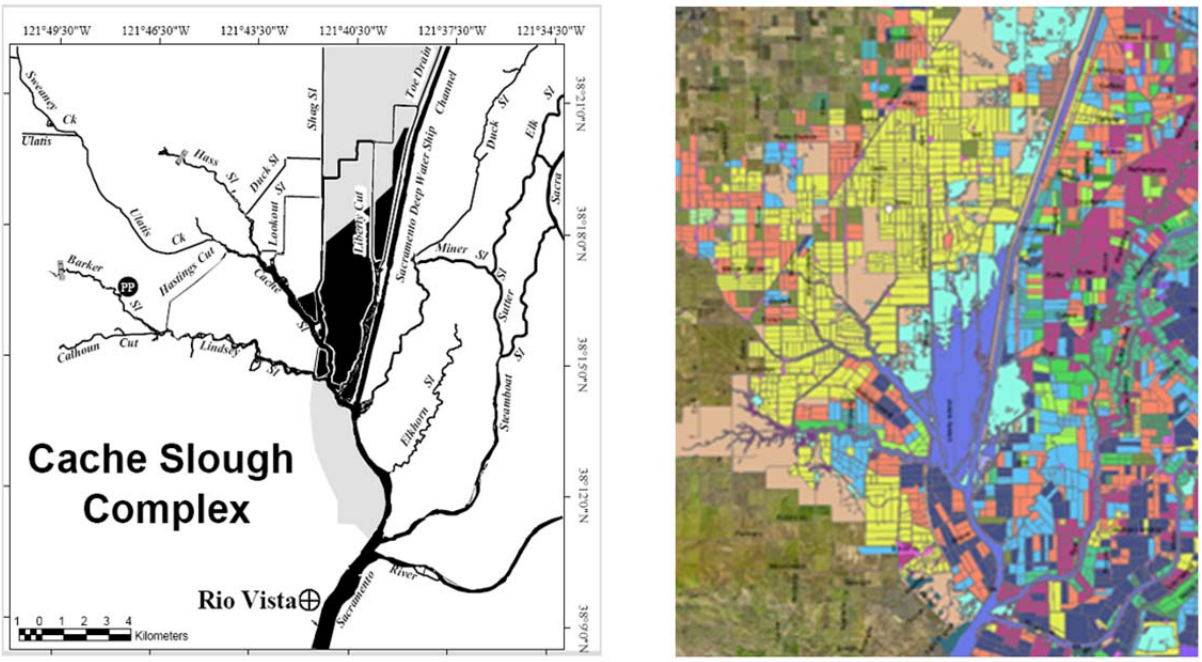
- **Regional integration.** To what extent do (or could) Solano and neighboring counties function as an economically aligned “foodshed” that creates beneficial synergies?
- **Cannabis.** Experts predict an explosion of cannabis cultivation in response to California’s legalization of recreational marijuana use. What economic opportunities and risks does this change present?
- **Ecosystem services.** What is the annual dollar value of wildlife habitat, open space, scenic beauty, carbon sequestration, pollination, and more than 20 other "ecosystem services" that the county's agricultural lands provide to society?
- **Diversity.** How diverse is Solano County agriculture not just in terms of economic production across crop types, but also across farm sizes, geographical markets, and organic/conventional?
- **Processing.** What new policies, programs, and other initiatives could expand locally sourced, value-added food processing?
- **Defining local wines.** Would it be worthwhile to establish a county policy clarifying what “local wine” entails, to strengthen the Solano brand further and support boutique wineries?
- **Economic shocks.** How would potential "shocks" affect agriculture's economic results, for example significant new regulations, labor policies, farm land expropriations, water issues, or changes in the price of key inputs?

PART 2:
Cache Slough Case Study

Introduction

The Cache Slough area of southeastern Solano County attracts considerable attention for its current and potential future uses. Despite a strong agricultural presence in the area, little information exists regarding economic aspects of Cache Slough agriculture. Part 2 helps fill that knowledge gap and consists of three main sections. The first section assesses the economic value of Cache Slough crop production, including employment and multiplier effects. The second section analyzes economic implications of recreational activities that occur on Cache Slough agricultural lands, especially hunting. The final section examines linkages between Cache Slough agriculture and the larger, Solano County economy, including potential effects of reducing or eliminating Cache Slough agriculture. Part 2 concludes with a list of priority information gaps that, if filled, could shed additional insights into economic implications of Cache Slough agriculture. The findings should be of interest to a wide range of stakeholders interested in the future of this important region.

Figure 7. Cache Slough Area Map



Sources: California Department of Water Resources & FlowWest

Direct and Multiplier Effects of Cache Slough Area Farm Production

This section analyzes Cache Slough agriculture's economic structure. It emphasizes economic output, employment, and multiplier effects and uses the same definitions of *direct*, *indirect* and *induced* effects as Part 1. Our estimated economic value of Cache Slough agriculture focuses on two main components: 1) the value of crop production in terms of output, employment, and multiplier effects; and 2) estimated economic output and employment effects that Cache Slough agriculture creates across Solano County's other economic sectors.

Methods. In order to assess the economic value of agriculture, we started with a detailed list of crops grown in Cache Slough during 2016 and the acreage of each crop. These crops and acreage data originated in a separate, parallel study focusing on a formal Land Evaluation and Site Assessment (LESA) process. The other starting point was our estimation of the per acre value of production for different crops. We generated these per acre estimates from numbers reported in the 2015 Solano County *Crop and Livestock Report*. Of the estimated 65,500 Solano County acres within Cache Slough, we focused on the 38,133 acres (58.2%) used for agriculture in 2016. Areas excluded from our analysis included riparian zones, floating vegetation, urban areas, and flooded areas.

