Joel Kimmelshue

Title: Owner/Principal Soil & Agricultural Scientist, Land IQ

Topic: Land IQ – ET and groundwater management

MY JOB DEPENDS ON WATER
Farming in the SGMA Era

MY JOB DEPENDS ON WATER - FARMING IN THE SGMA ERA

MANAGEMENT OF GROUNDWATER RESOURCES THROUGH EVAPOTRANSPIRATION AND UNDERSTANDING CROP TYPE

EAST KAWEAH GROUNDWATER SUSTAINABILITY AGENCY

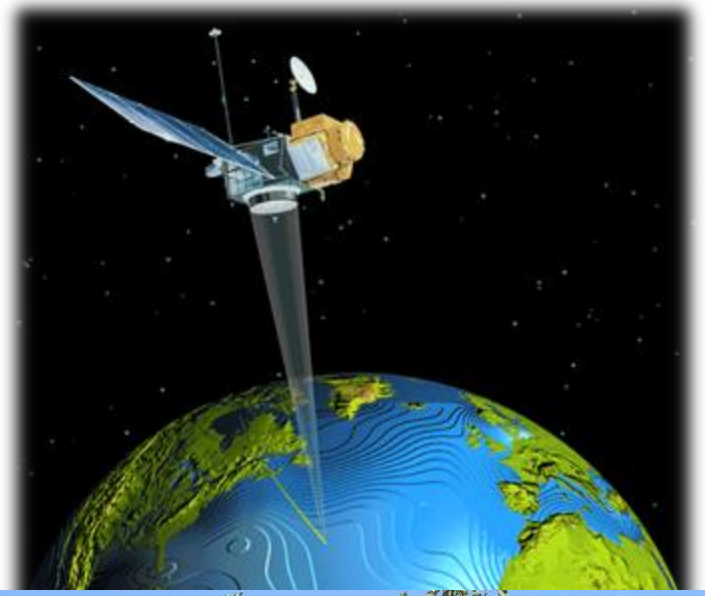
GREATER KAWEAH GROUNDWATER SUSTAINABILITY AGENCY

MID-KAWEAH GSA

LAND IQ

JULY 13, 2023

LAND IQ TECHNICAL DISCIPLINES



Land-Based Sciences: Land and Water Resources

- Agronomic assessments/soil science
- Water quality and supply evaluations
- Salinity and nutrient management
- Agricultural reuse
- Land stabilization and erosion control
- Soil reclamation and irrigation/drainage

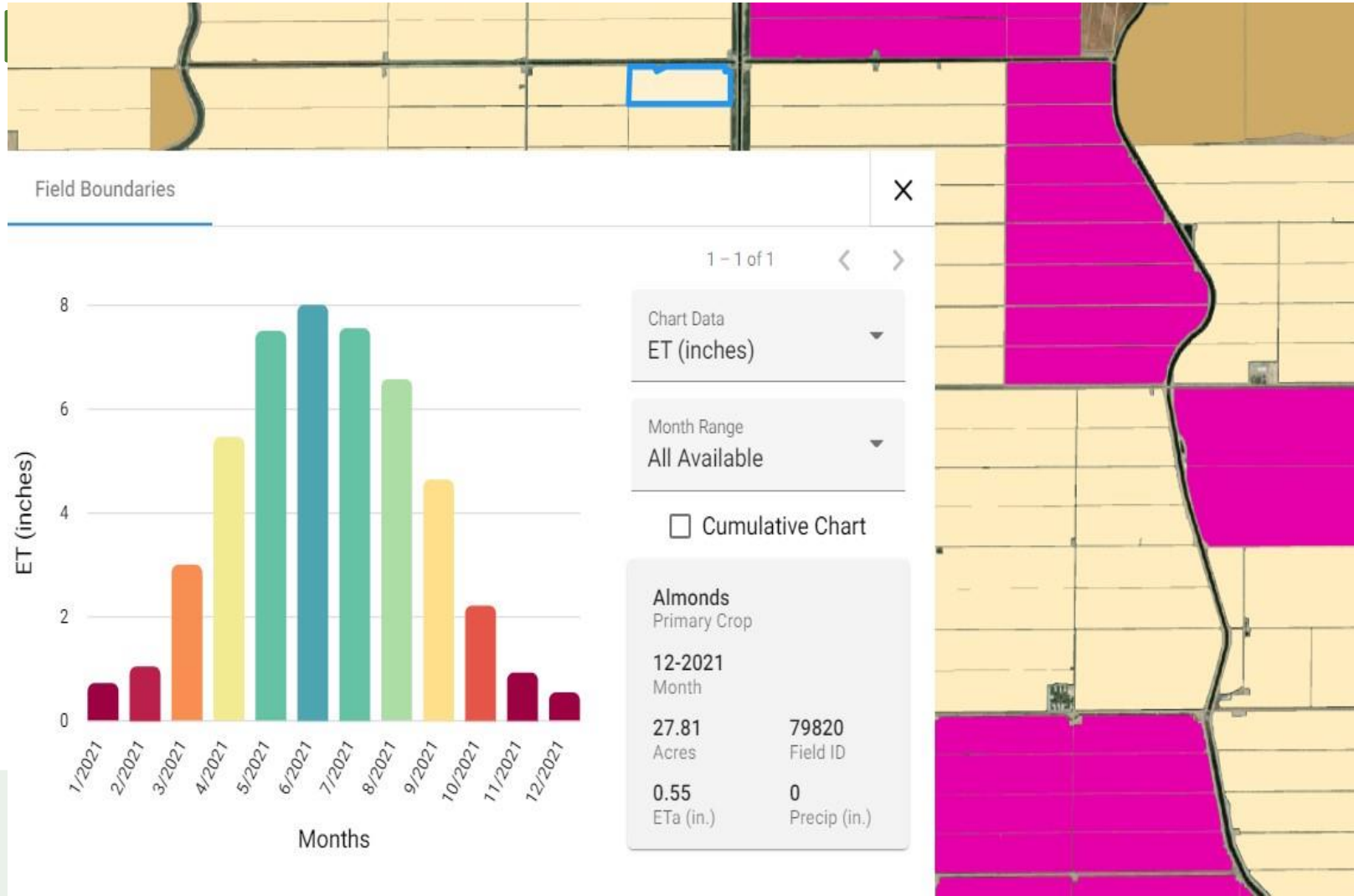
Spatial Sciences: Remote Sensing and GIS

- Consumptive use estimation and crop identification
- Large landscape evaluations
- Irrigation and drainage
- Production agriculture

Development

- Data management tools

Evapotranspiration and Ground Truthing Cali and validation



Ground Truthing – Why?

Ground truthing quantification of ETa using specialized scientific instrumentation

- Widely accepted, scientifically proven, methodologies for quantifying ETa
- Two station types employed
  - Eddy Covariance (Full)
  - Surface Renewal (Water IQ/H2Q)
- Strategically placed throughout AOI to characterize spectrum of water use conditions
  - Low water use environments are just as important as high use conditions
  - Minimum field size requirements based on crop type
- Built and maintained by Land IQ
  - Not possible without grower cooperators willing to grant permission to install and work around infrastructure
  - Require monthly visits to clean/maintain
  - Telemetered via cellular modems

LAND IQ

GROUND TRUTHING FOR CALIBRATION – WHY?

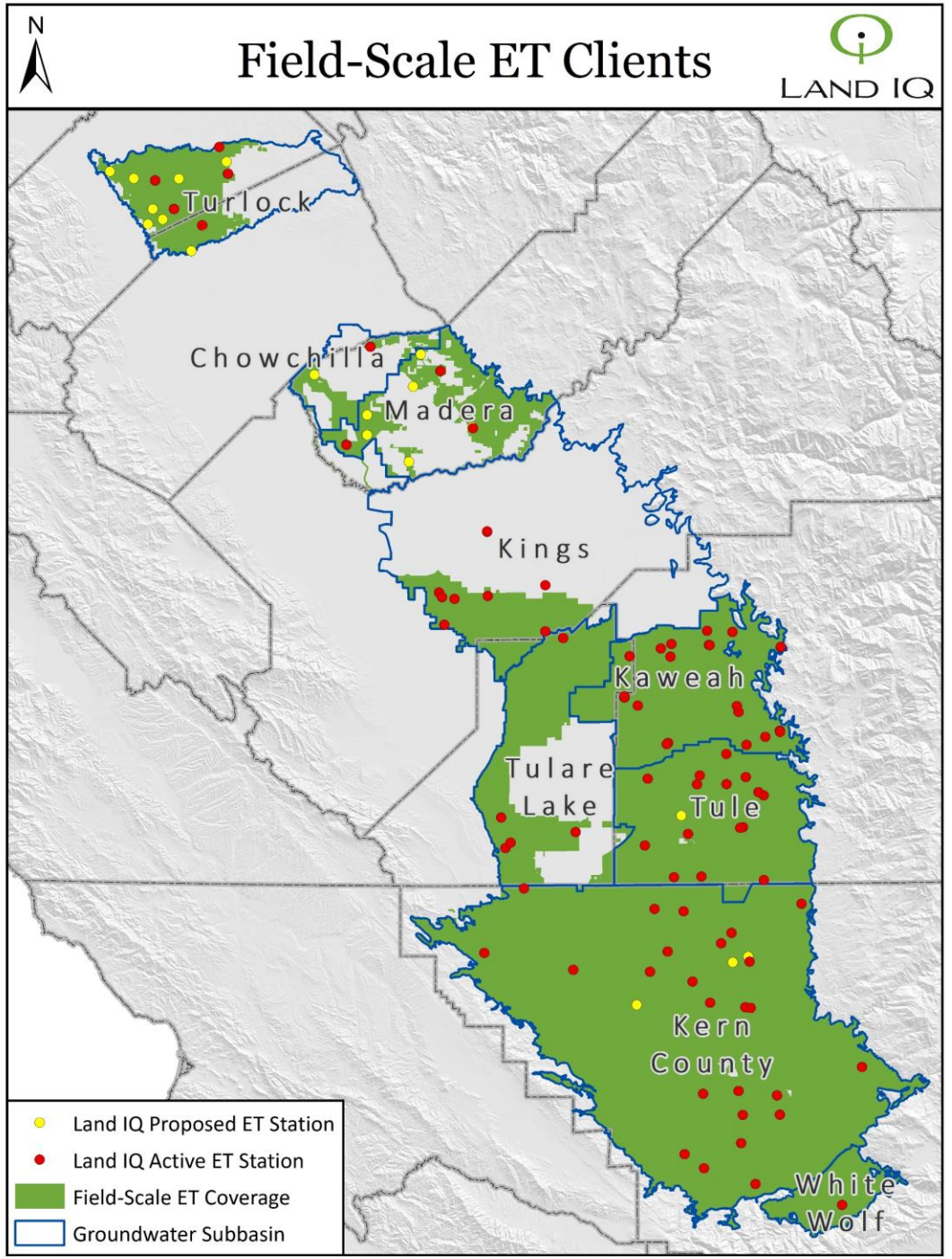
- Defensible
- Independent validation
- Calibration to actual conditions
- Avoiding interpolation during cloud and smoke cover
- Understanding specific field conditions and management
- Allows for continual improvement of models
- Allows for crop-specific modeling
- Stations used are a combination of eddy covariance and surface renewal approaches developed through collaboration with DWR (Delta) and UC Davis researchers
- A “ground up” approach

CURRENT ET WORK EFFORTS

Land IQ currently provides monthly, field by field consumptive use, land use, and precipitation results for:

- Approaching 100 ground truthing stations
- Approximately 40 GSAs or Districts
- 3.3 million acres
- 35-40 different crops
- Multiple water sources
- Supports various allocation methods and water management strategies
- Monthly reports with accuracies
- Delivery within about 30 days
- Integration to on-line platform results
- Collaboration with UC Davis, UC Cooperative Extension and USDA Agricultural Research Service

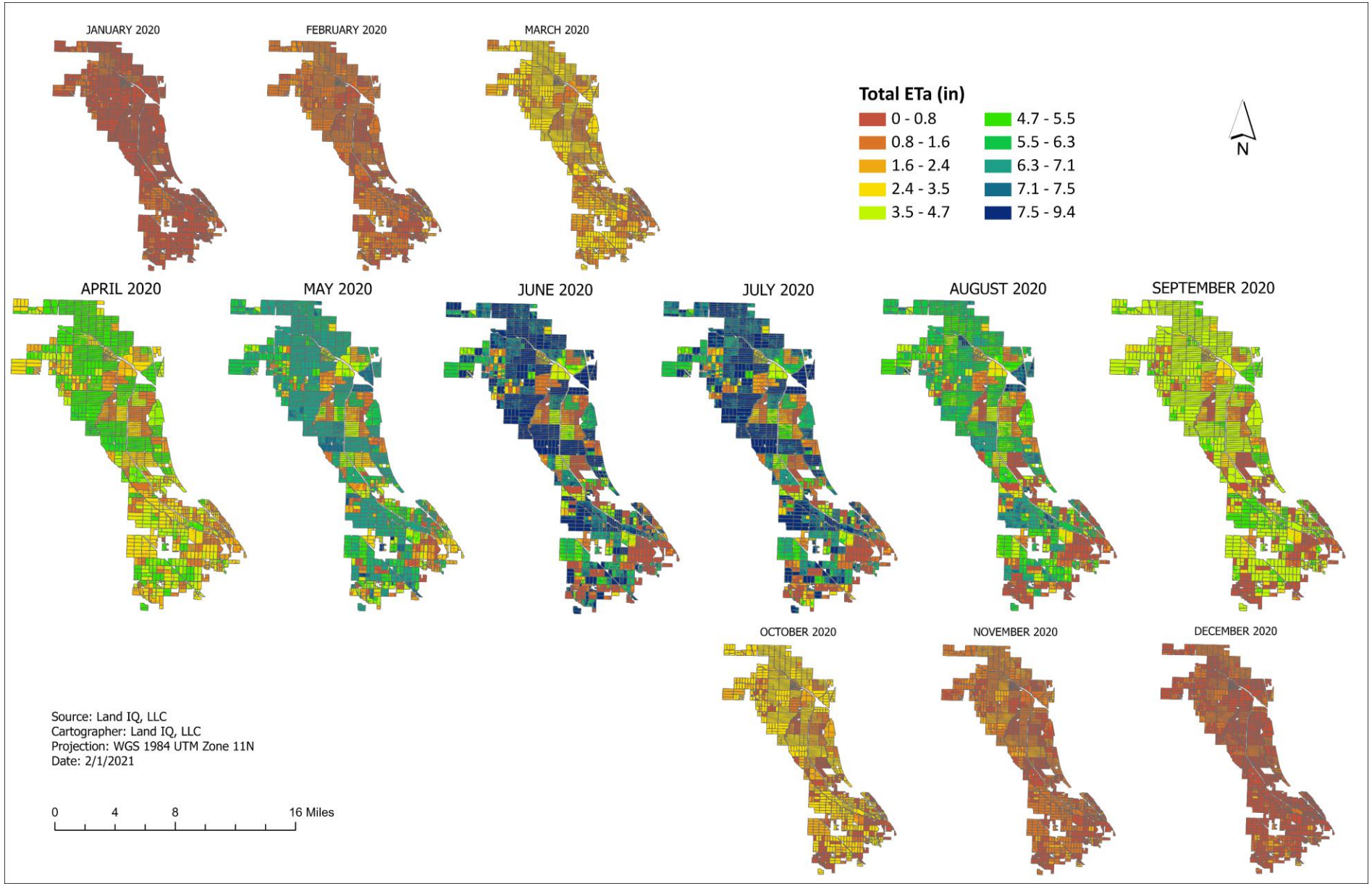
Necessary for more accurate estimation of consumed water in any water allocation/market approach



