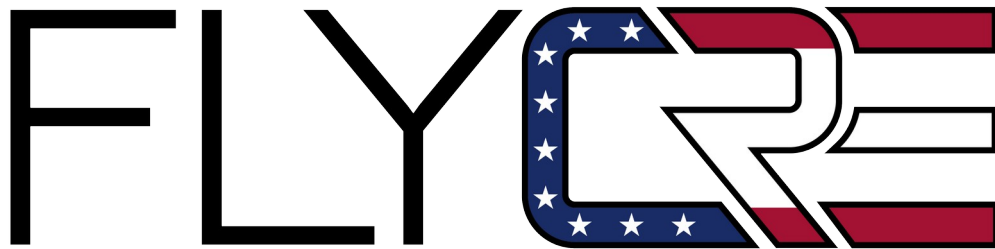


Rows on the Record: Aerial Documentation for California Orchards



A DIVISION OF BURGE CORPORATION

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Executive Summary

An orchard is a long bet. Trees go in the ground and are expected to produce for years, through droughts, heat, wind, pests, and changing rules about water and nutrients. Over that time, the basic facts about the orchard keep changing: how many trees are standing, how big their canopies are, which blocks were replanted, and what happened after the last storm.

Those facts now matter to regulators, lenders, and disaster programs. Under the Sustainable Groundwater Management Act, local groundwater sustainability agencies in high and medium priority basins can limit extractions and impose fees, and must bring their basins to sustainability by 2040 or 2042 [1]. Under the Irrigated Lands Regulatory Program, the State Water Board has directed regional water boards to require farm evaluations, irrigation and nitrogen management plans, and recordkeeping, with details that vary by region [2]. After a natural disaster, the USDA Tree Assistance Program can help replace trees lost in excess of normal mortality, and the loss generally must be visible to the Farm Service Agency [3].

All three come back to the same questions: what is in the orchard, and what changed? Aerial documentation gives growers, farm managers, and owners a dated, consistent record of every block, captured on a schedule that follows the season.

This paper covers the programs that make orchard records matter, what published research says about aerial sensors on tree crops, how an aerial record is captured, and where its limits are. It closes with a recordkeeping checklist for orchard operations.

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1. Introduction

Most orchard records are written down after the fact: spray logs, irrigation sets, fertilizer applications, harvest weights. They describe what was done. Very few records show what the orchard itself looked like, block by block, at a known point in time.

1.1 Who This Paper Is For

- **Growers and orchard owners** managing trees across one or many ranches.
- **Farm managers and custom operators** who work on behalf of owners and need a shared record of conditions.
- **Crop advisers and agronomists** who interpret data and make recommendations to growers.
- **Investors, lenders, and buyers** evaluating orchard property over time.

1.2 Scope of This Paper

This paper is about documentation. It does not tell anyone how to irrigate, fertilize, prune, or treat pests, and it does not explain how to comply with any program. Those decisions belong to growers and to qualified professionals such as licensed pest control advisers, certified crop advisers, agronomists, and program staff.

2. Programs That Shape Orchard Records

2.1 Sustainable Groundwater Management Act

California enacted the Sustainable Groundwater Management Act (SGMA) in 2014 [1]. It applies to the state's high and medium priority groundwater basins [1]. The Department of Water Resources' 2019 basin prioritization, its most recent, identifies 94 such basins out of 515. Together with adjudicated areas, they account for about 98 percent of statewide groundwater pumping [12].

- **Local agencies:** groundwater sustainability agencies manage each covered basin and have broad authority, including setting sustainable yield, limiting extractions, and imposing fees [1].
- **Plans and deadlines:** basins in critical overdraft had to adopt plans by January 31, 2020, and other covered basins by January 31, 2022. Critically overdrafted basins must reach sustainability by January 31, 2040, and other basins by January 31, 2042 [1].
- **State role:** the State Water Resources Control Board can designate probationary basins, and its intervention can include reporting requirements and fees [1].

How a basin's agency allocates or charges for groundwater varies by basin. For growers, the practical point is that a basin's agency may ask how land is used, and a dated record of what is planted where can help answer that question.

2.2 Irrigated Lands Regulatory Program

The Irrigated Lands Regulatory Program regulates discharges from irrigated agricultural lands to prevent them from impairing the waters that receive them, through orders each regional water board adopts [2]. Statewide, more than 29,000 farm operations covering more than six million acres are enrolled [2].

- **Statewide direction:** the State Water Board's 2018 Eastern San Joaquin order directed regional boards to incorporate its requirements into their agricultural orders by 2023, including on-farm drinking water well monitoring, farm evaluations, irrigation and nitrogen management plans, education, recordkeeping, and sediment and erosion control plans where needed [2].
- **Nitrogen reporting example:** on the Central Coast, the regional board's agricultural order requires growers to report annually the nitrogen applied to their crops. Reporting of nitrogen removed is being phased in through the Irrigation

and Nutrient Management Plan Summary Report, beginning with ranches in the areas the board considers at highest risk for nitrogen reaching groundwater [4].

