



2021

STATEWIDE AVOCADO ACREAGE & CONDITION ANALYSIS

Prepared for
California Avocado Commission

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EXECUTIVE SUMMARY

Spatial land use information is essential for the California Avocado Commission to make informed decisions for budgeting and marketing of crops. Accurate and timely land use information is the foundation of these analyses and is vital to the decision-making process.

Increased availability of digital satellite imagery, aerial photography and new analytical tools make remote sensing land use surveys possible at the grove scale. These technologies allow accurate, large-scale crop and land use identification to be performed at time increments as desired and make highly accurate and comprehensive statewide avocado mapping possible.

Growers, industry, regulators, government agencies, and commodity groups also benefit from applying spatial data for crop type, location, condition, and density. These data are key components for management of environmental resources and proximity to sensitive areas including water quality, air quality, and disease or pest vectors.

For 2021, the total planted avocado acreage in California was 51,988 acres.



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INTRODUCTION

Accurate acreage information is critically important to the work of the California Avocado Commission. Acreage drives a multitude of activities that range from yield forecasting, to member data tracking, and budgeting. In response to this need for information, Land IQ was contracted by CAC to develop a comprehensive and accurate statewide spatial land use database of avocado groves and condition on a grove scale using remote sensing, statistical, and temporal analysis methods.





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FORECASTING METHODS

Land IQ integrated crop production knowledge with multiple satellite and aerial image resources to conduct remote sensing land use analysis at the grove scale. The mapping approach employs advanced spatial statistical analysis to determine prediction probabilities and inform QA/QC efforts. A rigorous QA/QC and photo interpretive analysis refinement process is employed to improve predictions on all lower probability groves. In addition, these groves are also back-checked with the CAC industry representatives as well.

Individual avocado polygon boundaries (areas of homogeneous crop types representing true cropped area, rather than legal parcel boundaries) are used so that each independent avocado polygon could be analyzed independently and assigned a condition class. The results represent the true cropped area and not legal or other less detailed boundaries that may be available elsewhere.

The condition legend was developed by CAC and is summarized in Table 1.

Table 1. Avocado Condition Description

Condition	Description
Producing	Groves that are greater than 4 years old.
Topped/Stumped	Groves that have been topped and/or stumped and not producing.
New/Young	Groves that are 4 years old or younger.
Abandoned	Groves previously identified as avocados that do not return to healthy spectral readings.



Data Collection

Both aerial and satellite data resources were used for the classification. Avocado boundaries from 2020 avocado mapping were used as a base layer for 2021. Multiple Landsat 8 images were used for the initial crop classification. Imagery from the Landsat 8 satellite is free and available every 16 days and provided for temporal analysis throughout the growing season. Following analysis with Landsat 8 images, various sources of localized high resolution imagery were used to further evaluate groves for condition, age, density, and boundary updates. Data provided by Maxar is higher resolution but requires a paid subscription.



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Analysis

The Land IQ avocado mapping unit is a grove-scale layer focused on avocado polygons equal to or greater than 0.5 acres across the state. 15,640 delineated polygons were classified using multiple image sources and dates. The images are used as the base layer data, in which classification algorithms are applied for crop identification.

Classified groves with a lower confidence level are carefully reviewed by assessing image resources using photo interpretation methods. Results are also cross-validated with ancillary data sources such as the coinciding USDA Crop Data Layer, county agricultural surveys and county crop reports, to assess and evaluate significant differences.

The geospatial database is attributed with avocado polygon size in acres, relevant county, and the appropriate condition category per the CAC legend (Table 1). Table 2 summarizes the database attributes (columns) associated with the final mapping product and their definitions.

Table 2. Definition of Database Fields

Avocado Polygon Attribute	Description
Acres	Area of the avocado polygon
County	Indicates the county that the centroid of each avocado polygon resides in
Crop 2021	Crop classification type for the year 2021
Modified By	Name of person who last modified the record
Date Data Refers To	Date the data refers to
Last Modified Date	Date record was last modified
Condition	Describes condition of the avocado polygon
Year Planted	Year the grove was planted or stumped
Density	Describes the planting density of the grove
Comments	Any user-provided comments
Source	Original source of the boundary and attribute information



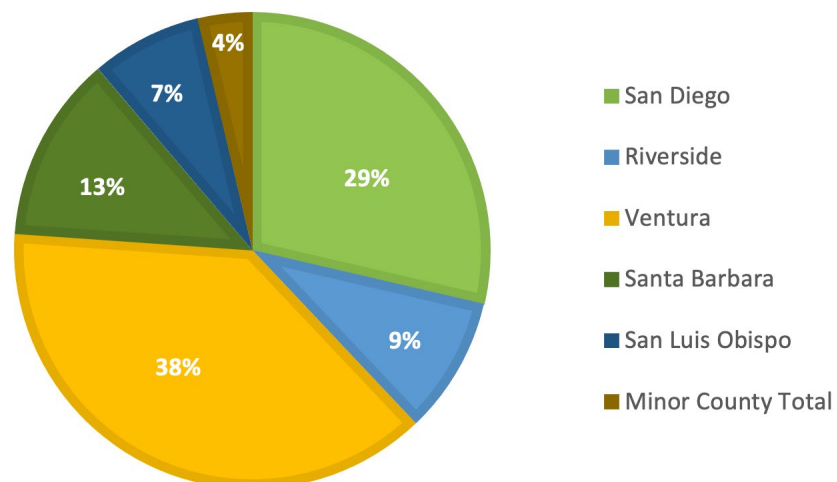
Numeric Results

The avocado acreage classification for the 2021 year totaled 15,640 avocado polygons and 51,988 planted acres. The five main avocado growing counties are Ventura, San Diego, Santa Barbara, Riverside, and San Luis Obispo. Small acreages were also present in Orange, San Bernardino, Monterey, Tulare, Los Angeles, Fresno, and Kern Counties. Statewide avocado acreages by county are summarized in Table 3 and Figure 1.