EVAPOTRANSPIRATION

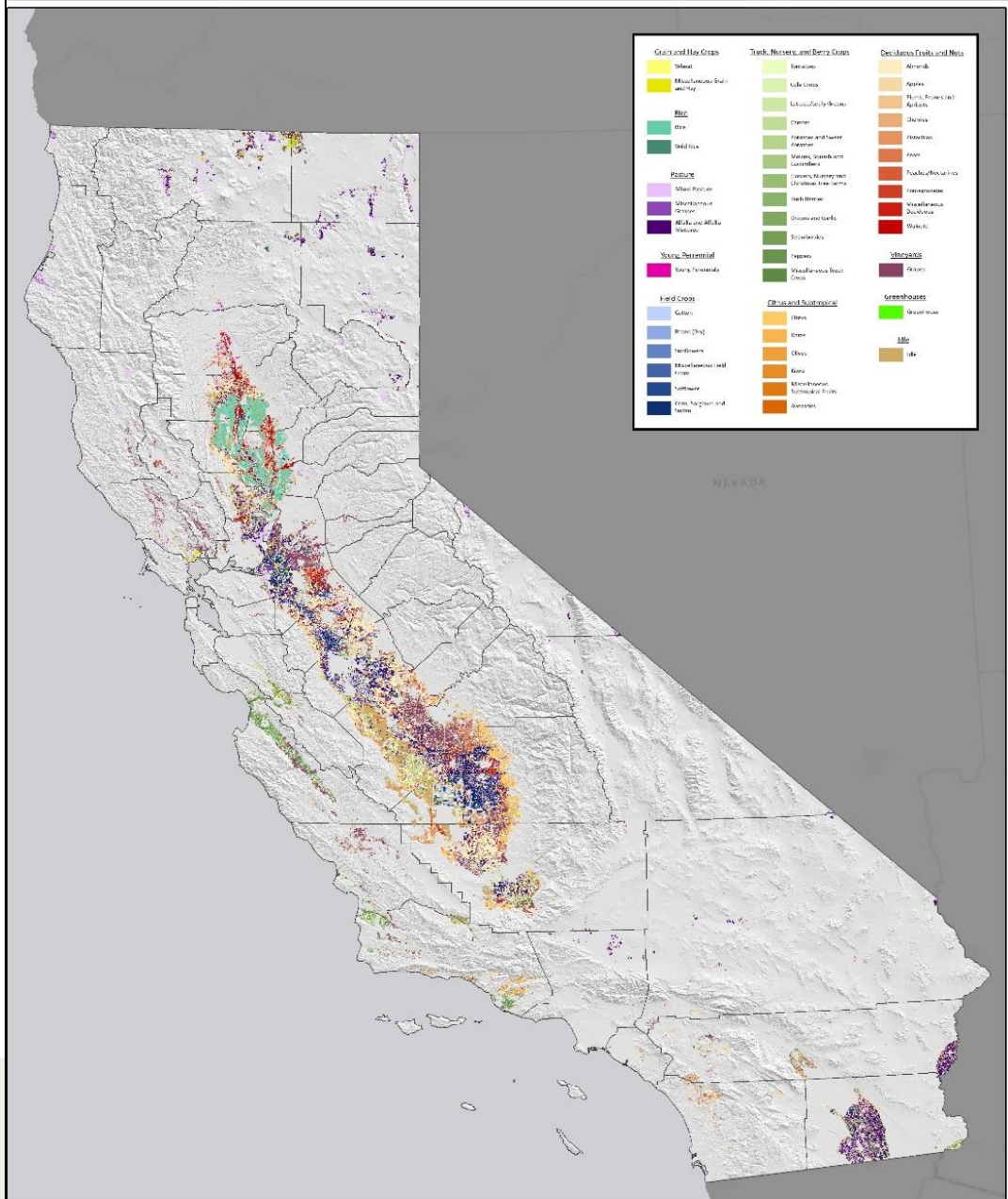
DELIVERABLE – FIELD BY FIELD ET

- Monthly results delivered to the GSA within 25 days of the previous month
- Calibrated and validated by ground truthing climatic stations
- Reviewed by independent advisors
- Used for tracking water use, water management, reporting, allocations, water markets, etc.



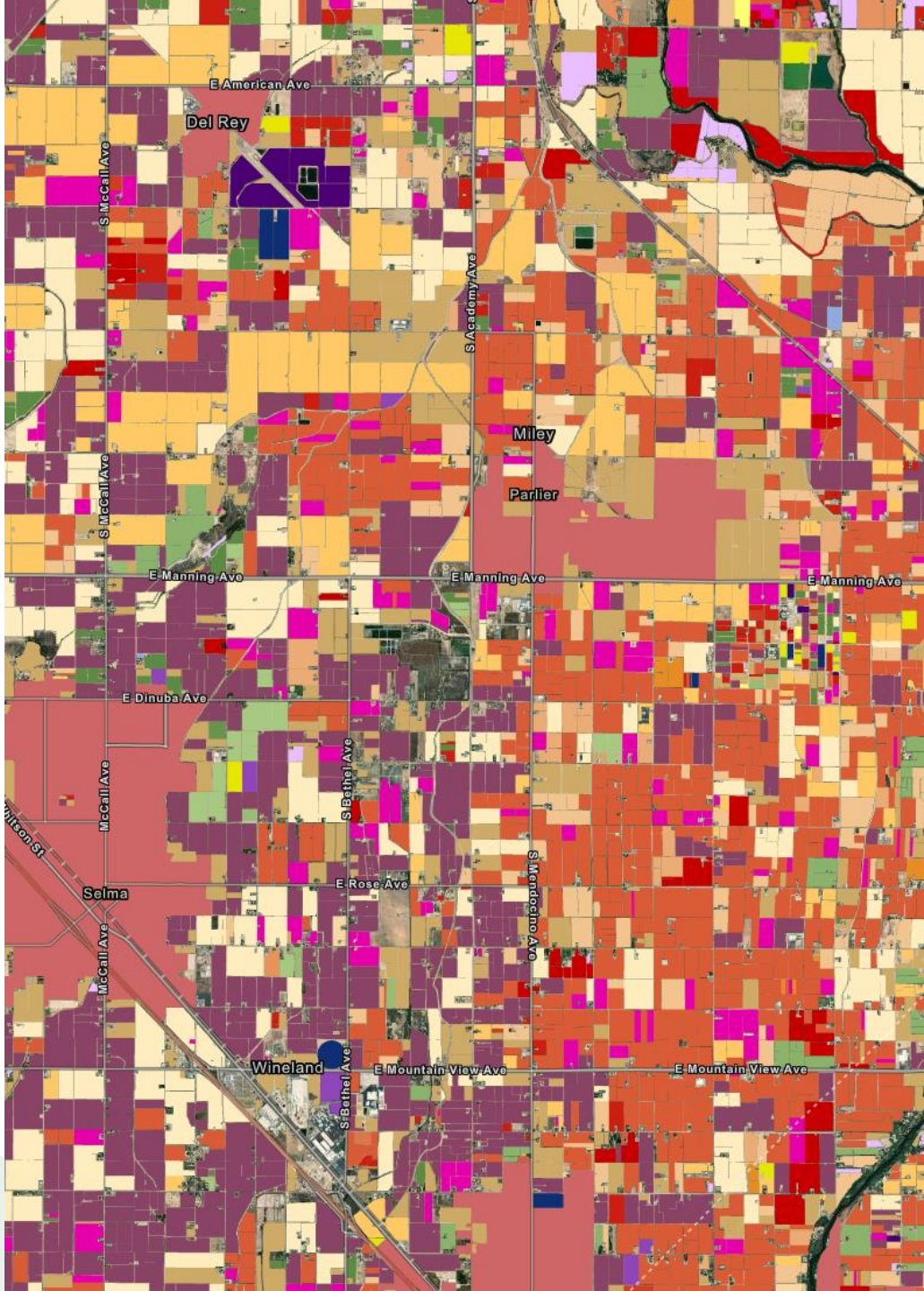
Crop Mapping

2021 DWR STATEWIDE LAND USE



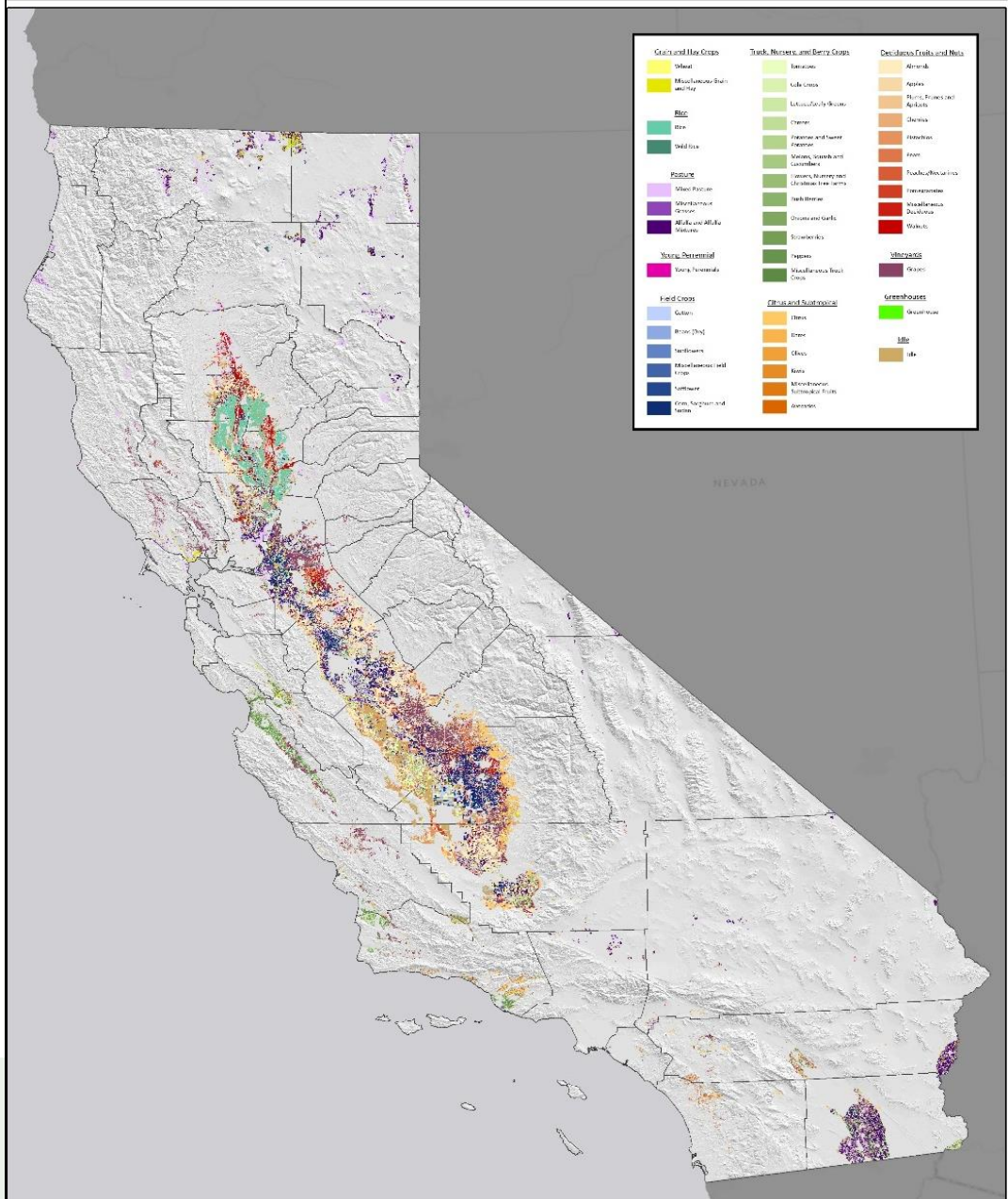
STATEWIDE LAND USE – ALL CROPS

- Minimum field size of 2.0 acres – many times less
- Overall accuracy of 97.6% based on independent ground-truth validation dataset
- Approximately 50 crop legend categories, which represent 98% of all irrigated lands
- Over 17,000 miles of ground truthing each year
- Fact: Urban is approximately 50% of ag footprint (4.7 million acres versus 9.6)



