Field-Level Land and Water Use

Using Accurate and Objective Science for Informed Policy Decisions

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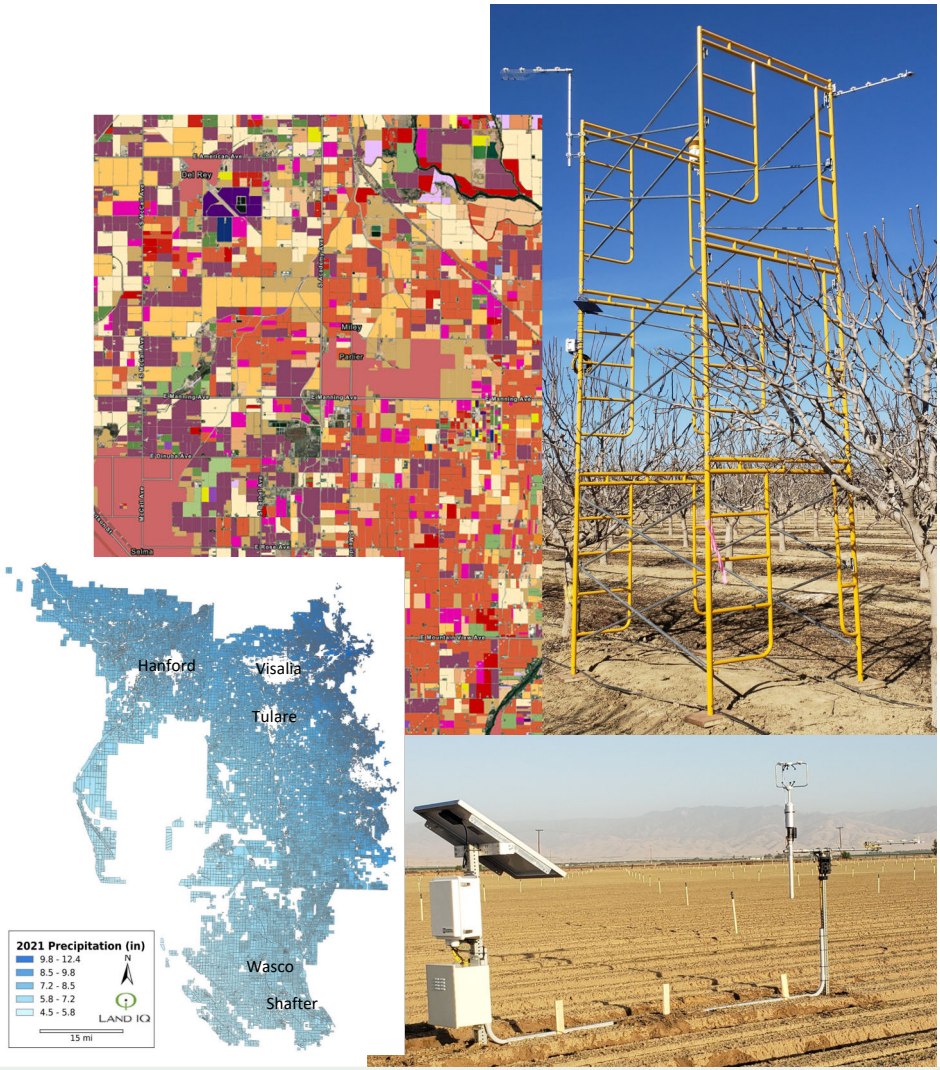
LAND IQ

Northern Sacramento Valley Integrated Regional Water Management Board

November 6, 2023

OUTLINE

- Land IQ Background
- Estimating Water Use
  - Applied Water
    - Meters
  - Consumed Water
    - Land Use
    - Evapotranspiration
- Policy and Regulatory Application



LAND IQ BACKGROUND

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
- Research design studies and implementation

Spatial Sciences: Remote Sensing and GIS

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

Development

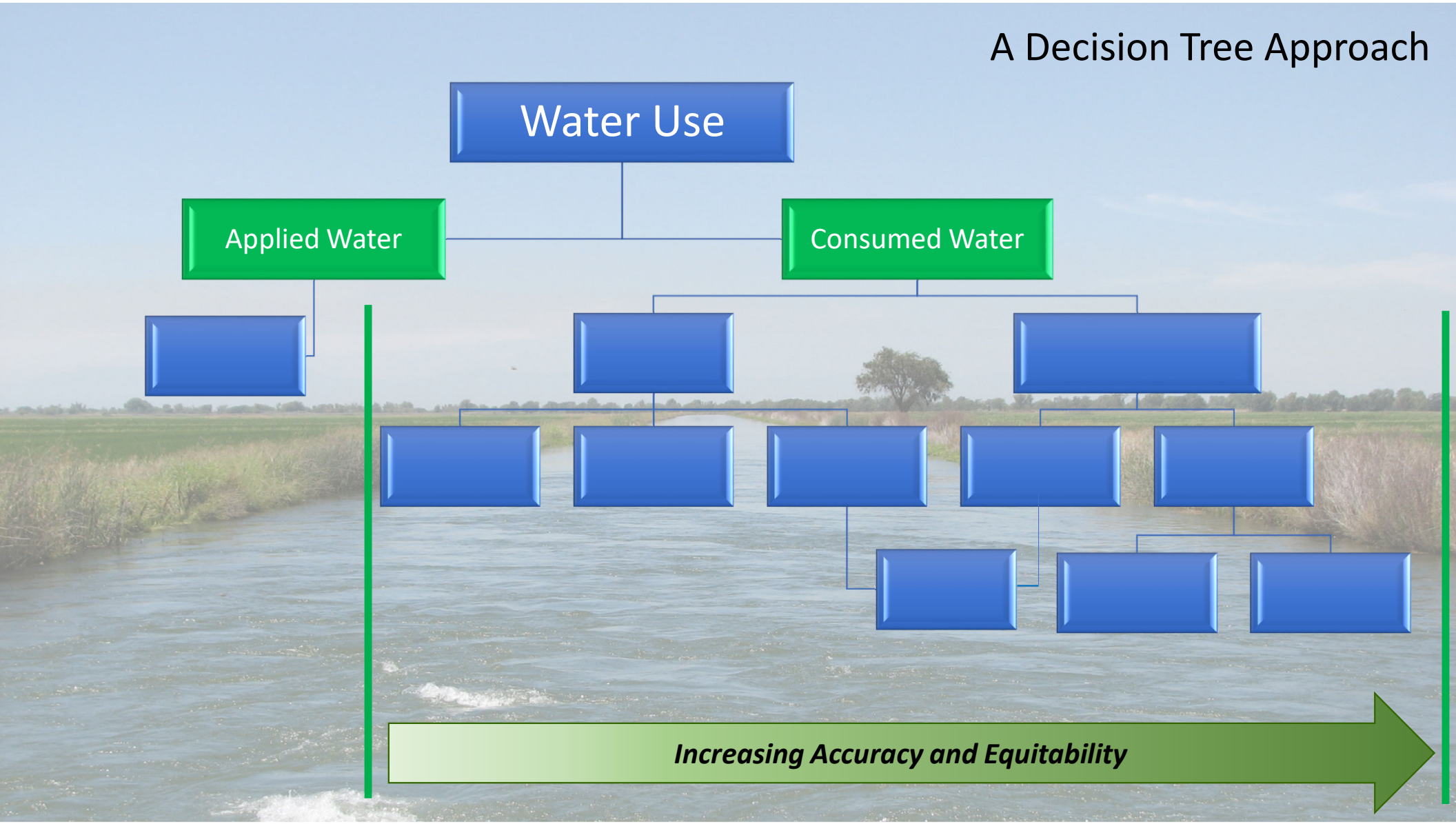
- Data management tools

Estimating Water Use

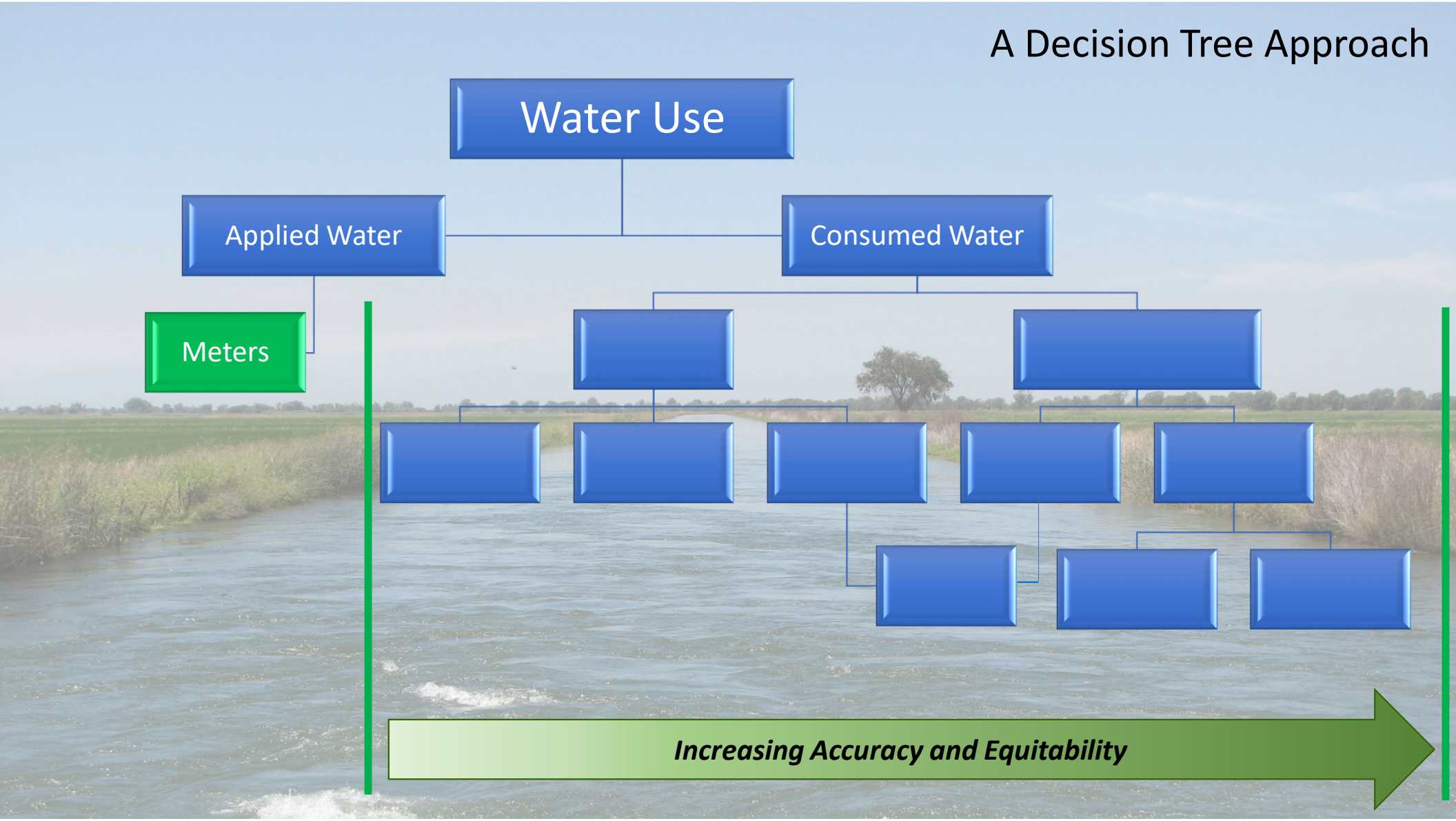
Applied Versus Consumed Water

- San Joaquin Valley experience:
  "Just tell me how much water I use"
- Applied Water
  - Water that is pumped or diverted
  - Measured via meters or other flow device
- Consumed Water
  - Water that is evapotranspired
  - Measured via knowledge of the crop type and crop coefficients, or
  - Measured via remotely sensed methods
- Applied ≠ Consumed
- Applied + Precipitation > Consumed

A Decision Tree Approach



A Decision Tree Approach



Applied Water - Meters

- Different types of meters
- Requires appropriate installation
- Requires maintenance
- Requires updating and calibration
- Requires checking, downloading readings, interpreting readings, matching readings to a field, etc.
- Does measure water applied
- Does NOT measure the water lost from the system

Applied Water - Meters

- Default choice by some because it is familiar
- Not just water monitoring, but human monitoring too

Ventura County FOLLOW 25 Followers

Water conservation board member charged with years of felony water theft

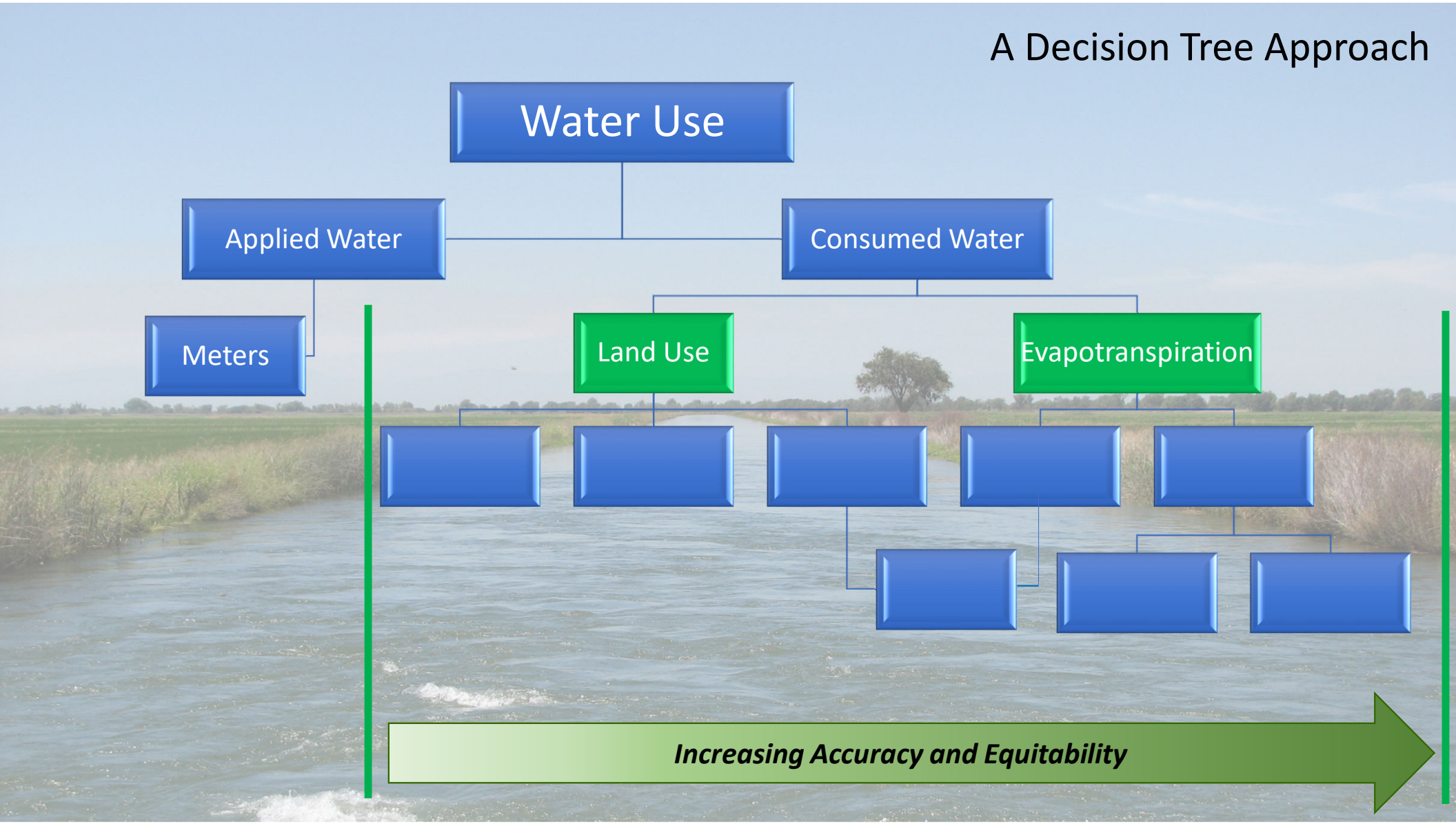
Ventura County District Attorney's Office