Table 3. Summary of 2021 Statewide Avocado Acreage by County

Five County	Classified Acres	Number of Polygons	Minor County	Classified Acres	Number of Polygons
San Diego	14,879	5,103	Orange	1,073	349
Riverside	4,834	1,984	San Bernardino	490	104
Ventura	19,852	5,725	Monterey	229	37
Santa Barbara	6,583	1,521	Tulare	107	30
San Luis Obispo	3,927	773	Los Angeles	11	11
			Fresno	1	1
			Kern	3	2
Five County Total	52,075	15,106	Minor County Total	1,913	534
Overall Total: 51,988 Classified Acres / 15,640 Polygons					

Figure 1. Summary of 2021 Statewide Avocado Acreage by County





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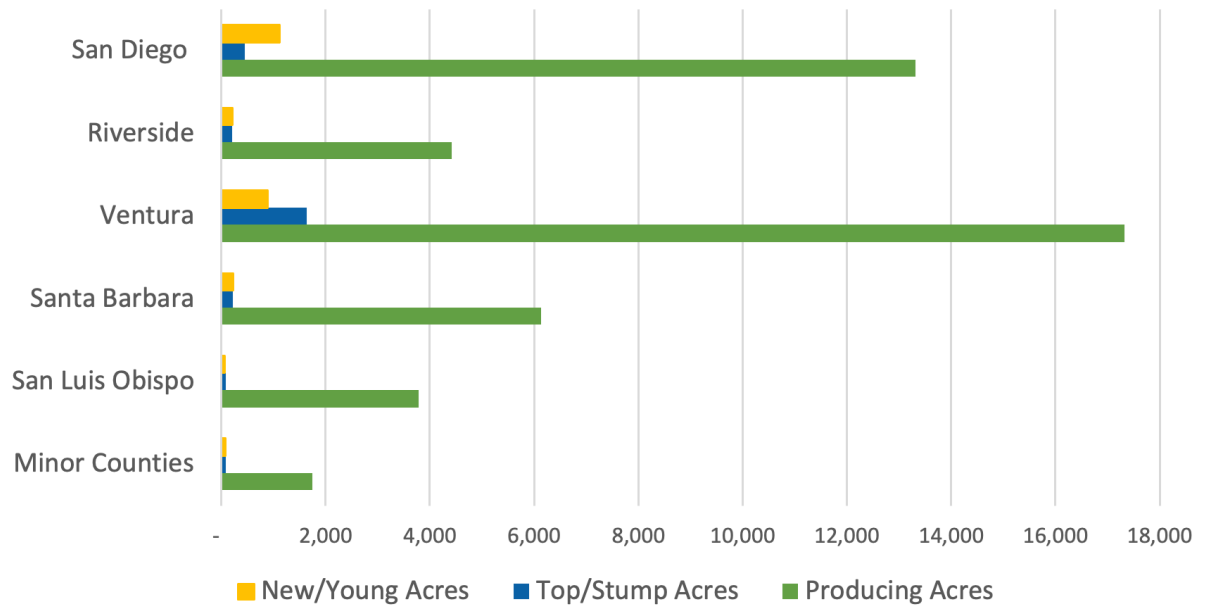
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Acreage by county and condition for the five main growing areas are summarized in Table 4 and Figures 2 and 3.

Table 4. Summary of 2021 Statewide Avocado Acreage by Condition

County	Producing Acres	Topped/Stumped Acres	New/Young Acres	Planted Acres
San Diego	13,315	1,121	444	14,879
Riverside	4,416	211	208	4,834
Ventura	17,326	892	1,634	19,852
Santa Barbara	6,139	225	218	6,583
San Luis Obispo	3,788	60	79	3,927
Five County Total	44,984	2,508	2,582	50,075
Minor Counties	1,743	84	86	1,913
Total	46,727	2,592	2,668	51,988

Figure 2. 2021 Avocado Acreage by Condition and County





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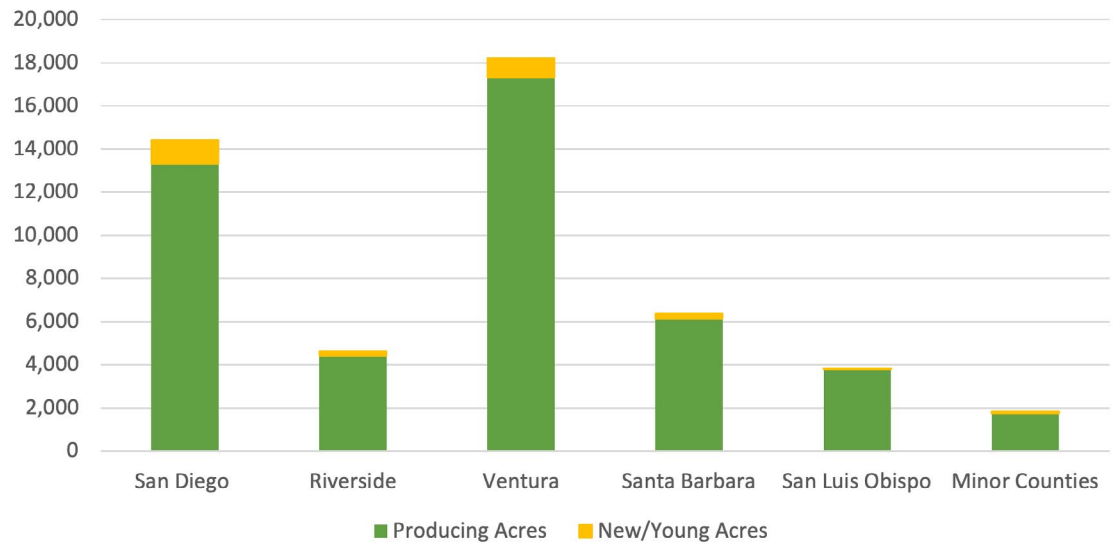
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Figure 3. 2021 Avocado Acreage of Producing and New/Young Acreage by County





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In addition to acreage and condition summaries, a spatial analysis was completed to determine acreage by other jurisdictional boundaries including zip code. Acreage by zip code is summarized in Table 5.