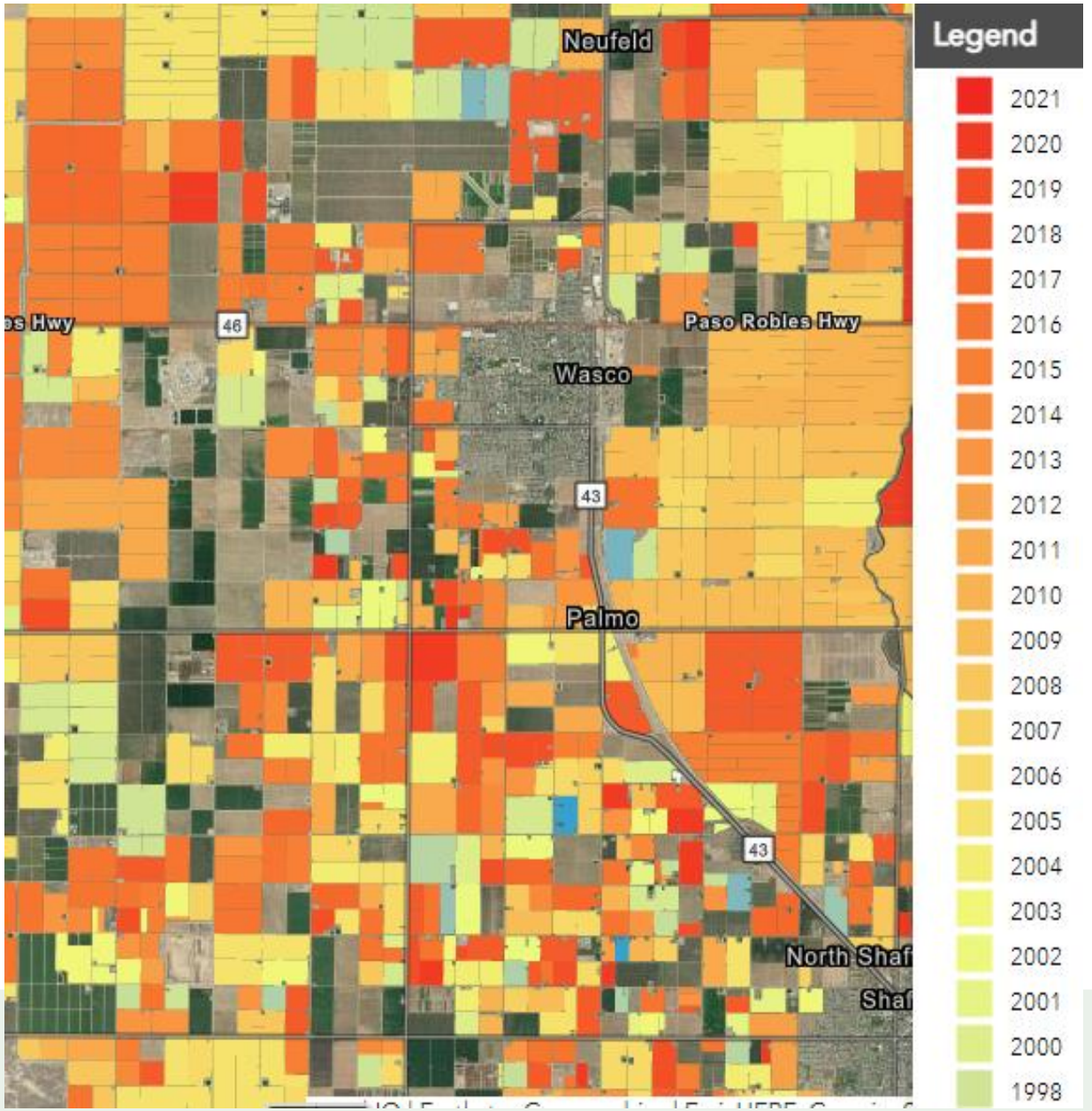
PERMANENT CROP AGE

2021 DWR STATEWIDE LAND USE

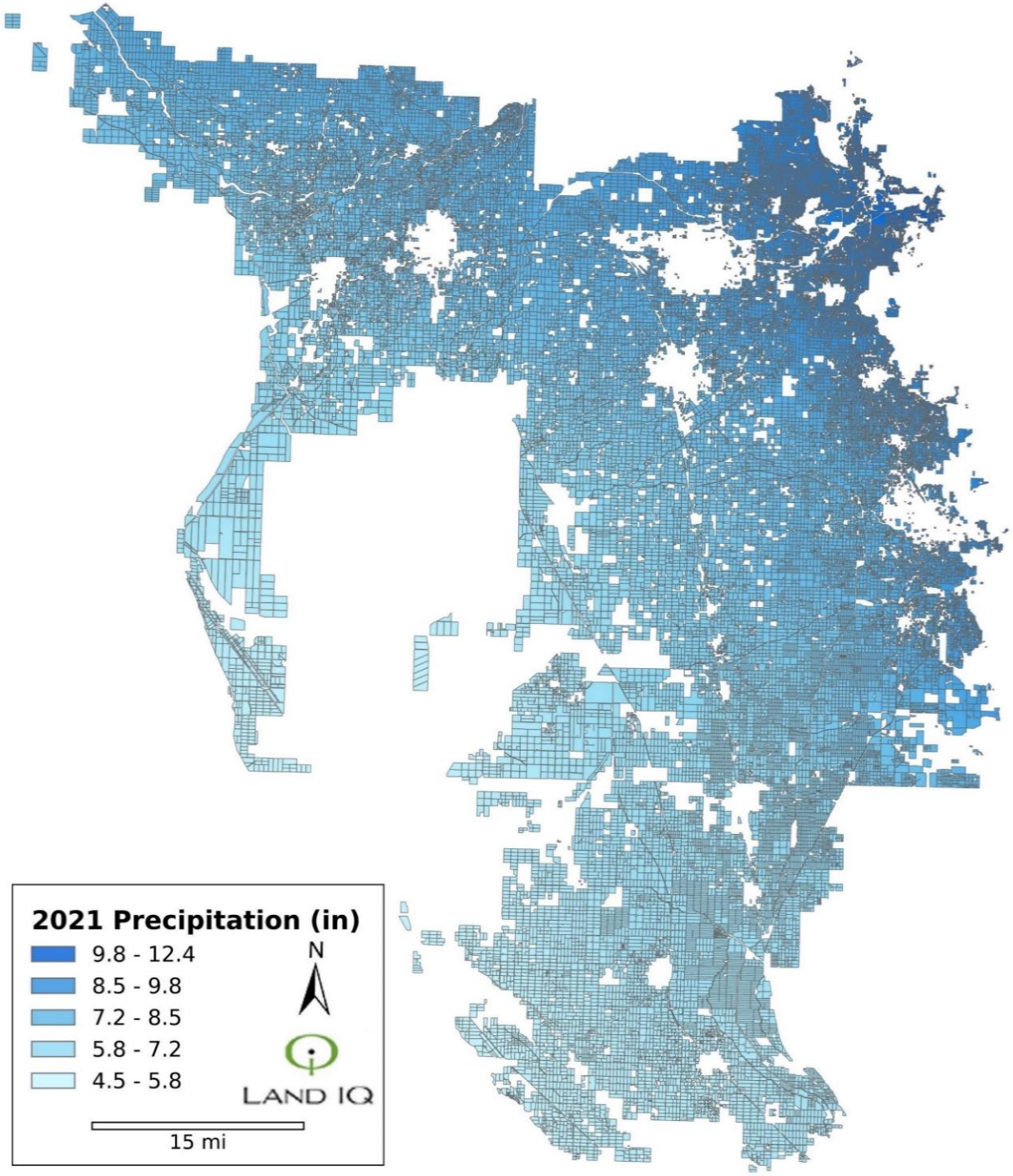


DELIVERABLE – PERMANENT CROP AGE

- Same methodology used to provide crop type to CA Dept of Water Resources as a requirement of SGMA
- Consistent with results for DWR
- Highly correlated to consumed water
- ETo x Kc = ETc (not true for trees)
- Yet another line of evidence that people can use to refine their water management allocations

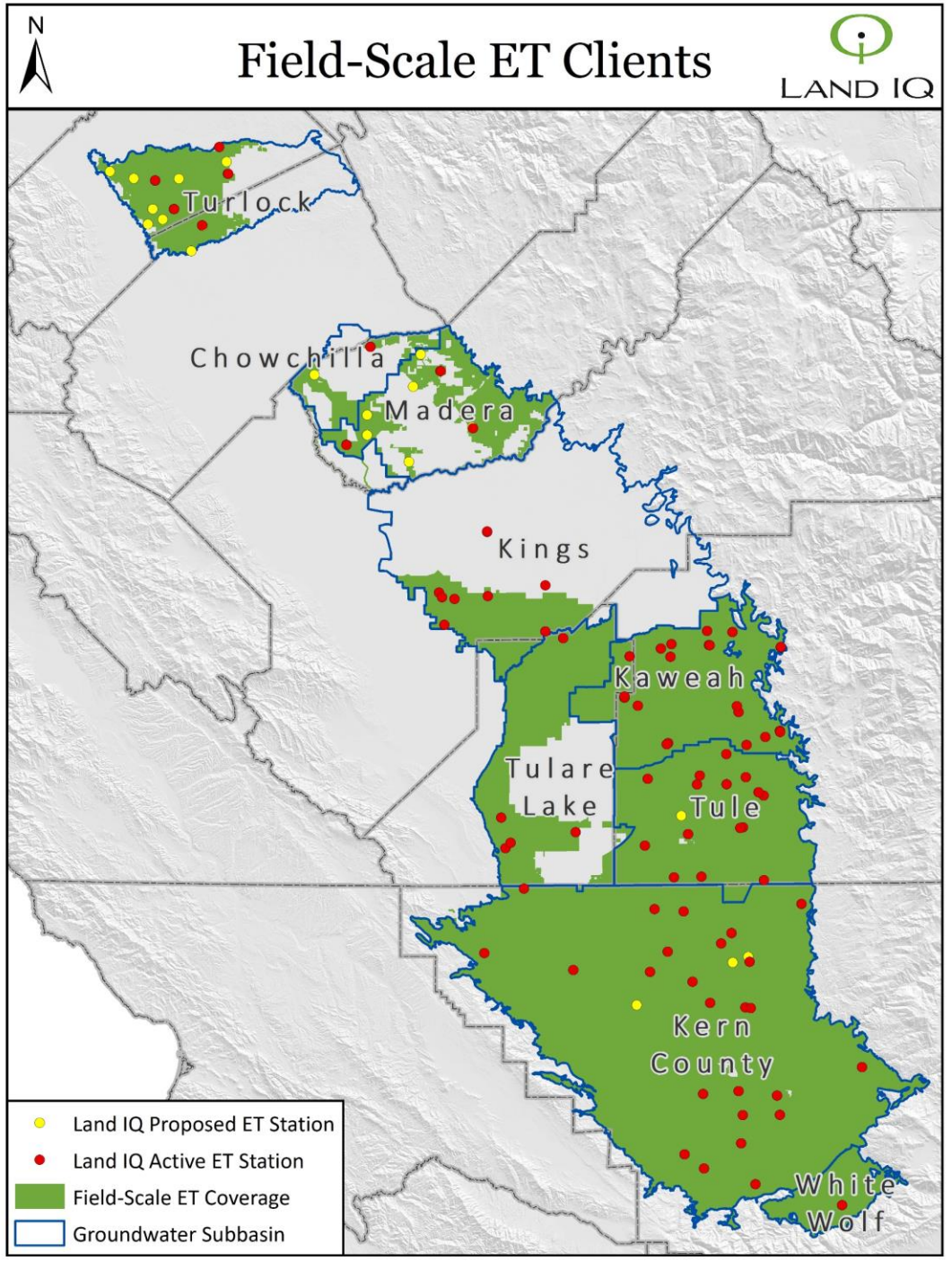


PRECIPITATION



DELIVERABLE – FIELD BY FIELD PRECIPITATION

- Results collected by rain gauges at ground truthing stations
- Incorporation of other public rain gauge results (e.g. CIMIS, airports, cities, etc.
- Conversion of point data into a spatial precipitation map by month and by year
- Assignment of a field-by-field precipitation for rainfall contribution to ET, water budget tracking, allocations, modeling, etc.