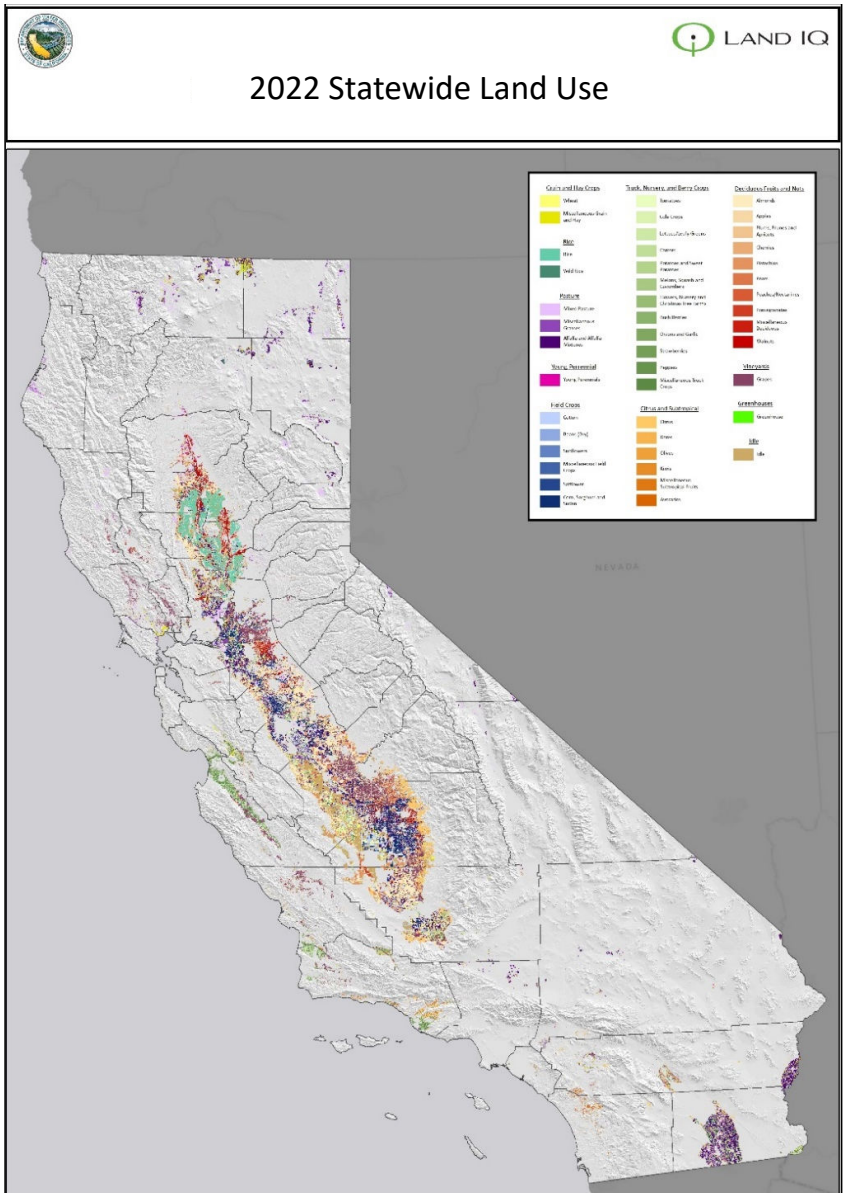
By Andrew Gillies FOLLOW

August 21, 2023 5:47 pm Published August 21, 2023 6:25 pm

VENTURA COUNTY, Calif. – Ventura County District Attorney Erik Nasarenko announced on Monday that charges have been filed against Daniel Conklin Naumann for multiple felony counts of grand theft and theft of utility services after diversion bypasses were discovered on two commercial pumps that irrigated Naumann's crops.

A Decision Tree Approach

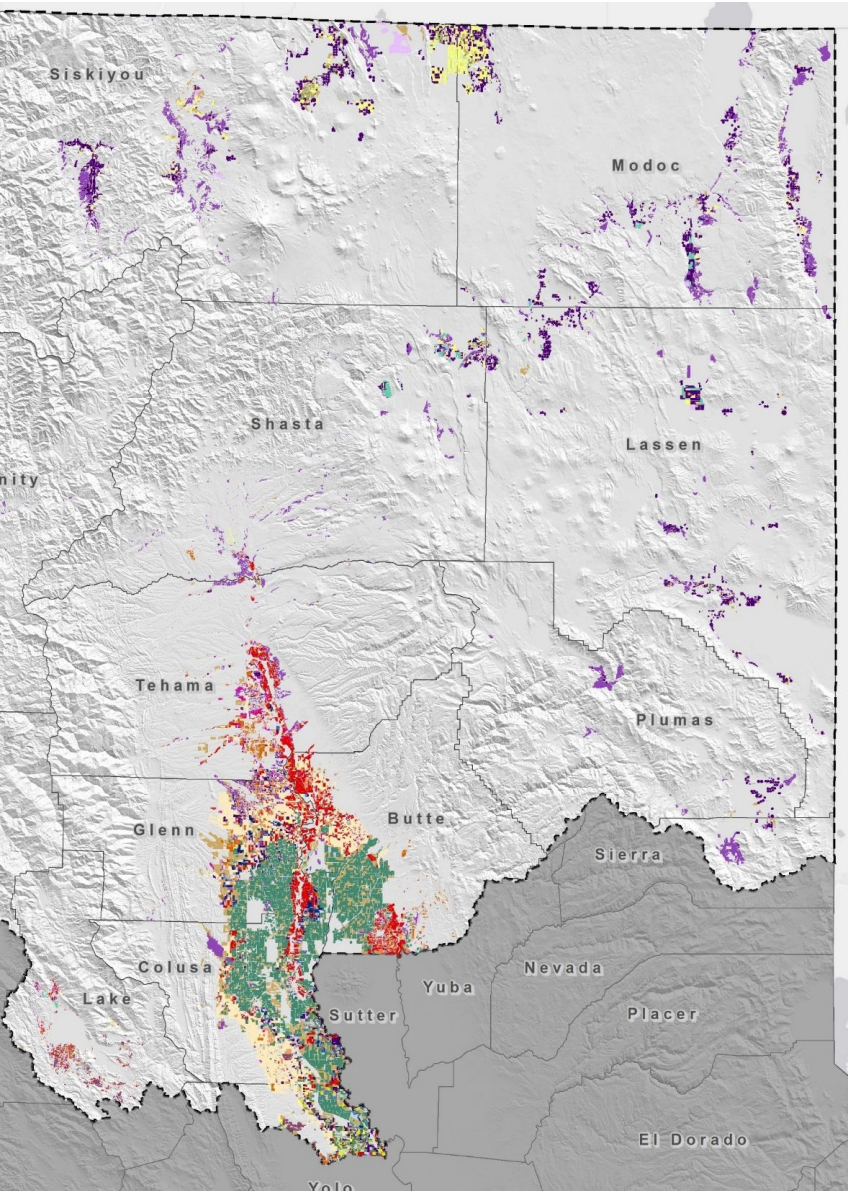




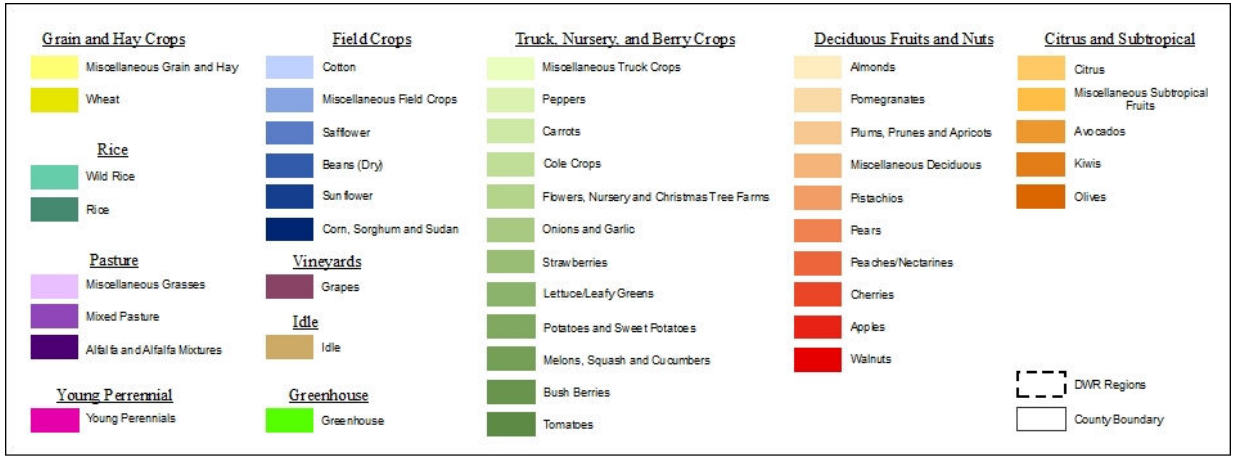
Statewide Land Use Mapping

- Approximately 470,000 individual fields
- 10.7 million acres
- Minimum field size of 2.0 acres
- 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 23,000 miles of ground truthing each year
- 2014, 2016, 2018, 2019, 2020, 2021, 2022, 2023*

* In process

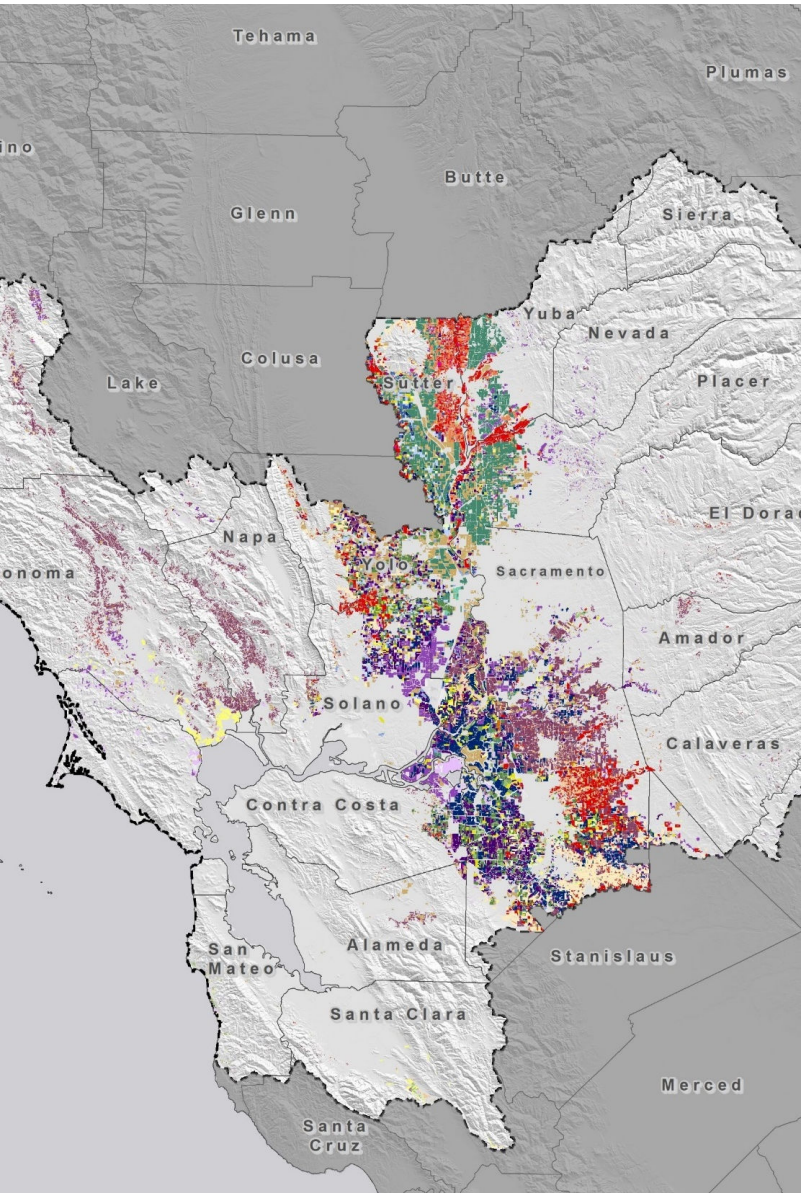


CA - DWR
NORTHERN REGION

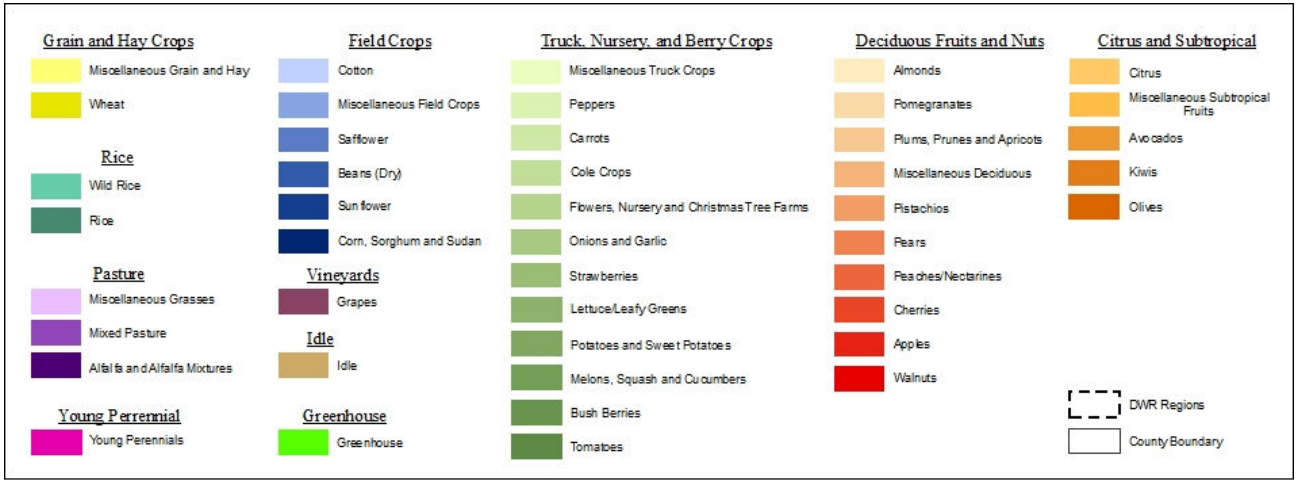


- Major crops include:
  - Rice, Mixed Pasture, Almonds, Walnuts, Alfalfa, Miscellaneous Grain & Hay, Miscellaneous Grasses, Tomatoes, Olives
  - Total Irrigated & Idle Land = 1,680,725

LAND IQ



CA - DWR
North Central Region



- Major crops include:
  - Grapes, Rice, Miscellaneous Grain & Hay, Mixed Pasture, Walnuts, Almonds, Corn, Alfalfa, Tomatoes, Wheat
  - Total Irrigated & Idle Land = 1,896,015