Table 5. Summary of 2021 Statewide Avocado Acreage by Zip Code

San Diego		Riverside		Ventura	
Zip Code	Producing Acres	Zip Code	Producing Acres	Zip Code	Producing Acres
91935	0	92028	44	90265	3
92003	672	92503	17	91320	2
92019	3	92504	43	91360	26
92021	243	92506	4	91361	6
92025	329	92507	17	93001	1,177
92026	916	92521	7	93003	207
92027	1,248	92544	7	93004	117
92028	3,512	92557	12	93010	253
92029	36	92562	184	93012	1,220
92040	5	92570	6	93013	24
92055	1	92590	3,997	93015	2,847
92057	266	92592	18	93021	2,202
92059	141	92595	30	93022	2
92061	1,267	92881	6	93023	692
92064	249	92882	24	93030	0
92065	161	92883	2	93033	221
92069	162			93036	101
92078	68			93040	437
92082	3,498			93060	4,115
92084	536			93065	119
				93066	3,556



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Santa Barbara

Zip Code	Producing Acres
93013	1,819
93103	38
93105	250
93108	121
93109	11
93110	14
93111	507
93117	3,014
93436	39
93454	29
93455	297

San Luis Obispo

Zip Code	Producing Acres
93401	240
93402	15
93405	124
93420	494
93422	2
93428	199
93430	332
93442	569
93444	488
93446	2
93452	29
93454	1,248
93465	45

Fresno

Zip Code	Producing Acres
93662	1

Orange

Zip Code	Producing Acres
92602	686
92610	57
92618	50
92620	30
92675	102
92694	0
92705	4
92782	7
92887	1

Los Angeles

Zip Code	Producing Acres
90265	1
90631	4
91301	8
91711	1

Monterey

Zip Code	Producing Acres
93960	213
95076	8

Kern

Zip Code	Producing Acres
93308	3

San Bernardino

Zip Code	Producing Acres
91709	17
92313	12
92346	1
92359	114
92373	38
92374	182
92880	102

Tulare

Zip Code	Producing Acres
93221	5
93244	3
93247	3
93257	20
93286	16
93292	43
93647	15



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In 2021, a separate algorithm was applied to the mapping to determine the year the grove was either planted or stumped.

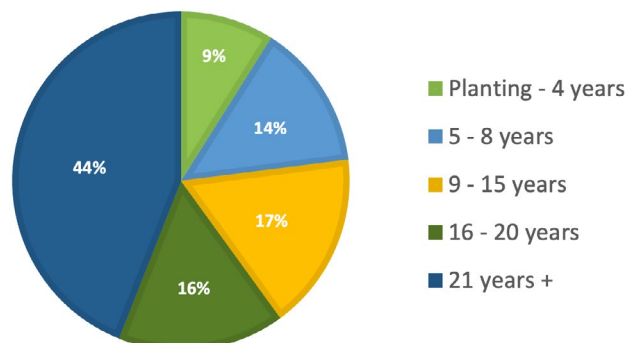
Table 6. 2021 Planted Avocado Acreage by Year Planted or Stumped

Year Planted	Planted Acres	Year Planted	Planted Acres	Year Planted	Planted Acres	Year Planted	Planted Acres
1984	17,859	1993	168	2002	2,682	2011	1,064
1985	4	1994	527	2003	1,416	2012	855
1986	50	1995	80	2004	2,204	2013	2,380
1987	183	1996	183	2005	1,256	2014	1,511
1988	13	1997	188	2006	800	2015	1,483
1989	132	1998	198	2007	1,614	2016	3,126
1990	511	1999	942	2008	1,068	2017	1,049
1991	204	2000	339	2009	1,028	2018	1,581
1992	171	2001	1,080	2010	849	2019	1,211
						2020	1,229
						2021	750

Table 7. 2021 Age as a Percentage of Planted Acreage

Age	Acreage	Percentage of Planted Acres
Planting to 4 years	4,771	9%
5 - 8 years	7,170	14%
9 - 15 years	8,858	17%
16 - 20 years	8,358	16%
21 years +	22,831	44%

Figure 4. Age as a Percentage of Planted Acres





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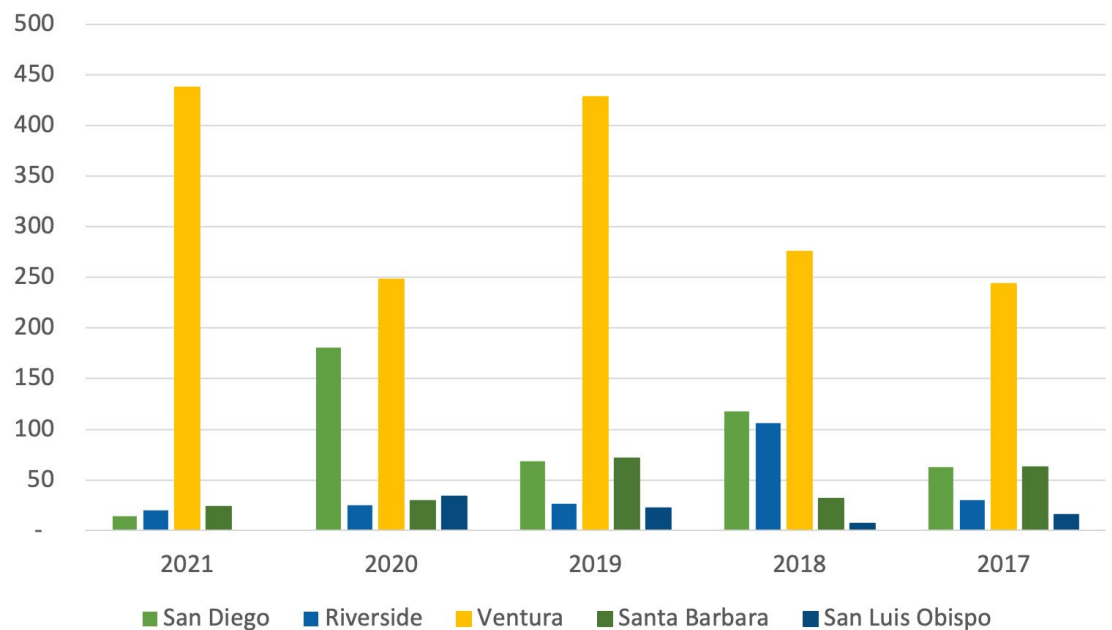
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The following tables and figures show the amount of new plantings that have occurred over the last five years. The spatial analysis can only be performed once new groves have reached a certain canopy size. Thus, the acres reported for 2020 and 2021 are only those that have been visually confirmed through ground truthing efforts.