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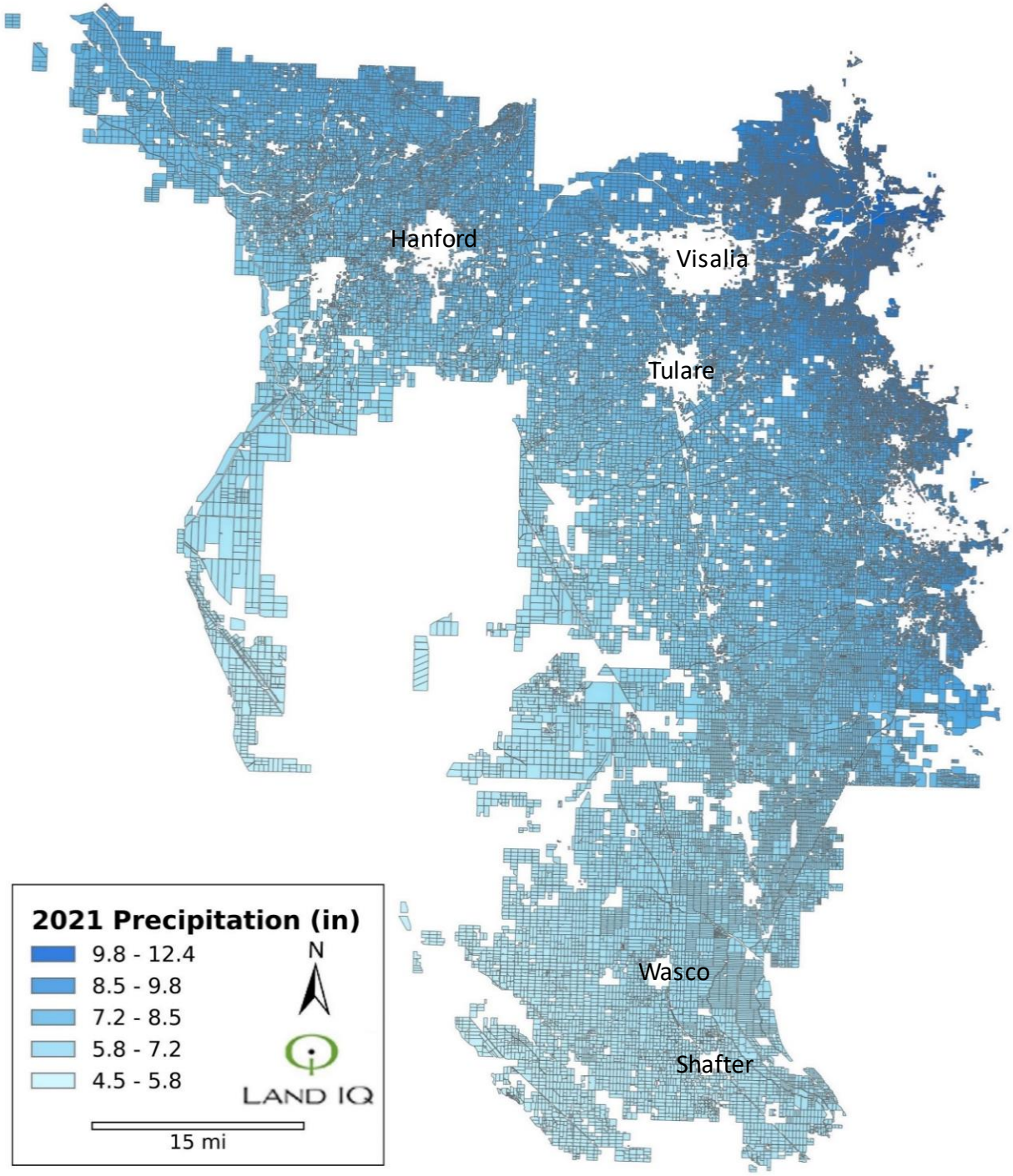
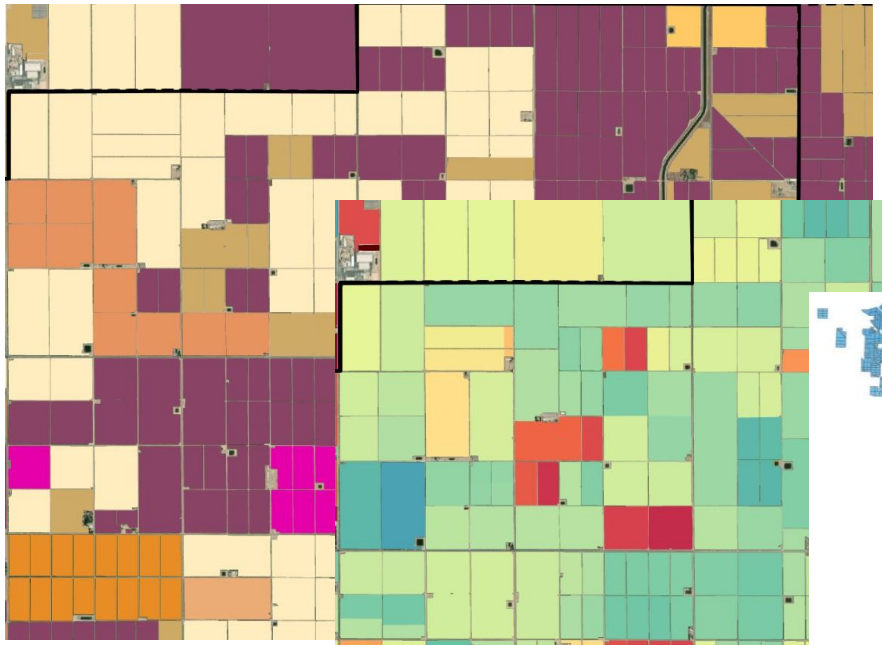
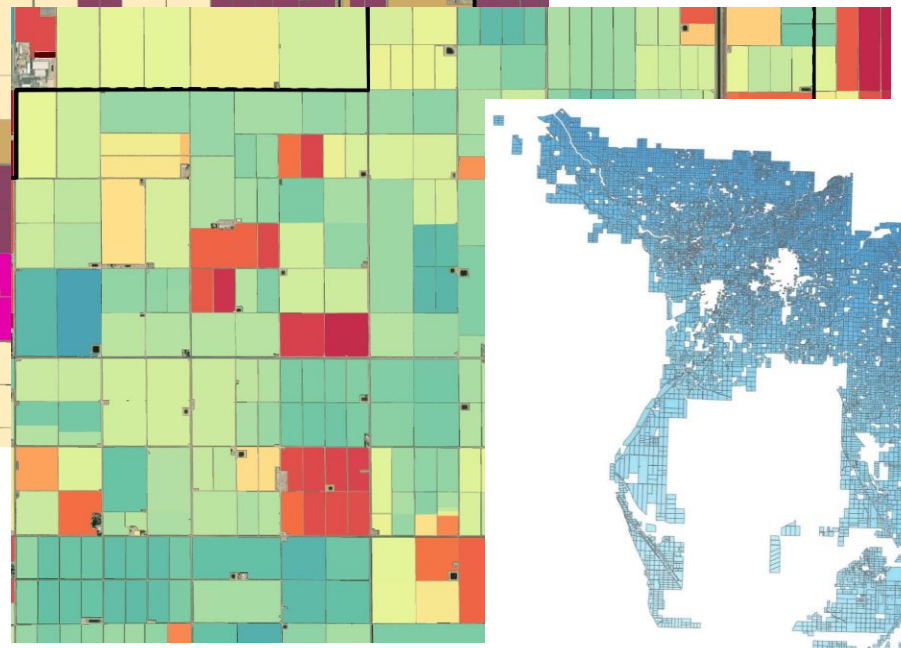