Requirements differ by region and by coalition and change as orders are revised; the Central Coast board, for example, proposed amendments to its agricultural order in 2026 [13]. Growers should confirm their current obligations with their regional board or third-party group.

2.3 Tree Assistance Program

The USDA Farm Service Agency's Tree Assistance Program helps eligible orchardists and nursery tree growers replant or rehabilitate trees, bushes, and vines lost to natural disasters [3]. Key points from the program fact sheet:

- **Loss threshold:** the loss must exceed normal mortality. The Working Families Tax Cuts Act removed the former 15 percent mortality requirement [3].
- **Visible loss:** the loss must be visible and obvious to the FSA representative and not preventable through reasonable measures. FSA may accept other evidence of loss if the loss is no longer visible [3].
- **Timing:** applications are generally due within 90 calendar days of the disaster or of when the loss becomes apparent, and lost trees must be replaced within 24 months of application approval [3].

Because FSA looks at whether a loss is visible and how it compares with normal mortality, a dated record of the stand before and after an event can help a grower answer FSA's questions. Imagery does not replace FSA's own inspection, and FSA decides what evidence it accepts and makes every eligibility and loss determination.

3. Why Records Matter

3.1 A Baseline Inventory

A dated map of each block shows where trees stand, where gaps are, and how canopies are distributed at a known point in time. It is the reference every later record is compared to.

3.2 Change Over Time

Orchards change through removals, replants, top-working, and losses from weather and pests. A series of records captured on a schedule shows when each change became visible and where.

3.3 After an Event

Wind, frost, heat, flood, and fire can damage or kill trees in a single event. A record captured soon after, compared with the one before, shows the grower, and anyone they share it with, what changed.

3.4 Owners, Managers, and Transactions

Some orchards are owned by one party and farmed by another. A shared, dated record gives owners and managers the same view of the property, and gives buyers and lenders a consistent history when an orchard changes hands.

4. What the Research Says About Aerial Sensors on Tree Crops

Researchers have been flying sensors over orchards for years. Some results are strong, and the authors are upfront about what did not work.

- **Tree geometry:** a 2015 study of olive orchards in Spain combined drone-based 3-D surface models with image analysis to measure canopy area, tree height, and crown volume for single trees and tree rows. The authors reported up to 97 percent accuracy in canopy area and close agreement with field measurements of tree height, with crown volume matching less closely [5].
- **Citrus water status:** a 2012 study flew thermal and hyperspectral sensors over a citrus orchard under different irrigation treatments. Crown temperature was the best single predictor of stomatal conductance, while NDVI showed no significant relationship with it [6].
- **Almonds in California:** a 2017 study flew a multispectral drone weekly over an almond orchard in Merced County under five irrigation treatments, alongside stem water potential measurements. Analyzing pixels within the canopy and applying a lower NDVI threshold improved the correlation between canopy NDVI and stem water potential, but canopy NDVI differed significantly between flights on the same day, which the authors linked to the sun's movement, and they concluded further calibration was needed [7].
- **Across crops:** a 2015 review found that multispectral and thermal data relate to plant water status, but that reflectance indices have performed differently in different crops [8].

Here is what I take from these studies. In research settings, drones have measured tree size closely and recorded patterns across whole orchards; those are study results, not accuracy figures for any FlyCRE deliverable. The same index can read differently by crop, by part of the canopy, and by time of day. And turning any of it into a water, nutrient, or tree health decision takes someone who knows the orchard. A consistent record gives that person something solid to start from.

5. Aerial Documentation for Orchards

5.1 What Is Captured

Every FlyCRE flight captures four data layers, delivered in this order:

- **Orthomosaic:** a single overhead map of each block built from many overlapping images, showing rows, gaps, roads, and infrastructure in one view.
- **Thermal:** a record of surface temperature differences across the canopy and ground at the time of capture.
- **Asset Visibility:** close views of features such as wells, pumps, reservoirs, irrigation lines, fences, and access roads.
- **Multispectral:** spectral bands that can be used to calculate vegetation indexes such as NDVI, which the U.S. Geological Survey describes as a way to quantify vegetation greenness, useful for understanding vegetation density and changes in plant health [9].

Each layer records how the orchard looked at one time under one set of conditions. The research above shows why that matters: readings change with the sensor layer, the crop, the part of the canopy analyzed, and the time of day [6][7][8].

5.2 Timing

The most useful schedule follows the orchard's calendar: dormancy, bloom, mid-season, pre-harvest, and post-harvest, plus a capture as soon as practical after any major weather event. Capturing at a consistent time of day helps keep thermal and multispectral records more comparable from one flight to the next, though readings can still vary with conditions [7].

5.3 Consistency

Saved flight plans let us fly each block the same way each cycle. Every image carries a GPS position and capture time, and every capture is stored so it can be compared with earlier and later flights.

5.4 Measurements

Orthomosaic maps and 3-D models allow approximate measurements, such as block acreage, row length, canopy area, and tree height. They are for tracking and reference.