Table 8. New Acres by County and Planting Year

County	2021	2020	2019	2018	2017
San Diego	14	180	68	118	63
Riverside	20	25	27	106	30
Ventura	437	248	429	276	244
Santa Barbara	24	29	71	31	63
San Luis Obispo	-	34	22	7	15
Total	240	426	477	419	2,204

Figure 5. Young Avocado Acreage by Planting Year





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In addition to age, a density analysis was conducted. Groves were classified according to the following standards:

High Density: 15x15 or closer and 20x10

Standard Density: 15x20 or greater

Table 9. 2021 Avocado Acreage by Planting Density

County	Condition	High Density	Standard	County	Condition	High Density	Standard
San Diego	Producing	2,197	11,118	San Bernardino	Producing	36	429
	Stumped	187	933		Stumped	2	1
	Young*	204	239		Young	15	7
	Abandon	580	3,466		Abandon		
Riverside	Producing	1,241	3,175	Monterey	Producing	3	218
	Stumped	56	155		Stumped		7
	Young	114	94		Young		
	Abandon	365	715		Abandon		
Ventura	Producing	3,273	14,053	Tulare	Producing	13	91
	Stumped	115	776		Stumped	1	1
	Young*	819	749		Young		1
	Abandon	191	448		Abandon		
Santa Barbara	Producing	1,074	5,065	Los Angeles	Producing		10
	Stumped	60	165		Stumped		
	Young	136	82		Young		
	Abandon	64	504		Abandon	4	19
San Luis Obispo	Producing	406	3,383	Fresno	Producing		1
	Stumped	4	56		Stumped		
	Young	33	46		Young		
	Abandon	7	62		Abandon		
Orange	Producing	52	886	Kern	Producing		3
	Stumped	3	69		Stumped		
	Young	33	30		Young		
	Abandon		17		Abandon		

The following table demonstrates the percentage of planted acres that are considered high density.

Table 10. Percentage of High Density Plantings by Condition

County	Producing	Young*	Stumped
San Diego	16%	46%	17%
Riverside	28%	55%	26%
Ventura	19%	52%	13%
Santa Barbara	17%	62%	27%
San Luis Obispo	11%	42%	7%
Other	6%	56%	7%

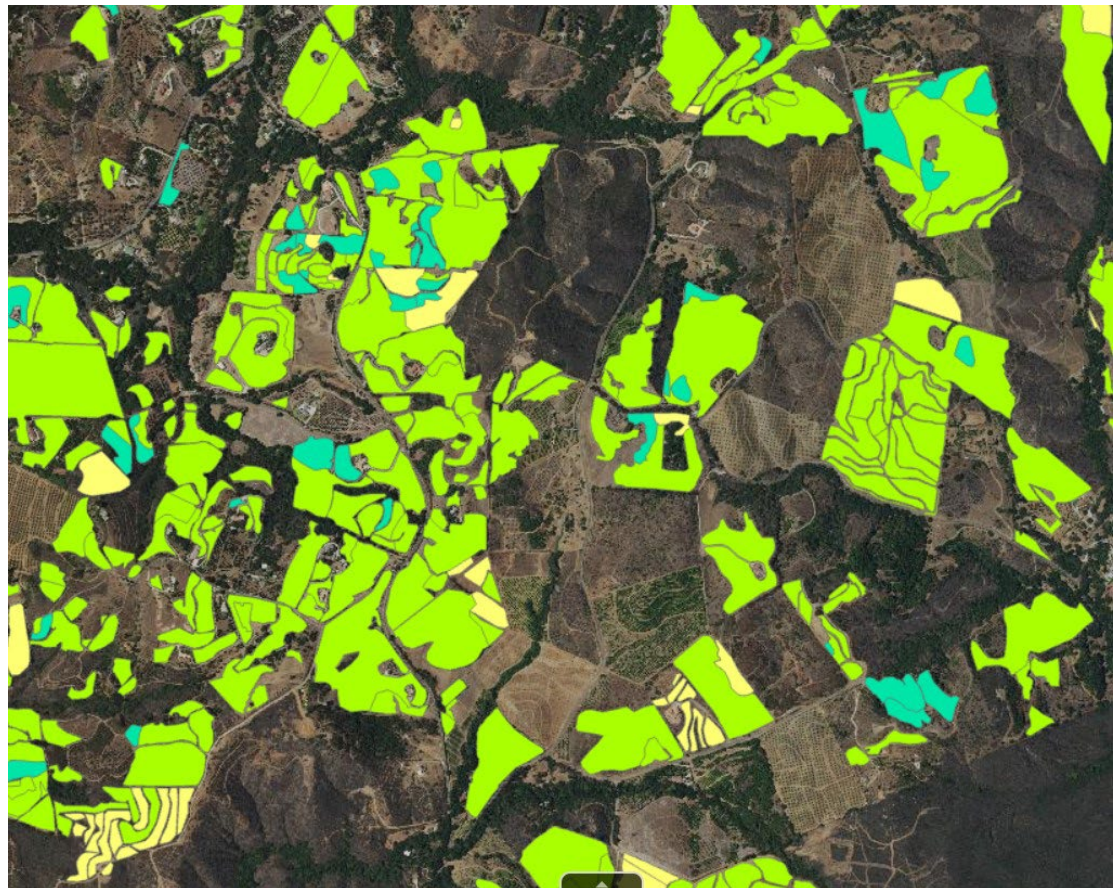
* A small amount of young acreage could not be analyzed for density due to being so young they did not appear on imagery. These groves were physically confirmed during ground truthing.