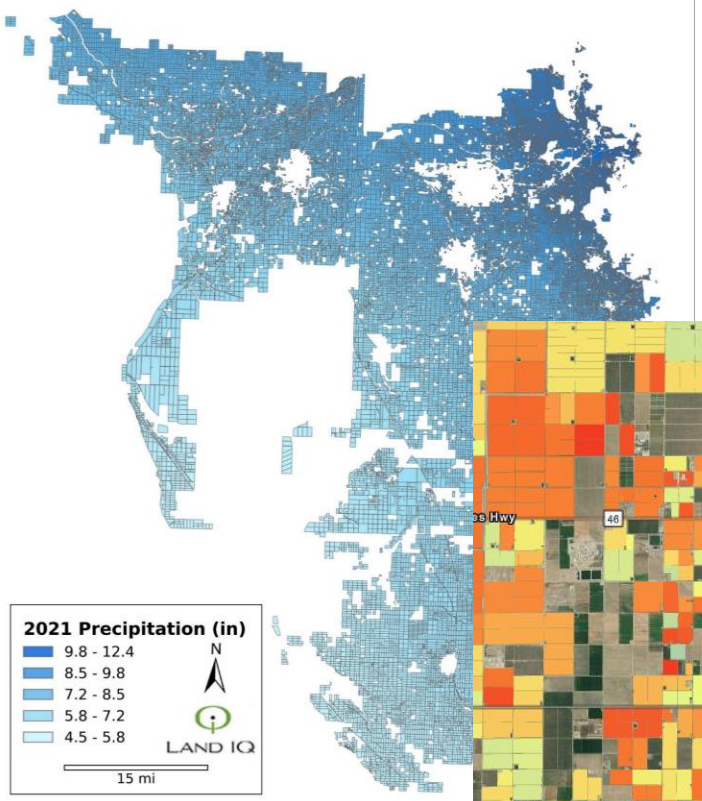
FIELD-BY-FIELD RESULTS



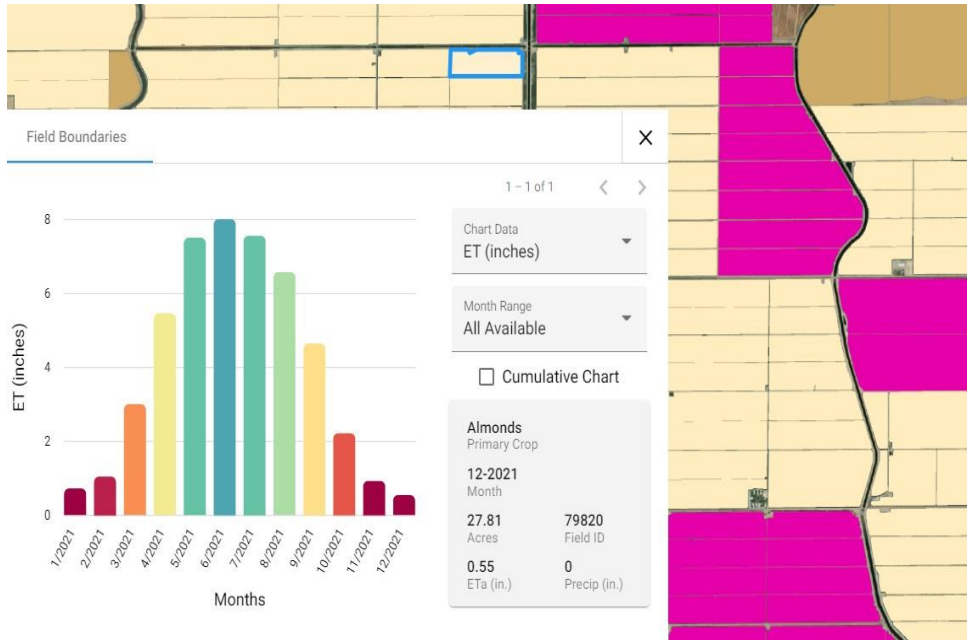
Land Use



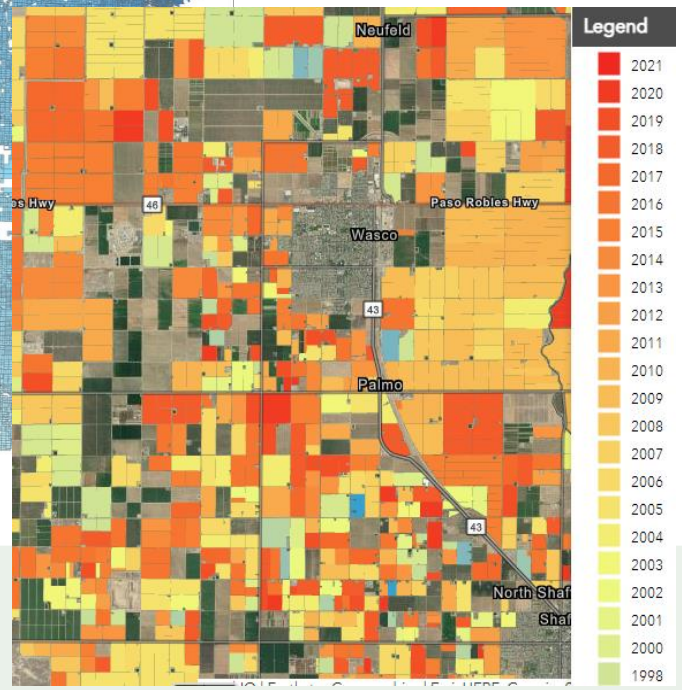
Monthly ET



Monthly Precipitation



Online Viewer and Data Download Tool

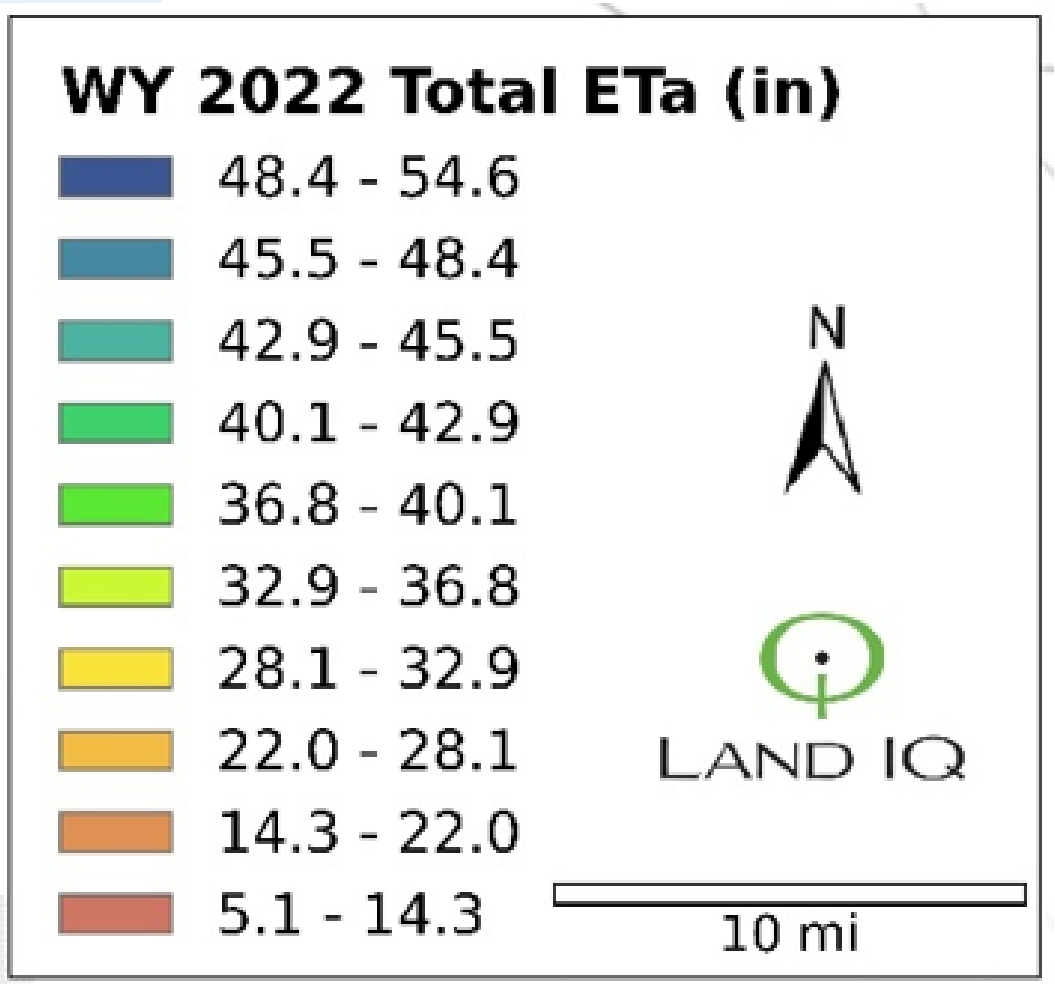


Age

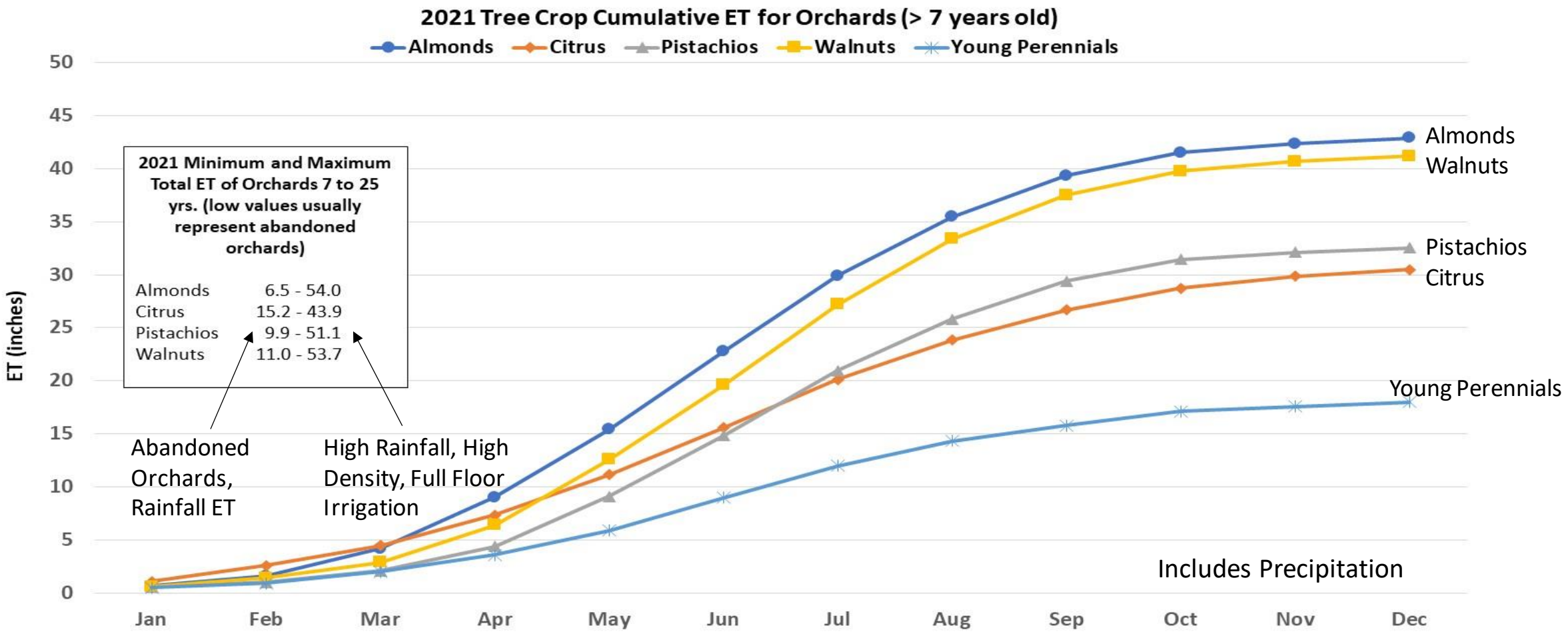
LAND IQ

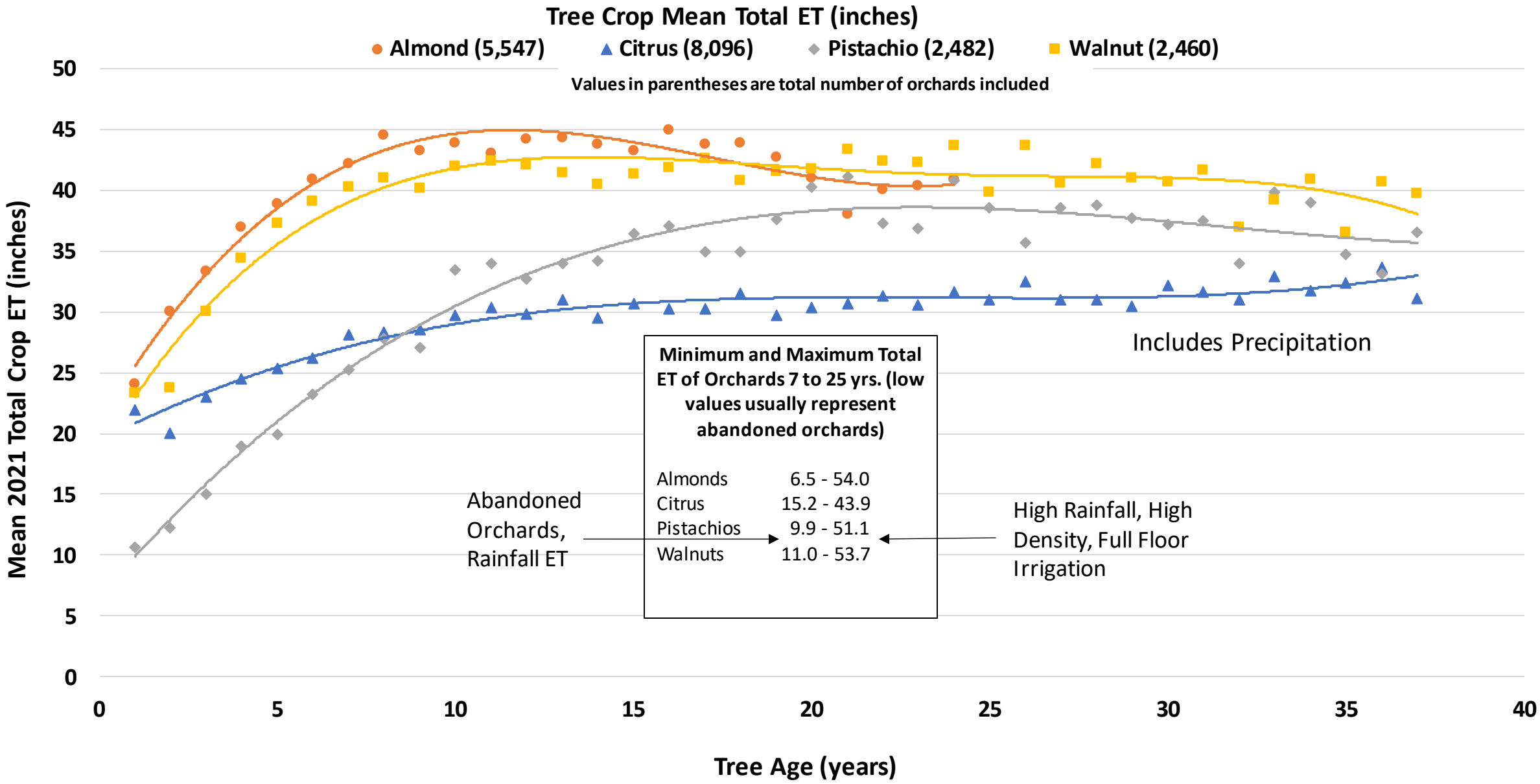
Results

ALMOND ET – SPATIAL REPRESENTATION

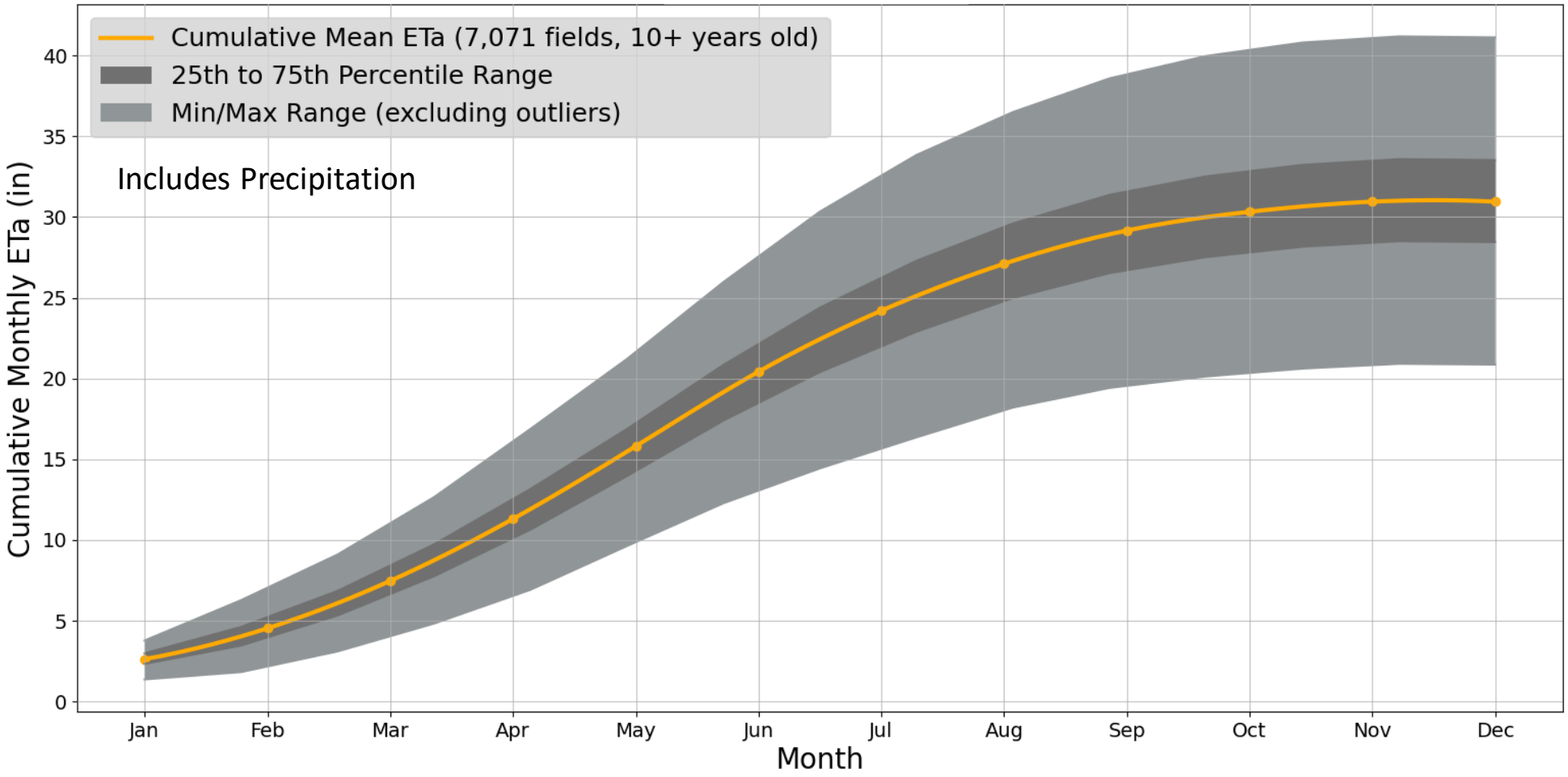


PERMANENT TREE CROP AVERAGE ANNUAL CONSUMPTIVE USE

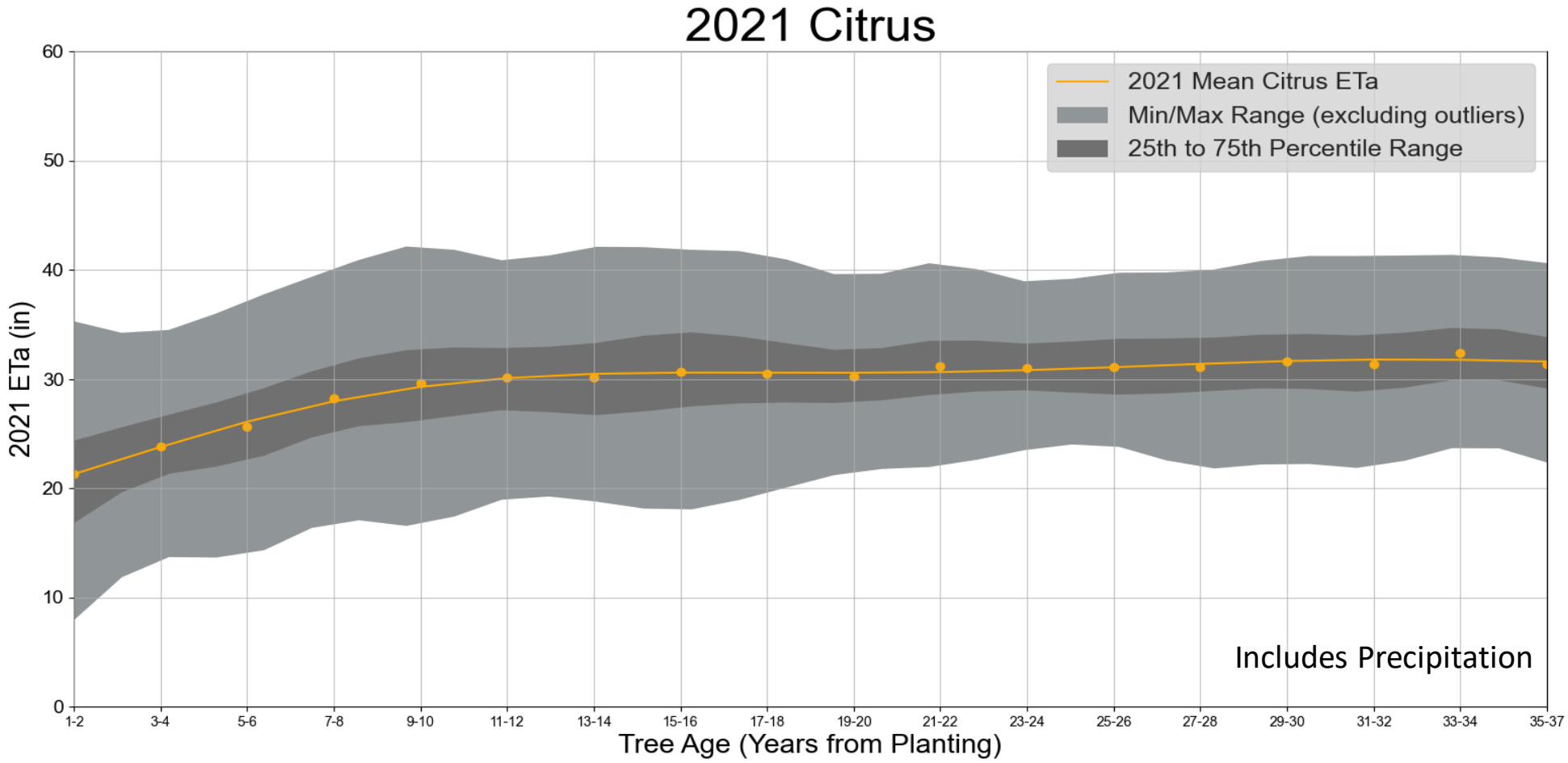



Tree Crop Mean Total ET (inches)
Almond (5,547)
Citrus (8,096)
Pistachio (2,482)
Walnut (2,460)
Values in parentheses are total number of orchards included
Mean 2021 Total Crop ET (inches)
Tree Age (years)
Includes Precipitation
Minimum and Maximum Total ET of Orchards 7 to 25 yrs. (low values usually represent abandoned orchards)
Almonds 6.5 - 54.0
Citrus 15.2 - 43.9
Pistachios 9.9 - 51.1
Walnuts 11.0 - 53.7
Abandoned Orchards, Rainfall ET
High Rainfall, High Density, Full Floor Irrigation