For each Cache Slough crop type, we used one of following two methods to compute the estimated value in *dollars per acre*:

a) If the *Crop and Livestock Report* indicated acreage and total value of production, then:

Value [in $/acre] = Total value [in $] / total acreage [in acres]

For some crops, the coefficients used correspond to an entire class of crops; for example, cucurbits belong to "Miscellaneous Vegetables - Fresh" as reported in the *Crop and Livestock Report*. In that case, we used a cucurbits value based on the weighted average of all miscellaneous vegetables produced.

b) If the *Crop and Livestock Report* indicated a number of units per acre (such as tons or pounds) and the value per unit ($/ton or $/lb), then:

Value [in $/acre] = Unit per acre [in ton/acre or lb/acre] * Value per unit [in $/unit]

Next, we calculated the total value of each crop. This consisted of multiplying the value per acre by the total acreage allocated to each crop type. The resulting totals provided the basis for ensuing estimates of output and employment multiplier effects.

We built an input-output model for Solano County using proprietary datasets and software from IMPLAN. We assigned each of the 15 different crop types to a relevant IMPLAN sector. For example, we assigned Cache Slough vineyards to IMPLAN's "Fruit farming" (Sector #4). We put walnuts into Sector #5, "Tree nut farming." Other IMPLAN sectors used were "Grain farming" (#2), "Vegetable and melon farming" (#3), and "All other crop farming" (#10).

An important caveat to the analysis is that crop coverage changes year to year. Farmers made it clear to us that they can and do switch crops around. They also move lands into and out of production for a variety of economic and management reasons. Our analysis, for example, excludes 2,411 acres that were fallow at the time but could come back into production soon.

Economic Effects of Cache Slough Crop Production. **Table 4** shows the *direct*, *indirect*, and *induced* output effects for each crop. The total output effect was $42.9 million for the entire Cache Slough Area. This total included a direct effect of $29.0 million, indirect effects of $9.4 million, and induced effects of $4.5 million. As noted earlier, this economic output occurred not just within Cache Slough but also across Solano County.

Note that *alfalfa* was especially impactful, accounting for 39% of agriculture's total direct value with only 24% of the total acreage. *Walnuts* had the highest value per acre ($36,000) while *pasture* had the lowest ($23).

Table 4. Output Effects of Cache Slough Crop Production

CACHE SLOUGH CROP TYPE	# ACRES CROPPED	PRODUCTION PER ACRE	DIRECT VALUE	INDIRECT VALUE	INDUCED VALUE	TOTAL VALUE
Alfalfa	9,269	$1,199	$11,113,497	$4,154,417	$1,299,084	$16,566,999
Corn	2,661	$941	$2,504,070	$936,065	$292,707	$3,732,842
Cucurbit	197	$21,314	$4,198,860	$635,841	$1,160,893	$5,995,595
Forage Grass	2,043	$523	$1,068,600	$399,461	$124,911	$1,592,972
Olives	101	$3,507	$355,169	$55,576	$108,036	$518,781
Other Deciduous	20	$4,168	$82,344	$12,885	$25,047	$120,276
Pasture	18,302	$23	$412,511	$154,204	$48,219	$614,934
Safflower	436	$620	$270,608	$70,589	$74,719	$415,916
Sunflower	501	$1,464	$732,728	$273,906	$85,650	$1,092,285
Tomatoes	358	$3,573	$1,280,262	$193,873	$353,964	$1,828,099
Truck Crops	78	$1,095	$85,452	$22,290	$23,595	$131,337
Turf	340	$17,334	$5,900,872	$2,205,848	$689,768	$8,796,488
Vineyards	101	$3,376	$342,571	$53,605	$104,203	$500,379
Walnuts	5	$36,000	$181,523	$27,745	$58,228	$267,496
Sub-irrig. Pasture	3,720	$128	$476,328	$178,059	$55,679	$710,066
TOTALS	**38,133**		**$29,005,395**	**$9,374,364**	**$4,504,703**	**$42,884,465**

Source: Calculations based on LESA crop data combined with relevant IMPLAN multipliers.

Cache Slough agricultural production created $42.9 million in total economic output and 171 jobs across Solano County. Of these totals, multiplier effects accounted for $13.9 million and 98 jobs, respectively.

Table 5 shows employment effects. Cache Slough crop production supported 171 total jobs. This included 72 *direct* jobs, 67 *indirect*, and 31 *induced*. Cucurbits had an outsized effect on labor, with 22 jobs. As noted earlier, cucurbits do not appear in the *Crop and Livestock Report* so we used "Miscellaneous Vegetables – Fresh" as a proxy. Future research should take a closer look at this and other potential anomalies.

Table 5. Employment Effects of Cache Slough Crop Production

CACHE SLOUGH CROP TYPE	DIRECT JOBS	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Alfalfa	14.4	29.4	9.1	52.9
Corn	3.3	6.6	2.0	11.9
Cucurbit	21.7	5.0	8.1	34.8
Forage Grass	1.4	2.8	0.9	5.1
Olives	4.3	0.5	0.8	5.6
Other Deciduous	1.0	0.1	0.2	1.3
Pasture	0.5	1.1	0.3	2.0
Safflower	3.4	0.5	0.5	4.4
Sunflower	1.0	1.9	0.6	3.5
Tomatoes	6.6	1.5	2.5	10.6
Truck Crops	1.1	0.2	0.2	1.4
Turf	7.7	15.6	4.8	28.1
Vineyards	4.2	0.5	0.7	5.4
Walnuts	1.0	0.3	0.4	1.6
Sub-irrig. Pasture	0.6	1.3	0.4	2.3
TOTALS	**72**	**67**	**31**	**171**

Source: Calculations based on LESA crop data combined with relevant IMPLAN multipliers.