LAND IQ

Independent Ground Truthing Accuracies

- Overall accuracy of 97.6% based on independent ground-truth validation dataset for specific crop type.
- Overall accuracy of 98.3% based on independent ground-truth validation dataset for grouped crop type.
- Mapping completed for water years: 2014, 2016, 2018, 2019, 2020, 2021, 2022, 2023 (in process)
- Publicly available for 2014, 2016, 2018, 2019, 2020, 2021

Crop Class	User's Accuracy (area correctly classified/total area classified)	Total validation area (counts)	95% Two-tailed Confidence Interval
Alfalfa and Alfalfa Mixtures	97%	1,027	1%
Almonds	100%	1,817	0%
Apples	100%	15	0%
Apricots	93%	13	14%
Avocados	96%	429	2%
Beans (Dry)	77%	24	18%
Bush Berries	98%	95	3%
Carrots	98%	55	4%
Cherries	98%	89	3%
Citrus	99%	348	1%
Cole Crops	96%	513	2%
Corn, Sorghum and Sudan	98%	851	1%
Cotton	100%	164	0%
Dates	99%	111	2%
Flowers, Nursery and Christmas Tree Farms	94%	118	4
Grapes	99%	796	1
Lettuce/Leafy Greens	94%	512	2
Melons, Squash and Cucumbers	92%	91	6
Miscellaneous Deciduous	100%	17	0
Miscellaneous Field Crops	95%	984	1
Miscellaneous Grain and Hay	85%	331	4
Miscellaneous Grasses	97%	363	2
Miscellaneous Truck Crops	95%	521	2
Mixed Pasture	96%	71	5
Olives	100%	83	0
Onions and Garlic	99%	103	2
Peaches/Nectarines	100%	35	0
Pears	86%	12	1
Pecans	91%	37	1
Peppers	98%	350	1
Pistachios	100%	28	0
Plums	100%	18	0
Pomegranates	97%	36	6
Potatoes	97%	71	4

		Predicted																						
		Alfalfa and Alfalfa Mixtures	Almonds	Corn, Sorghum and Sudan	Grapes	Melons, Squash and Cucumbers	Miscellaneous Grain and Hay	Miscellaneous Grasses	Mixed Pasture	Olives	Peaches/Nectarines	Pears	Pistachios	Plums, Prunes and Apricots	Rice	Safflower	Sunflowers	Tomatoes	Unclassified Fallow	Walnuts	Young Perennials	Reference Total	Omission Error	Producers Accuracy	Kappa Coefficient
Reference	Alfalfa and Alfalfa Mixtures	126	0	0	0	0	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	132	5%	95%	
	Almonds	0	382	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	385	1%	99%	
	Corn, Sorghum and Sudan	1	0	71	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	73	3%	97%	
	Grapes	0	0	0	112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	112	0%	100%	
	Melons, Squash and Cucumbers	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	23	9%	91%	
	Miscellaneous Grain and Hay	1	0	0	0	0	125	3	0	0	0	0	0	0	0	0	0	1	7	0	0	137	9%	91%	
	Miscellaneous Grasses	3	0	1	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0	0	0	41	10%	90%	
	Mixed Pasture	0	0	0	0	0	8	0	119	0	0	0	0	0	0	0	0	0	0	0	0	127	6%	94%	
	Olives	0	0	0	0	0	0	0	0	53	0	0	0	0	0	0	0	0	0	0	0	53	0%	100%	
	Peaches/Nectarines	0	0	0	0	0	0	0	0	0	27	0	0	1	0	0	0	0	0	1	0	29	7%	93%	
	Pears	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	24	0%	100%	
	Pistachios	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	17	0%	100%	
	Prunes	0	0	0	0	0	0	0	0	0	0	0	0	69	0	0	0	0	0	0	0	69	0%	100%	
	Rice	0	0	1	0	0	0	0	0	0	0	0	0	0	302	0	0	0	2	0	0	305	1%	99%	
	Safflower	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	1	0	0	10	10%	90%	
	Sunflowers	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	61	1	0	0	0	64	5%	95%	
	Tomatoes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	0	0	0	90	0%	100%	
	Unclassified Fallow	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	223	0	1	229	3%	97%	
	Walnuts	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	351	0	354	1%	99%	
	Young Perennials	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	20	0%	100%	
	Predicted Total	131	383	74	112	22	136	44	124	53	28	24	18	71	302	9	62	93	233	354	21	2,294			
	Comission Error	4%	0%	4%	0%	5%	8%	16%	4%	0%	4%	0%	6%	3%	0%	0%	2%	3%	4%	1%	5%				
	Users Error	96%	100%	96%	100%	95%	92%	84%	96%	100%	96%	100%	94%	97%	100%	100%	98%	97%	96%	99%	95%				
	Kappa Coefficient																								0.97

Value-Added Attributes Each Year

2014

- ★ X Crop Classes
- ★ Urban Footprint
- Special Conditions
- Irrigation Status
- 2nd Gen Multi-Cropping
- Peak Dates
- Percent Cover
- Main Crop & Date
- Inter-Annual Crops
- Permanent Crop Age
- Inter-Annual Dates
- Irrigated Golf Courses
- 1st Gen Multi-Cropping
- ★ Managed Wetlands

2016

- ★ X Crop Classes
- ★ Urban Footprint
- ★ Special Conditions
- ★ Irrigation Status
- 2nd Gen Multi-Cropping
- Peak Dates
- Percent Cover
- Main Crop & Date
- Inter-Annual Crops
- Permanent Crop Age
- Inter-Annual Dates
- Irrigated Golf Courses
- ★ 1st Gen Multi-Cropping
- Managed Wetlands

2018

- ★ X Crop Classes
- ★ Urban Footprint
- ★ Special Conditions
- ★ Irrigation Status
- ★ 2nd Gen Multi-Cropping
- ★ Peak Dates
- ★ Percent Cover
- Main Crop & Date
- Inter-Annual Crops
- Permanent Crop Age
- Inter-Annual Dates
- Irrigated Golf Courses
- 1st Gen Multi-Cropping
- Managed Wetlands

2019

- ★ X Crop Classes
- ★ Urban Footprint
- ★ Special Conditions
- ★ Irrigation Status
- ★ 2nd Gen Multi-Cropping
- ★ Peak Dates
- ★ Percent Cover
- ★ Main Crop & Date
- Inter-Annual Crops
- Permanent Crop Age
- Inter-Annual Dates
- Irrigated Golf Courses
- 1st Gen Multi-Cropping
- Managed Wetlands

2020

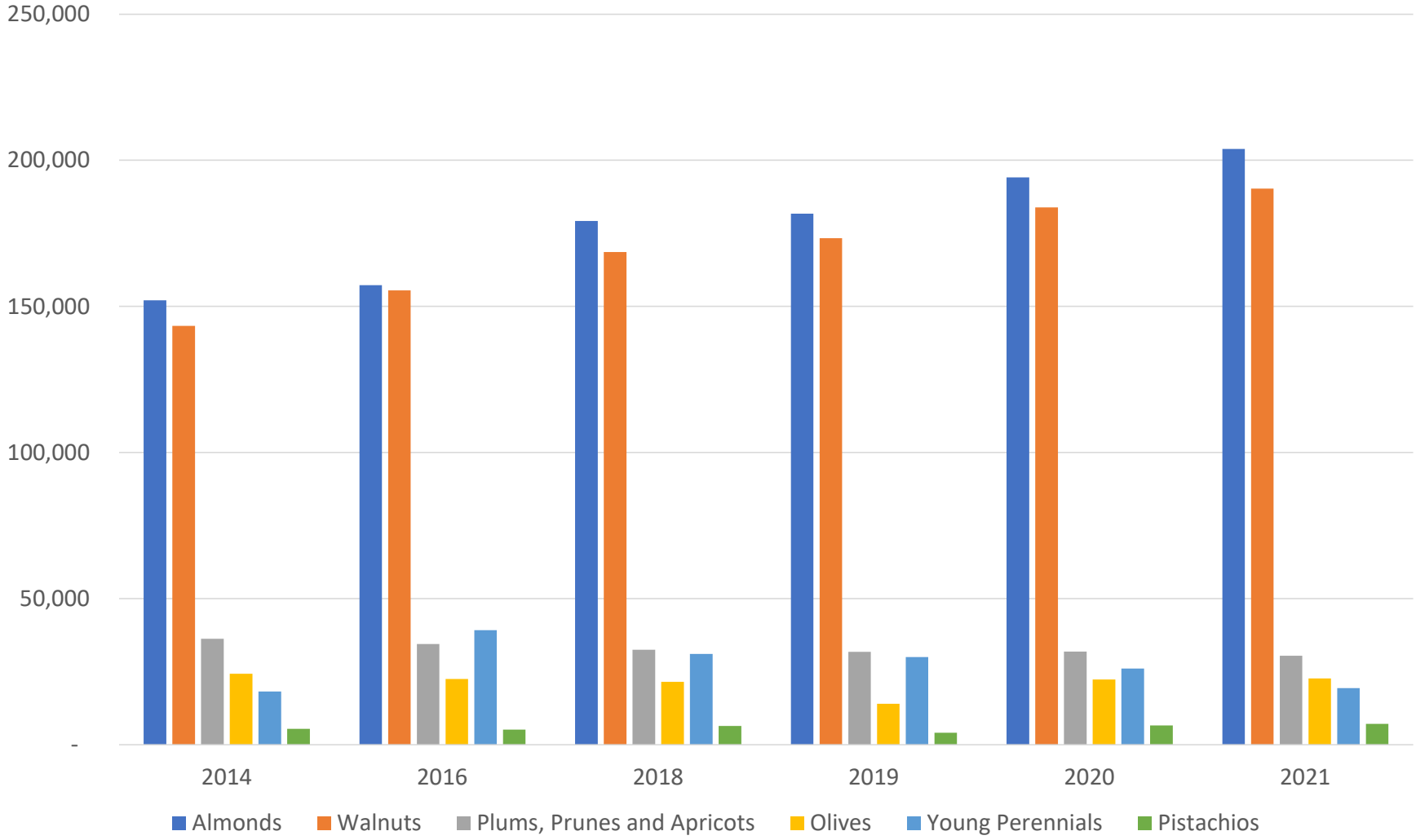
- ★ X Crop Classes
- ★ Urban Footprint
- ★ Special Conditions
- ★ Irrigation Status
- ★ 2nd Gen Multi-Cropping
- ★ Peak Dates
- ★ Percent Cover
- ★ Main Crop & Date
- ★ Inter-Annual Crops
- ★ Permanent Crop Age
- Inter-Annual Dates
- Irrigated Golf Courses
- 1st Gen Multi-Cropping
- Managed Wetlands

2021

- ★ X Crop Classes
- ★ Urban Footprint
- ★ Special Conditions
- ★ Irrigation Status
- ★ 2nd Gen Multi-Cropping
- ★ Peak Dates
- ★ Percent Cover
- ★ Main Crop & Date
- ★ Inter-Annual Crops
- ★ Permanent Crop Age
- ★ Inter-Annual Dates
- ★ Irrigated Golf Courses
- 1st Gen Multi-Cropping
- Managed Wetlands

