

The State of Delta Agriculture: Economic Impact, Conservation and Trends

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Contents

Tables	ii
Key Findings	1
Section 1 - Introduction	2
Section 2 - Crop Data	3
2.1 Crop and Land Use Data	3
2.2 Crop Valuation and Aggregation	3
Section 3 - Crop Acreage and Trends.....	5
Section 4 - Delta Crop Revenue	17
Section 5 - Animal Production and Delta-Supported Food and Beverage Manufacturing	19
5.1 Animal Production in the Delta	19
5.2 Delta-supported Food and Beverage Manufacturing	20
Section 6 - Economic Impact of Delta Agriculture	24
6.1 Economic Impact Estimates	25
Section 7 - Conservation and Restoration Impacts on Delta Agriculture	29
7.1 Completed Conservation and Restoration Projects	32
7.2 In Progress and Under Construction Conservation and Restoration Projects	33
7.3 Planned and Proposed Conservation and Restoration Projects	33
7.4 Potential Impact of Conservation and Restoration Projects on Delta Agriculture	34
Section 8 - Summary and Conclusion	38
Appendix	39

Tables

Table 1 DWR Crop Category Examples	4
Table 2 Delta Agricultural Acreage, 2016	5
Table 3 Top 20 Delta Crops by Acreage, 2016	8
Table 4 Crops with Largest Acreage Change Between 2009 and 2016.	9
Table 5 Delta Agricultural Revenues, 2016 (in \$1,000s)	17
Table 6 Top 20 Delta Crops by Value, 2016	18
Table 7 Animal Output in the Delta	19
Table 8 Output of Delta Agriculture Related Value-Added Processing	22
Table 9a Direct Agriculture Related Output in 2016 Used for the IMPLAN model	26
Table 10 (A, B and C) Economic Impact in 2016 of Delta Agriculture on Five Delta Counties	27
Table 11 (A, B and C) Economic Impact in 2016 of Delta Agriculture on California	28
Table 12 Delta Conservation and Restoration Projects With 2016 Agricultural Acres and Revenue	30
Table 13 Summary of Completed Conservation and Restoration Projects	32
Table 14 Summary of In-Progress Conservation and Restoration Projects	33
Table 15 Summary of Planned and Proposed Conservation and Restoration Projects	34

Figures

Figure 1 Delta Crop Coverage in 2016	6
Figure 2 Maps of 2011 and 2016 Alfalfa Acreage in the Legal Delta	11
Figure 3 Maps of 2011 and 2016 Almond Acreage in the Legal Delta	12
Figure 4 Maps of 2011 and 2016 Asparagus Acreage in the Legal Delta	13
Figure 5 Maps of 2011 and 2016 Corn Acreage in the Legal Delta	14
Figure 6 Maps of 2011 and 2016 Vineyard Acreage in the Legal Delta	15
Figure 7 Map of Conservation and Restoration Projects in the Delta from EcoAtlas	31

Key Findings

Agricultural Output and Trends

- Over 70 crops are harvested from 415,000 farmed acres in the Delta.
- Gross revenue of farms within the legal Delta totaled \$965 million in 2016.
- Corn and alfalfa are the most common crops in the Delta by acreage.
- Wine grapes are now the leading revenue crop in the Delta with \$212 million in gross revenue in 2016, and processing tomatoes are second at \$116 million.
- Almonds and wine grapes are the fastest growing crops in the Delta, each adding over 10,000 acres between 2009 and 2016.
- Corn and alfalfa saw the biggest decreases in acreage with each decreasing by more than 10,000 acres between 2009 and 2016.
- The Delta's iconic asparagus crop continues to decline, falling below 2,000 acres in 2016 and out of the top 20 crops.
- San Joaquin County accounts for about 50% of Delta agriculture as measured by both acreage and revenue, followed by Sacramento County at about 18%.

Economic Impact

- In 2016, Delta farms supported about 12,400 jobs and \$1.7 billion in economic output in the five Delta counties, and 13,800 jobs and \$2 billion in output statewide.
- In addition, Delta-supported food and beverage manufacturing supported 3,350 jobs and \$972 million in output in Delta counties, and over 9,000 jobs and \$2.6 billion in output statewide.
- In total, Delta farms and related food and beverage manufacturing supported over 23,000 jobs across California and \$4.6 billion in output.

Conservation and Restoration

- Crop production occurs on more than 14,000 acres of farmland with completed conservation projects (including Staten Island), producing over \$24 million in agricultural output.
- Currently planned wetland restoration projects in the Delta could affect about 2,000 acres and \$3 million in agricultural revenue, less than 0.5% of current Delta agricultural gross revenues.

Section 1 - Introduction

The purpose of this study is to provide the Delta Protection Commission (DPC) and other stakeholders with an objective evaluation of agricultural land use in the Delta and the economic impact of Delta agriculture on Delta counties and the state of California. This study updates the analysis in the agricultural chapter of the Delta Protection Commission's 2012 Economic Sustainability Plan for the Sacramento-San Joaquin Delta, which was based on 2009 agricultural land use data. This update is based on 2016 agricultural land use in the Delta and finds a number of changes and emerging trends. While overall agricultural acreage has declined slightly, the value of Delta agriculture has grown and the number of jobs it supports has remained steady. Like much of the Central Valley, the Delta has shifted towards higher revenue permanent crops like almonds and wine grapes while the acreage dedicated to field and forage crops like alfalfa and corn has declined. Alfalfa and corn remain the most common crops in the Delta, and wine grapes have soared past processing tomatoes as the biggest revenue generator.

The next section of this report describes the data used in this analysis, and section 3 presents detailed data on the acreage of individual crops and broader crop categories and how these cropping patterns have changed since 2009. Section 4 tabulates and analyzes the revenue generated by the various crops grown in the Delta. Section 5 looks at the production of animal products in the Delta and estimates the amount of food and beverage processing such as wineries, canneries, and dairy products that are directly dependent on Delta agricultural output. Section 6 uses an input-output model to estimate the economic impact of Delta agriculture on the economy of the five Delta counties and the state of California. Section 7 describes conservation and restoration actions in the Delta and their potential impact on agricultural production. Section 8 is a summary and conclusions.

Section 2 - Crop Data

2.1 Crop and Land Use Data

Field level crop data was obtained from the California Agricultural Commissioners and Sealers Association (CACASA) and processed by the Geographic Information Center (GIC) at CSU, Chico. The CACASA land use data is based on pesticide use reports filed by farmers. This provided crop data for approximately 394,000 acres in the Delta, nearly 90% of Delta cropland. The GIC also obtained remote sensing data developed by LandIQ for the Department of Water Resources as a quality control check on CACASA. Analysis by the GIC found strong agreement between the individual crop data in CACASA and the crop groups reported by LandIQ. Because LandIQ covered all agricultural land in the Delta, we used it to fill in the data set for fields that were not available in CACASA. This is the same approach used in the Delta Protection Commission's 2012 Economic Sustainability Plan which used satellite data from the National Agricultural Statistics Service (NASS) to fill in data for fields missing from the pesticide use data. For this study and the 2012 ESP, the data shows that the majority of fields missing in the CACASA pesticide use data is relatively low value pasture. It makes sense that many farmers would not file pesticide use reports for grazing land.

There are advantages and disadvantages with any data set, and we chose to utilize CACASA as the base dataset for several reasons. First, it provides crop data at a high level of detail whereas LandIQ reports a crop group for most fields. Thus, CACASA allows us to fully describe the rich variety of Delta crops. For example, it allows us to differentiate between various types of truck crops like broccoli, peppers, watermelon, potatoes, and more. Another advantage of CACASA is that it is year-round data, whereas LandIQ is a survey at a point in time during the summer. Thus, CACASA allows us to include the economic value of double-cropping and fully capture fall/winter crops, such as wheat and oats. Finally, utilizing CACASA and filling in a small amount of missing acreage, mostly pasture, with remote sensing data is consistent with the 2012 Economic Sustainability Plan and thus facilitates analysis of changes in trends in Delta crops. The primary disadvantage of CACASA data is that it is missing land use data for about 10% of Delta cropland where we relied on alternative data sets as described in the preceding paragraph.

2.2 Crop Valuation and Aggregation

In order to determine aggregate revenues from Delta crop production, crop yield and price figures published in each county's 2016 crop report were used to determine an average revenue per acre for each listed crop. Though the values used in the crop reports reflect average yields and value for the entire county, they offer the most practical means of determining total revenues from the crop acreage data in the Delta. Values for specific crops

were not available in a few counties, particularly crops that only had a small number of acres in a given county. In these cases, we substituted a per acre value from the Delta county with the highest acreage for that specific crop since there are not large differences in crop prices between counties. In most cases, this meant using the estimate from the San Joaquin County crop report since it is the largest agricultural county in the Delta and has the most crop level detail in the crop report. For a very small number of crops with low acreages, there was no available value from any of the Delta county crop reports, so we used statewide values from the California Department of Food and Agriculture.

The data show 70 distinct crops are grown by Delta farms. To facilitate presentation and analysis of Delta agriculture in economic models, it is necessary to categorize crops into a limited number of discrete groups. For most of the report, we utilize the Department of Water Resources' categorization of eight crop groups listed in Table 1. This categorization has been used for many years throughout California, and thus facilitates easy comparison and interpretation of our results with other statewide studies. The more detailed DWR crop category definitions are in Appendix Table A1. For the economic impact analysis in section 6, we had to aggregate the individual crop data into the groupings defined by the IMPLAN economic impact model.

Table 1 DWR Crop Category Examples¹

Category	Example Crops
Citrus & Subtropical	<i>Olive, Kiwi, Nectarine</i>
Deciduous Fruit & Nuts	<i>Almond, Cherry, Pear, Walnut</i>
Field Crops	<i>Beans, Corn, Sunflower</i>
Grain and Hay Crops	<i>Barley, Oats, Wheat</i>
Pasture	<i>Alfalfa, Ryegrass, Turf</i>
Rice	<i>Rice</i>
Truck, Nursery and Berry Crops	<i>Tomato, Asparagus, Potato, Blueberry</i>
Vineyards	<i>Grapes</i>

¹See Appendix Table A1 for more detailed DWR crop category definitions.

Section 3 - Crop Acreage and Trends

Figure 1 shows a map of Delta crop coverage by the 8 DWR crop categories. This map shows spatial patterns in the distribution of crop groups that is further illustrated by the county level breakdowns of crop acreage in Table 2. Pasture and field crops dominate the west and central Delta where elevations and water quality are typically lower than other areas of the Delta. In contrast, higher-value vineyard, deciduous fruit and nuts such as pears and almonds, are most commonly found along the northern, eastern, and southern perimeter of the Delta. Truck and berry crops, mostly vegetables, are most common in the south Delta.

San Joaquin County has the largest agricultural area and accounts for almost half of total Delta cropland and has the highest number of acres for every crop category. San Joaquin County is particularly prominent in truck/vegetable crops, deciduous fruit and nuts, and field crops where San Joaquin accounts for over half of Delta acreage in these categories. Sacramento County is second in agricultural acreage with pasture, field crops, and vineyards being the most common. Solano and Yolo counties have similar levels of total acreage at just over 48,000 acres of Delta cropland, closely followed by Contra Costa County at 41,000 acres. Yolo County has the highest portion of its land in vineyards, but pasture-land is the most common agricultural acreage. Two-thirds of Solano County's Delta farmland is in pasture with the rest balanced among other crops. Contra Costa is second in truck crops behind San Joaquin County despite being fifth in total acreage, but field crops are the most common type of crop in Contra Costa County. A very small section of Alameda County is located in the legal Delta and is mostly in pasture.