Countywide Economic Effects of Cache Slough Agriculture. This section builds on the previous one by considering Cache Slough agriculture as an industry unto itself, then quantifying that industry's economic contributions to other industries. The previous section examined specific crops such as alfalfa and corn to identify individual, isolated effects. It analyzed each crop as if it were a micro-economy consisting of just one product. This section takes a more integrated approach. It analyzes "agriculture" as a whole rather than by individual crops. This step may seem confusing but it allows economists to capture complex economic interactions and effects. For example, Cache Slough agriculture involves interdependencies and spillover effects in the Solano County economy that go beyond what a single crop might create.

Using IMPLAN's input-output model, we built a scenario starting with the $29 million in direct crop value from **Table 4**. We then propagated effects throughout other county industries. As **Table 6** shows, the $29 million in Cache Slough direct agricultural value produced a total economic effect of $52.6 million across multiple industries. As with previous sections, these effects occur countywide, i.e. within and beyond Cache Slough.

Table 6. Output Effects Cache Slough Agriculture Creates in Other Sectors

INDUSTRIAL SECTOR:	INDIRECT VALUE	INDUCED VALUE	TOTAL VALUE
Agriculture, Forestry & Commercial Fishing	$2,358,841	$71,567	$31,430,408
Mining	$47,173	$18,883	$66,056
Utilities	$342,297	$283,114	$625,411
Construction	$250,601	$139,194	$389,795
Manufacturing	$5,484,524	$2,409,654	$7,894,178
Wholesale Trade	$1,050,849	$410,893	$1,461,741
Retail trade	$39,882	$1,093,354	$1,133,236
Transportation & Warehousing	$465,533	$259,433	$724,966
Information	$56,688	$242,481	$299,169
Finance & insurance	$437,855	$804,598	$1,242,452
Real estate & rental	$724,143	$1,947,179	$2,671,322
Professional- scientific & technical services	$194,128	$250,350	$444,479
Management of companies	$48,632	$41,644	$90,276
Administrative & waste services	$121,619	$223,892	$345,511
Educational services	$4,719	$103,428	$108,147
Health & social services	-	$1,744,106	$1,744,137
Arts- entertainment & recreation	$9,133	$123,480	$132,613
Accommodation & food services	$36,448	$596,150	$632,597
Other services	$59,106	$561,535	$620,641
Government & non NAICs	$188,386	$397,119	$585,505
TOTALS	**$11,920,557**	**$11,722,054**	**$52,642,640**

NOTE: Results based on IMPLAN modeling, based on a direct output value of $29 million. Industrial sector names roughly correspond to the NAICS (North American Industrial Classification System) at 2-digit level. For details, please see https://www.census.gov/eos/www/naics/

Table 7 shows employment effects that Cache Slough agriculture creates across other Solano County industries. It uses the same scenario model as **Table 6**. The total aggregate employment effect is 310 jobs, or about 7.0% of the county's 4,454 jobs attributable to agriculture (see **Table 1**). The economic models we use to estimate these figures consider all jobs as full-time equivalent (FTE). Since many people work part-time jobs, the actual number of employees might be higher.

Table 7. Employment Effects Cache Slough Agriculture Creates in Other Sectors

INDUSTRIAL SECTOR:	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
Agriculture, Forestry, Etc. (200 Direct Jobs)	**16.0**	**1.0**	**216.0**
Mining	-	-	-
Utilities	-	-	1.0
Construction	1.0	1.0	2.0
Manufacturing	5.0	2.0	7.0
Wholesale Trade	4.0	2.0	6.0
Retail trade	1.0	13.0	13.0
Transportation & Warehousing	3.0	2.0	5.0
Information	-	1.0	1.0
Finance & insurance	2.0	4.0	6.0
Real estate & rental	2.0	4.0	6.0
Professional- scientific & technical services	1.0	2.0	3.0
Management of companies	-	-	-
Administrative & waste services	2.0	3.0	5.0
Educational services	-	2.0	2.0
Health & social services	-	14.0	14.0
Arts- entertainment & recreation	-	2.0	2.0
Accommodation & food services	1.0	9.0	10.0
Other services	1.0	6.0	7.0
Government & non NAICs	1.0	3.0	4.0
TOTAL	**40**	**71**	**310**

NOTE: Results based on IMPLAN modeling of 200 direct, full-time equivalent jobs. Industrial sector names roughly correspond to the NAICS (North American Industrial Classification System) at 2-digit level. For details, please see https://www.census.gov/eos/www/naics/

Section Summary. The four tables above show the economic contribution that Cache Slough agriculture makes to Solano County. Including multiplier effects, crop production contributed $42.9 million and 171 jobs. This represents 8.1% of Solano County's total farm production value of $531.0 million reported in Part 1 and 3.8% of the county's 4,454 jobs attributable to agriculture. In simpler terms, Cache Slough produced 1 out of every 12 dollars generated by Solano County agriculture and 1 out of every 26 jobs. Considered as a whole rather than by individual crops, Cache Slough agriculture contributed $52.6 million and 310 jobs across a wide range of Solano County industries. The next section builds on this analysis by estimating the economic value of recreational activities on Cache Slough agricultural lands.

Economic Implications of Recreation Activities in the Cache Slough

Introduction. Cache Slough agricultural lands not only produce crops, they also support recreational activities. No information currently exists on the nature and extent of economic contributions from these recreational activities. This section takes an initial step toward filling that knowledge gap. It briefly introduces recreational activities then examines their economic impact across the county.