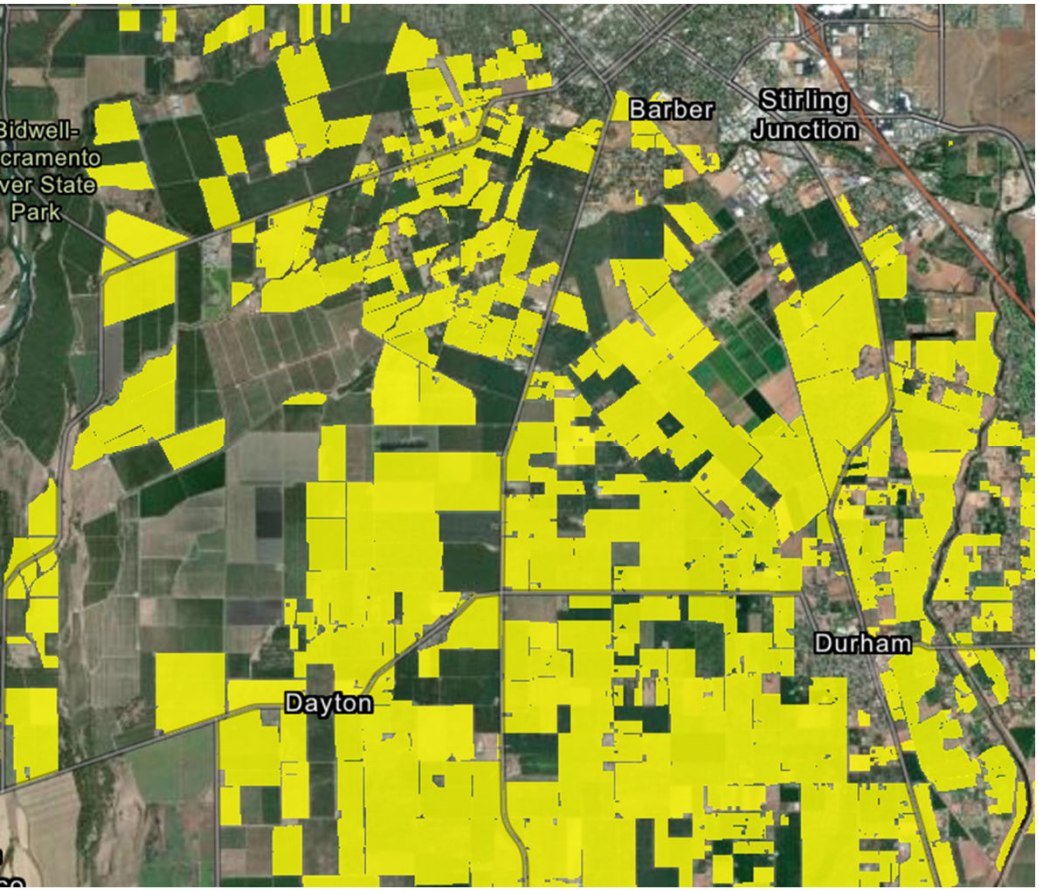
NORTHERN CALIFORNIA LAND USE TRENDS

Perennial Crops – Northern California Acreage

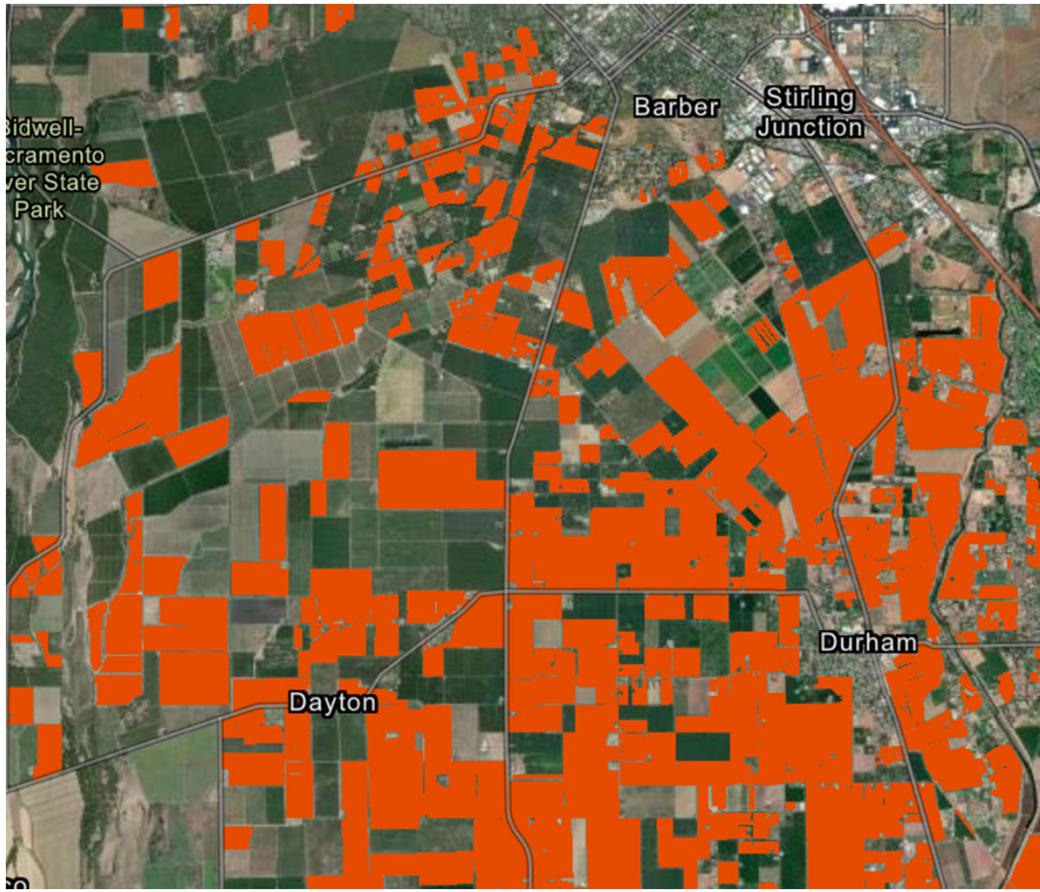


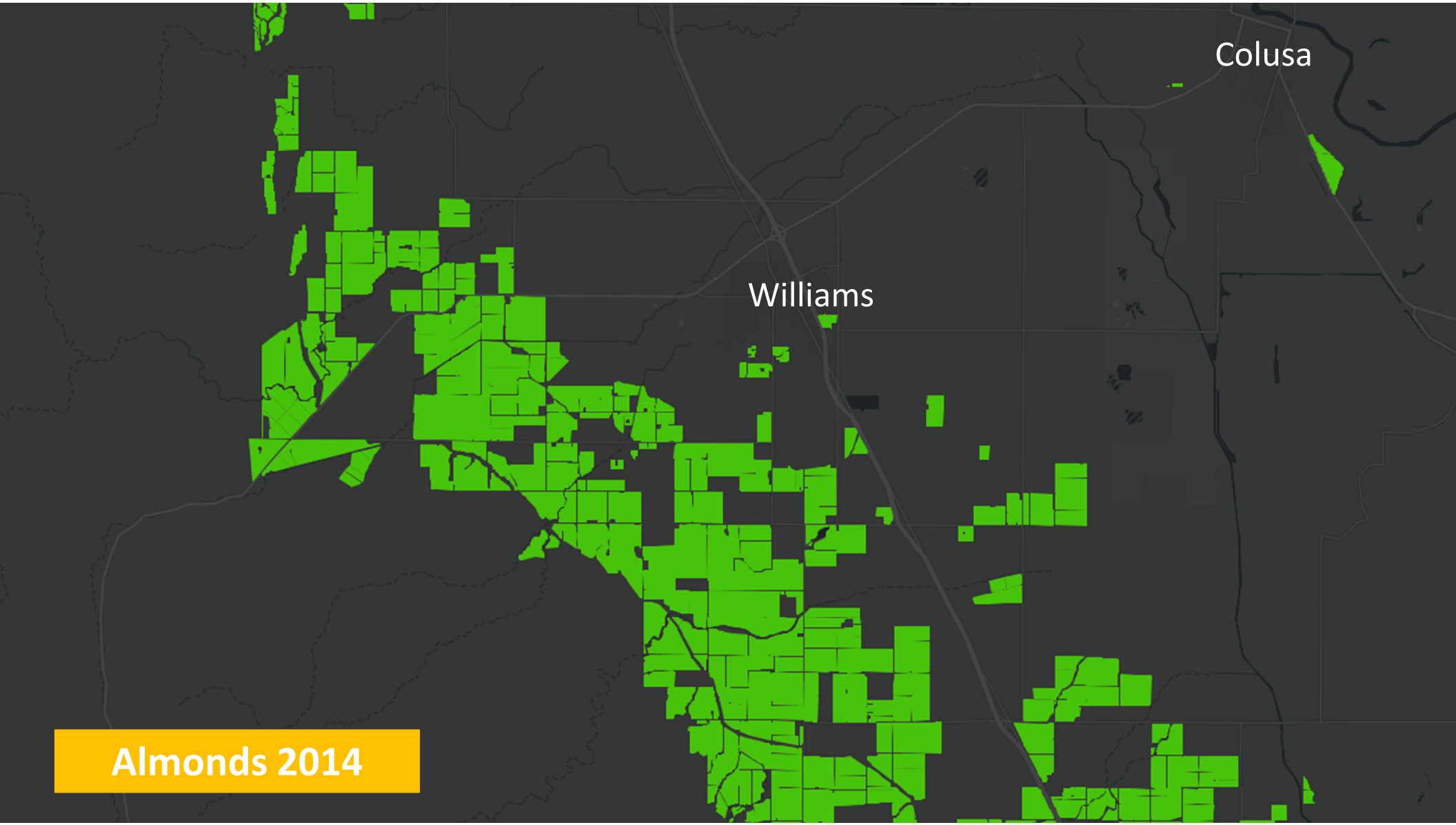
A Decade Change in Almond Footprint

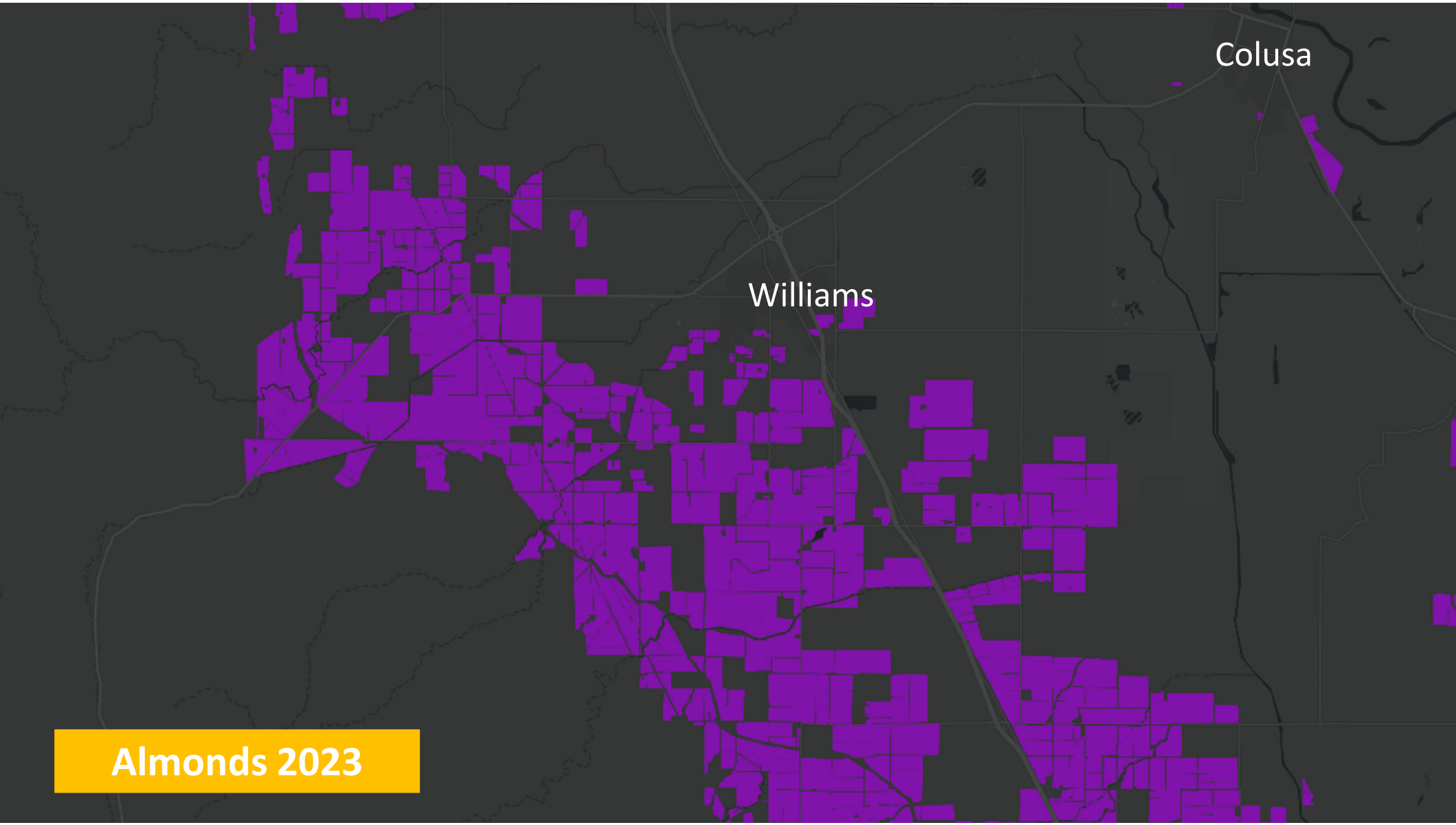
2014



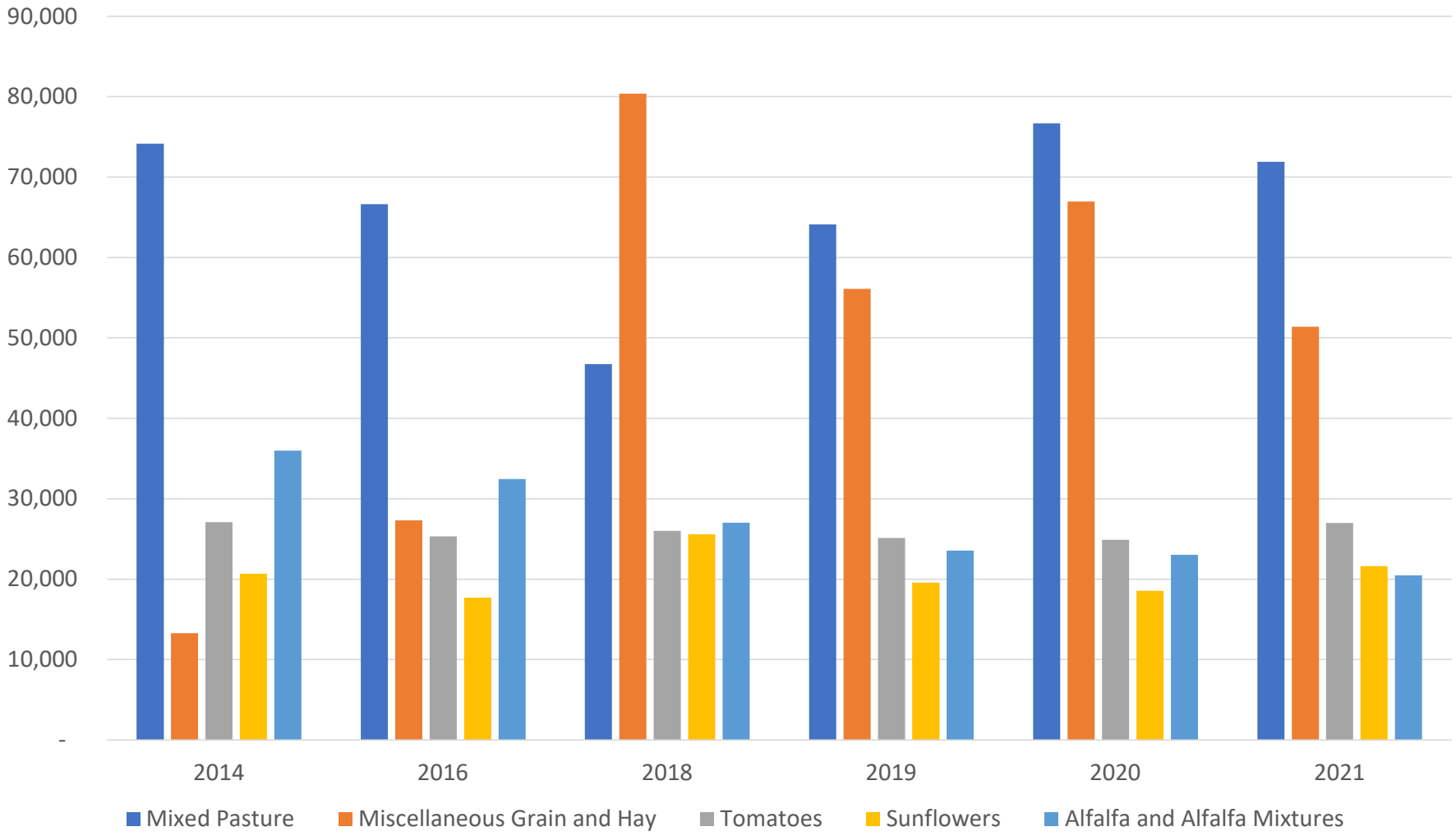
2023



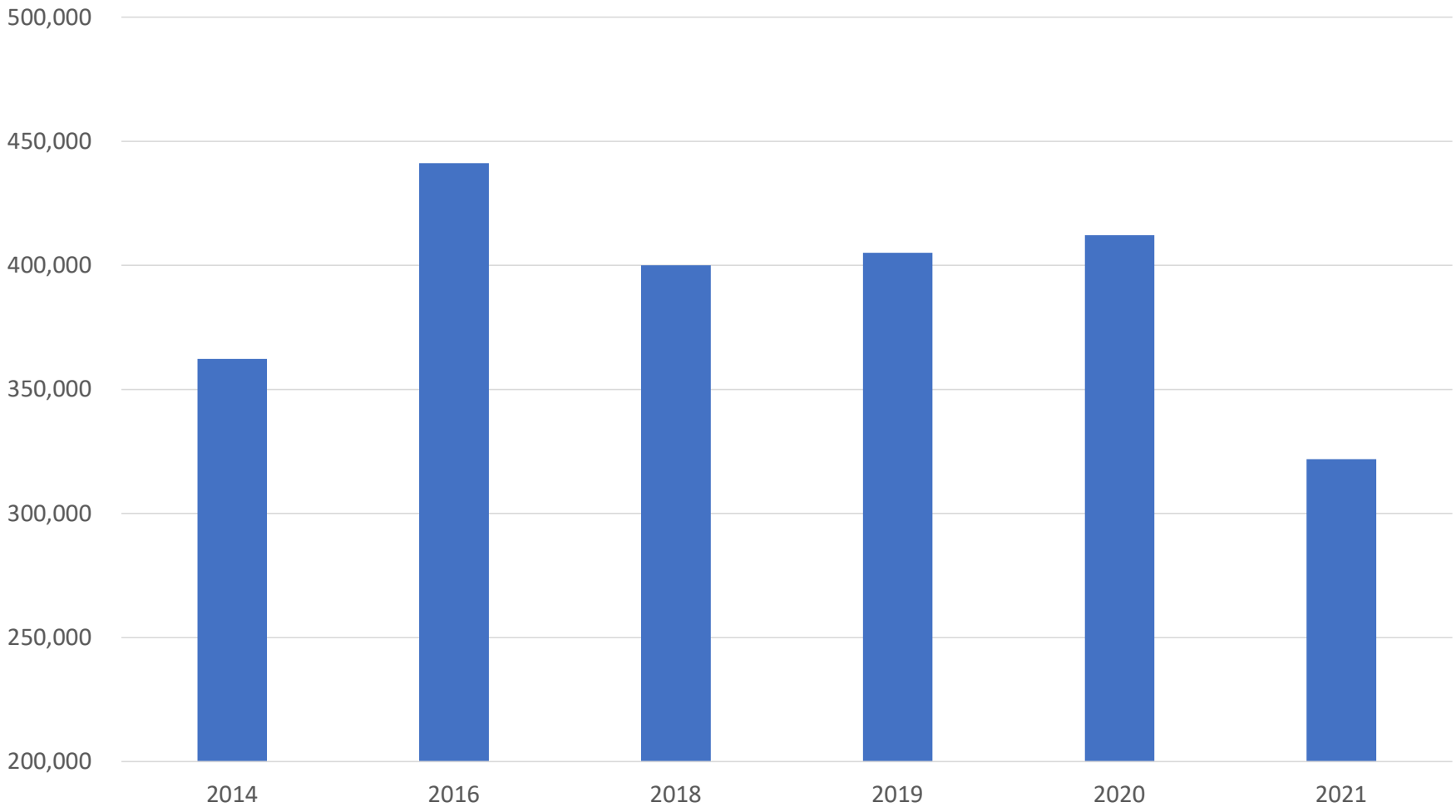

Colusa