Table 2 Delta Agricultural Acreage, 2016

Crop Category	<i>Alameda</i>	<i>Contra Costa</i>	<i>Sacramento</i>	<i>San Joaquin</i>	<i>Solano</i>	<i>Yolo</i>	TOTAL
Pasture	1,983	10,742	21,497	48,484	32,660	19,159	134,526
Field Crops	178	15,720	19,459	63,808	5,235	3,966	108,367
Truck, Nursery & Berry Crops	23	5,188	4,461	33,868	1,846	4,033	49,419
Grain & Hay Crops	783	4,999	7,150	19,271	4,804	5,173	42,181
Vineyards	4	2,026	11,568	14,204	1,454	12,358	41,613
Deciduous Fruit & Nuts	0	2,661	6,778	17,408	2,432	944	30,224
Rice	0	0	1,234	3,607	0	2,627	7,468
Citrus & Subtropical	7	118	23	1,501	223	135	2,009
TOTAL	2,978	41,455	72,170	202,151	48,655	48,396	415,805

This map illustrates the agricultural land use in the Central Valley of California, with a focus on the Sacramento-San Joaquin River Delta and the surrounding Central Valley region. The map is color-coded to show different types of agricultural land use, with a legend in the bottom left corner:

- Pasture (Green)
- Grain/Hay Crops (Yellow)
- Field Crops (Orange)
- Rice (Light Green)
- Truck Crops (Red)
- Vineyards (Dark Purple)
- Other Deciduous (Dark Blue)
- Citrus/Subtropical (Purple)

The map shows a high density of agricultural land use in the Central Valley, particularly in the Sacramento-San Joaquin River Delta and the surrounding Central Valley region. Major cities and towns labeled on the map include Sacramento, Elk Grove, Vacaville, Lodi, Stockton, Antioch, and Tracy. The map also shows major highways, including Interstate 5 (I-5), Interstate 80 (I-80), Interstate 95 (I-95), and State Routes 99, 152, 168, 169, 170, 174, 178, 180, 188, 199, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955,

Figure 1 Delta Crop Coverage in 2016 is a map of the legal Delta with color coded blocks of acreage representing different crop groups. The crop groups represented by the different colors are Pasture, Grain/Hay Crops, Field Crops, Rice, Truck Crops, Vineyards, Other Deciduous and Citrus/Subtropical.

Much of the land in Solano County to the northwest is in Pasture with some rice and other deciduous crops. There are several large areas mixed in that were planted in truck crops. In Sacramento County there is a mixture of crop types, with vineyards being dominant but all of the crops being represented. In the central Delta the predominant crop is field crops with grain/hay crops and truck crops also being farmed. In the western Delta pasture and field crops are planted. In the south Delta, which is also in San Joaquin County all of the crop categories are represented, with some rice being planted west of Stockton, and to the south pasture, grain/hay, field, truck, vineyard, other deciduous and citrus/subtropical all being represented in 2016.

The data came from the California Agricultural Commissioners and Sealers Association submittals to the Pesticide Use Reporting database and was analyzed by the Geographic Information Center at California State University, Chico. The data was compiled from field level data that is submitted by the farmer to report what crops will be grown for their pesticide use report. The field level data is reported to the California Department of Food and Agriculture.

Table 3 lists the top 20 Delta crops by acreage. Corn and alfalfa are the most common crops in the Delta, each accounting for almost 20% of total Delta cropland. Pasture (grazing land) is the third most common agricultural land use and is a subset of the pasture crop group which includes alfalfa. It was the most common of the eight aggregated crop groups (see Table 1), since pasture included two of the three most common crops. Wine grapes are now grown on over 40,000 acres in the Delta and account for almost 7% of total wine grape acreage in California. Processing tomatoes and wheat were grown on just under 30,000 acres in 2016 while almonds grew to seventh place. Safflower, rice and beans round out the top 10, and asparagus is no longer among the top 20 crops by acreage.

Following trends seen across the Central Valley, Delta cropland is shifting towards higher-revenue permanent crops and away from field crops. The largest acreage gains have been seen for almonds and wine grapes, both adding more than 10,000 acres since 2009. Safflower and rice have also seen significant gains in acreage. Acreage dedicated to pasture also increased over this period, but we did not include it in Table 4 because of the low economic value of pasture and because our estimates of pasture acres were estimated inconsistently in 2009 and

Table 3 Top 20 Delta Crops by Acreage, 2016

Rank	Crop	Acreage	Value (\$)
1	Corn	82,392	\$85,908,676
2	Alfalfa	77,576	\$65,573,721
3	Pasture	46,878	\$7,611,903
4	Wine Grapes	41,613	\$212,221,541
5	Processing Tomatoes	29,181	\$115,765,217
6	Wheat	28,548	\$11,693,072
7	Almond ^[1]	15,651	\$32,578,060
8	Safflower	12,852	\$6,874,980
9	Rice	7,468	\$7,800,789
10	Bean, Dried	7,287	\$8,365,476
11	Oat	6,743	\$1,909,741
12	Forage Hay	5,874	\$1,781,381
13	Pear	5,429	\$44,128,504
14	Walnut	4,580	\$18,354,212
15	Sorghum	4,069	\$1,965,520
16	Potato	4,054	\$49,870,709
17	Cucumber	3,593	\$5,102,709
18	Ryegrass	3,135	\$501,791
19	Turf	2,986	\$34,081,253
20	Cherry	2,927	\$14,355,913

[1] Almond crop values exclude recent non-bearing plantings, but those plantings are included in acreage.

2016.² The largest acreage declines have been seen for some of the Delta's highest acreage mainstay crops: corn, alfalfa and tomatoes. Corn and alfalfa acreage was at a cyclical peak in 2009, driven by strong price gains, but in 2016 there was a combined acreage decline of over 40,000 acres to these crops. Another change with economic and historical significance is the decline in the Delta's iconic asparagus acreage. Asparagus fell below 2,000 acres in 2016. Several decades ago, it was estimated that asparagus was grown on as much as 70,000 acres in the Delta, and the 7,000 acres in 2009 already was a precipitous decline. Our data show an additional 82% decline since 2009. Delta farmers report that growing asparagus is simply

² As discussed in section 2.1, a large amount of the pasture acreage in both 2009 and 2016 came from remote sensing data from two different sources, LandIQ in 2016 and NASS in 2009. We cannot be sure whether the acreage differences in pasture reflect changes in the amount of land used for pasture or how the two different data sources coded these acres. Any differences are not economically meaningful given the low revenue per acre for pasture.

unprofitable in the face of lower priced foreign imports and high production costs for this labor-intensive product, and some believe there will be no Delta asparagus at all in a few years. Delta asparagus can no longer be found in the produce section of most local supermarkets, although it is still featured seasonally in many restaurants.

Almonds have been expanding at an extremely rapid rate across the Central Valley in recent decades. Until recently, the Delta was not part of this trend as orchards are less common in the low-lying Delta than field crops and vegetables. However, the high profitability of almonds has inspired Delta farmers to join the trend of almond farming seen throughout the Central Valley, although almonds are still significantly less prevalent in the Delta than other parts of the Valley. The Delta is more prominent in California's wine grape production and is adding wine grapes at a somewhat faster rate than the state overall. In 2009, the Delta's 30,000 acres of wine grapes represented 5.6% of California's total wine grape acreage, and by 2016 Delta wine grapes increased to nearly 42,000 acres which represented 6.9% of California's total acreage. Thus, the Delta is increasingly important to the State's wine industry.

Table 4 Crops with Largest Acreage Change Between 2009 and 2016.

Increasing Acreage

Crop	2009 acres	2016 acres	Change	% Change
Almonds	3,121	15,651	12,530	401%
Wine Grapes	30,148	41,613	11,465	38%
Safflower	8,874	12,852	3,978	45%
Rice	4,874	7,468	2,594	53%
Walnut	2,512	4,580	2,068	82%

Decreasing Acreage

Crop	2009 acres	2016 acres	Change	% Change
Corn	105,362	82,392	-22,970	-22%
Alfalfa	91,978	77,576	-14,402	-16%
Oats	15,847	6,743	-9,104	-57%
Tomatoes	38,123	29,181	-8,942	-23%
Wheat	34,151	28,548	-5,603	-16%
Asparagus	7,217	1,964	-5,253	-73%

Figures 2 through 6 use the CACASA data to provide a detailed look at the geographical distribution and change for some of the Delta's most important and fast-changing crops between 2011 and 2016: alfalfa, almonds, asparagus, corn, and wine grapes.³ The CACASA data used in these figures only goes back to 2011 for all counties, thus 2011 is the base year in the maps rather than 2009 which is the year used in Table 4. Figure 2 shows a decline in alfalfa coverage, and that alfalfa is most common in the south Delta with significant additional acres in the north Delta and comparably little in the central and west Delta. Figure 3 shows the expansion of almonds, once very rare in the Delta and only found in the secondary zone. New almond plantings have appeared in the south Delta area of the primary zone and in Solano County near the edge of the Delta. Figure 4 shows the decline in the iconic asparagus crop which is almost invisible in 2016 except for a few small south Delta patches. Figure 5 shows that the decline in corn acreage is most visible in the central and south Delta of the primary zone. Finally, Figure 6 shows the expansion of wine grapes, which now cover most acres in the Clarksburg area and a notable expansion south along the Sacramento River corridor.

³The CACASA data used to make these figures only goes back to 2011 for all counties, thus 2011 is the base year in the maps rather than 2009.