Based on conversations with landowners, agency personnel, and other experts, hunting offers the most relevant recreational activity for economic analysis. Other forms of recreation certainly exist. For example, landowners at a workshop we attended emphasized that boats enter the slough "daily" for fishing and kayaking, especially near the Liberty Island flooded area. Unfortunately, no detailed information exists on boating, fishing, and other non-hunting activities. Even the hunting data face limitations, yet exist in sufficient quantity and quality to make this analysis worthwhile.

Hunting varies across Cache Slough. Most hunters hunt birds, in particular pheasant and "chukar" partridge. Others hunt duck and dove during migration periods. Beyond these variations, our conversations with landowners revealed three major differences among hunting operations. First, a few operations hunt year-round whereas most only hunt during a 45- to 60-day season. Second, some operate as small, family-based entities that only host individual hunters, whereas an estimated three to ten properties operate as "clubs" with dues-paying members. Finally, although much hunting occurs informally, a few operations exist as formal, commercial enterprises that pay for insurance, business licenses, and other services that increase their economic ripple effect.

Scenario Modeling. Confidentiality and anonymity concerns limited our access to detailed financial records. Nevertheless, landowners provided sufficient detail on hunting revenues, hunting intensity, and other variables to develop a rigorous input-output model. The model captures the economic impacts of hunting, based on a level of activity equivalent to *one year* of hunting operations.

What exactly does *one year* of hunting operations entail? For analytical purposes, we assumed 5,000 acres dedicated to hunting that generate $750,000 in annual revenues. Although these numbers might not capture all Cache Slough hunting, they provide a necessary starting point for the analysis. Equally important, the linear nature of these economic effects make the numbers scale in direct proportion, at least for the short-term. For example, if a stakeholder wants to assume a scenario that triples Cache Sough hunting acres and revenues, i.e., to 15,000 acres and $2,250,000 respectively, then the results we present below would triple, as well.

To analyze hunting, we used the IMPLAN commercial platform mentioned earlier. IMPLAN uses a set of 536 sectors to characterize a local economy. The IMPLAN sectors often do not align perfectly with the actual sector under study. That is the case here. No IMPLAN sector directly corresponds to "recreational hunting and fishing." Thus, we needed a proxy. After careful consideration and detailed analysis of the IMPLAN data, we selected IMPLAN Sector #493 as the closest match to Cache Slough recreational

activities. Titled "Museums, historical sites, zoos and parks," Sector #493 encompasses many things, including recreational activities that occur within natural areas such as hiking, fishing, boating, and hunting. Despite the sector's confusing name, it best captures the economic characteristics of recreation as it occurs in Cache Slough. The tables below show a series of results from the scenario models we developed.

Estimated Economic Effects of Cache Sough Recreation. Table 8 displays a summary of the impacts, assuming the $750,000 starting point mentioned above. Note that recreation produced $1.3 million in total economic output and 13 jobs. Of these totals, $555,768 and 4 jobs came from *indirect* and *induced* multiplier effects.

Table 8. Summary of Effects from Cache Slough Recreational Activities

IMPACT TYPE	DIRECT EFFECT	INDIRECT EFFECT	INDUCED EFFECT	TOTAL EFFECT
Output	$750,000	$269,136	$286,632	**$1,305,768**
Employment	9.0	2.0	2.0	**13.0**

Source: Author's calculations based on IMPLAN input-output model results.

Output and Employment Effects of Cache Slough Recreation. The previous section showed that for an initial direct effect of $750,000, recreation activities in the Cache Slough will contribute additional effects of $555,768. It is not clear, however, how this effect will impact other economic sectors. This section answers that question**. Tables 9 and 10** below show the input-output model's estimated impacts across multiple economic sectors.

Note that *direct* impacts in the input-output model only occur within our starting sector, #493. *Induced* and *indirect* impacts, however, occur across a wide range of sectors. Also, we simplified the display of results by only showing the top (most impacted) sectors, rather than all 536 sectors. The top 20 sectors account for more than 85% of all impacts.

Table 9 shows the top 20 sectors ranked by Total Effect. For these sectors, the total value contributed by Cache Slough recreation activities was $1.1 million. This included $750,000 in *direct* effects plus a combined $360,212 in multiplier effects. The multiplier effect combined *indirect* ($198,773) and *induced* ($161,439). As the table's bottom row shows, additional effects spread across hundreds of other sectors.

Table 9. Output Effects Cache Slough Recreation Creates in Other Sectors

(based on a direct value of $750,000)

SECTOR #	SECTOR DESCRIPTION	INDIRECT EFFECT	INDUCED EFFECT	TOTAL EFFECT
493	**Museums, historical sites, zoos, and parks (DIRECT)**		**$39**	**$750,039**
440	Real estate	$97,653	$15,656	$113,309
441	Owner-occupied dwellings	$0	$48,753	$48,753
437	Insurance carriers	$23,441	$8,160	$31,600
395	Wholesale trade	$6,081	$11,101	$17,182
482	Hospitals		$16,963	$16,963
414	Sightseeing transport. & transport. support activities	$15,022	$667	$15,689
62	Nonresidential structures maintenance & repair	$11,701	$2,102	$13,803
433	Monetary authorities & depository credit intermediation	$3,724	$7,713	$11,438
502	Limited-service restaurants	$701	$10,505	$11,206
464	Employment services	$8,197	$1,615	$9,812
438	Insurance agencies, brokerages, and related activities	$6,560	$2,558	$9,118
174	Pharmaceutical preparation manufacturing	$578	$8,240	$8,818
415	Couriers and messengers	$8,130	$508	$8,638
156	Petroleum refineries	$4,572	$3,731	$8,303
475	Offices of physicians		$8,243	$8,243
526	Other local government enterprises	$4,587	$3,116	$7,702
457	Advertising, public relations, and related services	$5,888	$777	$6,665
405	Retail - General merchandise stores	$225	$6,276	$6,501
501	Full-service restaurants	$1,713	$4,716	$6,430
	TOTAL of Top-20 Sectors:	**$198,773**	**$161,439**	**$1,110,212**
	Total of all 536 sectors	$269,136	$286,632	$1,305,768