Williams
Almonds 2014

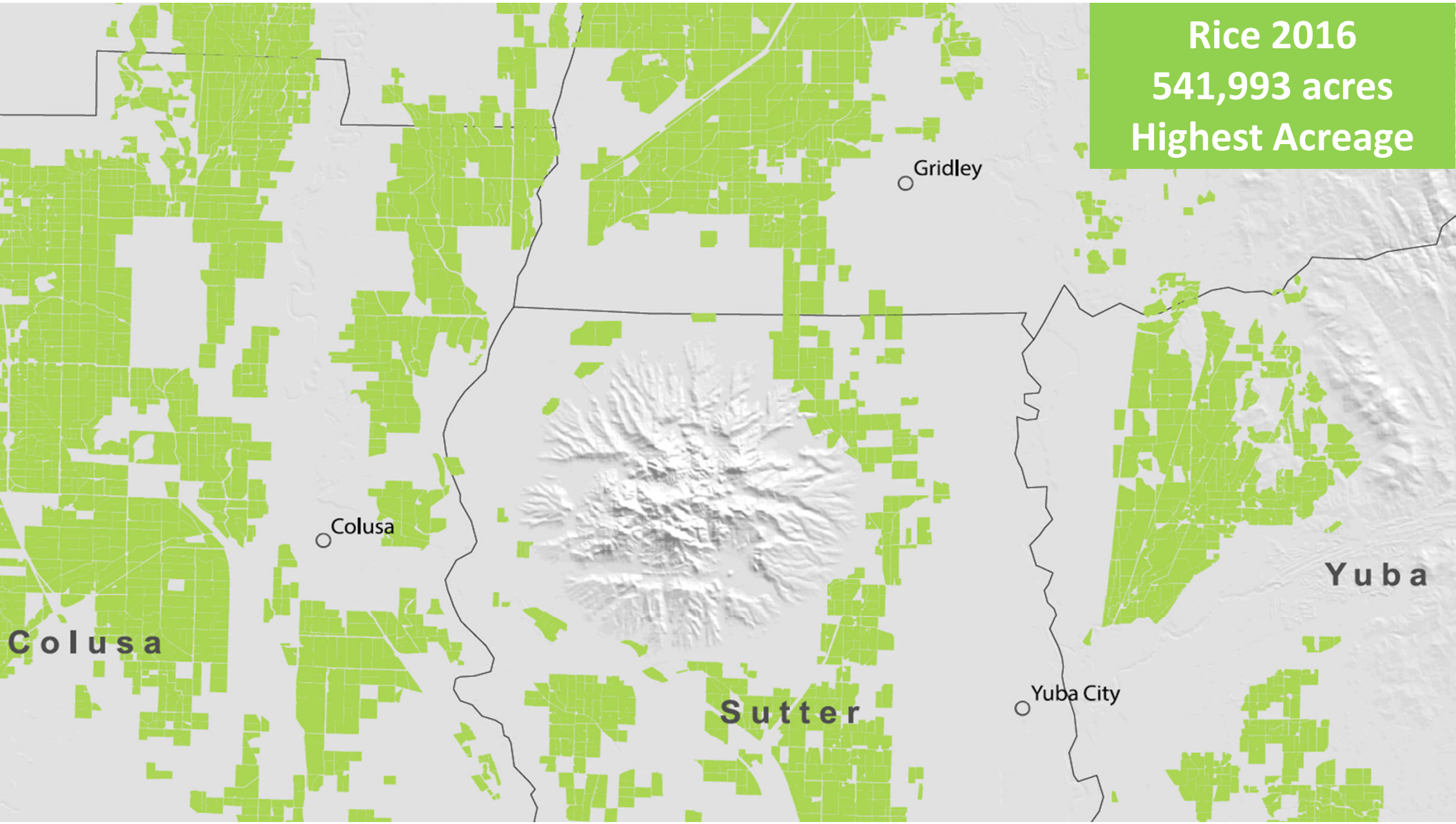

Colusa
Williams
Almonds 2023

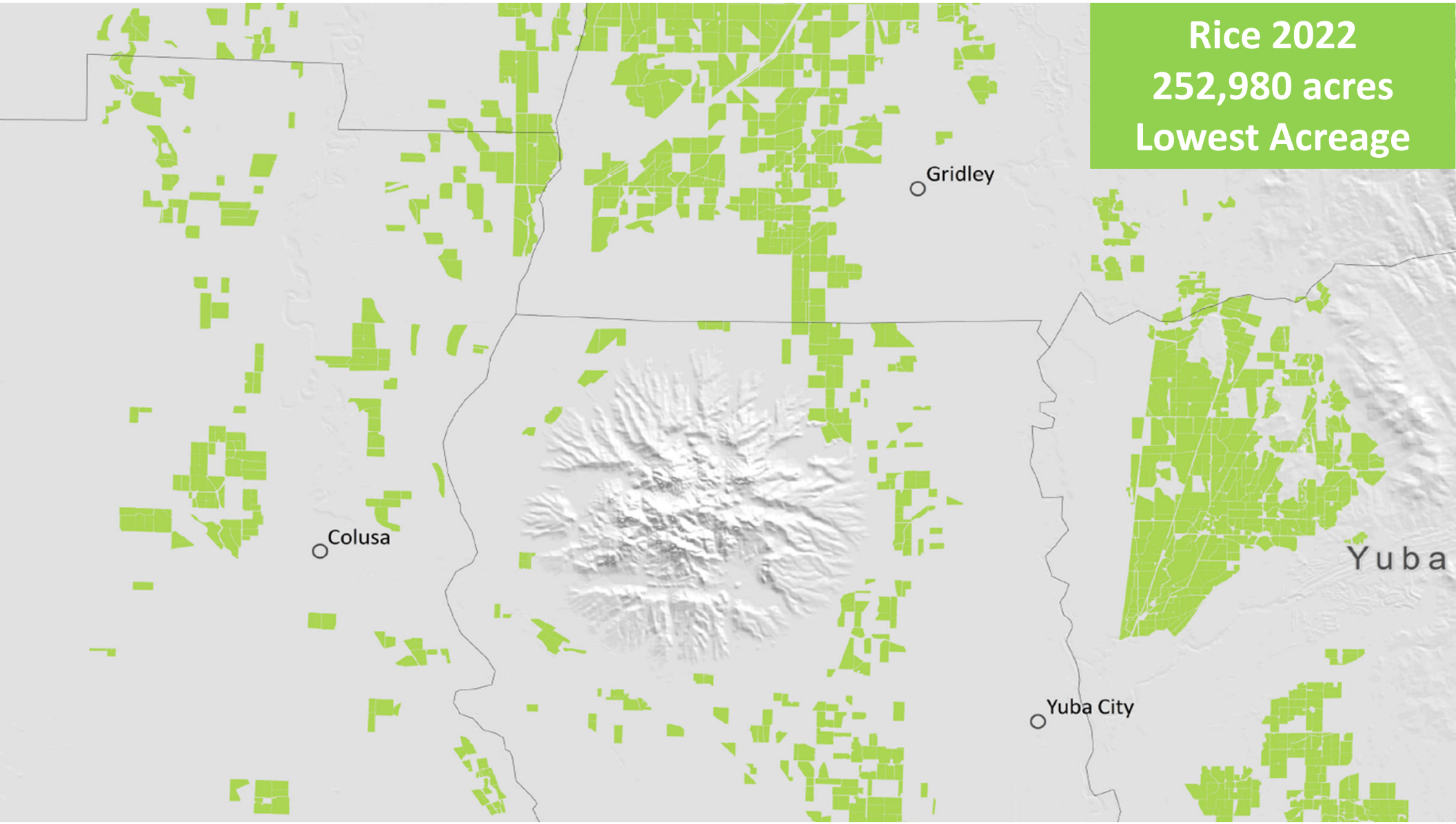
Annual Crops – Northern California Acreage



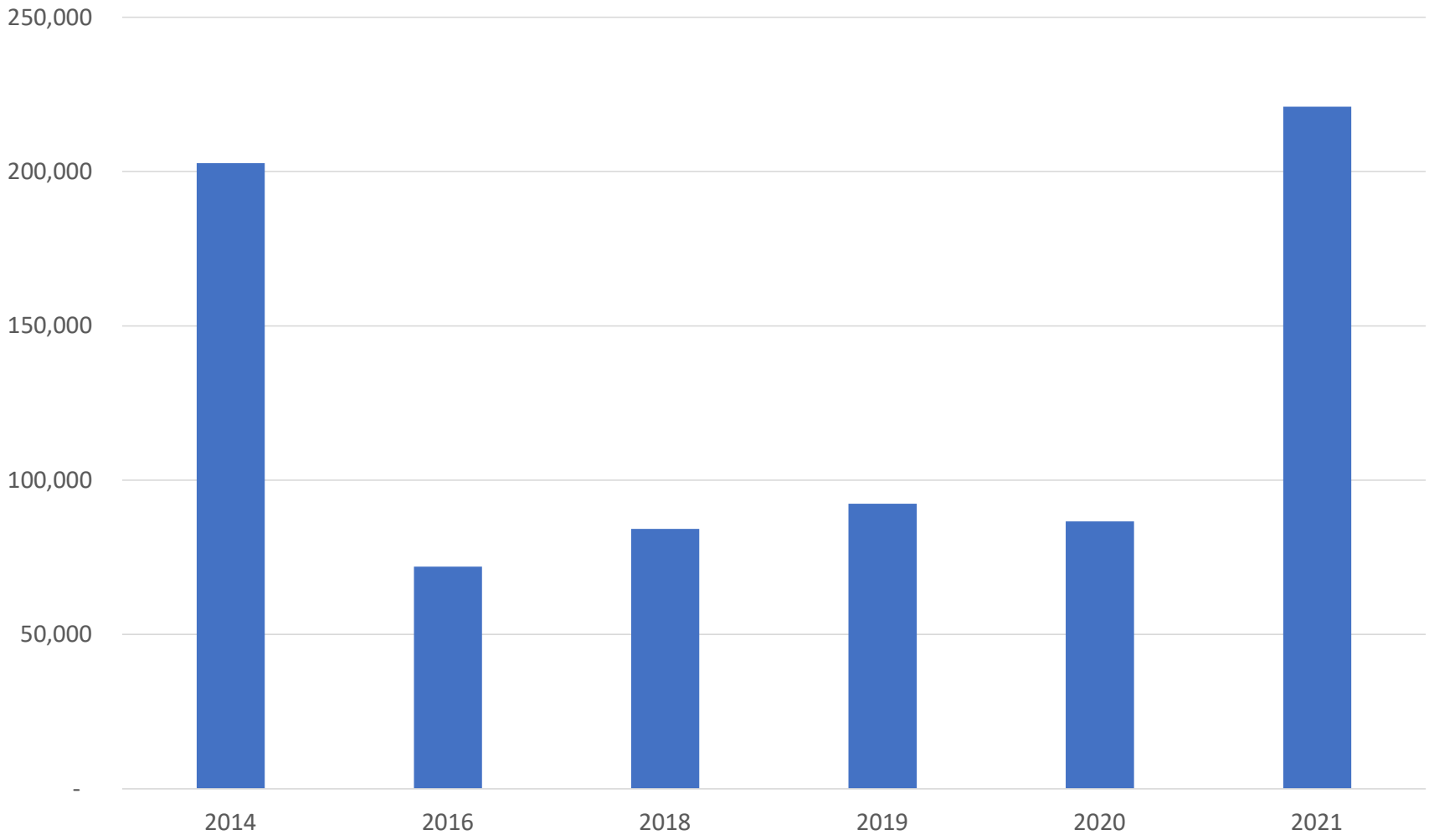
Rice – Northern California Acreage Only



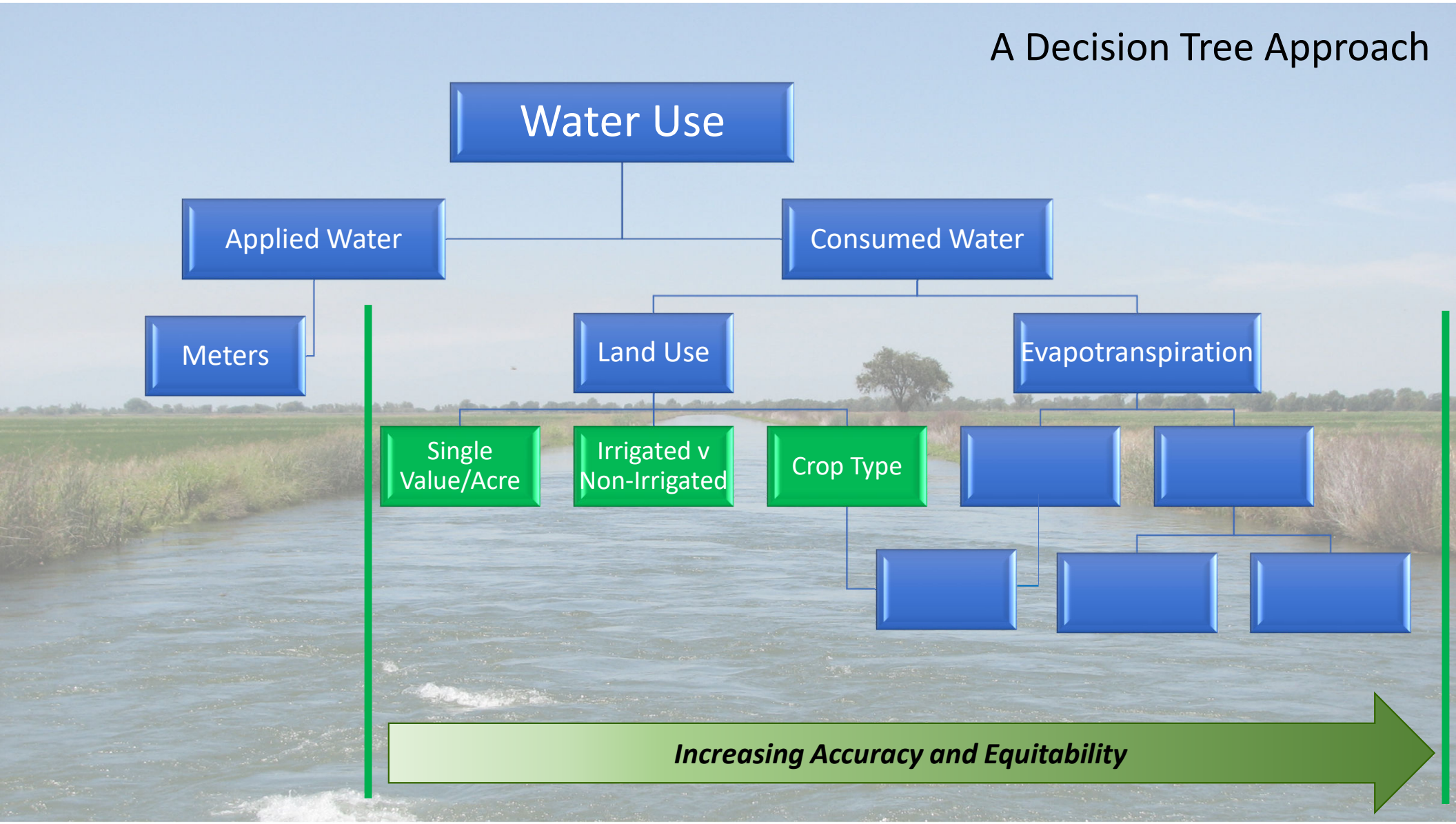

Rice 2016
541,993 acres
Highest Acreage
Gridley
Colusa
Colusa
Sutter
Yuba City
Yuba