Figure 2 Maps of 2011 and 2016 Alfalfa Acreage in the Legal Delta

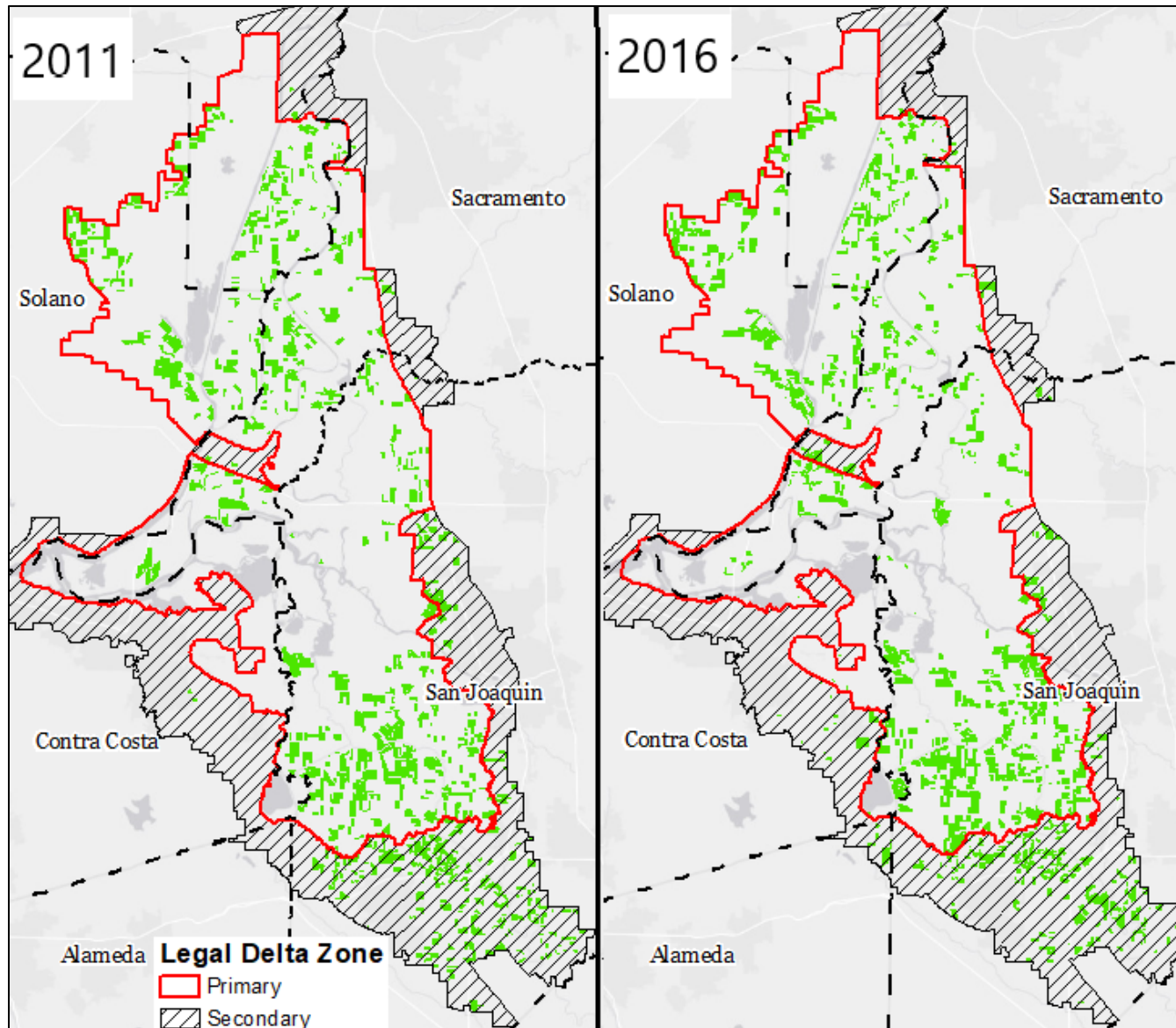


Figure 3 Maps of 2011 and 2016 Almond Acreage in the Legal Delta

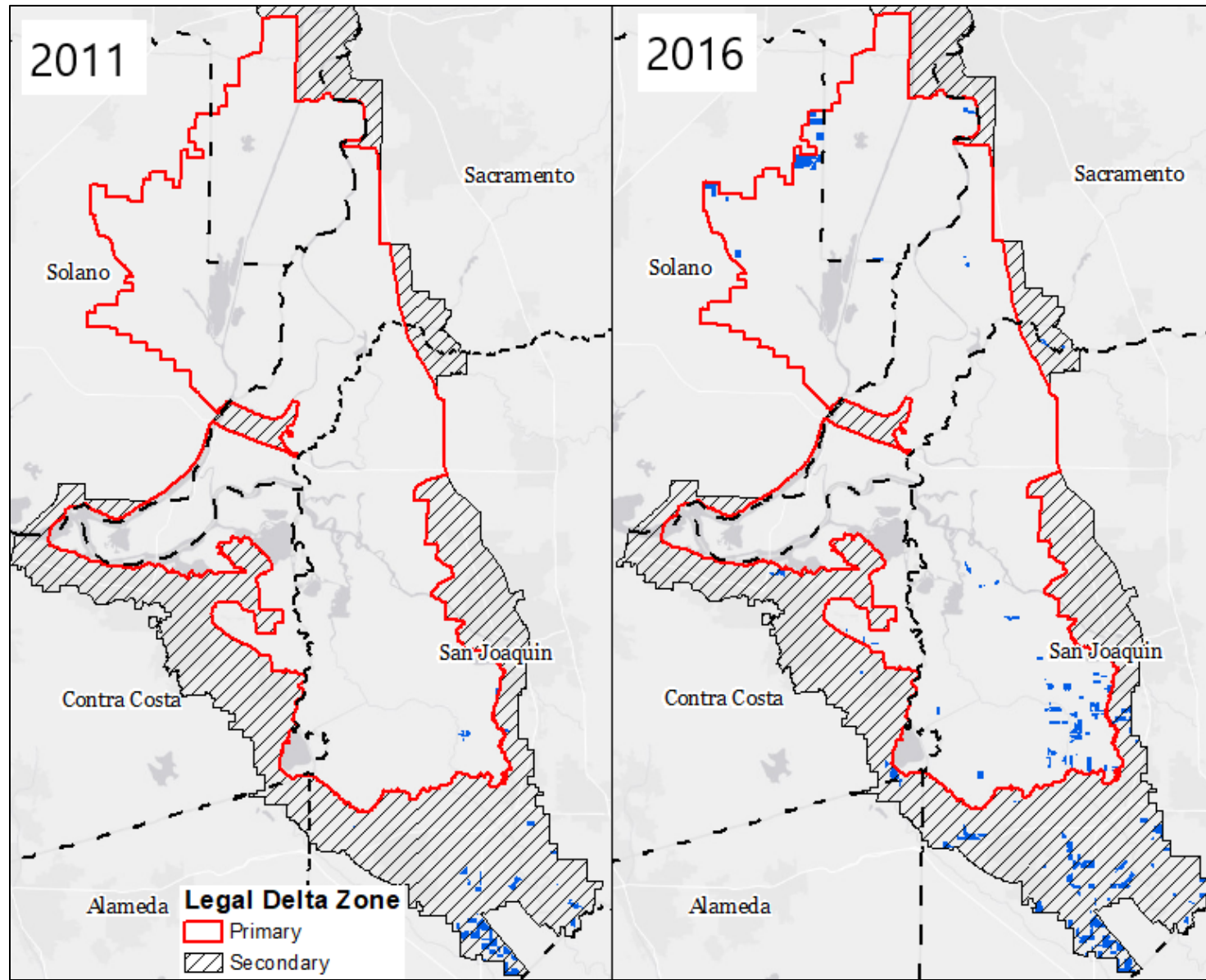


Figure 4 Maps of 2011 and 2016 Asparagus Acreage in the Legal Delta

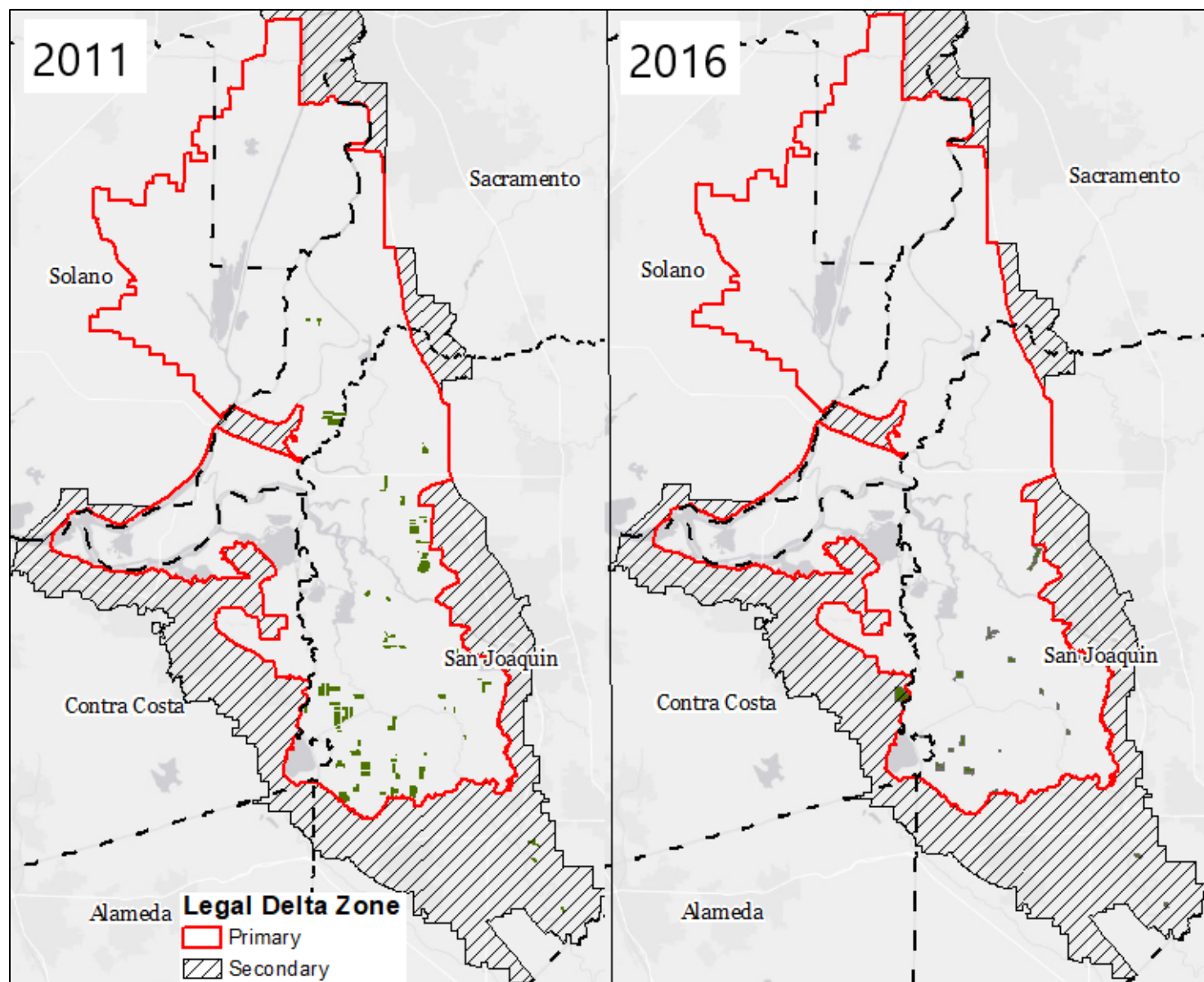


Figure 5 Maps of 2011 and 2016 Corn Acreage in the Legal Delta

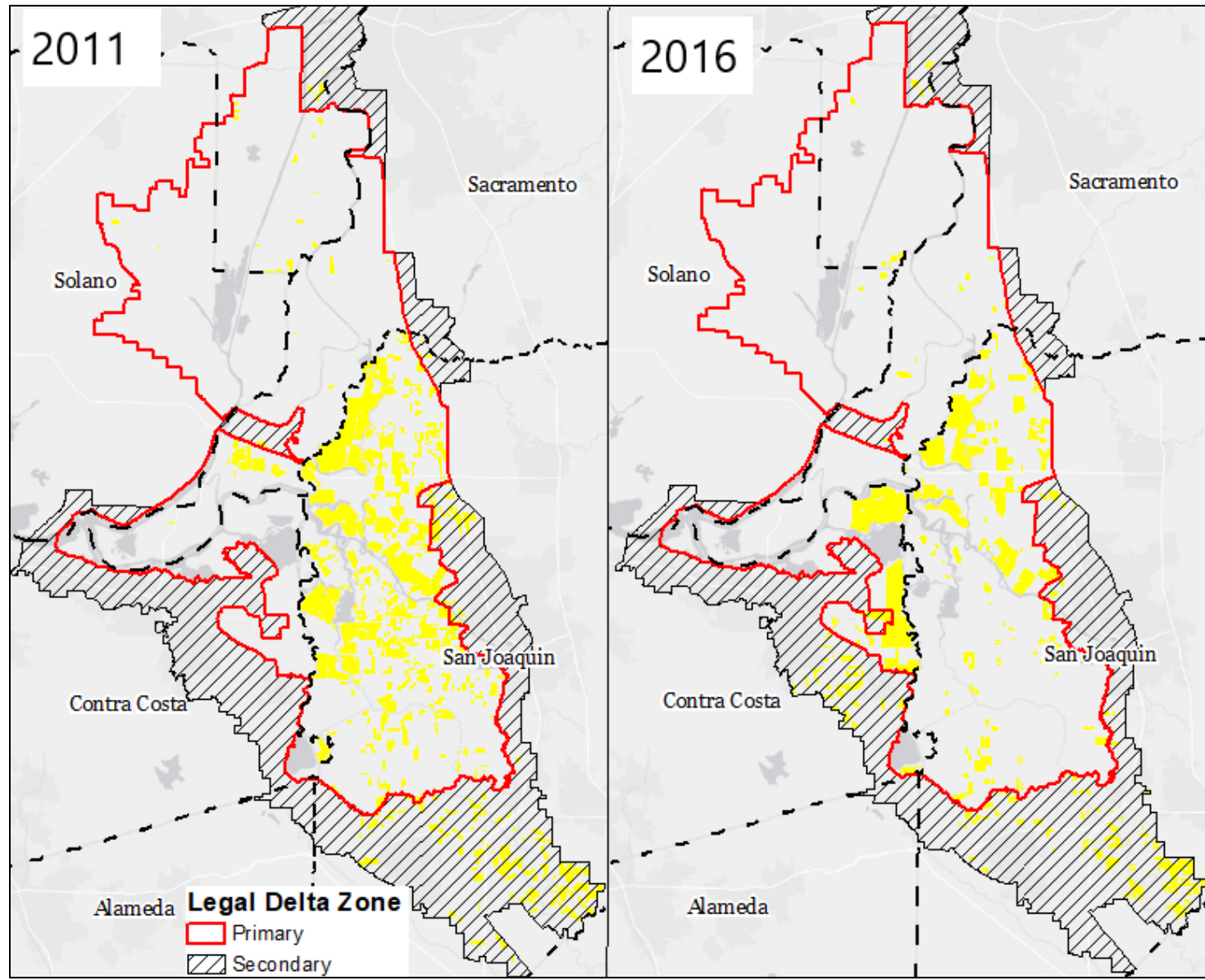


Figure 6 Maps of 2011 and 2016 Vineyard Acreage in the Legal Delta

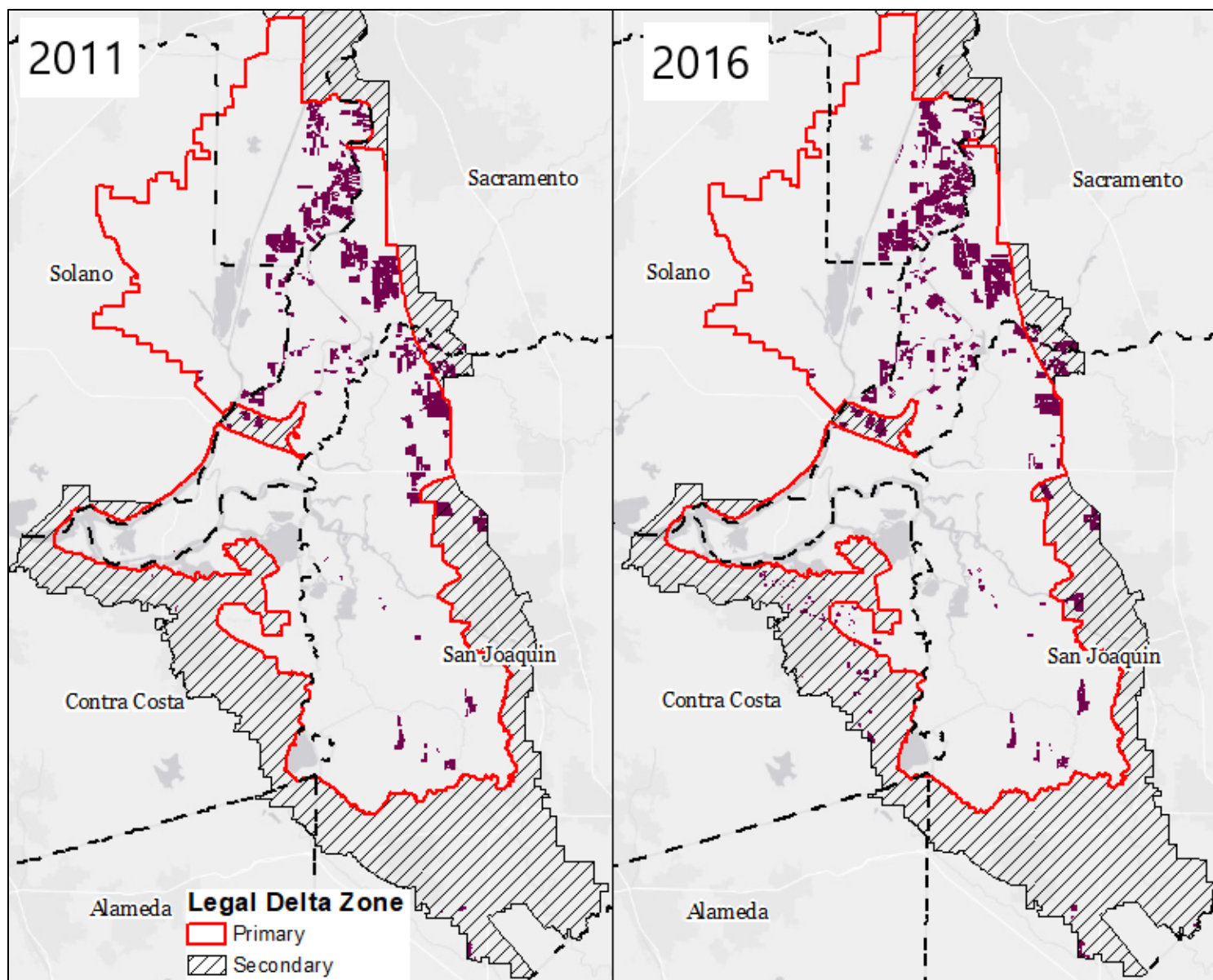


Figure 2 Maps of 2011 and 2016 Alfalfa Acreage in the Legal Delta. There are two maps of the legal Delta that show the change in alfalfa acreage from 2011 to 2016. The primary and secondary zone boundaries are outlined and include parts of the counties of Alameda, Contra Costa, Solano, Yolo, Sacramento and San Joaquin. The amount of alfalfa in the Delta decreased between 2011 and 2016 by 14,402 acres. Spatially, the acreage has reduced throughout the Delta although in 2016 there was still 77,576 acres being farmed.

Figure 3 Maps of 2011 and 2016 Almond Acreage in the Legal Delta. There are two maps of the legal Delta that show the change in almond acreage from 2011 to 2016. The primary and secondary zone boundaries are outlined and include parts of the counties of Alameda, Contra Costa, Solano, Yolo, Sacramento and San Joaquin. The amount of almond acreage in the Delta increased 12,530 acres. Spatially, the acreage has primarily increased in Solano and San Joaquin counties.

Figure 4 Maps of 2011 and 2016 Asparagus Acreage in the Legal Delta. There are two maps of the legal Delta that show the change in asparagus acreage from 2011 to 2016. The primary and secondary zone boundaries are outlined and include parts of the counties of Alameda, Contra Costa, Solano, Yolo, Sacramento and San Joaquin. The amount of asparagus acreage in the Delta decreased by 5,253 acres. Spatially, in 2011 asparagus was planted primarily in San Joaquin county with a few other fields planted in Sacramento County. In 2016 it was planted in San Joaquin County and in the eastern portion of Contra Costa County.

Figure 5 Maps of 2011 and 2016 Corn Acreage in the Legal Delta. There are two maps of the legal Delta that show the change in corn acreage from 2011 to 2016. The primary and secondary zone boundaries are outlined and include parts of the counties of Alameda, Contra Costa, Solano, Yolo, Sacramento and San Joaquin. The amount of corn acreage in the Delta decreased by 22,970 acres. Spatially, in 2011 corn was primarily planted in San Joaquin County with a few fields in Sacramento and Yolo County. In 2016 there was less corn planted in San Joaquin County, but additional corn planted in Contra Costa County in both the primary and secondary zone.