Source: Author's calculations based on IMPLAN model with 536 economic sectors.
Note: The table rows specify only those sectors with Total Effect larger than $6,000.

Table 10 shows the top 20 sectors ranked by Total Jobs. For these 20 sectors, the total employment contributed by Cache Slough recreation activities was roughly 11 jobs. This entailed approximately 9 direct jobs plus 2 positions from multiplier effects. As noted earlier, these estimates assume a specific volume of recreation activity within Cache Slough that may or may not reflect current conditions. Also, other employment effects spread across sectors not specified here, summarized in the bottom row.

Table 10. Employment Effects Cache Slough Recreation Creates in Other Sectors

(based on a direct value of $750,000)

SECTOR #	SECTOR DESCRIPTION	INDIRECT JOBS	INDUCED JOBS	TOTAL JOBS
493	Museums, historical sites, zoos, and parks (DIRECT)			9.1
440	Real estate	0.6	0.1	0.7
62	Nonresidential structures maintenance & repair	0.1		0.1
395	Wholesale trade			
400	Retail - Food and beverage stores		0.1	0.1
405	Retail - General merchandise stores		0.1	0.1
414	Sightseeing transport. & transport. support activities	0.1		0.1
415	Couriers and messengers	0.1		0.1
437	Insurance carriers	0.1		0.1
438	Insurance agencies, brokerages & related activities			
464	Employment services	0.1		0.1
468	Services to buildings	0.1		0.1
469	Landscape and horticultural services	0.1		0.1
474	Other educational services	0.1		0.1
475	Offices of physicians		0.1	0.1
482	Hospitals		0.1	0.1
485	Individual and family services		0.1	0.1
501	Full-service restaurants		0.1	0.1
502	Limited-service restaurants		0.1	0.1
503	All other food and drinking places			0.1
	TOTAL of Top-20 Sectors:	**1.3**	**0.8**	**11.4**
	Total of all 536 Sectors	**1.8**	**2.0**	**12.9**

Source: Author's calculations based on IMPLAN model with 536 economic sectors. Only the top 20 sectors appear here. Employment numbers include decimals for future calculations based on proportional expansion of the value of recreation in the Cache Slough. Empty cells correspond to either true zero or negligible values.

Among other things, the tables above highlight a strong economic connection between Cache Slough agricultural lands and Solano County's real estate sector. Cache Slough crop production contributed $2.7 million to the county's real estate sector (**Table 6**) and supported 6 jobs (**Table 7**). Per 5,000 acres, Cache Slough recreation also contributed an estimated $113,309 (**Table 9**) and 1 job (**Table 10**) to the real estate sector. These economic connections consisted of many things, for example commissions paid on property purchases and sales, property management fees, property leasing, and fees paid for title searches, appraisals, and escrow services. Further clarifying and refining these estimates would require detailed surveys of real estate professionals.

Fiscal Impact of Cache Slough Recreation. Economic output has powerful implications for tax revenues. In general, the greater the economic output, the more money local, state, and federal governments have available to fund various public services. **Table 11** shows estimated tax revenues attributable to Cache Slough recreational activities. With $54,849 in state & local taxes and $116,360 in federal taxes, recreational activities in Cache Slough accounted for a total of $171,209 in tax payments.

Table 11 introduces several tax concepts that might be new to some readers. For example, "Social Security" taxes are those that employees and employers make into the social insurance system. "Tax on Production and Imports" refers to property taxes, fees, tariffs, and other business taxes. "Personal Taxes" consist mostly of income tax. Please consult the authors for additional details.

Table 11. Tax Base Effects of Cache Slough Recreational Activities

LOCAL & STATE TAXES PAID	by HOUSEHOLDS	by BUSINESSES	TOTAL
Social Security	$464	$938	$1,402
Tax on Production and Imports	-	$32,099	$32,099
Personal Taxes	$20,003	-	$20,003
Corporate profits and dividends	-	$1,345	$1,345
Total Local & State	***$20,467***	***$34,382***	***$54,849***

FEDERAL TAXES PAID	by HOUSEHOLDS	by BUSINESSES	TOTAL
Social Security	$29,657	$26,238	$55,895
Tax on Production and Imports	-	$4,473	$4,473
Personal Taxes	$47,368	-	$47,368
Corporate profits and dividends	-	$8,624	$8,624
Total Federal	***$77,025***	***$39,335***	***$116,360***

Source: Authors' calculations based on IMPLAN input-output models

Key Points Regarding Cache Slough Recreation. This section has estimated economic contributions that Cache Slough recreational activities have on the larger, county economy. The findings point to three main conclusions:

- **Relatively small, especially compared to agriculture**. With $1.3 million in economic output and 13 jobs for 5,000 acres, recreation seems small compared to the contributions that agriculture makes, both overall and on a per acre basis. As **Table 4** shows, Cache Slough crop production contributed $42.9 million across 38,133 acres. Thus, agriculture has an average total output of $1,125 per acre. This is 4.3 times higher than recreation's $261 per acre output. Although we have limited data on Cache Slough recreation, initial estimates suggest that Cache Slough agriculture adds significantly more economic value to Solano County than Cache Slough recreation.