Rice 2022
252,980 acres
Lowest Acreage
Gridley
Colusa
Yuba City
Yuba

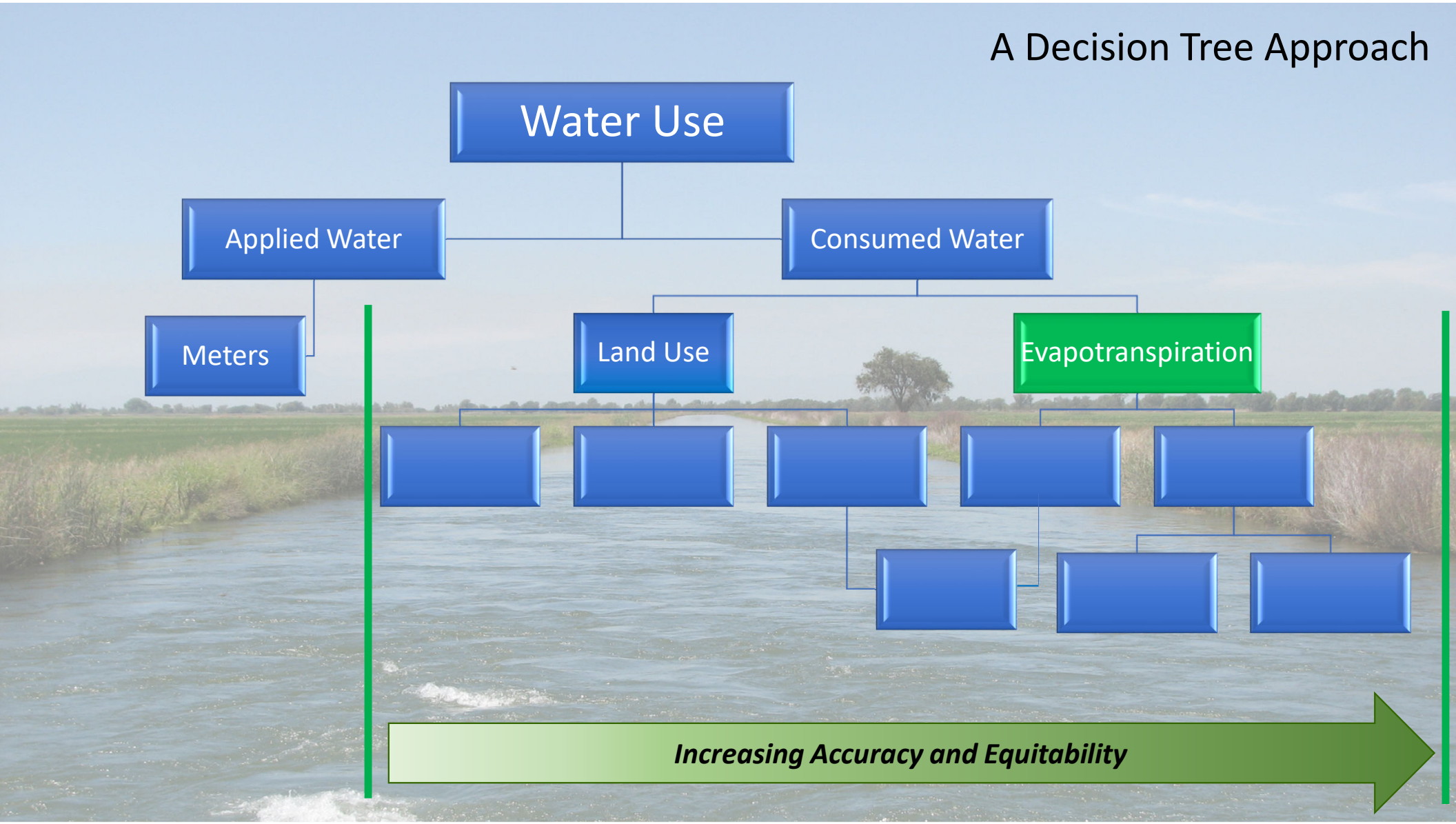
Fallow – Northern California Acreage



A Decision Tree Approach



A Decision Tree Approach

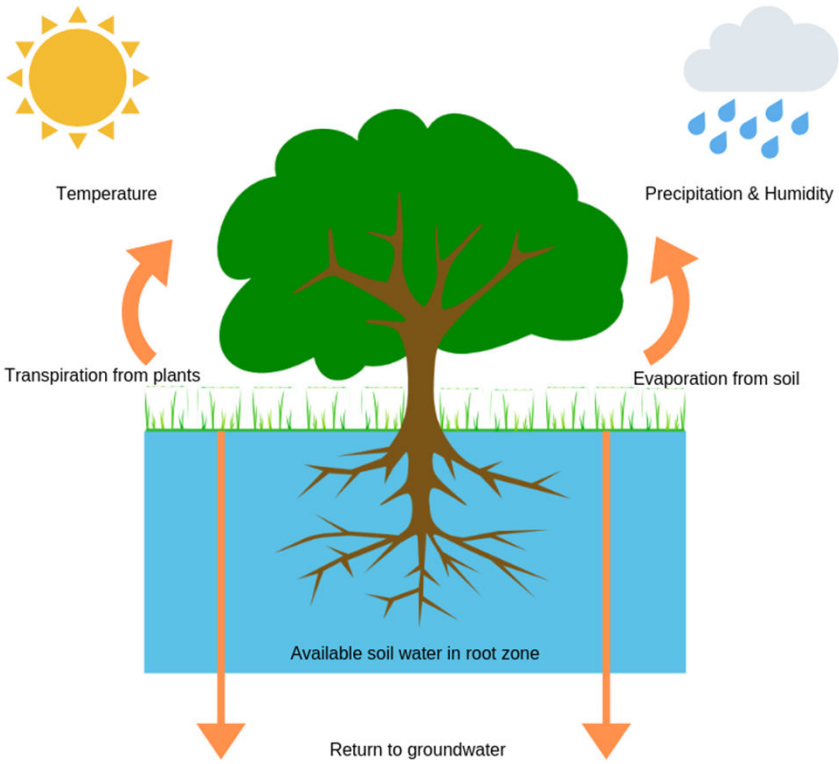


Consumed Water: Evapotranspiration

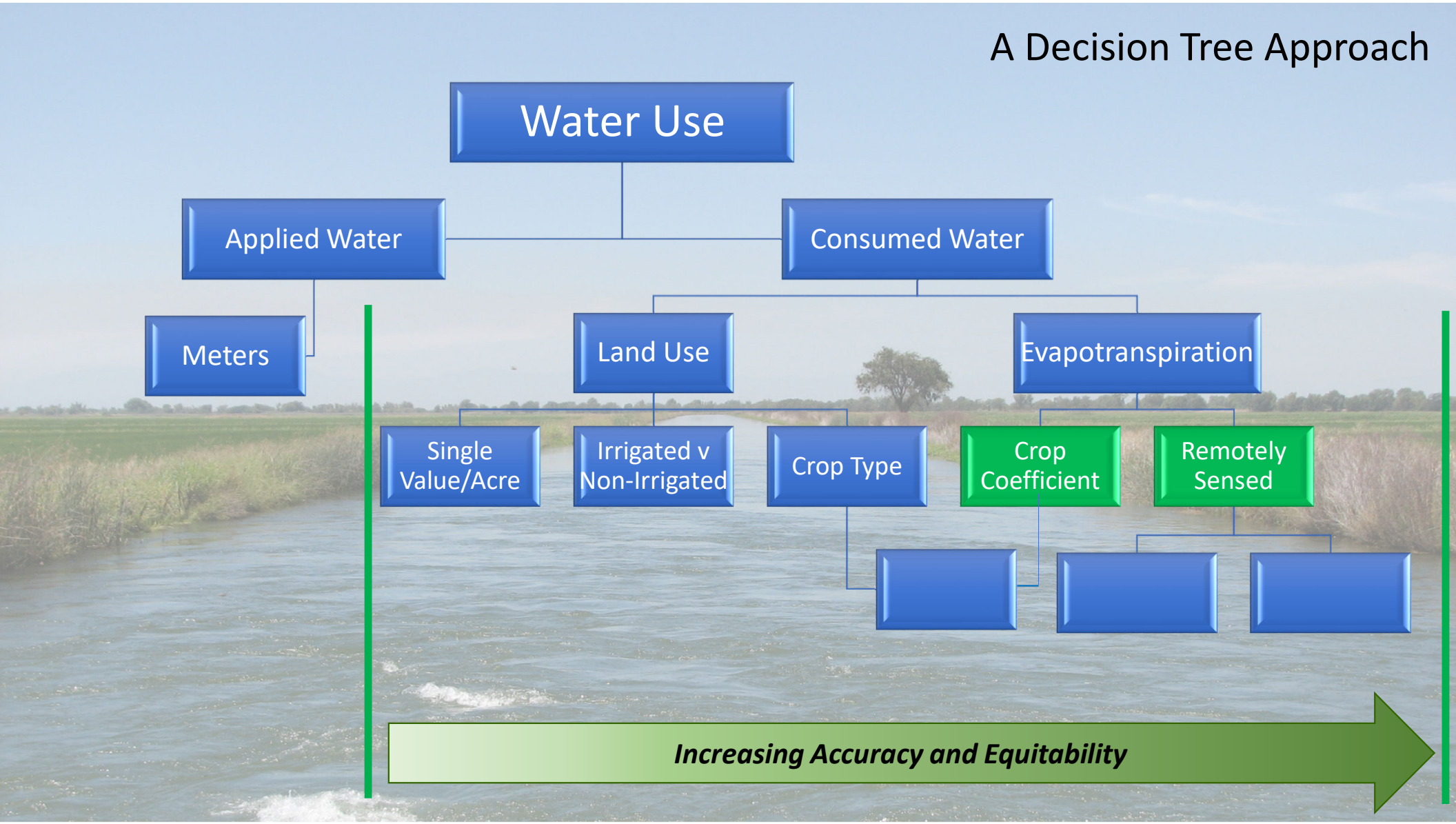
Evapotranspiration = Evaporation + Transpiration

- Evaporation: Water evolved into the atmosphere from soil and plant surfaces after precipitation or irrigation (never goes through the plant)

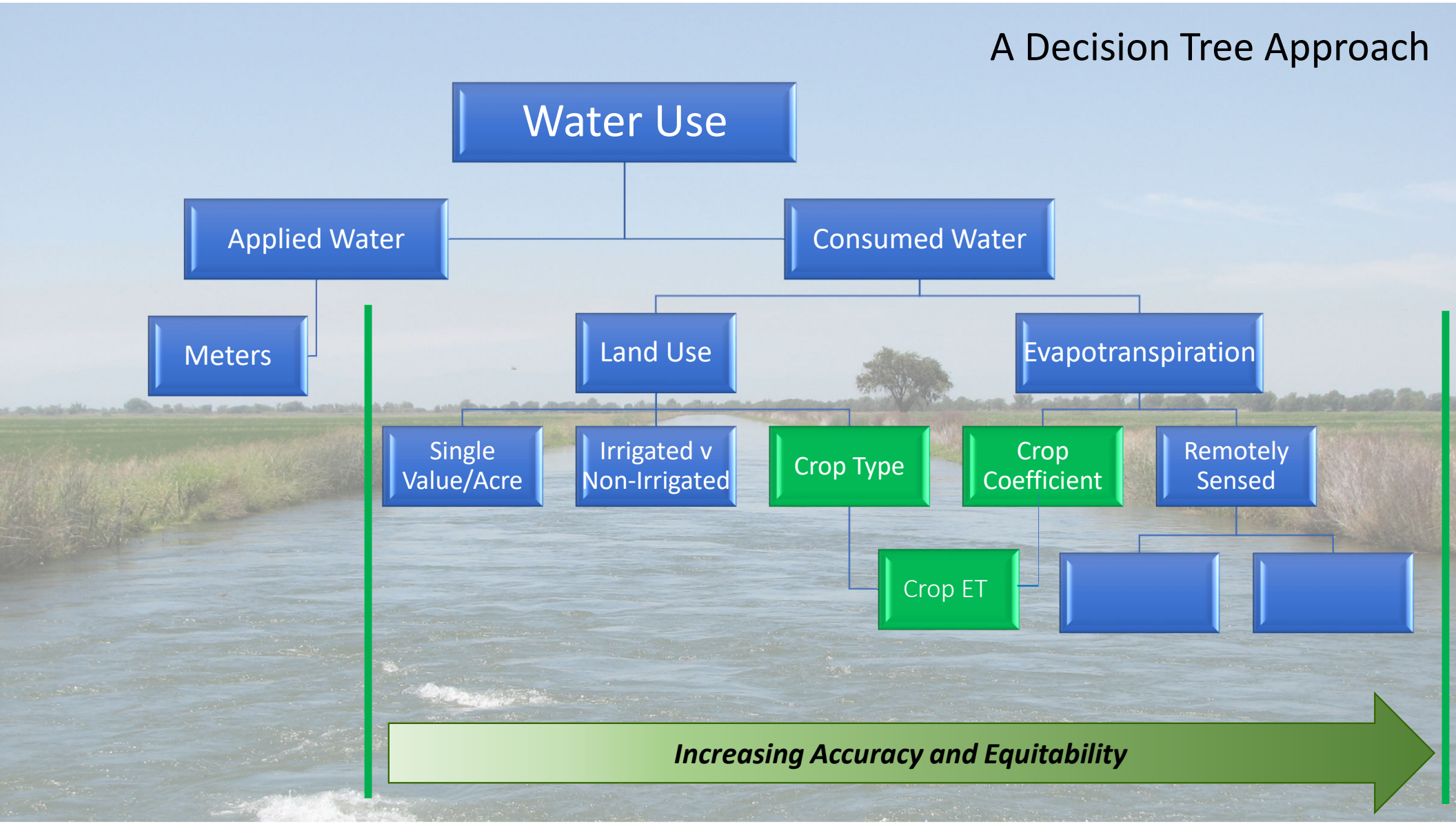
- Transpiration: Water evolved into the atmosphere from translocation through the plant (goes from roots to leaves)