Mapping Results

A series of maps are provided to demonstrate the avocado classification results. Figures 6 through 11 show the avocado acreage and condition classification example as well as maps of the five CAC districts.

Figure 6. Example of 2021 Avocado Classification Conditions



Legend

CAC Webmap Inventory
CAC_NoAbandoned2021

-  Young
-  Producing
-  Stumped

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Figure 7. 2021 Avocado Planted Polygons in CAC District 1

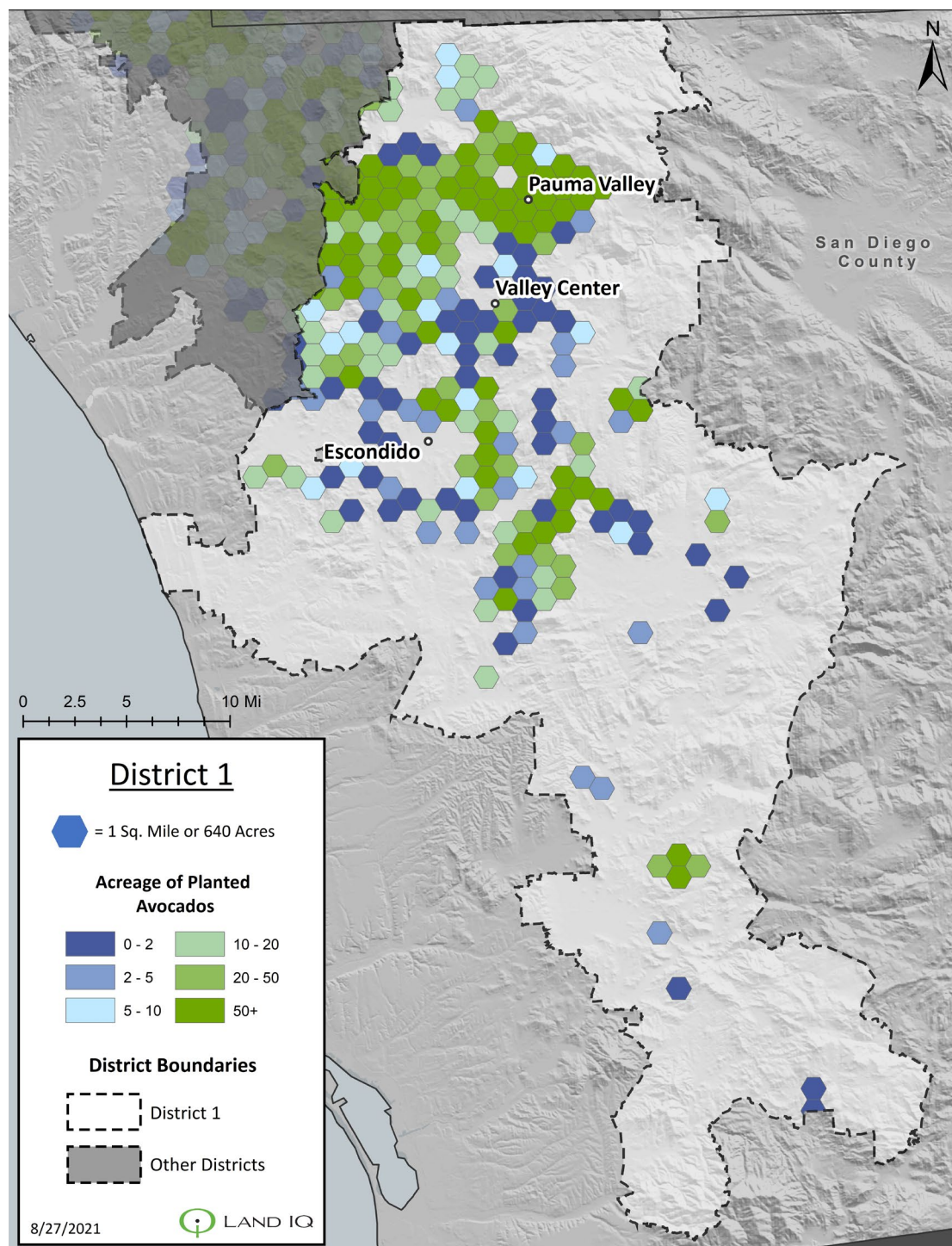




Figure 8. 2021 Avocado Planted Polygons in CAC District 2

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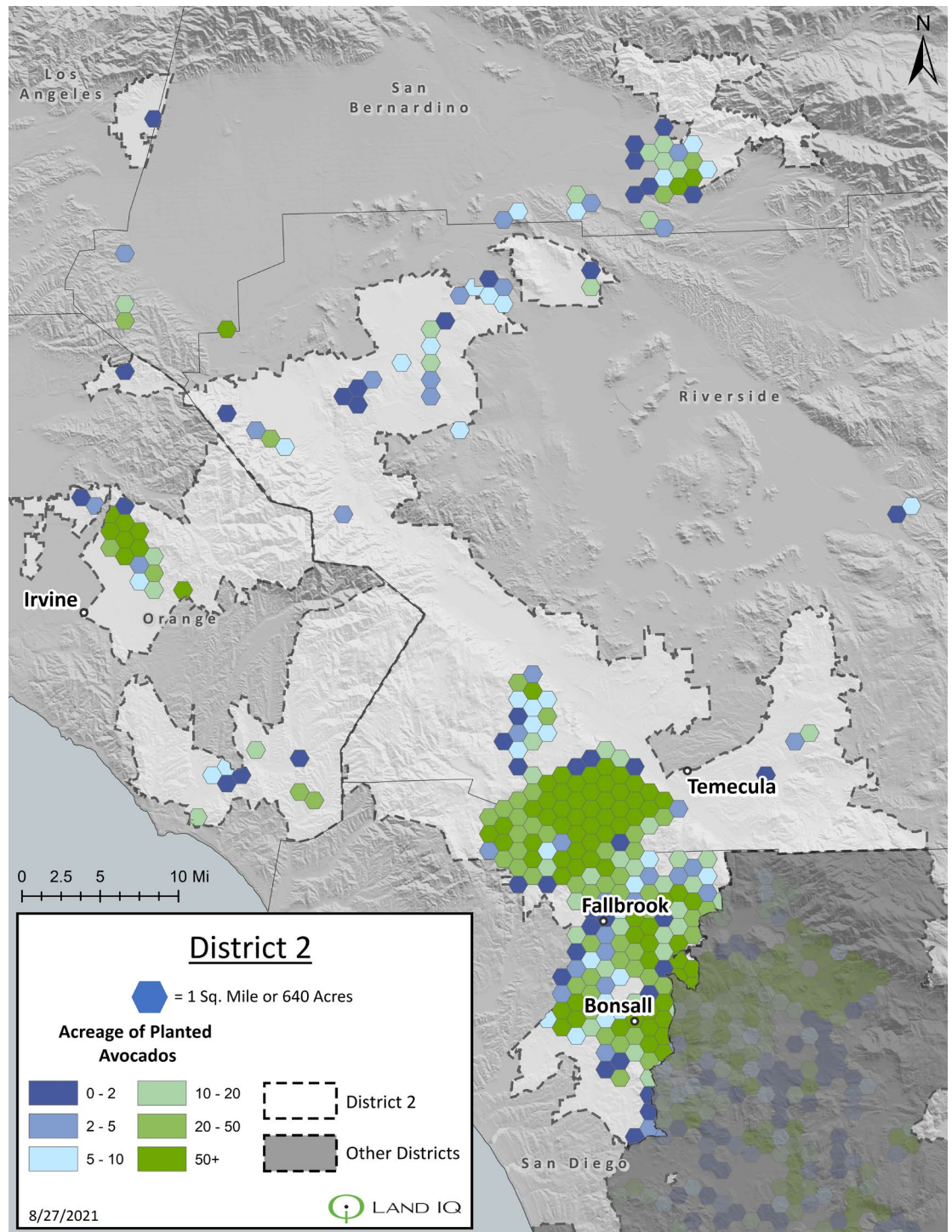
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Figure 9. 2021 Avocado Planted Polygons in CAC District 3