- **Potential growth?** Our model assumed 5,000 acres devoted to recreation but this number is just a proxy. As note earlier, we lack detailed data on recreation's current scope let alone its future extent. Potential certainly exists for recreation to expand much further into the 65,500-acre area. Diversity of recreation types could also expand, for example greater emphasis on fishing, bird watching, kayaking, canoeing, and other activities.

- **Probable linear effects**. Although we cannot predict future growth in recreation, the economic effects of any growth would probably be linear, at least for the short-term. For example, we modeled the main scenario with 5,000 acres devoted to recreation, about 7.6% of the slough's total area. If we modeled 100% of Cache Slough allocated to recreation (65,500 acres), then we can simply multiply all the original **Table 8** results by 13. For example, total output would rise from $1,305,768 to $16,974,984. Total employment would grow from 13 to 169. The linearity assumption generally holds for a three to five year planning horizon. Longer periods would require additional research into potentially non-linear variables and interactions.

Potential Secondary Effects of Reducing Agriculture's Economic Output

Introduction. This section explores potential secondary effects that could result from a reduction or elimination of Cache Slough agriculture. It begins with quantitative analysis of a simulated 75% reduction of Cache Slough agriculture's economic output. What effect would such a reduction have on Solano County's economic output? Employment? Tax revenues? The section concludes with a qualitative discussion of three additional secondary effects with potential to occur.

Economists use the term "negative shock" to describe events like the significant reduction modelled here. Such shocks can and do occur in a wide range of industries and take many forms in agriculture. Examples include weather-related events such as droughts and floods, foodborne illness outbreaks, game-changing technological advances, influxes of lower cost imports, or major policy changes. These and many other events can create rapid, dramatic changes in agriculture's economic output.

When such events occur, consequences ripple beyond the industry in which they originated. For example, a negative shock to agriculture could make farmers and ranchers less able to make payments to employees, suppliers, contractors, and lenders. The nature and extent of these complex effects depends on economic interdependencies and spillover effects across sectors.

In general, the more specialized an economy becomes, the great its vulnerability to negative shocks. As Part 1 noted, Solano County agriculture currently scores high on the economic diversity index. This high level of diversity mitigates risk to economic shocks. Calculating a diversity index score for Cache Slough agriculture would require significant, additional research.

In order to simulate a negative shock to Cache Slough agriculture, we built an input-output model to represent the Solano County economy. The model includes 536 economic sectors from IMPLAN. To "shock" the system, we impacted the model with a 75% reduction in the value of economic output from Cache Slough agriculture. We spread the reduction proportionally across Cache Slough crop production categories and their corresponding IMPLAN sectors, as described in **Table 4** and the Methods section preceding it. For example, most of the $20.9 million "shock" ($16 million) occurred in "Grain farming." Other impacted sectors included "Vegetable and melon farming" ($4 million), "Fruit farming" ($0.5 million), "Tree nut farming" ($130,000), and "All other crop farming" ($270,000).

The tables below show the results for output, employment, and tax revenues. They provide a fuller economic picture than one would get simply subtracting 75% from Cache Slough agriculture's total output. As the tables show, direct effects of the economic shock impact only five sectors but indirect and induced effects affect most of the model's 536 sectors. In order to make the results more readable, the tables below only show output and employment effects for the 20 most affected sectors.

Most Impacted Sectors. **Table 12** shows how a 75% reduction Cache Slough's agricultural production would affect various sectors countywide. The results are a derivation of multiplier coefficients from the IMPLAN input-output models we built to simulate this effect. Highlighted numbers in the "DIRECT VALUE" column correspond to impacts we introduced into the model. As noted earlier, these represent five IMPLAN sectors that are representative of, and proportional to, Cache Slough crops.

The three most impacted sectors were "Support activities for agriculture," "Real estate" and "Wholesale trade," in that order. Regarding the first item on the list, a reduction in agricultural activity will certainly lower demand for soil preparation, planting, cultivating, harvesting, labor contracting, postharvest crop activities, and various other farm management services that comprise the "Support activities for agriculture" sector.

As the table shows, a reduction in agriculture also affects "Real estate" (e.g., less home renting and buying), "Wholesale trade" (less merchandise to sell), "Fertilizer mixing" (e.g., less need for fertilizer), and "Truck transportation" (e.g., fewer farm products to haul). As farm workers reduce their consumption levels or move out of the county, they will affect "Hospitality" (e.g., fewer meals at restaurants), "Health services" (e.g., fewer doctor visits), and many other sectors.