Figure 6 Maps of 2011 and 2016 Vineyard Acreage in the Legal Delta. There are two maps of the legal Delta that show the change in vineyard acreage from 2011 to 2016. The primary and secondary zone boundaries are outlined and include parts of the counties of Alameda, Contra Costa, Solano, Yolo, Sacramento and San Joaquin. The amount of vineyard acreage in the Delta increased by 11,465 acres. Spatially, in 2011 vineyards were primarily in Yolo and Sacramento County with additional acreage planted in San Joaquin County. In 2016 there was an increase in Yolo, Sacramento, San Joaquin counties and some additional plantings in Contra Costa County.

Section 4 - Delta Crop Revenue

Total Delta agriculture revenues can be calculated using the acreage analysis described above and multiplying the 2016 acreage of each individual crop by the yield and unit price reported in county crop reports, as described in Section 2.2. This produces a total of \$882.2 million in revenues from Delta agriculture in 2016. Table 5 depicts the total revenue by crop category in each county. Truck, Nursery and Berry Crops are the largest category by revenue reflecting the wide variety of vegetables grown in the Delta. Truck crops have high revenue per acre, as this category generates about one-third of total Delta crop revenue on about one-eighth of Delta crop land. Vineyards are the second highest category at more than \$200 million, while Deciduous Fruit and Nuts is third at nearly \$120 million in revenue in 2016. Field and pasture crops also are important contributors with each over \$100 million in revenue, but these lower-value crop categories are found on over half the Delta crop acreage.

San Joaquin County is the largest agricultural county in the Delta, generating slightly more than half the Delta's crop revenue with about half the Delta's agricultural land. Truck, Nursery and Berry crops are the biggest revenue generators in the south Delta counties of San Joaquin and Contra Costa, whereas vineyards generate the most revenue in the north Delta counties of Sacramento and Yolo. Pasture crops generate the most revenue in Solano and Alameda counties, and these two counties also generate a small amount of total Delta crop revenue.