A Decision Tree Approach



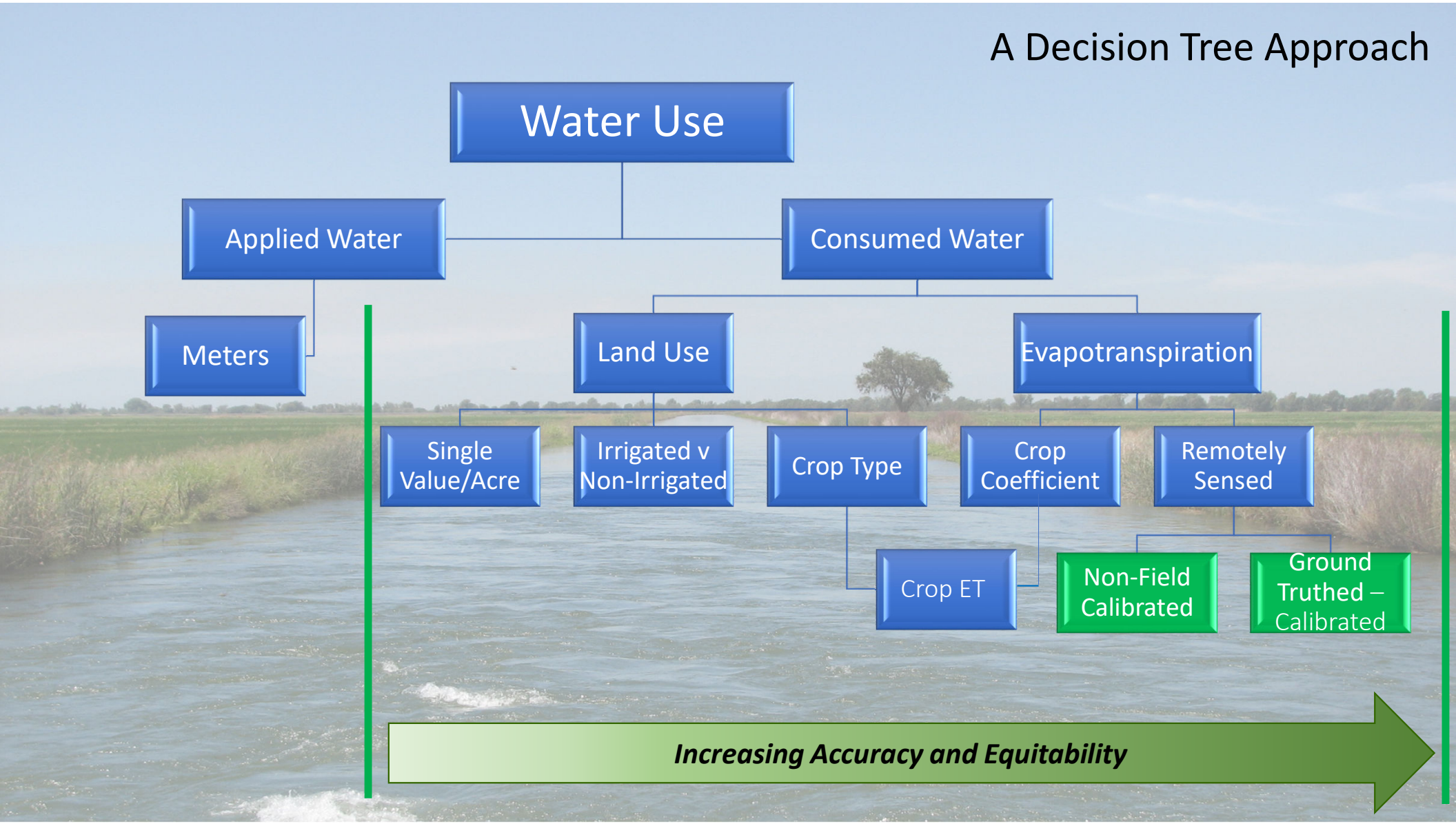
A Decision Tree Approach



Crop ET – Crop Coefficient Approach

- CIMIS Reference Crop ET x Crop Coefficient = Crop ET (ETo x Kc = ETc) – Traditional Approach
- Range in quality of CIMIS stations
- Must have crop mapping
- All walnuts have the same ET
- All pasture has the same ET
- There is differentiation between crop types
- There is not differentiation between actual water use from one grower to another within the same crop
- No differentiation by permanent crop age, more or less densely planted orchards, different irrigation management, etc.
- Some incentive for improved irrigation management

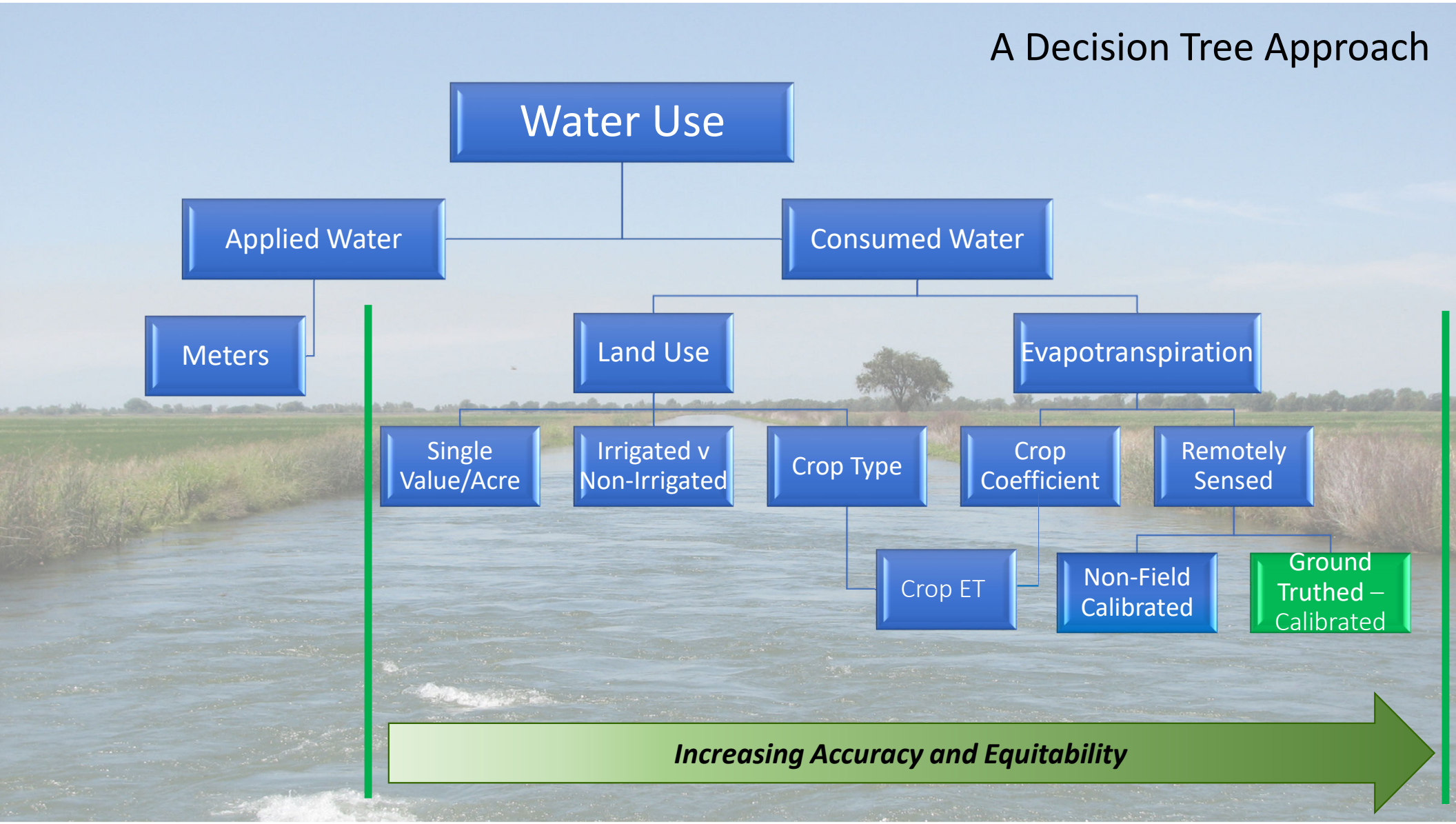
A Decision Tree Approach



Remotely Sensed Approaches

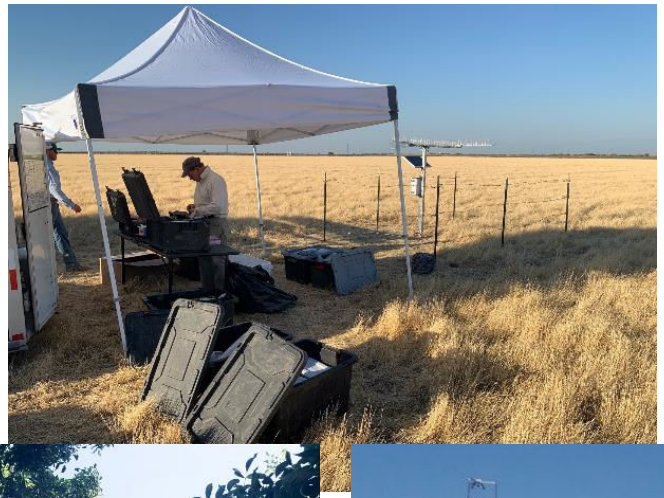
- Non-Field Calibrated
  - A top down/sky down approach
  - METRIC, Sebal, SIMS, etc.
  - Image interpretation and analysis
- Ground Truthed – Field Calibrated
  - A ground up approach
  - Remotely sensed models are data driven and calibrated to a network of ET stations
  - ET stations measure actual environmental conditions and impact on consumed water
  - Accounts for crop and land use type
  - Harder and takes more time to implement
  - Only provides ET where ground truthing exists
  - Cost depends on area analyzed and complexity

A Decision Tree Approach



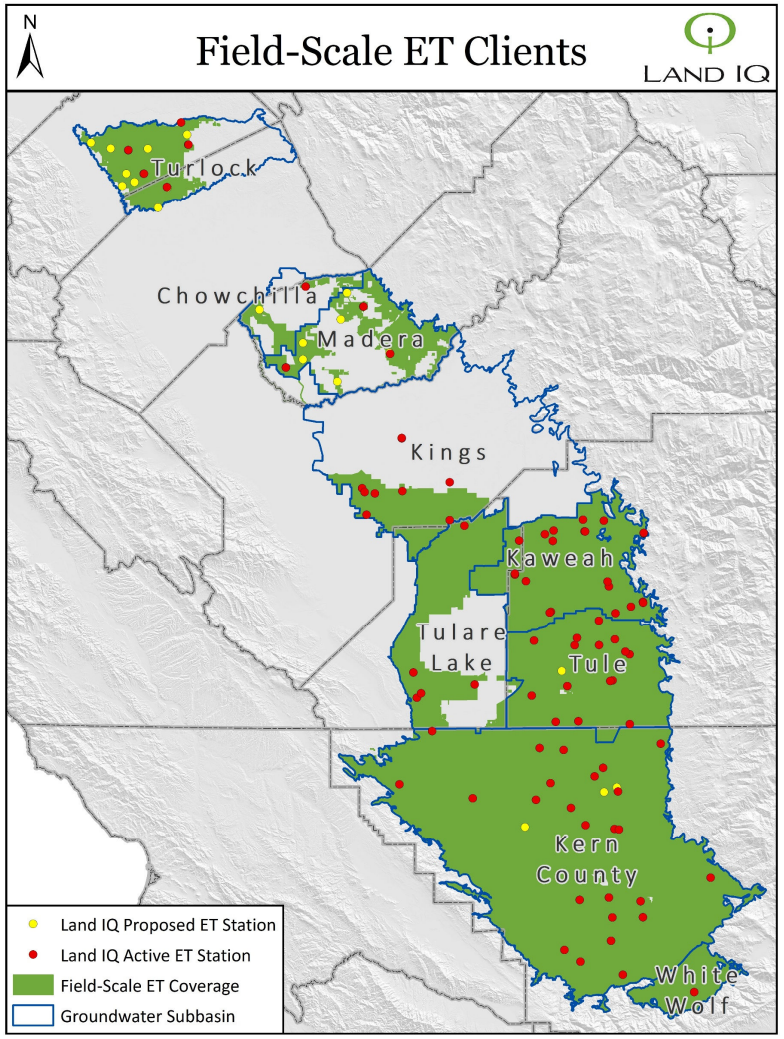
GROUND TRUTHING FOR CALIBRATION – WHY?

- Defensible
- Independent validation
- Calibration to actual conditions
- Avoiding interpolation during lengthy cloud and smoke cover
- Understanding specific field conditions and management
- 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



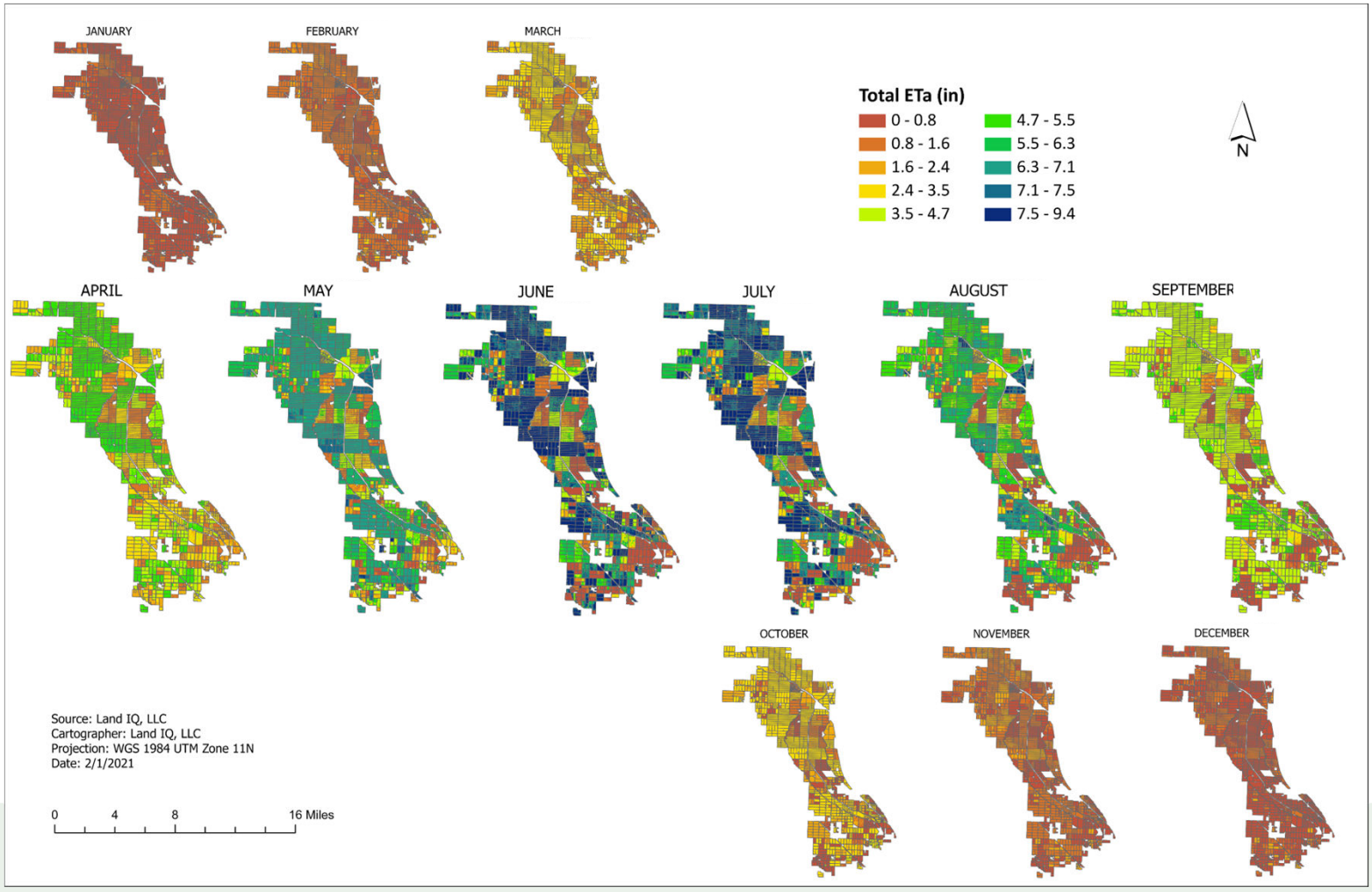
GROUND TRUTHING FOR CALIBRATION – WHERE?