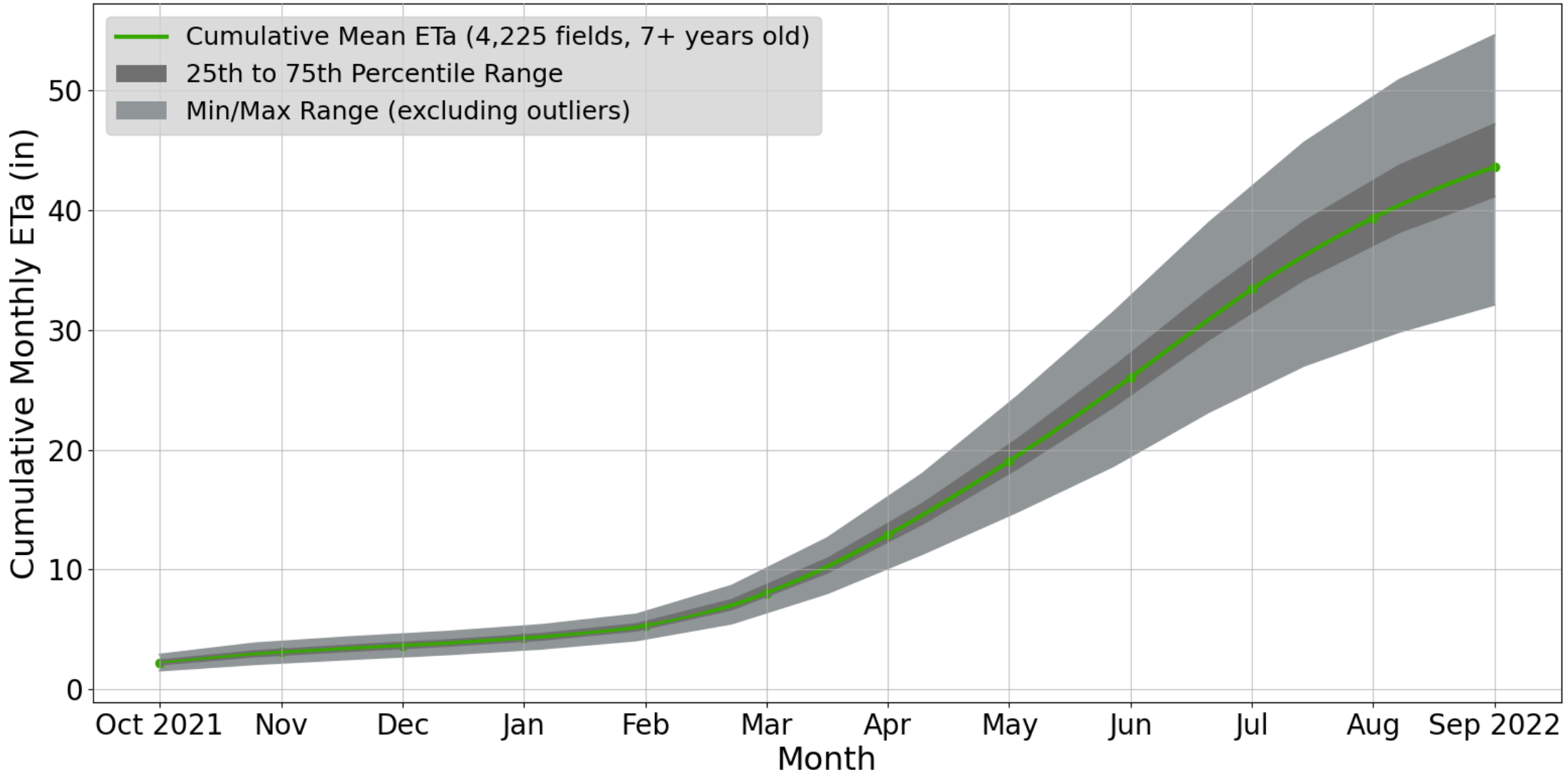
CITRUS CUMULATIVE ET



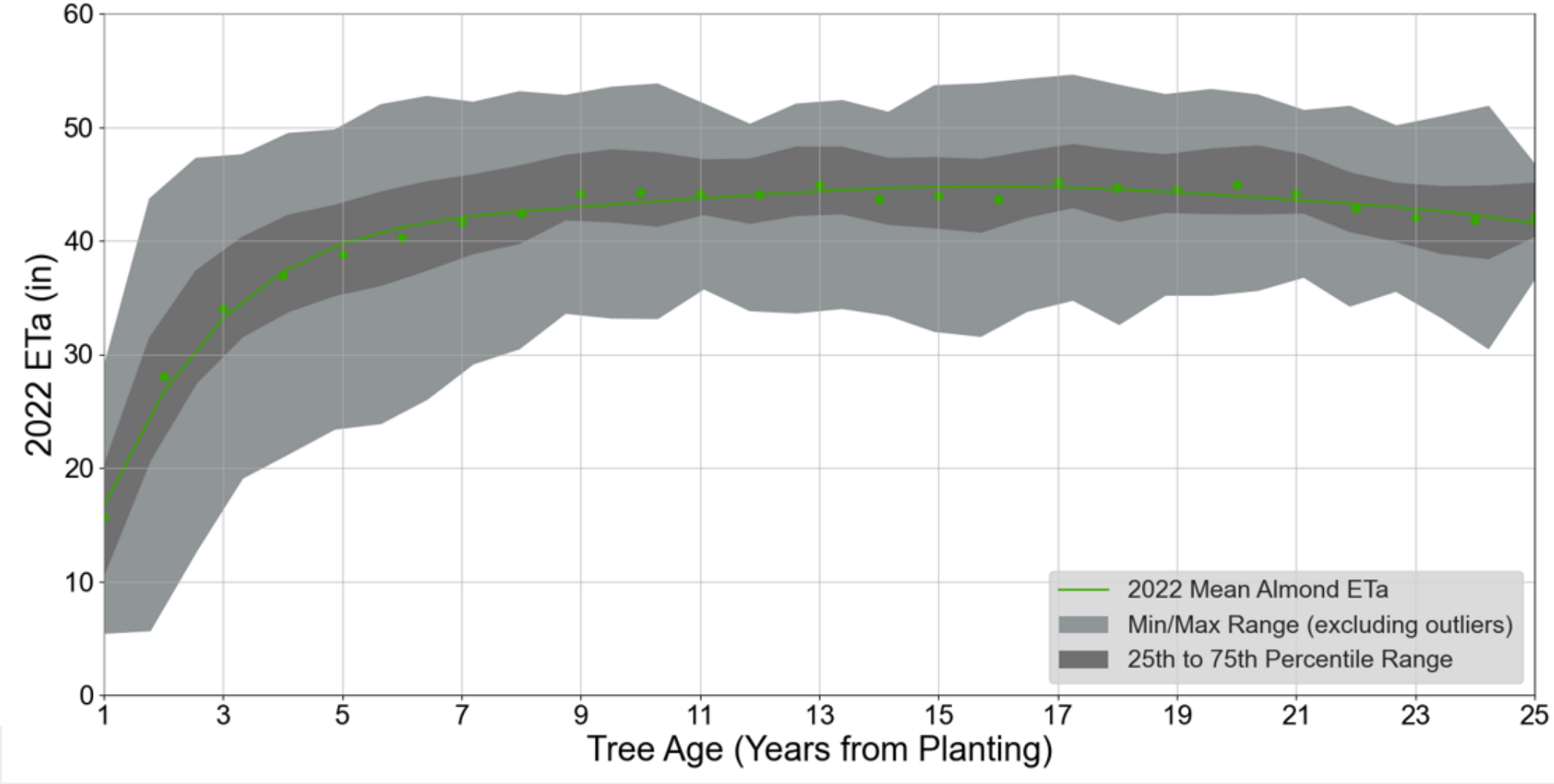
Citrus Evapotranspiration By Age



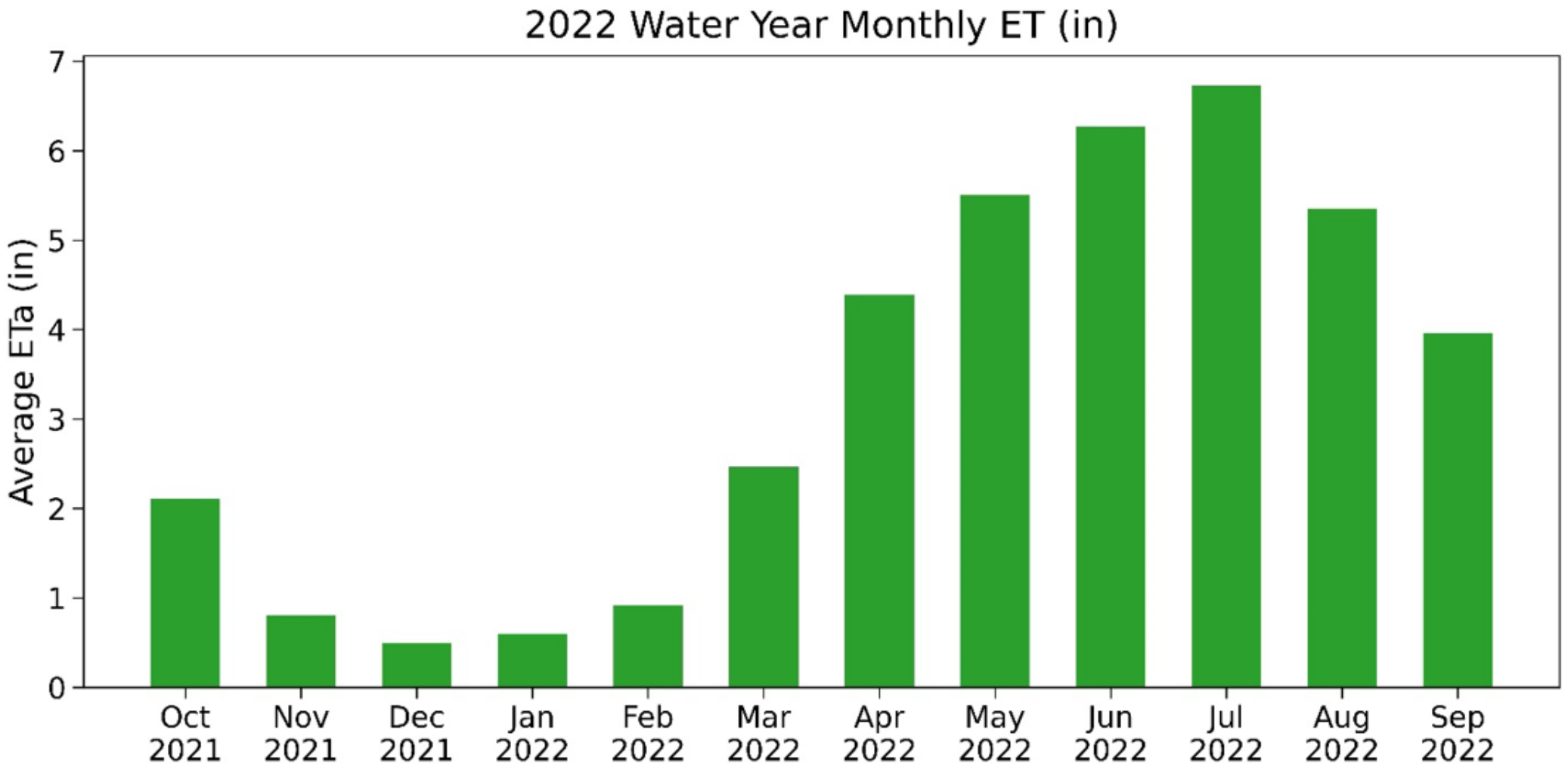
Almond Cumulative ET



Almond Evapotranspiration By Age



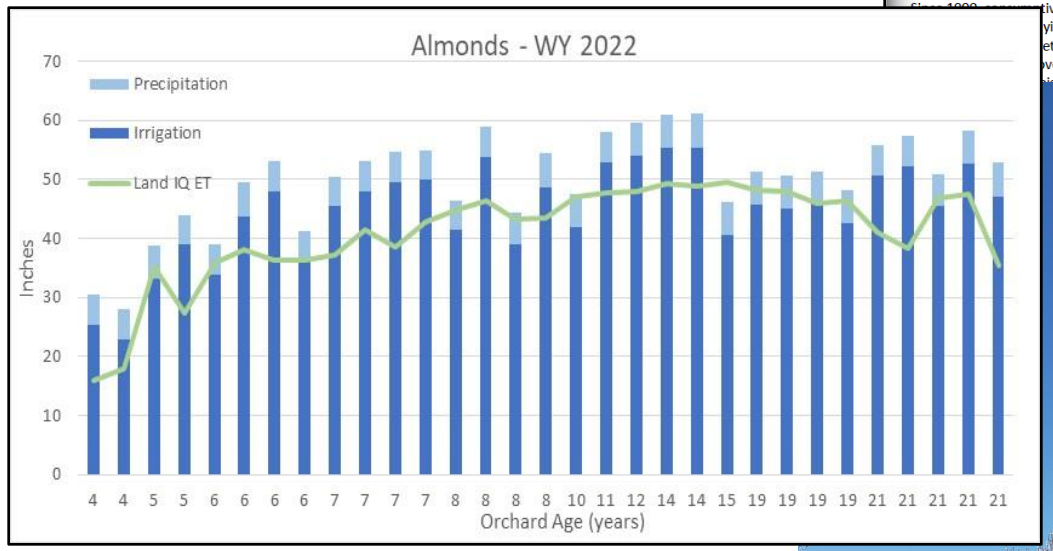
Almond Average Monthly ET

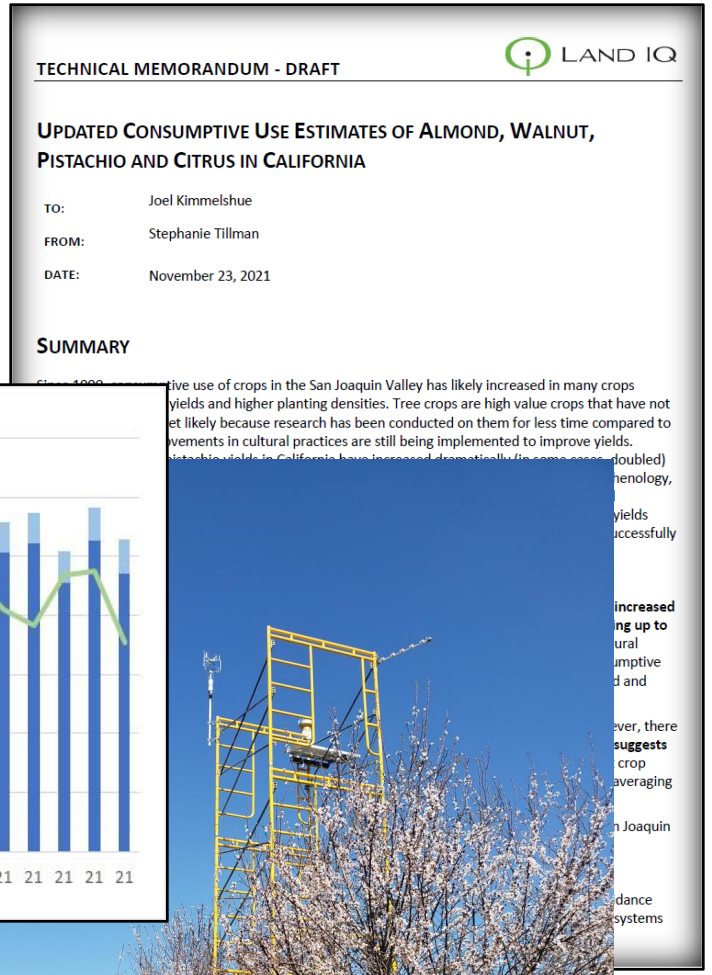


VALIDATION

MULTIPLE APPROACHES TO CALIBRATION AND VALIDATION

- Ground Truthing
  - Eddy Covariance
  - Surface Renewal
- Measured versus Predicted
- Applied Versus Consumed
- Literature Comparisons
- Independent Reviews (UC, ARS, and Cal Poly-ITRC)
- Agronomic Knowledge and Experience
- Grower Acceptance




TECHNICAL MEMORANDUM - DRAFT

LAND IQ

UPDATED CONSUMPTIVE USE ESTIMATES OF ALMOND, WALNUT, PISTACHIO AND CITRUS IN CALIFORNIA

TO: Joel Kimmelshue

FROM: Stephanie Tillman

DATE: November 23, 2021

SUMMARY

tive use of crops in the San Joaquin Valley has likely increased in many crops yields and higher planting densities. Tree crops are high value crops that have not et likely because research has been conducted on them for less time compared to vements in cultural practices are still being implemented to improve yields.