Table 5 Delta Agricultural Revenues, 2016 (in \$1,000s)

Crop Category	<i>Alameda</i>	<i>Contra Costa</i>	<i>Sacramento</i>	<i>San Joaquin</i>	<i>Solano</i>	<i>Yolo</i>	TOTAL
Citrus & Subtropical	17	797	281	5,741	874	444	8,154
Deciduous Fruit & Nuts	1	14,662	47,210	46,561	6,181	4,778	119,393
Field Crops	115	31,638	15,242	52,416	3,586	2,941	105,938
Grain & Hay Crops	245	1,551	2,913	7,259	1,794	1,937	15,700
Pasture	1,346	11,480	10,647	58,865	13,252	13,179	108,769
Rice	0	0	1,166	3,477	0	3,158	7,801
Truck, Nursery & Berry Crops	333	40,484	26,228	213,125	8,437	15,645	304,252
Vineyards	24	11,196	62,916	61,714	6,918	69,453	212,222
TOTAL	2,081	111,808	166,604	449,158	41,042	111,535	882,228

Wine grapes are by far the most valuable individual crop in the Delta in 2016 at \$212 million, or about \$5,000 in revenue per acre. This total value is more than double the value in 2009 when wine grapes were second behind processing tomatoes. Tomatoes are second in revenue in 2016 at \$115 million, followed by corn and alfalfa which also ranked in 3rd and 4th place in 2009. Potatoes have increased to nearly \$50 million in annual value, jumping from 8th place in 2009 to 5th in 2016, surpassing Pears and Turf. Almonds have also increased revenue substantially and ranked eighth in 2016 but will likely break into the top 5 soon as non-bearing orchards begin producing nuts. Blueberry and watermelon round out the top 10 crops by revenue. The most notable decline is asparagus, which dropped from the 5th highest valued crop in the Delta in 2009 to the 12th in 2016 as the acreage growing asparagus fell below 2,000 acres.

Table 6 Top 20 Delta Crops by Value, 2016

Rank	Crop	Acreage	Value (\$)
1	Wine Grapes	41,613	\$212,221,541
2	Processing Tomatoes	29,181	\$115,765,217
3	Corn	82,392	\$85,908,676
4	Alfalfa	77,576	\$65,573,721
5	Potato	4,054	\$49,870,709
6	Pear	5,429	\$44,128,504
7	Turf	2,986	\$34,081,253
8	Almond ^[1]	15,651	\$32,578,060
9	Blueberry	1,307	\$27,813,538
10	Watermelon	1,242	\$24,076,276
11	Walnut	4,580	\$18,354,212
12	Asparagus	1,964	\$17,217,002
13	Pumpkin	1,968	\$16,573,095
14	Cherry	2,927	\$14,355,913
15	Pepper	1,218	\$11,997,560
16	Wheat	28,548	\$11,693,072
17	Bean, Dried	7,287	\$8,365,476
18	Rice	7,468	\$7,800,789
19	Pastureland	46,878	\$7,611,903
20	Safflower	12,852	\$6,874,980

[1] Almond crop values exclude non-bearing orchards, defined as those 3 years or younger, but the non-bearing orchards are included in acreage.

Section 5 - Animal Production and Delta-Supported Food and Beverage Manufacturing

The previous sections focused on the value and composition of crop production in Delta agriculture. To calculate the economic impact of agriculture in the Delta, two additional areas need to be considered: 1) the value of animal products in the Delta, and 2) the output of local food and beverage manufacturing firms located in the region because of Delta crop output.

5.1 Animal Production in the Delta

Animal and animal product output in the Delta is more difficult to estimate than crop production. While the Delta is not as oriented towards animal production as other areas in the Central Valley, a significant amount of its crop production is alfalfa and other field crops that are consumed by animal enterprises. Thus, there are important linkages with animal production enterprises that are located both inside and outside the Delta. For these estimates, we focus just on businesses in the Delta.

Table 7 lists the dairy, cattle, and other animal production enterprises that we analyzed, along with the value of their Delta attributable operations. Geospatial enterprise data from Dun and Bradstreet allowed us to identify the businesses located in the legal Delta. This number of Delta-based establishments was compared to the total number of animal product agricultural enterprises in the counties. That percentage from each county was then applied to the total animal production in the crop reports from the individual Delta counties, resulting in an estimate of \$82 million in animal output.

Table 7 Animal Output in the Delta⁴

Animal Output	Value
Cattle	\$22,449,450
Sheep, Poultry, other Livestock	\$3,569,364
Milk	\$53,968,727
Apiculture	\$2,350,321
Total Animal and Animal Products	\$82,337,862

⁴These products correspond with the following industries' direct output impacts reported in Table 9 in terms of the IMPLAN model: Cattle=>Cattle Ranching (\$22.5m); Other Livestock (\$3.6m) & Apiculture (\$2.4m)=>Animal Production (\$5.9); Milk=>Milk Production (\$54m).

5.2 Delta-supported Food and Beverage Manufacturing

The value of farm production is typically measured as the revenue earned by farm operations for selling crops. “Farm gate” values are reported in County crop reports and are the measures of agricultural revenues used in this section and most other discussions of agricultural values. Some farm products are not transformed significantly, and therefore have little additional value added to them between the farm and when they are shipped out of the region or received by retailers or food service providers for sale to local consumers. Tree nuts such as almonds and walnuts, cotton, and many fresh fruits and vegetables are examples of high-value agricultural crops that have little additional value added to them before they are exported from the state or region. In contrast, wine grapes, processing tomatoes and milk are examples of farm products that have significant processing and value added by local food and beverage manufacturers.

Food and beverage manufacturing is an important economic sector in California and the five Delta counties. Some of that manufacturing only exists in the region because of local farm output, whereas many food and beverage manufacturing enterprises such as bakeries locate in a region to serve the local consumer market. Wineries, most fruit and vegetable canneries such as tomato processing facilities, and most dairy product manufacturing such as cheese, butter, and fluid milk in California is closely linked to local farm production.⁵ It should be noted that relatively “low value” alfalfa and corn silage production in California is an important part of the dairy product value chain as well. Wine grapes also have a large associated tourist economy. Thus, it is important to capture local processing of certain agricultural commodities to capture their full value to the economy. This is particularly true in the Delta where the two highest value crops, wine grapes and processing tomatoes, have significant value added through local processing. In contrast, some agricultural commodities such as almonds and rice have less value added through local manufacturing before they are exported from the region.

Only food and beverage manufacturing - where a clear link to regional production could be identified and reasonably estimated - are included: wineries, tomato canneries, and dairy product manufacturing. This is a conservative approach. For example, Delta crops such as alfalfa and silage corn are consumed in large quantities by dairies in the region outside the legal Delta. While those dairies benefit substantially from Delta agriculture, the dairies also use grain and alfalfa transported significant distances and could increase the use of these imported feeds if necessary, although at a higher cost. Thus, dairy production outside the Legal Delta is not attributed to Delta agriculture. Some additional value-added processing to cattle production and fruits and vegetables (other than tomatoes and cattle) are excluded due to measurement difficulties. The complexity of the industry and limited data makes it difficult to precisely

⁵ It should be noted that relatively “low value” alfalfa and corn silage production in California is an important part of the dairy product value chain as well.

estimate the entire value-chain and linkages, but this analysis of these three value-added manufacturing sectors is important to capture the overall scale and contribution of agricultural production to the region.

Estimating the scale of wineries' operations inside the legal Delta and the contribution of Delta-grown wine grapes to wineries outside the Delta begins by comparing the value of wine grapes purchased and the value of the wine sold. According to the California Department of Food and Agriculture (CDFA) the statewide farm gate value of wine grapes in 2016 was \$3.6 billion; an IMPLAN model of the California economy estimates the value of shipments from wineries was \$14.8 billion,⁶ 4.05 times the agricultural value of the wine grapes. In comparison, the 2012 Economic Census (the most recent year available at a level that identifies wineries as a separate manufacturing category)⁷ estimates the value of wineries shipments was \$13.1 billion; with the CDFA's 2012 farm gate value of wine production at \$3.1 billion, a ratio of wine shipments to grapes of 4.21. Similar calculations for data from 2007 lead to an estimated ratio of 5.8, suggesting the value of wine grapes to wineries is steadily rising.

Before analyzing the 2016 statewide impacts of wineries using Delta-grown wine grapes with the 4.05 ratio, the value of wineries in the legal Delta is needed. Using the share of wine grape output from the legal Delta to the total 5-county Delta production, we estimate the value of sales from wineries in the legal Delta to be \$298.1 million.⁸ After subtracting the Delta wine grape production used by wineries inside the legal Delta, we estimate \$150.1 million in wine grapes from the Delta, about two-thirds of Delta wine grape production, is shipped to outside wineries resulting in a further \$607.2 million of winery output from other parts of the California, which is shown in Table 8 along with the other output components. Therefore, the \$212 million in Delta wine grapes are estimated to have a statewide output value of \$905 million in winery sales.

⁶ The statewide output value of wineries is taken from the IMPLAN 2016 model. IMPLAN is an economic modelling software, see Section 6 for further details about the software and its models.

⁷ Wineries are defined at the 5-digit NAICS level under the sector code 31213.

⁸ According to the County Crop Reports total wine grape value in 2016 was \$724.6 million.

Table 8 Output of Delta Agriculture Related Value-Added Processing⁹

Sector	Output in 5-Delta Counties	Output in Rest of California (excl. Delta)	Total Statewide Output
Wineries	\$298.1 million	\$607.2 million	\$905.3 million
Tomato Canning	\$231.5 million	0	\$231.5 million
Dairy Products Manufacturing	\$91.7 million	\$142.9 million	\$234.6 million

Disaggregated data on manufactured products made from processing tomatoes is unavailable as it is combined in North American Industrial Classification System (NAICS) code with all fruit and vegetable canning, but data from major tomato processor Morning Star suggests that the value of shipments in canned tomato products production is roughly 2 times the value of processing tomatoes purchased from local farms.¹⁰ Thus, the \$115.7 million in processing tomatoes produced in 2016 from the legal Delta would be conservatively supporting about \$231.5 million in canned tomato products production.¹¹

Milk is the highest value California farm product, valued at approximately \$7 billion in recent years. Virtually all the milk was used by various segments of California's dairy product manufacturing industry (NAICS 3115, includes fluid milk, cheese, ice cream, etc.) which recorded a value of shipments of \$15.584 billion in 2012, 2.26 times the value of raw milk in agricultural reports.¹²

Delta farms produce less than 1 percent of California's milk, but produce roughly 10 percent of the state's alfalfa and forage crops, critical and increasingly scarce and costly inputs to the dairy industry. Although there are few dairies in the Delta, maps of dairy cow concentration in the San Joaquin Valley indicate large nearby clusters between Highway 99 and I-5 between

⁹ These sectors correspond with the following industries' direct output impacts reported in Table 9 of the IMPLAN model: Wineries=> Wineries; Tomato Canning=> Fruit and vegetable canning, pickling, and drying; Dairy Products Manufacturing => Fluid milk, Creamery butter, Cheese, Dry/condensed/evaporated dairy products, and Ice cream/frozen dessert manufacturing

¹⁰ See exhibit 2 and exhibit 8 in this presentation: [Morning Star farms tomato processor](#)

¹¹ Morning Star is known for low cost tomato paste production; other higher valued canned tomato products are likely adding more value than bulk tomato paste production, which absorbs roughly 75 percent of California's processing tomato production, according to Morning Star.

¹² Using the statewide output value from the IMPLAN 2016 model the value of dairy product manufacturing is estimated to have risen to \$15.9 billion with milk production, according to CDFA, at the farm gate declining to \$6.07 billion resulting in an increase in the ratio to 2.62.