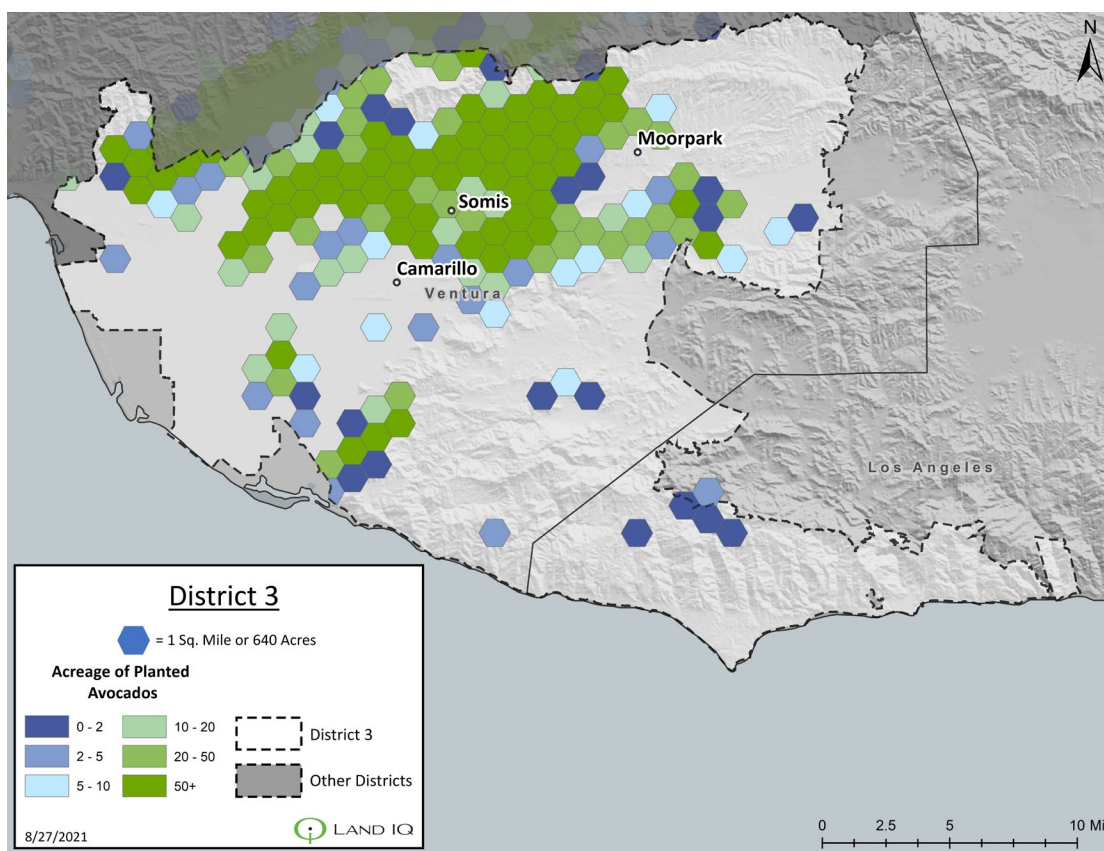




Figure 10. 2021 Avocado Planted Polygons in CAC District 4

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