Measured versus Predicted ET – Multiple Crops

$R^2 = 0.97$
RMSE = 0.41 in

1:1 Line

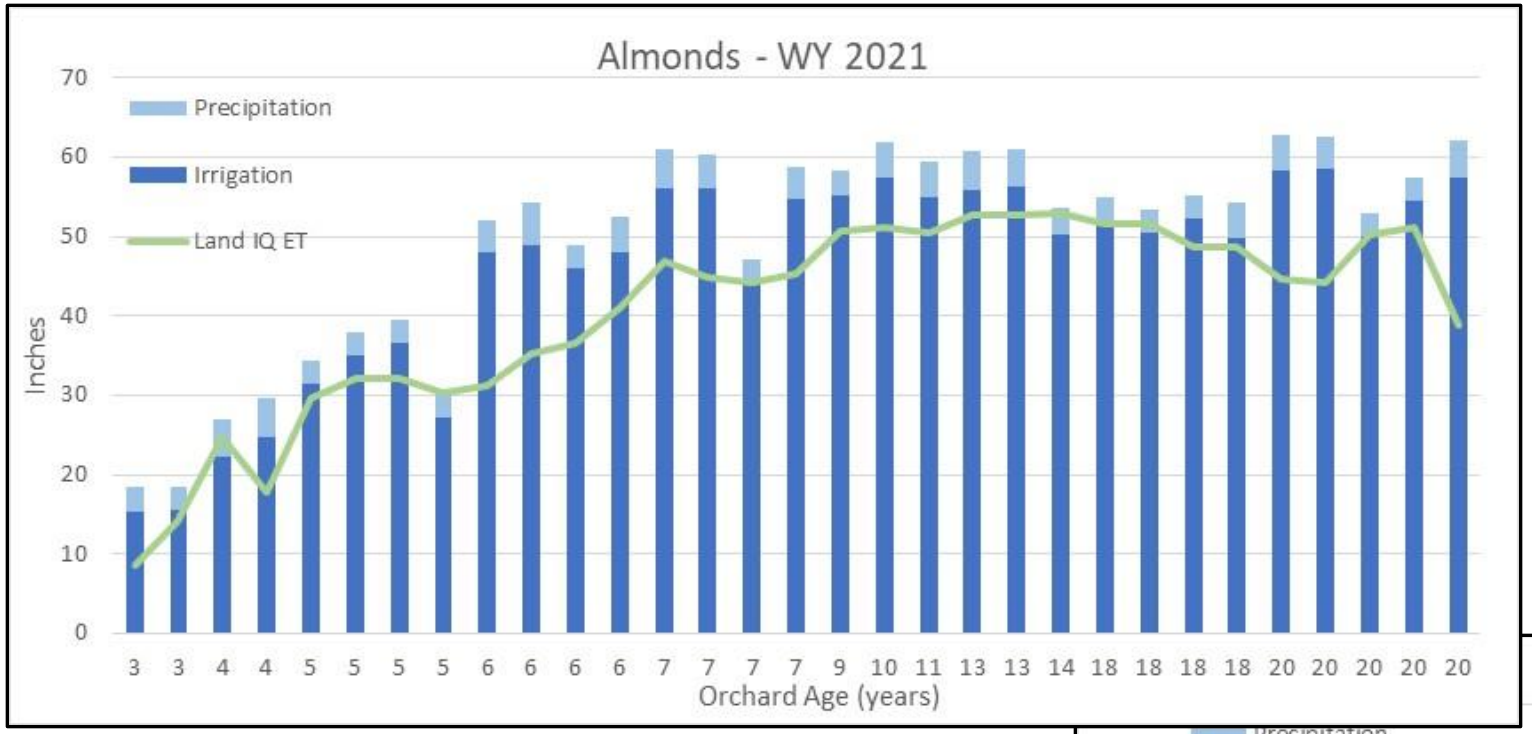
Predicted ETa (in)

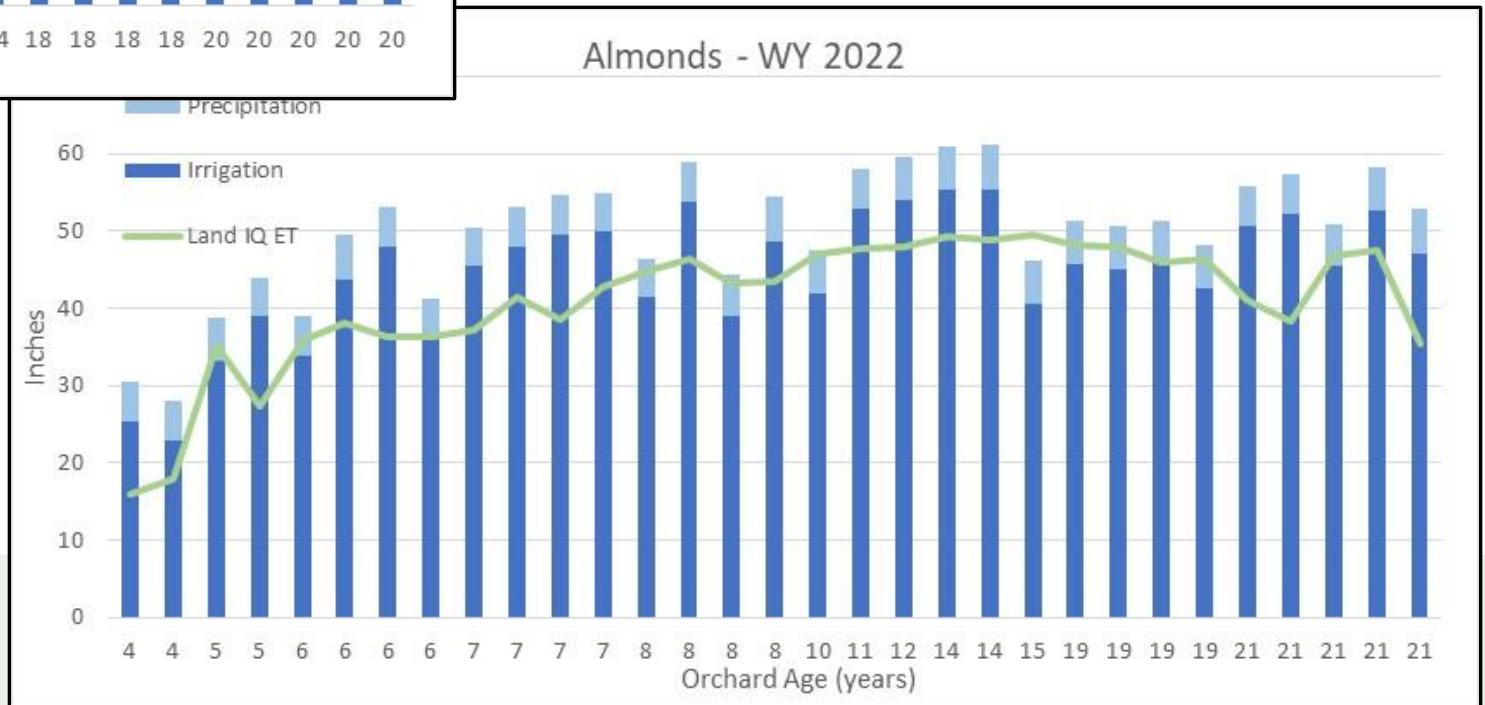
Measured ETa (in)

0 1 2 3 4 5 6 7 8 9 10

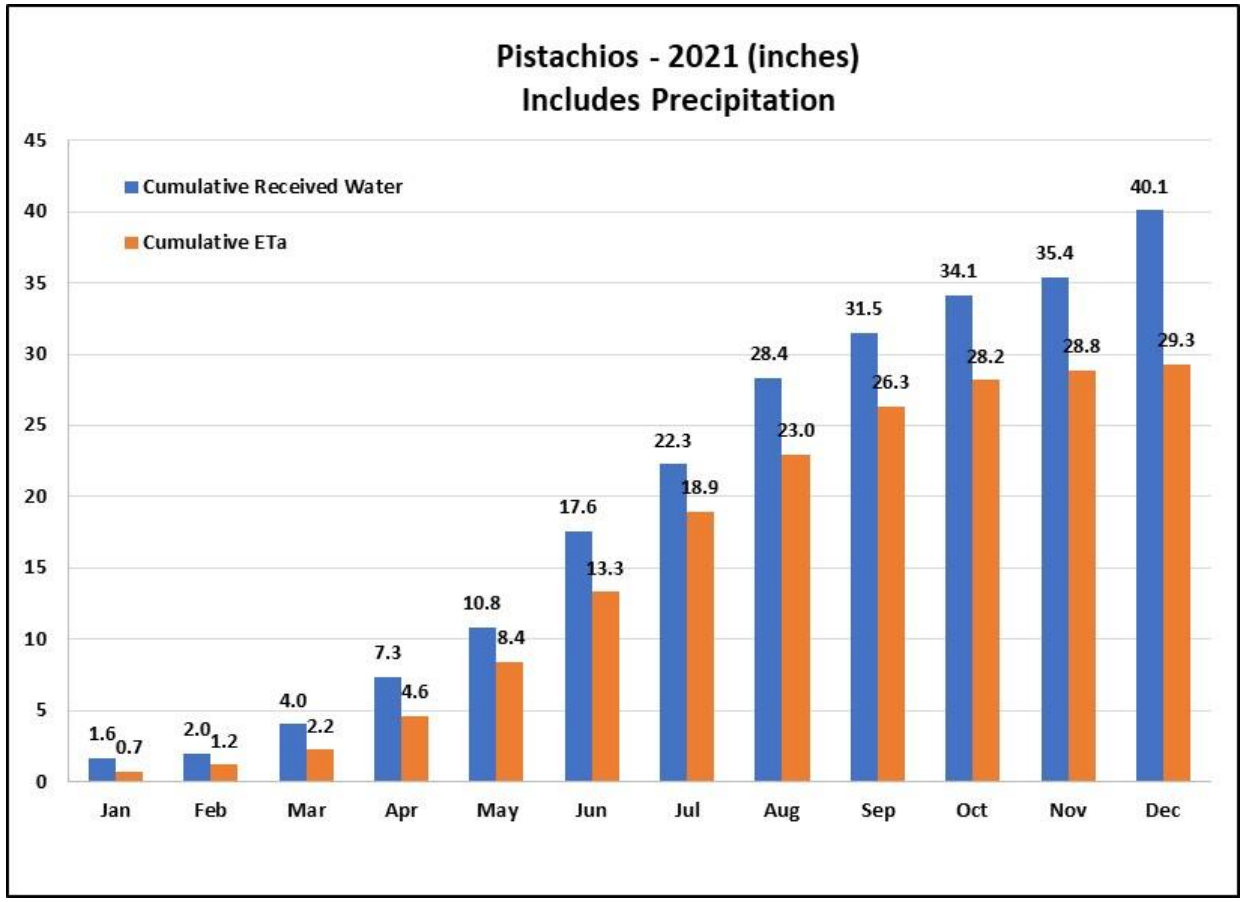
Alfalfa
Almonds
Annuals
Citrus
Fallow/Native
Table Grapes
Wine Grapes
Olives
Pistachios
Pomegranates
Walnuts

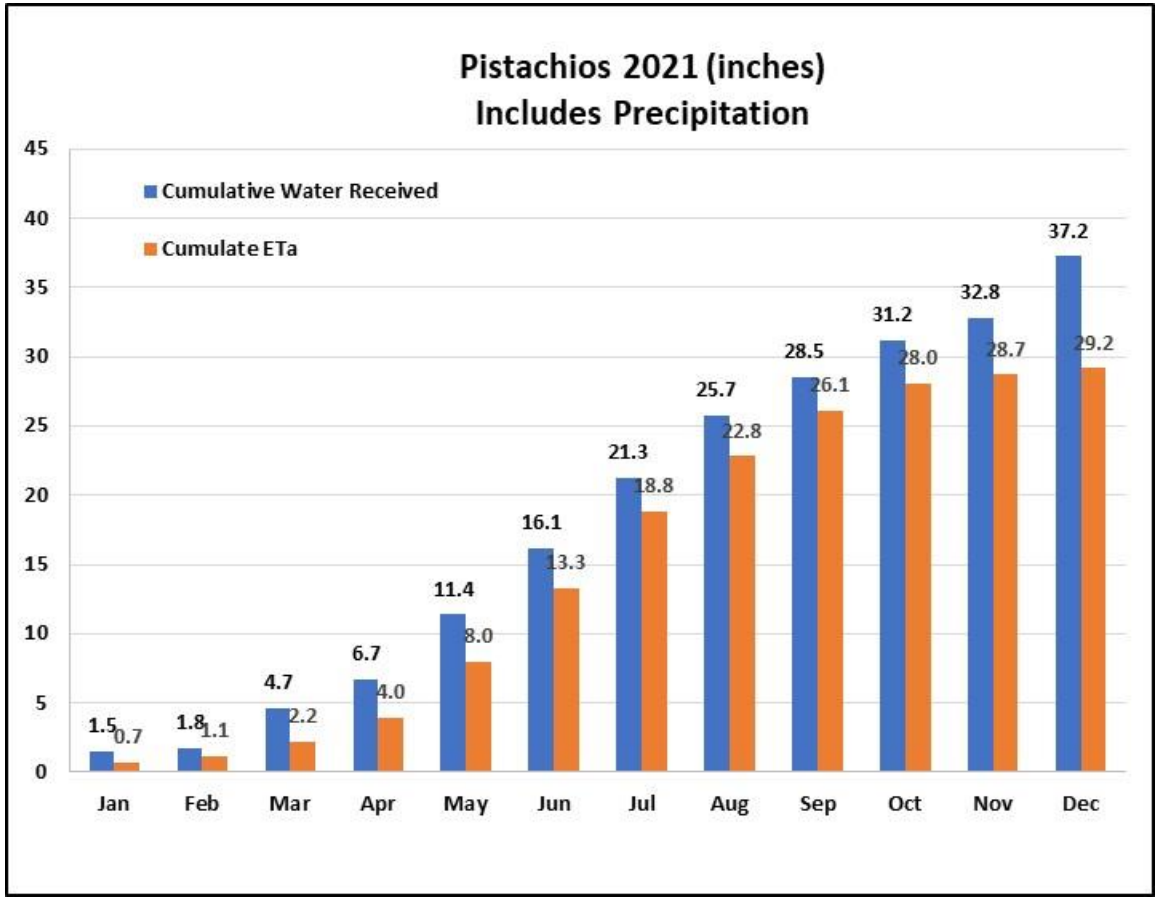
Water Received versus Consumed by Age - Almonds