Manteca and Merced, and in southeast San Joaquin County near Escalon.¹³ Clearly the Delta is more critical to the state's industry than the milk production data shows, but quantifying its importance is difficult since dairy producers can import feed and adjust the mix of feeds in cow rations in response to scarce local feed sources. One could argue Delta agriculture supports anywhere from 1 percent (\$137 million) to 10 percent (\$1.37 billion) of California's dairy product industry. However, we conservatively follow the same methodology used to estimate wineries and only look at dairy manufacturing from milk that is produced in the Delta. Thus, we link 12 percent (\$90.4 million) of the five Delta counties dairy product manufacturing to Delta agriculture, and attribute its share of statewide milk, 0.89%, to dairy products produced in California (\$142.9 million).¹⁴

¹³ For further details see the maps in the appendix of the 2016 Annual Report on the Central Valley Dairy Representative Monitoring Program, which are available at: https://www.waterboards.ca.gov/centralvalley/water_issues/confined_animal_facilities/groundwater_monitoring/phase2_rmp_wkpln_figs.pdf

¹⁴ There is one very large cheese manufacturer of note in the legal Delta, Leprino Foods in Tracy.

Section 6 - Economic Impact of Delta Agriculture

To analyze the economic impacts of Delta agriculture, we utilize the economic modelling software IMPLAN, which allows us to develop models of the State and 5-County Delta economies.¹⁵ This model is in a sense a general accounting system of transactions between industries, businesses, and consumers that estimates a range of economic impacts. We thereby create complete, extremely detailed Social Accounting Matrices and Multiplier Models of these economies that enables in-depth examination of the total economic contributions of Delta agriculture.

IMPLAN was developed in the late-1970s by the United States Forest Service and researchers at the University of Minnesota. The software was initially based on input-output accounts whose analysis was pioneered in the Nobel Prize-winning work of Wassily Leontief. As the software evolved, it began using Social Accounting Matrices to incorporate transactions among institutional agents in its analysis. Currently, IMPLAN is among the most widely used economic impact modeling systems. It provides a transparent and detailed approximation of economic impacts that is widely utilized by businesses and government agencies.

The full range of economic impacts from Delta agriculture and its associated sectors, known as the Total Effect, is the sum of the direct, indirect, and induced effects:

- **Direct Effects** are the changes in sales (output), value (value-added), wages (personal income), and jobs (employment) directly supported by Delta agriculture and its associated sectors.
- **Indirect Effects** represent the iterative impacts of inter-industry transactions as supplying industries respond to demand from the sector(s) where the initial expenditures occurred. An example of an indirect impact would be employees of a hardware store supplying Delta farmers.
- **Induced Effects** reflect the expenditures made by recipients of wages in the direct and indirect industries. Examples of induced impacts include employees' expenditures on items such as retail purchases, housing, food, medical services, banking, and insurance.

In this analysis, the total, direct, indirect, and induced effects are reported by employment, labor income, value added, and output:

- **Employment** is the number of full- and part-time jobs based on an annual average of monthly jobs. In other words, employment is measured as a full year of employment. Thus, 3 temporary jobs that lasted for 4 months are reported as 1 job.

¹⁵ Specifically, in this analysis we use IMPLAN Version 3.1 with calendar year 2016 data.

- **Labor Income** is the sum of employee compensation and proprietor income. Employee compensation includes wages, salaries, benefits, and all other employer contributions, while proprietor income consists of payments received by self-employed individuals, and unincorporated business owners.
- **Value Added** represents the total value added to a product during the production process defined as the difference between gross sales and non-labor business expenses, or the sum of labor and business income.
- **Output** represents the value of industry production. It accounts for the total change in the value of production in an industry for a given time. Output varies as a measure across industries. For agriculture and service sectors, the value of production equals their sales. For manufacturers, the value of production is sales plus or minus any change in inventories. While for retail and wholesale trade, the value of production equals their gross margin and not their gross sales.

The economic model is defined for a specific geographic area, and economic impacts are calculated for that area. Indirect and induced effects are calculated using regional purchasing coefficients calculated by IMPLAN, and thus economic impacts do not include spending outside the region of analysis even if the purchases are made by individuals or businesses located within that region.

6.1 Economic Impact Estimates

As mentioned above, IMPLAN 3.1 Pro software with 2016 data was used to model the regional and statewide economies. Those models were then used to estimate the overall economic impact of Delta agriculture.¹⁶

¹⁶ In contrast to the 2012 Economic Sustainability Plan, we did not adjust the standard IMPLAN model to increase the use of local contract labor by Delta farms. Instead, we conservatively retained the default values in the 2016 IMPLAN model, because the 2016 IMPLAN model has higher local contract labor purchases than the 2010 model and generates reasonable estimates of total employment impact from the default model. However, this more conservative approach leads to slightly lower indirect and total employment effects than reported in the 2012 Economic Sustainability Plan.

Table 9a Direct Agriculture Related Output in 2016 Used for the IMPLAN model¹⁷

IMPLAN Industry	Output Value (millions \$)
Oilseed farming	7.9
Grain farming	89.4
Vegetable and melon farming	297.9
Fruit farming	321.5
Tree nut farming	51.6
All other crop farming	76.0
Cattle ranching and farming	22.5
Dairy Cattle and milk production	54
Animal production, except cattle and poultry and eggs	5.9

Table 9b Direct Agriculture Related Output in 2016 Used for the IMPLAN model to Calculate Expanded Analysis

Food/Beverage Manufacturing in Expanded Analysis	Delta Counties Output Value (millions \$)	Statewide Output Value (Millions \$)
Fruit and vegetable canning, pickling, and drying	231.5	231.5
Dairy Products Manufacturing	91.7	234.6
Wineries	298.1	905.3

For the five-county economic impact model, Delta agricultural production (Table 9a) and Delta-dependent food processing and winery production (Table 9b) was distributed across IMPLAN production sectors. In the first part, only the impacts of the \$965 million in direct agricultural production were modeled. As shown in Table 10(A), the approximately \$882 million in Delta crop production and \$82 million in Delta animal and animal product revenue has an economic impact of 12,367 jobs, \$966 million in value-added and \$1.74 billion in output in the five Delta counties. Table 11 (A) shows that across all of California, the economic impact of Delta agriculture is 13,804 jobs, \$1.08 billion in value added, and \$1.96 billion in output. This equates to an employment multiplier of 12.8 jobs per million dollars in output in the five Delta Counties and 14.3 jobs per million dollars in output when evaluated statewide. These multipliers are very consistent, if not low, compared to other studies.

To get a more complete picture of the full economic impact of Delta agriculture, the contribution of Delta-dependent food and beverage manufacturing for wineries, tomato

¹⁷ See Appendix Table A2 for a description of the crops contained in the IMPLAN farming industries. Similar descriptions of animal products and food/beverage manufacturing are in Section 5.1 and 5.2 respectively.

canning, and dairy products were included as described in the previous section. These upward linkages must be estimated separately, because the indirect effects of the IMPLAN model only includes backwards linkages from purchased inputs. To avoid double counting impacts from the initial stage, the indirect effects attributed to the purchase of crops as inputs were netted out of the results. For example, for wineries, the indirect effects associated with purchasing wine grapes were estimated and removed from the total to avoid double counting the impact of growing wine grapes. The total five-county economic impacts are displayed in Table 10 (C). Delta agriculture supported 15,717 jobs, \$1.3 billion in value-added, and \$2.7 billion in output in the five Delta counties. For the California economic impact model, the additional \$607.2 million of Delta dependent winery production and \$143 million in dairy product production from adjacent counties was added to the totals. The economic impact rises from this extra production, as well as the growth of indirect and induced effects when considered on a statewide rather than five-county basis. Table 11 (C) shows that across the State of California, Delta agriculture supports 23,064 jobs, over \$2.17 billion in value-added, and over \$4.59 billion in output.

Table 10 (A, B and C) Economic Impact in 2016 of Delta Agriculture on Five Delta Counties

(A) Delta Crop and Animal Production Impacts

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	6,322	\$364,395,182	\$481,193,798	\$964,565,976
Indirect Effect	3,450	\$171,223,634	\$248,520,286	\$396,393,527
Induced Effect	2,595	\$124,939,507	\$236,276,406	\$383,427,218
Total Effect	12,367	\$660,558,323	\$965,990,491	\$1,744,386,721

(B) Delta Agriculture Processing Impacts

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	1,404	\$91,833,790	\$145,439,795	\$621,276,863
Indirect Effect	1,116	\$76,971,001	\$124,479,764	\$227,938,340
Induced Effect	830	\$40,143,008	\$75,844,327	\$123,131,768
Total Effect	3,350	\$208,947,799	\$345,763,886	\$972,346,971

(C) Total Delta Agriculture Impacts

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	7,726	\$456,228,972	\$626,633,593	\$1,585,842,839
Indirect Effect	4,566	\$248,194,635	\$373,000,050	\$624,331,867
Induced Effect	3,425	\$165,082,515	\$312,120,733	\$506,558,986
Total Effect	15,717	\$869,506,122	\$1,311,754,377	\$2,716,733,692

Table 11 (A, B and C) Economic Impact in 2016 of Delta Agriculture on California**(A) Delta Crop and Animal Production Impacts**

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	6,757	\$374,191,459	\$481,169,895	\$964,565,976
Indirect Effect	3,936	\$205,538,640	\$297,020,710	\$500,979,706
Induced Effect	3,111	\$169,860,517	\$304,068,297	\$496,984,066
Total Effect	13,804	\$749,590,615	\$1,082,258,902	\$1,962,529,748

(B) Delta Agriculture Processing Impacts

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	3,142	\$255,547,075	\$393,873,774	\$1,371,454,760
Indirect Effect	3,282	\$264,218,237	\$419,556,233	\$796,851,020
Induced Effect	2,837	\$155,229,832	\$277,749,391	\$454,216,139
Total Effect	9,260	\$674,995,144	\$1,091,179,398	\$2,622,521,919

(C) Total Delta Agriculture Impacts

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	9,898	\$629,738,534	\$875,043,669	\$2,336,020,736
Indirect Effect	7,218	\$469,756,877	\$716,576,943	\$1,297,830,726
Induced Effect	5,948	\$325,090,349	\$581,817,688	\$951,200,205
Total Effect	23,064	\$1,424,585,759	\$2,173,438,300	\$4,585,051,667

Section 7 - Conservation and Restoration Impacts on Delta Agriculture

The Delta is home to a large number of conservation and restoration properties, and the number continues to grow. Conservation and restoration projects sometimes restrict or conflict with agricultural land uses, and thus can impact the agricultural economy in the Delta. The 2012 Economic Sustainability Plan found that the over 100,000 acres of conservation and restoration projects proposed in the 2010 Bay Delta Conservation Plan, including 65,000 acres of planned tidal marsh restoration, was the biggest threat to the long-term sustainability of Delta agriculture. Since 2012, the State has dropped the Bay Delta Conservation Plan and current plans for restoration have far less potential conflict with agriculture and have greater collaboration with Delta stakeholders.