They are not survey grade, are not certified by a licensed land surveyor, and should not be used to set property lines or legal boundaries.

5.5 Data Ownership and Privacy

All data from every flight is loaded into our encrypted platform and released only to the client who ordered it and to anyone the client authorizes, unless we are legally required to produce it. We do not publish client data or use it as a sample. Flight plans are limited to the areas we are hired to document, and we do not target private residences or property outside that scope, though neighboring property can appear at the edges of a capture.

6. Flight Operations

Every FlyCRE flight is flown by FAA certified remote pilots under 14 CFR Part 107, including its visual line of sight, altitude, right of way, and operations over people rules [10]. Part 107 requires small drones to yield the right of way to all aircraft, which matters around agricultural aircraft working nearby [10]. In controlled airspace, we obtain FAA authorization before takeoff, through LAANC where it is available [10][11]. We schedule flights around the grower's spray, harvest, and field crew operations.

7. What Aerial Documentation Does Not Do

FlyCRE documents sites from the air. Here is what we do not do:

- **No agronomic diagnosis:** we do not determine tree health, water status, nutrient status, pests, or disease, or the cause of any pattern in the data.
- **No recommendations:** we do not recommend irrigation, fertilizer, or pest control. Those belong to the grower and licensed or certified advisers.
- **No program reporting or determinations:** we do not prepare or certify reports for groundwater agencies, water boards, coalitions, or USDA, and we do not determine eligibility or compliance.
- **No loss determinations:** we do not determine whether a loss occurred, its cause, or its extent for any insurance or disaster program.
- **No surveying:** measurements are approximate and not survey grade.

Within those limits, we give the client, and anyone the client chooses to share it with, the same dated view of every block.

8. Conclusion

Orchards are managed over decades, but most of the records that describe them are notes about what was done, not pictures of what was there. Groundwater agencies, water boards, and disaster programs all ask growers about their land and their losses.

A dated aerial record, captured on the orchard's calendar and stored where it can be compared year over year, helps close that gap. It doesn't replace the grower or their advisers. It just puts everyone in front of the same pictures.

Documented Today, Defensible Tomorrow.

Appendix

A. Program and Regulatory References

- **Sustainable Groundwater Management Act (2014):** local groundwater management in high and medium priority basins [1].
- **Irrigated Lands Regulatory Program:** regional water board orders for discharges from irrigated agricultural land [2][4].
- **USDA Tree Assistance Program:** assistance to replant or rehabilitate trees, bushes, and vines lost to natural disasters [3].
- **14 CFR Part 107:** operating rules for small unmanned aircraft [10].

B. Research Summaries

Torres-Sanchez et al., PLoS ONE, 2015 [5]

- **What they did:** combined drone-based 3-D surface models with image analysis to measure canopy area, height, and crown volume of olive trees.
- **What they found:** up to 97 percent accuracy in canopy area and close agreement with field measurements of tree height, with crown volume matching less closely.
- **Why it matters:** aerial records can document tree geometry across whole blocks, though the method was tested on olives, not on other tree crops.

Zarco-Tejada, Gonzalez-Dugo, and Berni, Remote Sensing of Environment, 2012 [6]

- **What they did:** flew thermal and hyperspectral sensors over a citrus orchard under different irrigation treatments.
- **What they found:** crown temperature was the best single predictor of stomatal conductance; NDVI showed no significant relationship with it.
- **Why it matters:** different layers record different things, and greenness alone does not describe a tree's water status.

Zhao et al., Journal of Intelligent and Robotic Systems, 2017 [7]

- **What they did:** flew a multispectral drone weekly over a Merced County almond orchard and compared canopy NDVI with stem water potential under five irrigation treatments.
- **What they found:** analyzing pixels within the canopy with a lower NDVI threshold improved the correlation, but NDVI varied significantly between flights on the same day, and the authors called for further calibration.
- **Why it matters:** compare records flown at similar times, and leave the interpretation to qualified people.

Gago et al., Agricultural Water Management, 2015 [8]

- **What they did:** reviewed drone-based assessment of water stress in agriculture.
- **What they found:** multispectral and thermal data relate to plant water status, but reflectance indices have performed differently across crops.

- **Why it matters:** results from one crop or site do not automatically transfer to another.

C. Orchard Recordkeeping Checklist

This checklist applies whether or not you use aerial documentation. It is a starting point, not legal or agronomic advice.

- Confirm which groundwater basin and sustainability agency covers each ranch, and how it measures or charges for water use.
- Confirm your Irrigated Lands Regulatory Program enrollment, coalition, and annual reporting dates.
- Keep a dated baseline record of every block, including tree locations and gaps.
- Record removals, replants, and top-working with dates and block names.
- Capture a record as soon as practical after any major weather event, and keep the record from before it.
- Note the date, time of day, and conditions for every capture so records can be compared.
- Store original files with capture dates and who captured them.
- Keep program correspondence, applications, and approvals with your property records.

D. Sources

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