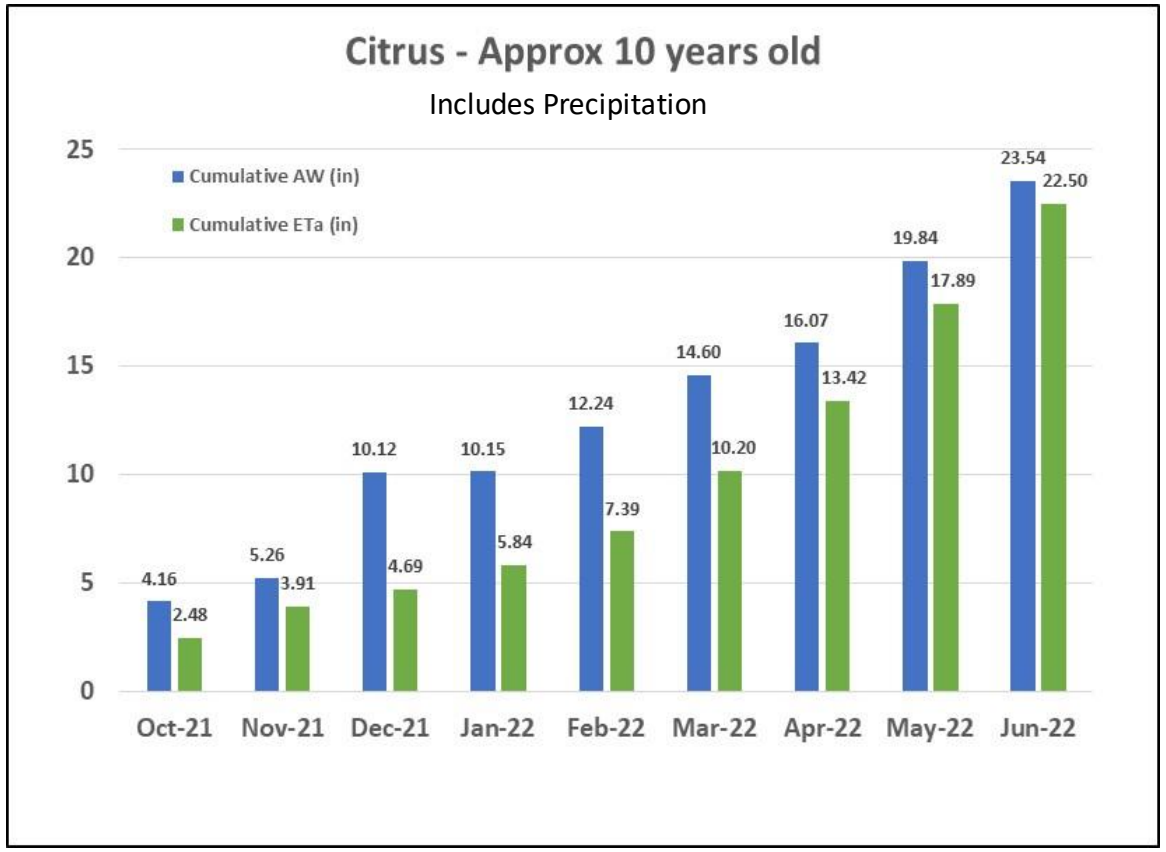


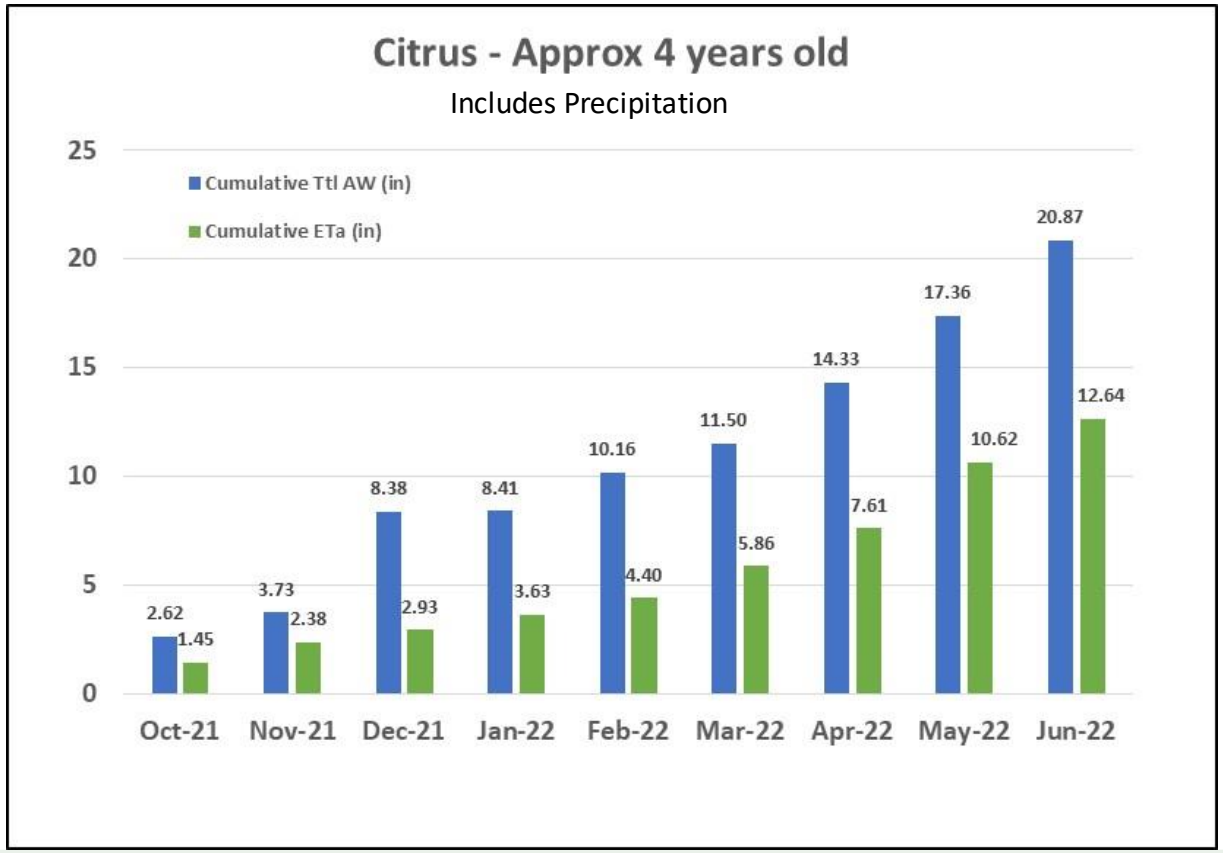
WATER RECEIVED VERSUS CONSUMED - PISTACHIOS



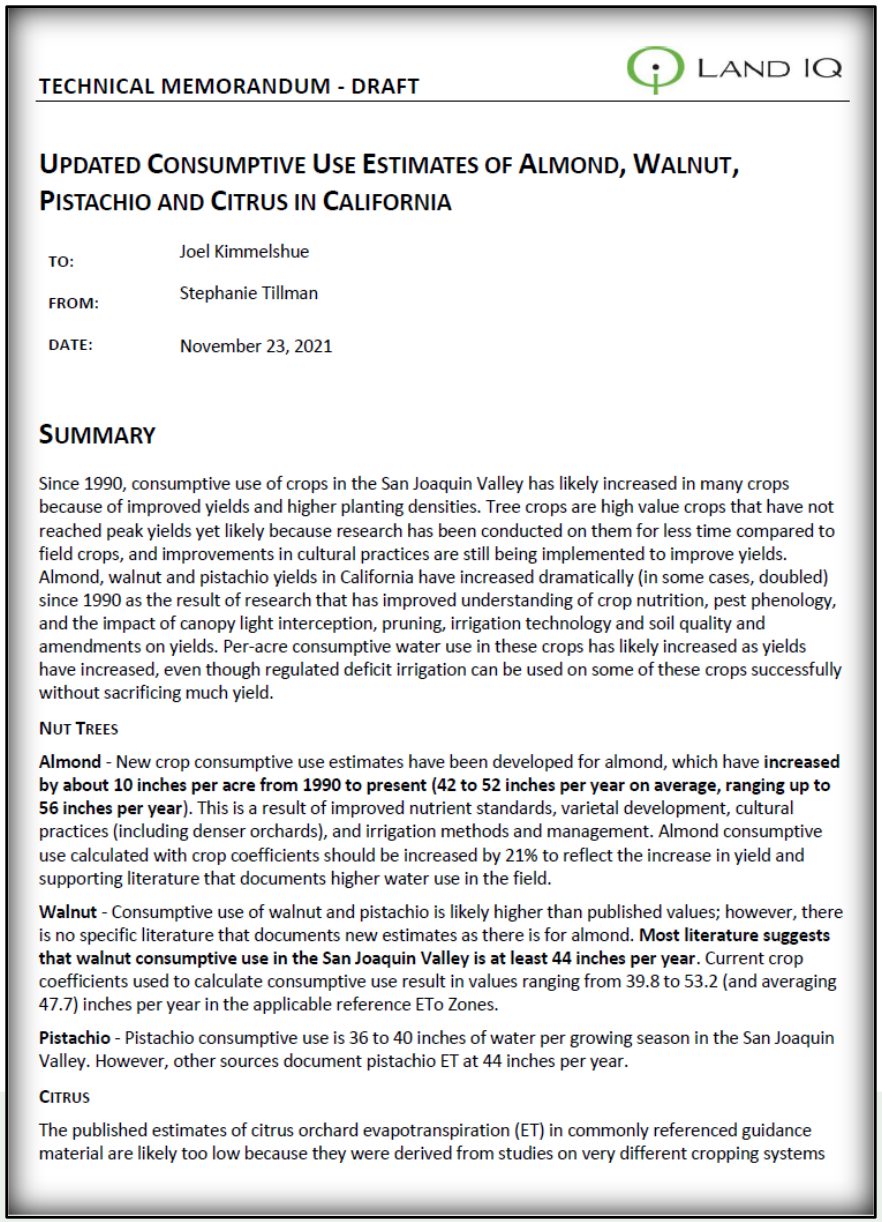


WATER RECEIVED VERSUS CONSUMED - CITRUS





LITERATURE COMPARISONS - ALMONDS



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TO: Joel Kimmelshue

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DATE: November 23, 2021

SUMMARY

Since 1990, consumptive use of crops in the San Joaquin Valley has likely increased in many crops because of improved yields and higher planting densities. Tree crops are high value crops that have not reached peak yields yet likely because research has been conducted on them for less time compared to field crops, and improvements in cultural practices are still being implemented to improve yields. Almond, walnut and pistachio yields in California have increased dramatically (in some cases, doubled) since 1990 as the result of research that has improved understanding of crop nutrition, pest phenology, and the impact of canopy light interception, pruning, irrigation technology and soil quality and amendments on yields. Per-acre consumptive water use in these crops has likely increased as yields have increased, even though regulated deficit irrigation can be used on some of these crops successfully without sacrificing much yield.

NUT TREES

Almond - New crop consumptive use estimates have been developed for almond, which have **increased by about 10 inches per acre from 1990 to present (42 to 52 inches per year on average, ranging up to 56 inches per year)**. This is a result of improved nutrient standards, varietal development, cultural practices (including denser orchards), and irrigation methods and management. Almond consumptive use calculated with crop coefficients should be increased by 21% to reflect the increase in yield and supporting literature that documents higher water use in the field.

Walnut - Consumptive use of walnut and pistachio is likely higher than published values; however, there is no specific literature that documents new estimates as there is for almond. **Most literature suggests that walnut consumptive use in the San Joaquin Valley is at least 44 inches per year**. Current crop coefficients used to calculate consumptive use result in values ranging from 39.8 to 53.2 (and averaging 47.7) inches per year in the applicable reference ETo Zones.

Pistachio - Pistachio consumptive use is 36 to 40 inches of water per growing season in the San Joaquin Valley. However, other sources document pistachio ET at 44 inches per year.

CITRUS

The published estimates of citrus orchard evapotranspiration (ET) in commonly referenced guidance material are likely too low because they were derived from studies on very different cropping systems

Findings

- Highest measured literature value published = 55 inches, including precipitation
- Highest Land IQ result = 54 inches, including precipitation
- Production practices are changing faster than published research
  - Growers are using different water management strategies
  - Compliance with allocations and short water supplies

DEVELOPMENT OF INDEPENDENT ADVISORY GROUP

- Retired UC Cooperative Extension Agents and Farm Advisors:
  - Blake Sanden, MS – 26 years in Kern County
  - Allan Fulton, MS – 35 years in Kings, and Northern CA counties
  - Review results every month beginning in 2021 and offer suggestions for improvements
- Larger Advisory Group:
  - Blake Sanden, MS - Retired
  - Allan Fulton, MS - Retired
  - Daniele Zaccaria, PhD – UC Davis
  - Rick Snyder, PhD – UC Davis, Emeritus
  - Dan Howes, PhD – Cal Poly ITRC
  - Khaled Bali, PhD – UC ANR
  - Pasquale Steduto, PhD – UN-FAO

Agronomic Knowledge and Grower Acceptance

Agronomic Knowledge

- New discoveries with production practices related to:
  - Water use
  - Harvest
  - Irrigation management
  - Regional differences (Critically over-drafted versus not)

Grower Acceptance

- ET is being used to charge growers for their water
- ET is being used to determine pumping allocations
- ET is being integrated into long-term water management planning and decisions
- 3.3 million acres total

CONCLUSIONS

- Accuracy matters
- Ground truthing provides:
  - Calibration
  - Validation
  - Defensibility
  - Confidence
  - Independent analyses
  - A data-driven approach
- Goal is to continually reduce variability
- Impactful on decision-making, water management, orchard management, and allocation management

Questions

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