In fact, many conservation projects in the Delta are designed to protect agricultural land from urban development or include agricultural land use that is beneficial to wildlife. For example, the largest conservation project in the Delta preserves corn farming on Staten Island that supports sandhill crane habitat, while others involve preservation of grasslands and can support cattle grazing or floodways where agricultural land use can help maintain floodwater conveyance while providing food for wildlife and fish after the growing season. While these projects may restrict potential agricultural revenue (for example, there could be a restriction that prevents planting lucrative vineyards or orchards), the land remains in active agricultural use and thus makes a positive contribution to Delta agriculture and conservation goals.

The data for conservation and restoration projects in this assessment was acquired from EcoAtlas' Habitat Projects data layer.¹⁸ We determined EcoAtlas was the most comprehensive database of its kind with a wide variety of contributing partners including state, federal, and local agencies as well as non-governmental organizations which included all the organizations most active in Delta conservation projects. The EcoAtlas data was joined with the 2016 agricultural production data previously described to determine crop production in each of the conservation project areas.

¹⁸ The EcoAtlas description of the Lower Marsh Creek and Sand Creek project in Contra Costa County extended beyond the project description in the project EIR, so we adjusted the boundaries from EcoAtlas for this project to match the project description in the EIR as described here <https://ceganet.opr.ca.gov/2019049002/2>. In addition, individual conservation projects within the Yolo Bypass area are in EcoAtlas rather than the entire project. The discussion of the Yolo Bypass in this project refers to the entire project, and thus extends beyond the areas included in the EcoAtlas data. For a more detailed description and to obtain the data, view the EcoAtlas project tracker at <https://ptrack.ecoatlas.org/>.

This assessment focuses exclusively on the properties included in the conservation and restoration projects, and thus does not consider any potential impact on agricultural properties that are adjacent to or near restoration areas. Off-site impacts that have been mentioned by some farmers include concerns about the impacts of flooding or levee breaches on nearby restoration properties, or conflicts with increased visitors or protected wildlife. Since these potential impacts are outside the scope of this descriptive analysis, the potential impacts here could be considered conservative.

Overall, the data shows 146 conservation and restoration projects in the Delta that are completed, in construction, or in planning. These 146 projects cover 57,738 acres in the Delta and include about 21,000 acres in crop production. Completed projects were less than half of total conservation and restoration acres but contained over two-thirds of the agricultural acres and nearly three-fourths of agricultural revenue. Crops grown in areas with conservation projects in the planning or proposal stage were valued at \$7.9 million in 2016, accounting for about 1% of all Delta crop revenue. As discussed below, many of these crops will continue to be grown after the conservation projects are implemented, thus planned conservation projects should have a very small effect on the overall Delta agricultural economy.

Table 12 Delta Conservation and Restoration Projects With 2016 Agricultural Acres and Revenue

Status	# Projects	# Projects With Ag Acres	Total Delta Acres	Delta Ag Acres	Delta Ag Revenue
Completed	63	26	27,974	14,407	\$23,955,929
In Construction/ Implementation	15	5	8,980	1,627	\$526,731
In Planning/ Proposed	68	25	20,784	4,984	\$7,937,799
Total	146	56	57,738	21,018	\$32,420,459

Figure 7 Map of Conservation and Restoration Projects in the Delta from EcoAtlas

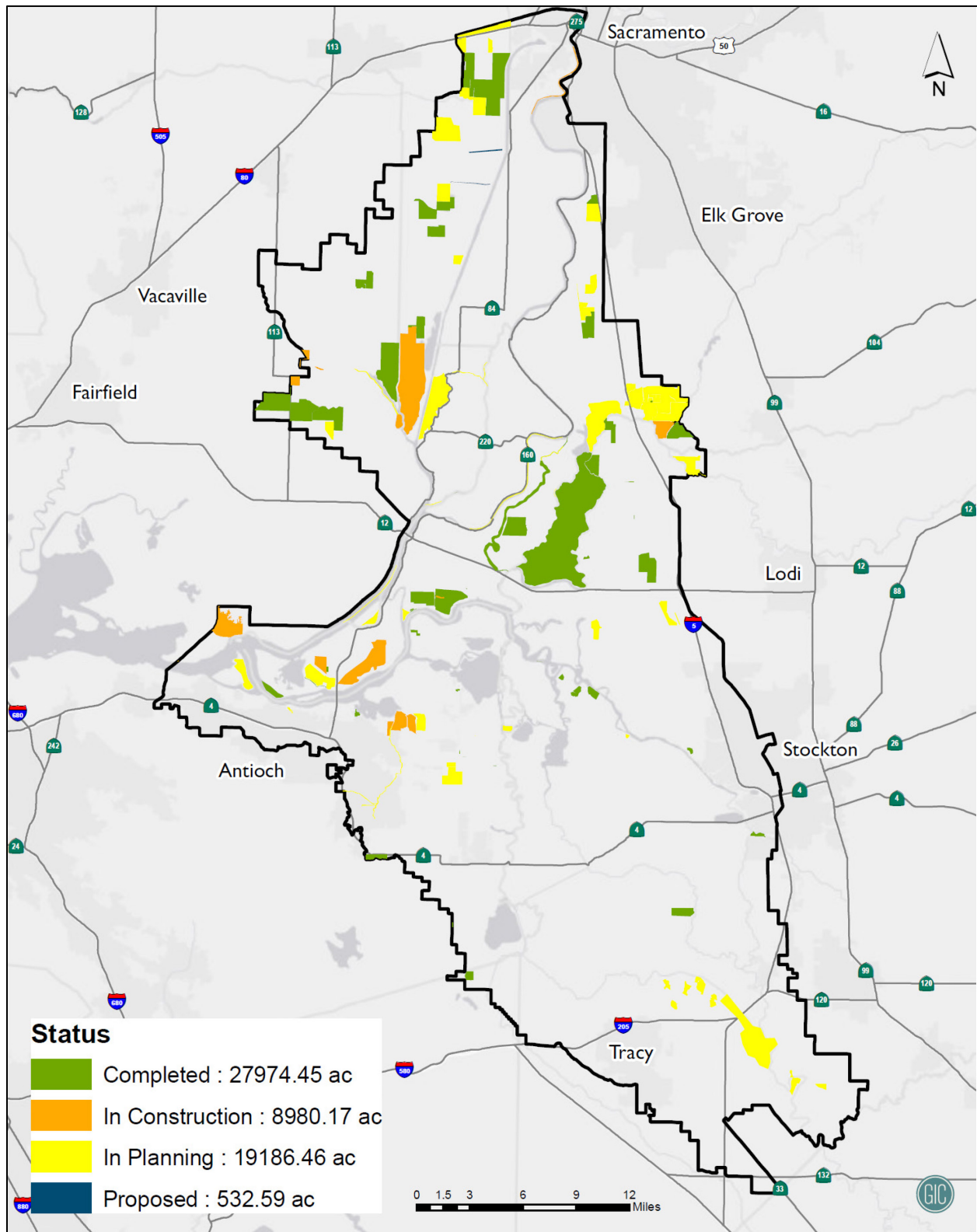


Figure 7 Map of Conservation and Restoration Projects in the Delta from EcoAtlas This figure shows the boundary of the legal Delta and the restoration projects that are in EcoAtlas. The categories of projects on the figure are Completed: 27,974.45 acres; In Construction: 8,980.17 acres; In Planning: 19,186.46; and Proposed: 532.59. The proposed category does not include Lookout Slough. The completed projects include several large projects in the northern portion of the Delta. The south Delta includes a large project that is being planned (Paradise Cut). Other areas on the map that show multiple conservation and restoration areas are around Cosumnes Preserve, Liberty Island and Staten Island. In addition, there are several parcels in the Western Delta that have restoration and conservation acreage.

7.1 Completed Conservation and Restoration Projects

The majority of completed conservation and restoration projects in the Delta are agricultural conservation, including many agricultural conservation easements that restrict non-agricultural use of the property. These completed agricultural conservation projects generated nearly \$22 million in crop revenue in 2016, over \$2,000 per acre. Wetland restoration projects do not usually include agricultural use and typically occur on lower-valued agricultural uses like pastureland. Agricultural acreage within completed wetland projects averaged less than \$1,000 per acre, and the small number of acres indicates these are just small portions of larger parcels that include wetland restoration. Most of the agricultural acreage reported in completed wetland restoration projects are pasture in the Liberty Farms wetland restoration in Solano County (a predecessor to the current tidal marsh restoration proposed as Lookout Slough).

Table 13 Summary of Completed Conservation and Restoration Projects

Project Type	Agricultural Acres in 2016 (CACASA)	Total Conservation Acres	Agricultural Revenue
Agriculture	10,754	11,721	\$21,988,182
Wetland	1,101	12,410	\$832,746
Upland	1,030	2,286	\$231,596
Unknown/Other	1,522	1,557	\$903,405
Total	14,407	27,974	\$23,955,929

The largest completed project is on Staten Island, which is classified as an agricultural conservation project in the EcoAtlas. Staten Island is owned by The Nature Conservancy, and the majority of the land is used to grow corn, when combined with management practices makes excellent winter habitat for sandhill cranes. Thus, Staten Island shows that conservation can be compatible with agriculture, although some agricultural uses would not be consistent with the conservation objective. For example, Staten Island is located in an area that is seeing

an increase in vineyard plantings, and thus the conservation project prevents vineyard establishment in the area since vineyards generally do not make good wildlife habitat.

7.2 In Progress and Under Construction Conservation and Restoration Projects

All of the conservation and restoration projects in the Delta that were classified as “in progress” or under construction during 2017-18 were defined as wetland projects. Unsurprisingly, these wetland projects had relatively little in the way of agricultural land in 2016. Many of these projects were at or near completion in 2019.

Table 14 Summary of In-Progress Conservation and Restoration Projects

Project Type	Agricultural Acres in 2016 (CACASA)	Total Conservation Acres	Agricultural Revenue
Agriculture	-	-	-
Wetland	1,627	8,980	\$526,731
Upland	-	-	-
Unknown/Other	-	-	-
Total	1,627	8,980	\$526,731

Most of the land that was in agricultural use within these wetland restoration areas was in low-revenue pasture and forage crops and averaged about \$400 per acre in revenue. A notable exception of high-value crops is some vineyard acreage. This acreage is a historic vineyard within the Dutch Slough restoration area that is being preserved as a vineyard and cultural site as part of the project. Thus, the wetland restoration in the Dutch Slough project will not result in the loss of any vineyards or high-value crops.

7.3 Planned and Proposed Conservation and Restoration Projects

The area of planned and proposed projects covers 20,784 acres, and just under 5,000 acres of these contained crops valued at \$7.9 million in 2016. Like the in-progress projects, planned projects are heavily focused on wetland restoration with over half of the total acres categorized as wetland. In addition to those classified as wetland projects, some of the unknown/other projects include wetlands and some of the agricultural projects include flood easements that could affect agriculture in some years

Table 15 Summary of Planned and Proposed Conservation and Restoration Projects

Project Type	Agricultural Acres in 2016 (CACASA)	Total Conservation Acres	Agricultural Revenue
Agriculture	1,924	2,936	\$1,878,481
Wetland	2,006	11,520	\$3,437,279
Upland	1,003	4,203	\$699,528
Unknown/Other	1,975	5,137	\$1,922,512
Total	4,984	20,784	\$7,937,799

In most cases the non-wetland projects have low conflict with agricultural use. Several of the larger projects categorized as agricultural are flood bypasses including areas that are within the Yolo Bypass and a proposed flood bypass at Paradise Cut in San Joaquin County. Unlike wetland restoration projects which rarely can accommodate higher-revenue agricultural crops, these projects involve flood easements on agricultural land that would allow winter and spring flooding during wet years to provide flood protection and ecosystem benefits. Agriculture would still be the dominant use but could be disrupted during years where the land floods in the spring and thus the land may not be suitable for permanent orchards and vines.