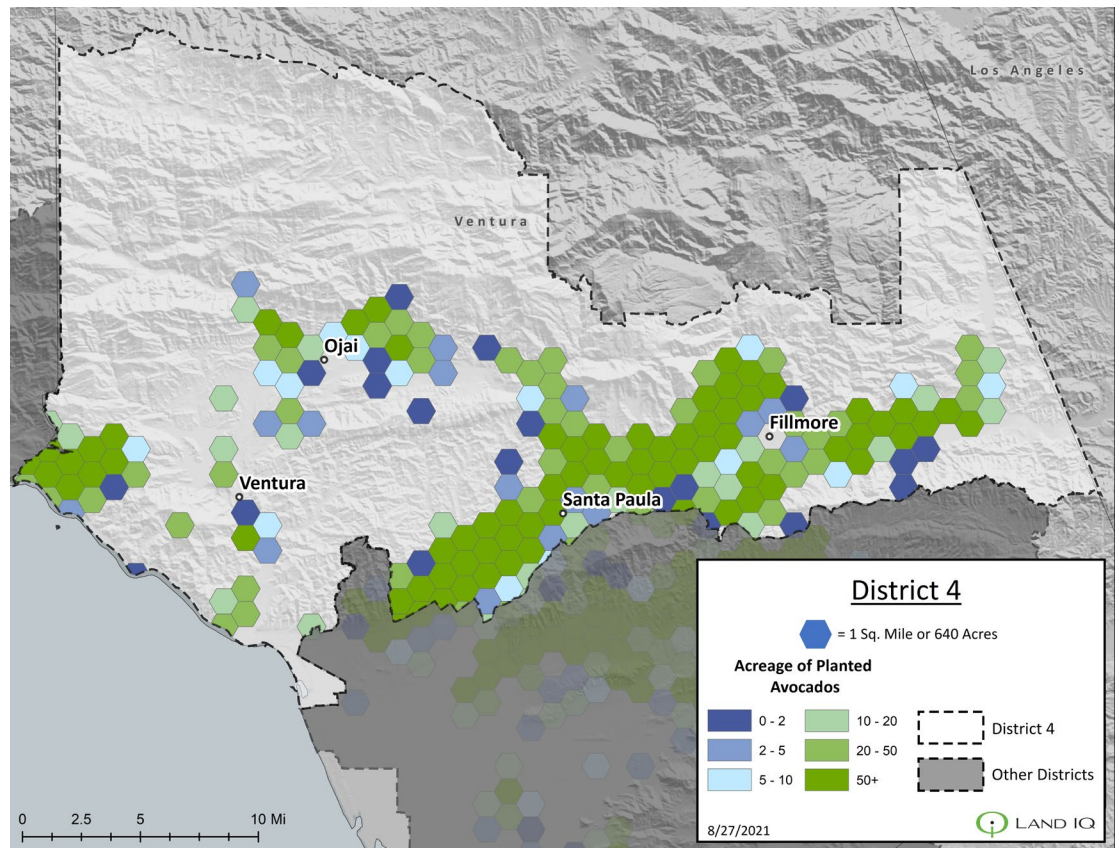
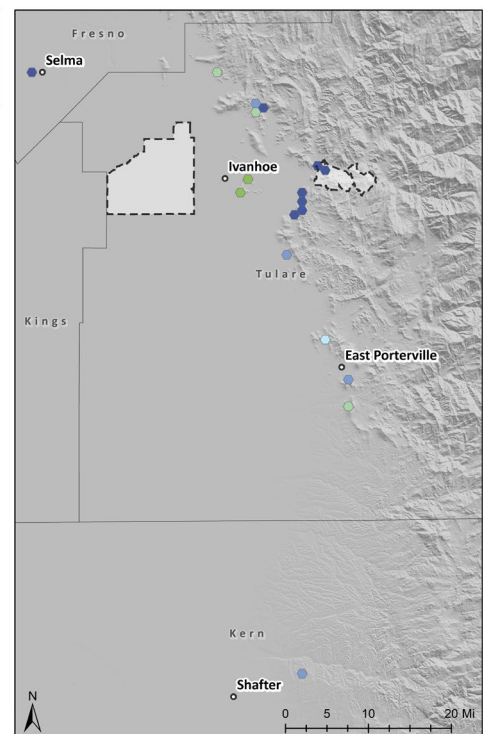
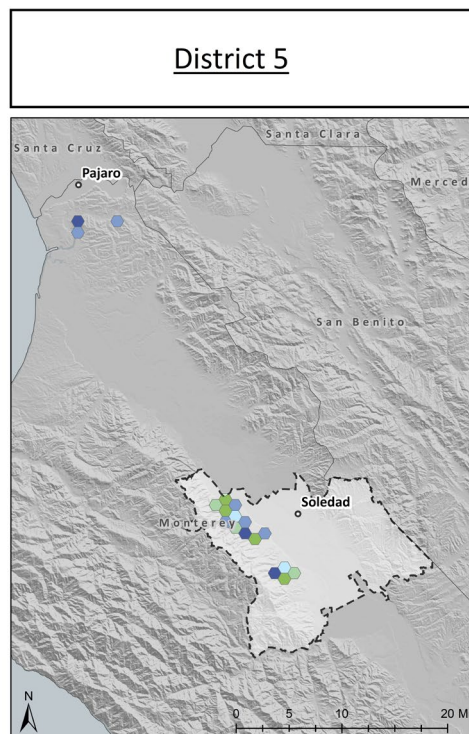
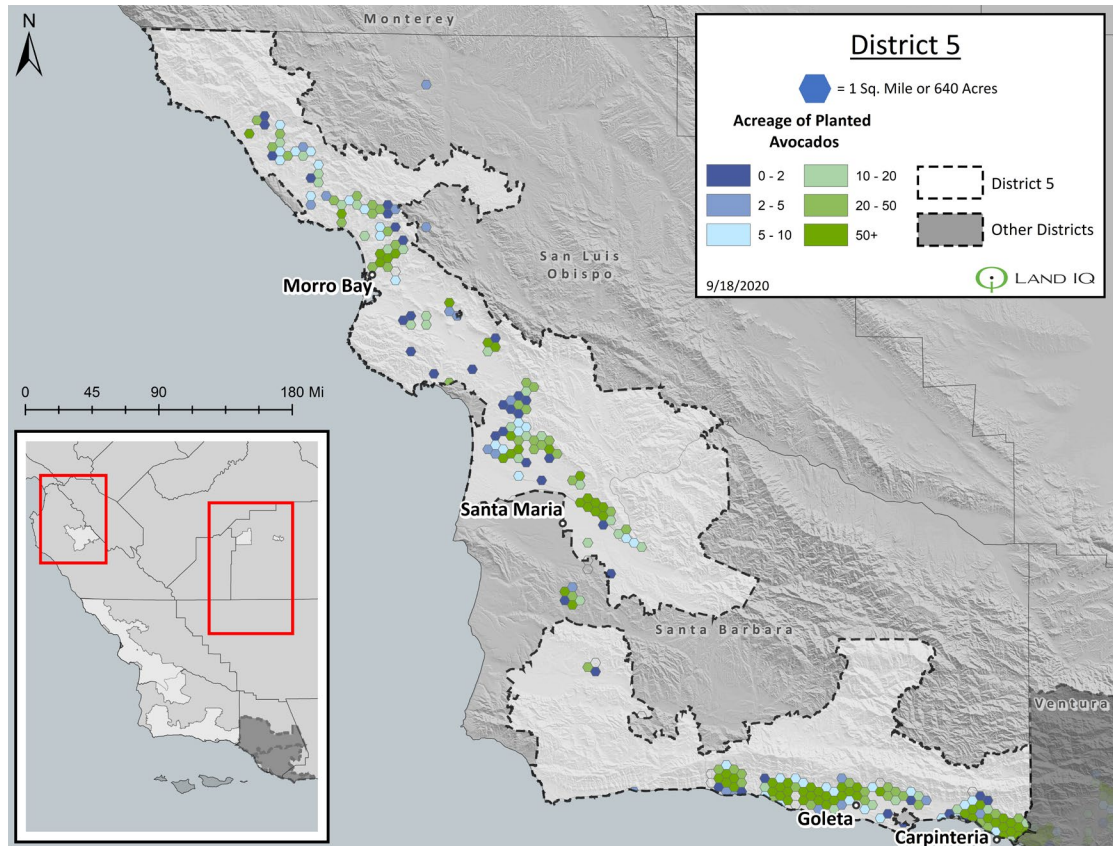