Table 12. Output Effects of 75% Reduction in Value of Cache Slough Agriculture

SECTOR #	SECTOR DESCRIPTION	DIRECT VALUE	INDIRECT VALUE	INDUCED VALUE	TOTAL VALUE
2	Grain farming	$16,000,000	$4,252	$4	$16,004,257
3	Vegetable and melon farming	$4,000,000	$76,320	$3,630	$4,079,949
19	Support activities for agriculture & forestry	$0	$1,475,630	$721	$1,476,352
440	Real estate	$0	$947,557	$173,807	$1,121,364
395	Wholesale trade	$0	$711,337	$125,242	$836,579
156	Petroleum refineries	$0	$614,997	$41,530	$656,527
441	Owner-occupied dwellings	$0	$0	$562,559	$562,559
4	Fruit farming	$500,000	$16,378	$2,596	$518,974
437	Insurance carriers	$0	$387,318	$92,392	$479,711
62	Non-residential structures maint. & repair	$0	$344,532	$23,512	$368,044
10	All other crop farming	$270,000	$85,734	$887	$356,621
433	Monetary authorities / credit intermediation	$0	$245,326	$85,788	$331,114
482	Hospitals	$0	$0	$187,373	$187,373
411	Truck transportation	$0	$152,673	$32,546	$185,218
526	Other local government enterprises	$0	$137,179	$34,598	$171,776
5	Tree nut farming	$130,000	$38,117	$553	$168,670
171	Fertilizer mixing	$0	$151,738	$163	$151,901
502	Limited-service restaurants	$0	$16,327	$119,007	$135,333
445	Commercial equipment rental & leasing	$0	$130,408	$3,310	$133,718
438	Insurance agencies, brokerages, & related	$0	$97,023	$28,936	$125,958
	TOTAL of Top-20 sectors:	**$20,900,000**	**$5,632,846**	**$1,519,154**	**$28,051,998**
	Total of all sectors	**-**	**$6,781,740**	**$3,240,324**	**$30,922,064**

Source: Author's calculations based on IMPLAN model with 536 economic sectors. For brevity, only the 20 most impacted sectors appear here. Some sector names shortened for formatting purposes. For correspondence between IMPLAN sectors and the NAICS (North American Industrial Classification System), please see:
http://support.implan.com/index.php?option=com_content&view=article&id=215:215&catid=222:222

Table 13 shows the most impacted sectors in terms of employment. Note that the three most impacted sectors match those from the previous table, in particular "Support activities for agriculture," "Real estate" and "Wholesale trade," in that order. As these sectors decline in economic output (**Table 12**), it makes sense that they will also require fewer employees.

Table 13. Employment Effects of 75% Reduction in Value of Cache Slough Agriculture

SECTOR #	SECTOR DESCRIPTION	DIRECT VALUE	INDIRECT VALUE	INDUCED VALUE	TOTAL VALUE
19	Support activities for agriculture & forestry	-	23.0	-	23.0
440	Real estate	-	6.0	1.1	7.1
395	Wholesale trade	-	2.7	0.5	3.2
62	Maintenance/Repair of nonres. Structures	-	1.8	0.1	2.0
10	All other crop farming	3.3	1.1	-	4.4
433	Monetary authorities / credit intermediation	-	0.9	0.3	1.2
411	Truck transportation	-	0.9	0.2	1.1
437	Insurance carriers	-	0.9	0.2	1.1
468	Services to buildings	-	0.6	0.3	0.9
3	Vegetable and melon farming	20.4	0.4	-	20.8
4	Fruit farming	6.0	0.2	-	6.2
502	Limited-service restaurants	-	0.2	1.4	1.6
5	Tree nut farming	0.7	0.2	-	0.9
501	Full-service restaurants	-	0.1	1.1	1.2
2	Grain farming	20.5	-	-	20.5
485	Individual and family services	-	-	1.2	1.2
405	Retail - General merchandise stores	-	-	0.9	0.9
482	Hospitals	-	-	0.9	0.9
	Total of Top 20 Sectors:	**50.9**	**39**	**8.2**	**98.2**
	Total of all Sectors:	**-**	**48**	**22.4**	**121.2**

Source: Author's calculations based on IMPLAN model with 536 economic sectors. For brevity, only the 20 most impacted sectors appear here. Some sector names shortened for formatting purposes. For correspondence between IMPLAN sectors and the NAICS (North American Industrial Classification System), please see:
http://support.implan.com/index.php?option=com_content&view=article&id=215:215&catid=222:222

Fiscal Impacts. We also modeled the effects that a 75% reduction in Cache Slough agricultural output would have on tax revenues. **Table 14** displays the potential losses in taxes. The table differentiates by taxpayer (Households and Businesses) as well as by jurisdiction (State/Local and Federal). The total expected loss in tax revenue is $2,281,300. This consists of $720,000 in State/Local taxes and $1,561,300 in Federal taxes. Households and businesses account for the lost tax revenues on a nearly even basis, totaling $1,101,303 and $1,179,997, respectively. For perspective, the Solano County government's fiscal year 2016-2017 budget assumed $166 million in tax revenues (see www.solanocounty.com). Thus, the scenario modelled here represents less than half a percent of that total.

Table 14. Tax Effects of 75% Reduction in Value of Cache Slough Agriculture

LOCAL & STATE TAXES PAID	by HOUSEHOLDS	by BUSINESSES	TOTAL
Social Security	$3,614	$7,302	$10,916
Tax on Production and Imports	-	$408,718	$408,718
Personal Taxes	$232,538		$232,538
Corporate profits and dividends	-	$67,828	$67,828
Total Local & State	***$236,152***	***$483,848***	***$720,000***
FEDERAL TAXES PAID	**by HOUSEHOLDS**	**by BUSINESSES**	**TOTAL**
Social Security	$314,485	$204,260	$518,745
Tax on Production and Imports		$56,948	$56,948
Personal Taxes	$550,666		$550,666
Corporate profits and dividends		$434,941	$434,941
Total Federal	***$865,151***	***$696,149***	***$1,561,300***

Source: Author's calculations based on IMPLAN model with 536 economic sectors.