7.4 Potential Impact of Conservation and Restoration Projects on Delta Agriculture

Well planned conservation and restoration projects in the Delta can complement and sustain agriculture and minimize conflicts. Potential agricultural conflict with restoration has been greatly diminished since 2012 due to the demise of the Bay Delta Conservation Plan. Currently planned restoration activities will provide substantial environmental and flood control benefits that could provide some benefits to Delta agriculture that could offset some of the potential loss of cropland. Even if all the currently planned wetland restoration projects eliminated agriculture within their footprints, the decrease in Delta agriculture would only be 2,000 acres and \$3.4 million in revenue, which represents less than 0.5% of current Delta agricultural production.¹⁹ Thus, Delta conservation and restoration projects as currently planned are consistent with agricultural economic sustainability.

There are four planned conservation project areas that had over \$1 million worth of crop production in 2016. Since these four projects contain most of the potential impact on Delta agriculture from planned restoration projects, they are profiled in more detail below. As the

¹⁹ This total does not include cropped acres in Lookout Slough, because these acres already counted as a completed project for the Liberty Farms Wetland Restoration project area.

discussion shows, the actual impact of these and other planned conservation actions on the Delta is likely to be smaller than our calculation of current crops within the planning areas.

Yolo Bypass

The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project is the largest conservation project within the region. About half of the Yolo Bypass project area is located outside the Delta, and only some of the potentially affected area in the Delta, primarily the Yolo Bypass Wildlife Area, is listed in the EcoAtlas data. The project would lower and add operable gates to the Fremont Weir on the Sacramento River north of the City of Sacramento to allow more frequent flooding of the Yolo Bypass to benefit salmon. Currently, the Yolo Bypass and Fremont Weir is a flood protection project for downstream cities and overtops during high-water events. Many studies have shown that salmon benefit from access to the food-rich flooded agricultural fields during years in which the river overtops the Weir and floods the Bypass. The project would allow more frequent and controlled flooding of the area to benefit salmon, and agricultural impacts can be controlled if the flooding is minimized during the spring planting season.

Early descriptions of the Yolo Bypass project were contained in the 2010 draft Bay Delta Conservation Plan that was the basis of the 2012 Economic Sustainability Plan. This document described thousands of acres where spring flooding would preclude agricultural production on thousands of acres in the majority of years. On the basis of this description, the 2012 ESP estimated a potential \$7 to \$10 million-dollar loss in annual agricultural output in the Bypass areas, including areas inside and outside the Delta.

Subsequent planning, supported by detailed studies from UC Davis agricultural economists conducted for Yolo County,²⁰ have led to a refined project with minimal agricultural impact. Like the ESP, those studies found that agricultural losses could exceed \$7 million across thousands of acres if flooding were allowed to extend to April 30 or later. However, those studies also showed that revenue loss would drop below \$1 million if flood flows were stopped before late March, and also considered that salmon did not benefit as much from flooding in the spring when waters are warmer and shallower. Subsequent to these studies, all of the

²⁰ The Bureau of Reclamation provides drafts, reports and information on the Yolo Bypass Project, which can be found here [USBR Yolo Bypass Environmental Impact Documents](#). This discussion is based on two 2017 drafts of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project EIS/EIR can be found here [DEIS for Yolo Bypass Salmonid Habitat Restoration and Fish Passage](#), [Agricultural economic model for USBR Yolo Bypass Project](#). The final EIR was released as this project was completed. For the latest information on the Yolo Bypass project, visit [USBR Yolo Bypass Website](#)

alternatives considered and modeled in the Bureau of Reclamation's environmental impact statement stopped inundation flows by March 15, and estimated agricultural revenue loss ranged from \$102,000 to \$361,000 with just over 100 acres of lost agricultural production in a typical year.²¹ This is more than a 95% decline in the potential impact estimated in the 2012 Economic Sustainability Plan based on a preliminary project description in the 2010 draft BDCP. It shows how agricultural impacts from conservation and restoration projects can be minimized with refined planning, more detailed research and collaboration with local stakeholders.

Paradise Cut Conservation and Flood Management Plan

The Paradise Cut Conservation and Flood Management Plan is a multi-benefit project that would provide flood protection and habitat benefits. It is sometimes described as a smaller, San Joaquin River version of the Yolo Bypass project. A new weir and flood bypass in Paradise Cut are projected to reduce flood stage on the San Joaquin River by up to 3 feet in the City of Stockton, and improve floodplain and riparian habitat. Flood easements would be acquired for agricultural properties within Paradise Cut that could restrict the types of crops grown and result in flood damage to agricultural production in occasional wet years. While the project would allow controlled flooding of farmland in certain years, it would also protect against uncontrolled flood risk to farmland which could offset some of the agricultural impact expected in the flood bypass.

The Paradise Cut project planning area includes 2,500 acres in the southwest portion of the Delta in San Joaquin County. Of the 2,500 acres in Paradise Cut, 1,814 acres grew crops in 2016 with a total value of \$1.76 million, or just under \$1,000 per acre. About half of these acres were in alfalfa with most of the rest growing corn and beans. A notable exception to these field and forage crops is nearly 60 acres of almonds that would likely be unviable if the project were implemented. However, agricultural production would likely continue as normal through most of the planning area in most years, such that lost agricultural production would be only a fraction of the \$1.76 million in current output.

McCormack-Williamson Tract

Like adjacent Staten Island, McCormack-Williamson tract was owned by The Nature Conservancy and in 2019 transferred to DWR. While classified as in planning in our data, this project broke ground in 2018. The project will involve a new weir, a combination of levee

²¹ Howitt, R., MacEwan, D., Garnache, C., Azuara, J., Marchand, P., Brown, D., Six, J., Lee, J. 2013. Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals. https://watershed.ucdavis.edu/files/biblio/Yolo_0.pdf The Bureau of Reclamation provides drafts, reports and information on the Yolo Bypass Project, which can be

breaches and reshaping that will result in tidal marsh habitat on the majority of the tract and floodplain, riparian and subtidal habitat in other areas. In addition to wildlife and environmental benefits, the project will provide flood protection benefits to downstream islands and communities by increasing the capacity of floodways and reducing the risk of an uncontrolled levee breach. In 2016, crops were grown on 950 acres of the total 1,742 acres in the McCormack-Williamson tract study area, generating \$1.5 million in revenue. Most of the acres were in wheat, but most of the revenue came from processing tomatoes. Because the project will convert the majority of the tract to tidal marsh, agricultural production in the area will be greatly reduced.

Knightsen Wetland Restoration and Flood Protection Project

The Knightsen Wetland Restoration project is in the early planning stages on a parcel recently acquired by the East Bay Regional Park District from a family farm. According to the Park District, the property will be restored to “tidal and freshwater wetlands, alkali meadow and oak savanna” providing wildlife habitat and flood protection benefits to the community of Knightsen. The project would also allow for trails and recreational benefits from the site. The data show that 511 of the 561 acres in the project area grew crops in 2016 generating \$1.25 million in agricultural revenue. Most of the acres were growing sweet corn and wheat. While the project is still in the early planning stages, it seems likely that most agricultural production on the property will end once the project is implemented.

Section 8 - Summary and Conclusion

We find \$965 million in Delta crop and animal product production in the Delta supported 12,367 jobs in the five Delta counties during 2016. In addition, we estimate \$621 million in food and beverage manufacturing in the five Delta counties was supported by Delta agriculture, creating an additional 3,350 jobs in Delta counties. Overall, Delta agriculture and related food and beverage manufacturing supports \$2.7 billion in economic output and 15,700 jobs in the five Delta counties alone. The impact of Delta agriculture is even greater to the State of California as a whole. We estimate the statewide economic impact of Delta agriculture and Delta supported food and beverage manufacturing in 2016 was about \$4.6 billion in output while directly and indirectly supporting over 23,000 jobs across California. This is slightly lower than the previous estimate in the 2012 Economic Sustainability Plan that Delta agriculture supported 25,000 jobs across California.

Delta crop patterns are changing in a way that is consistent with broader trends in California agriculture. For example, there is a clear shift towards permanent crops. Wine grapes have supplanted processing tomatoes as the highest revenue crop in the Delta, and almonds are the fastest growing crop in terms of acreage. Rice and safflower also saw an increase in acreage. The largest decreases in acreage were to the most common crops in the Delta: corn and alfalfa. Oats, tomatoes and wheat also saw declining acreage, and overall Delta crop acres have decreased since 2009. We examine the potential impact of conservation and restoration on Delta agriculture which was identified as the greatest threat to the sustainability of Delta agriculture in 2012 due to the now defunct Bay Delta Conservation Plan. We find the potential effects of currently planned conservation and restoration projects to be relatively small, up to 2,000 acres and \$3.5 million in agricultural output if all currently proposed wetland restoration displaced current agricultural production. Thus, the potential effect of restoration projects is less than 0.5% of current Delta agricultural production.

Appendix

Table A1. DWR Detailed Crop Categories

Citrus & Subtropical	Deciduous Fruits & Nuts	Field Crops	Grain & Hay Crops	Pasture	Rice	Truck, Nursery and Berry Crops	Vineyard
Citrus Kiwi Nectarine Olive Orange Prickly Pear Quince	Almond Apple Apricot Cherry Chestnut Fig Peach Pear Pecan Pistachio Plum Pomegranate Stone Fruit	Bean, Dried Bean, Lima Corn Safflower Sorghum Sunflower	Barley Forage Hay Oat Triticale Wheat	Alfalfa Orchardgrass Pastureland Rangeland* Ryegrass Sudangrass	Rice	Asparagus Blackberry Blueberry Boysenberry Broccoli Brussel Sprout Cabbage Herbs* Lettuce Melon Onion Outdoor Plants Pepper Potato	Grape, Wine

Note: A few Delta crops were not defined in the DWR crop categories. These were assigned by the authors' and indicated in the table with an "**"

Table A2 IMPLAN Detailed Crop Categories

Oilseed farming	Grain farming	Vegetable & melon farming	Fruit farming	Tree nut farming	Greenhouse, nursery, and floriculture production	All other crop farming
Safflower Sunflower	Barley Bean, Dried Corn, Grain Oat Rice Sorghum Triticale Wheat	Asparagus Bean, Lima Broccoli Brussel Sprout Cabbage Cantaloupe Carrot Cilantro Corn, Sweet Cucumber Garlic Lettuce Melon Onion Pepper Potato Pumpkin Squash Sweet Basil Tomato Watermelon	Apple Apricot Blackberry Blueberry Boysenberry Cactus Pear Cherry Citrus Fig Kiwi Nectarine Olive Orange Peach Pear Persimmon Plum Pomegranate Quince Stone Fruit Strawberry Wine Grape	Almond Chestnut Pecan Pistachio Walnut	Cannabis Herbs Greenhouse Plants Outdoor Plants Turf	Alfalfa Forage Hay Orchardgrass Pastureland Ryegrass Sudangrass