Figure 11. 2021 Avocado Planted Polygons in CAC District 5





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DATA DELIVERABLES

Data delivered to CAC as a part of the 2021 avocado mapping effort are listed and described in Table 11.

Table 11. Summary of 2021 Avocado Acreage Deliverables

File Name	Description
CAC_2021_Avocados_Districts_Zips	Spatial file of statewide avocado acreage with condition, age, density, zipcode and CAC district.
CAC_2021_Avocado_Acreage_Tables	Tabular data summarizing acreage by county, condition, age, density, zip code and CAC district.
2021_Statewide_Avocado_Mapping	Report

The net change in acreage from 2020 to 2021 is summarized in Table 12.

Table 12. Net Acreage Change from 2020 to 2021 by County

County	Producing	Young	Stumped	Abandoned	Total
San Diego	(1,106)	(340)	(163)	877	(732)
Riverside	80	(238)	(54)	120	(91)
Ventura	271	(191)	18	(162)	(65)
Santa Barbara	311	(411)	(59)	(67)	(225)
San Luis Obispo	(106)	(4)	(6)	(7)	(123)
Orange	(53)	(28)	61	14	(6)
San Bernardino	(1)	0	0	0	(1)
Monterey	(1)	0	0	0	(1)
Tulare	1	0	0	0	1
Los Angeles	(4)	(3)	0	6	(1)
Fresno	0	(3)	0	0	(3)
Kern	0	0	0	0	0
Total	(607)	(1,218)	(203)	783	(1,246)



The change in avocado classification from 2020 to 2021 is summarized in Table 13.

Table 13. Change in California Avocado Acreage Classification from 2020 to 2021

County	2020 Classification	2021 Classification			
		Producing	Top/Stump	New/Young	Abandon
San Diego	Producing	12,512	349	28	991
	Top/Stump	227	712	8	151
	New/Young	446	5	225	21
	Abandon	56	16	7	2,778
	Not Classified	73	39	175	105
Riverside	Producing	4,049	46	17	142
	Top/Stump	58	155	2	9
	New/Young	246		151	6
	Abandon	20	9	3	910
	Not Classified	43	1	35	13
Ventura	Producing	16,180	209	48	93
	Top/Stump	173	639	23	10
	New/Young	790	13	870	10
	Abandon	33	24	52	477
	Not Classified	151	7	640	50
Santa Barbara	Producing	5,527	31	26	40
	Top/Stump	80	190	1	2
	New/Young	459	3	141	
	Abandon	53	1	16	523
	Not Classified	21		35	3
San Luis Obispo	Producing	3,743	13	7	24
	Top/Stump		47		
	New/Young	39		41	
	Abandon				45
	Not Classified	5		31	1

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Department of Water Resources. 2020. Statewide Land Use Layer. Land IQ.

California Avocado Commission. 2020. Statewide Avocado Acreage and Condition Layer. Land IQ.

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