Qualitative Discussion of Additional, Potential Secondary Effects. Reducing or eliminating Cache Slough agriculture could cause myriad additional effects beyond those detailed above. Fully articulating those effects lies well beyond the scope of this study. This section highlights four examples that may warrant future, in-depth analysis. We pose all three as working hypotheses:

- **The "Invisible Threshold" Hypothesis**. We have heard concerns that the size of Cache Slough agriculture might drop so much that it reaches a "tipping point" after which the industry quickly collapses in a so-called "death spiral." The logic is that as fewer farmers and ranchers exist to support local vendors, those local vendors eventually leave due to declining sales. Remaining farmers and ranchers would then face diseconomies of scale in the form of higher costs. They would also need to travel greater distances to access supplies, equipment, labor, support services, and other key inputs. These added expenses, in turn, would adversely affect their already thin margins, hastening their exit.

  This phenomenon has precedent in the "Minimum Viable Population" concept from the field of population ecology. Ecologists have documented that if a wildlife population drops to a certain level, often around 500 individuals, then the population tends to spiral downward to extinction. Population Viability Assessment software such as Ramas (www.ramas.com) helps determine where the invisible threshold lies.

  Based on our consultations with agricultural experts, our direct agricultural experience, and a review of the relevant literature, we find no evidence of this phenomenon occurring in agricultural "populations." What tends to happen in agricultural settings is that if one farmer or rancher goes out of business, then another one leases or buys the property and continues producing. Indeed, consolidation of U.S. agriculture has been occurring for decades. The number of farmers and ranchers may decline but overall production levels generally hold steady or even increase.

Granted, the typical farm consolidation pattern occurring in California and so many other locations might not apply to Cache Slough. If a Cache Slough farmer or rancher exits the industry, then the land might be flooded as part of a state water project that either caused or resulted from the exit. In that case, no other farmer or rancher would lease or purchase the land for continued production. Thus, overall production would decline and the "death spiral" scenario described above might occur.

- **The "Increased Regulatory Burden" Hypothesis**. We have heard concerns that as ecological conservation and restoration projects proceed in Cache Slough, the regulatory burden on farmers and ranchers might increase, which in turn could reduce the financial viability of agriculture. The logic is that conservation and restoration activities will increase the presence of wildlife on and near remaining agricultural lands, leading to additional compliance costs for farmers and ranchers.

  For example, if an endangered fish species such as the Delta smelt returns to the area, then it may trigger requirements for farmers to reduce the amount agricultural runoff entering local waterways. This would require financial investments in new pollution mitigation practices and/or infrastructure.

- **The "Increased Predation Losses" Hypothesis**. We have heard concerns that ecological conservation and restoration projects in Cache Slough might lead to increased presence of coyotes and other predators on and near farms. This, in turn, could increase predation on lambs, calves, and other livestock. In addition to losing animals to predation, ranchers could face higher costs in the form of fencing, guard dogs, and other preventive measures. A similar concern exists for bird predation in fields, for example flocks of blackbirds devouring sunflower crops.

- **The "Invasive Plant Species Proliferation" Hypothesis**. We have heard concerns that ecological conservation and restoration projects in Cache Slough might inadvertently increase presence of invasive plant species on adjacent agricultural lands, leading to higher operating costs and lower crop yields. Traveling by water, aggressive nonnatives such as peppercress (*Lepidum latifolium*) and many others can infest agricultural fields, reducing crop production and pasture quality. Increased wildlife presence could also facilitate waterborne seed spread, for example when muskrats and beavers dig holes in levees.

  The Delta's many invasive plant species have wreaked havoc across the region and show no sign of abating. The concern here is that unless policy makers put adequate financial resources in place for long-term invasive species monitoring and mitigation on agricultural lands, well-meaning restoration projects will create an expensive problem for local farmers and ranchers.

Conclusion to Part 2

Part 2 has examined the economic role of Cache Slough agricultural lands. Cache Slough crop production created $42.9 million in total economic output and 171 jobs across Solano County. Of these totals, multiplier effects accounted for $13.9 million and 98 jobs, respectively. This production contributed an estimated $52.6 million and 310 jobs across other Solano County economic sectors.

Recreational activities on Cache Slough agricultural lands, especially hunting, contribute an estimated $261 per acre in direct and multiplier effects. These activities also create connections to other Solano County economic sectors, with an estimated total value of 1.3 million and 13 jobs per 5,000 acres.

Finally, reducing or eliminating Cache Slough agriculture would affect Solano County's economic output, employment, and tax revenues to varying degrees. For example, a 75% reduction in the value of Cache Slough agriculture would generate countywide losses estimated at $30.9 million in economic output, 121 jobs, and $2.3 million in tax revenues. Other economic effects are likely but not quantifiable without further research. **Box 2** below contains additional research questions that, if answered, could help improve our understanding of Cache Slough agriculture's economic profile.

Box 2: Priority Cache Slough Research Topics

- **A fuller understanding of agricultural production.** Due to its limited scope, this study has relied on limited, static estimates of crop production. What empirical patterns exist with respect to changing crops and rotating lands in and out of production? What is the maximum potential value of crop production, assuming the greatest possible acreage allocated to the highest value crops?
- **Clarifying the true value of agricultural lands.** This report has emphasized the economic value of crop production. What other economic values do Cache Slough agricultural lands have, for example the value of the land itself, unique water rights, and significant ecosystem services?
- **Additional documentation of recreational activities.** Few data exist on the nature and extent of Cache Slough recreational activities. What types of recreation currently occur, over what area, and with what frequency? What are the economic implications of these activities today and under various future scenarios?
- **Quantifying potential secondary effects.** This report has estimated certain economic effects of reducing Cache Slough agriculture but other effects exist. Future research should examine possible "tipping points" in agricultural production. It should also explore increased expenses due to wildlife predation on livestock, compliance with environmental regulations, invasive species impacts, and other factors.