- Approximately 80 stations installed in the San Joaquin Valley
- Establishment of spatial precipitation with multiple rain gauges
- For the purpose of understanding crop specific and repeated measurements
- 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 /fee-based approach



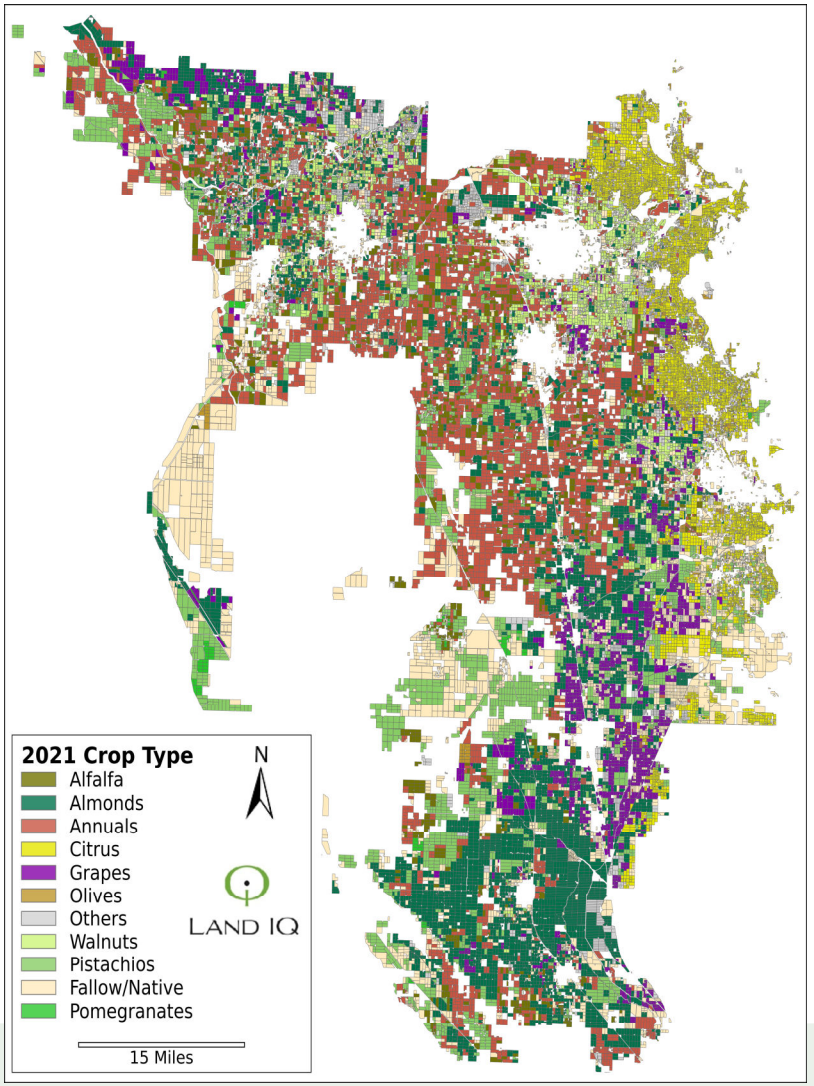
DELIVERABLE 1 – FIELD BY FIELD ET

- Monthly results delivered to the GSA within 25-30 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, fee structures, etc.



DELIVERABLE 2 – FIELD BY FIELD CROP TYPE

- Same methodology used to provide crop type to CA Dept of Water Resources as a requirement of SGMA
- Consistent with results for DWR
- Essentially real-time crop type for inclusion in modeling
- Can be used by GSAs/Districts for tracking irrigated acreage, customer base, in-season water planning and management



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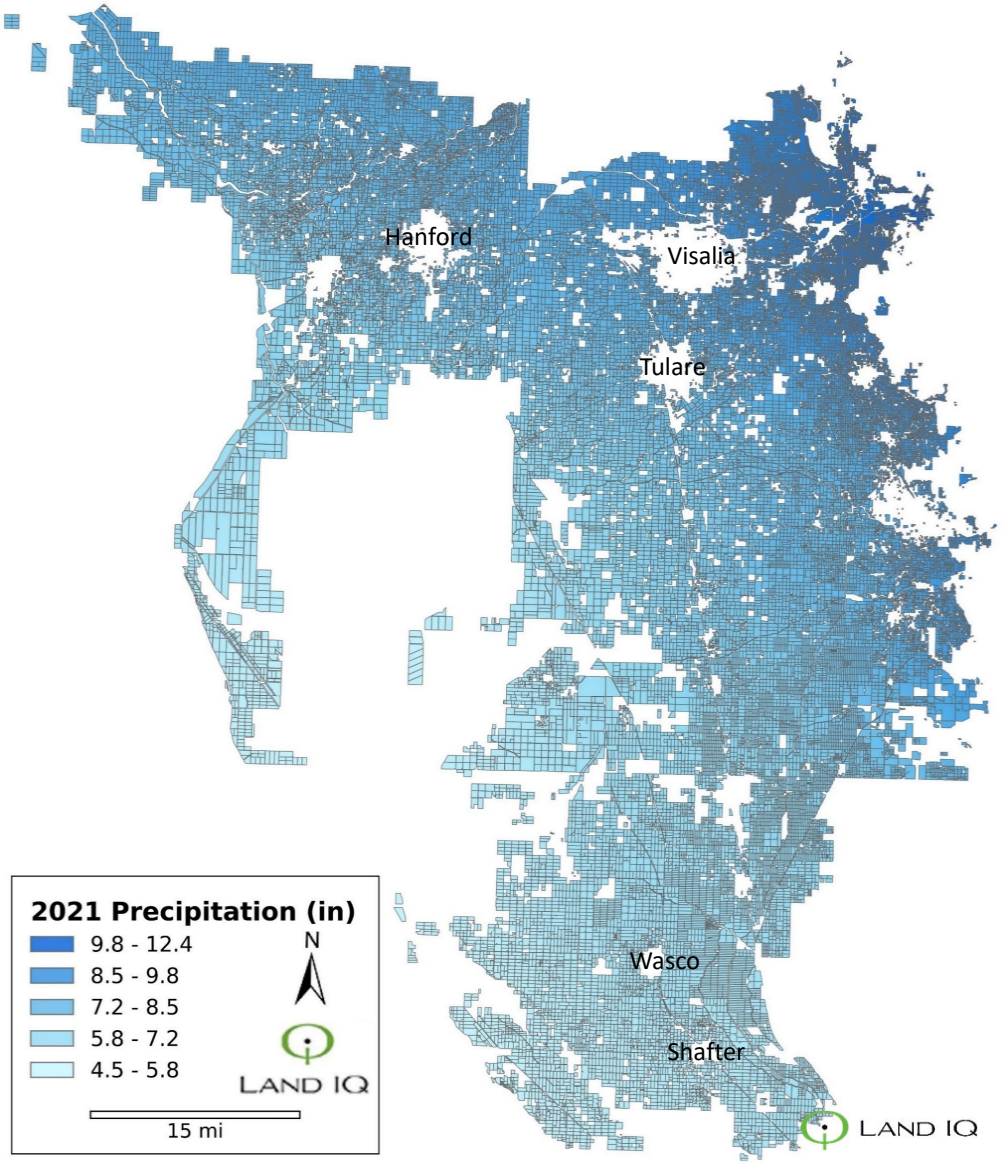
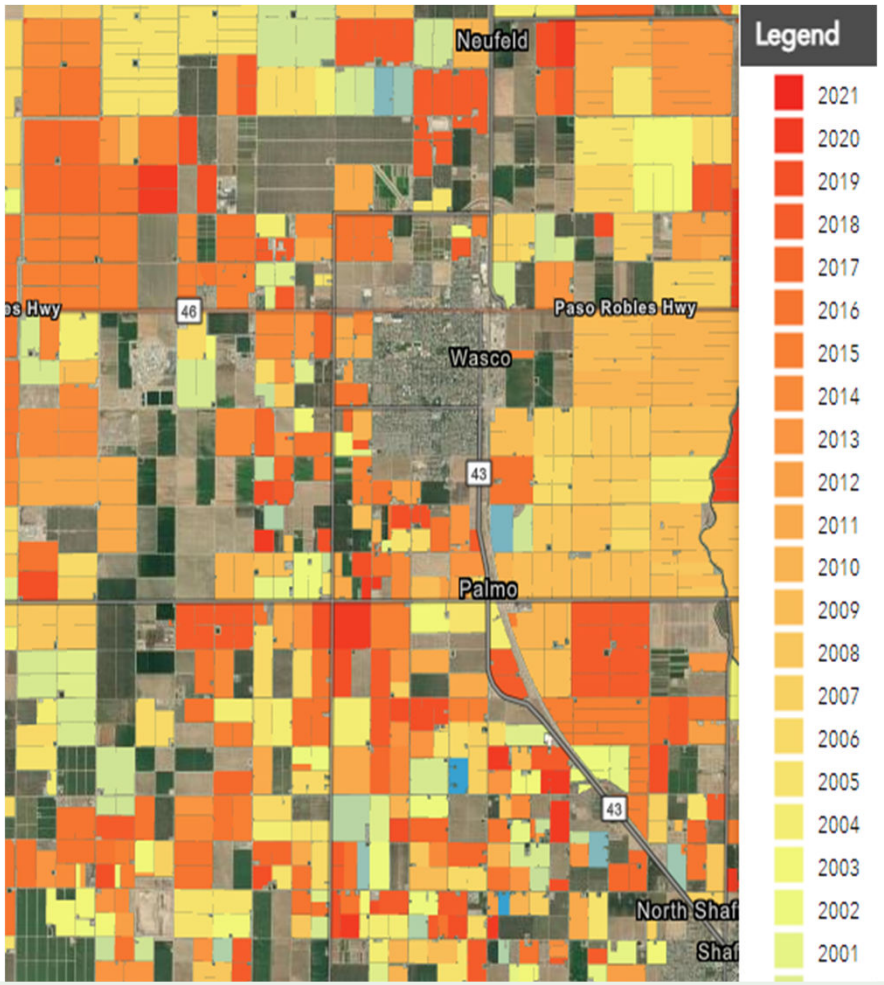
DELIVERABLE – FIELD BY FIELD PRECIPITATION

- 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.



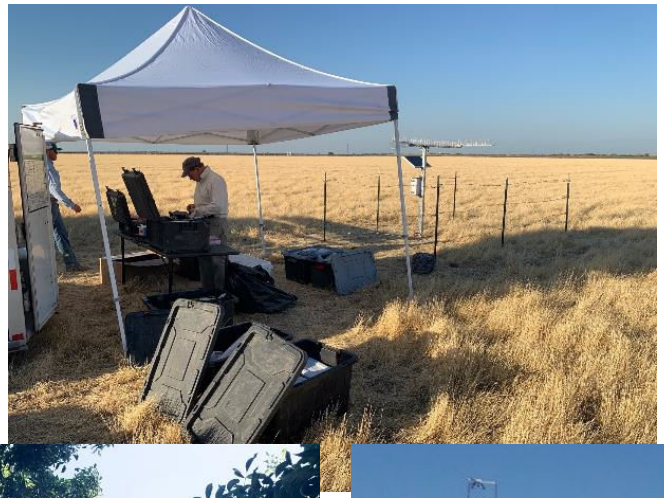
DELIVERABLE 4 – FIELD BY FIELD PERMANENT CROP AGE

- 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
- Yet another line of evidence that people can use to refine their water management allocations and land use forecasting



DELIVERABLE 5 – GROWER SUPPORT

- Dedicated team of agronomic scientist and biometeorologists
- Grower emails/calls/field visit deferred by clients to our scientists
- Overall communication and outreach at grower meetings and field days
- Field by field questions addressed



INDEPENDENT ADVISORY GROUP

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

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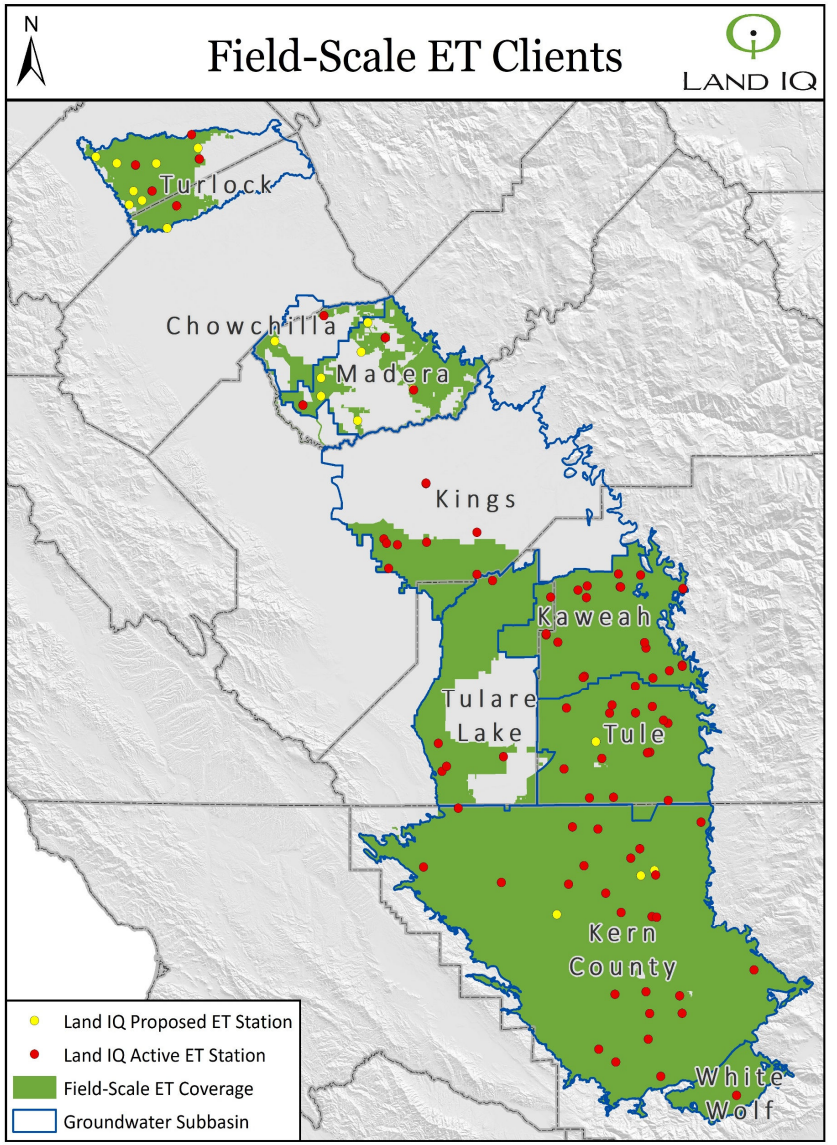
Grower Acceptance

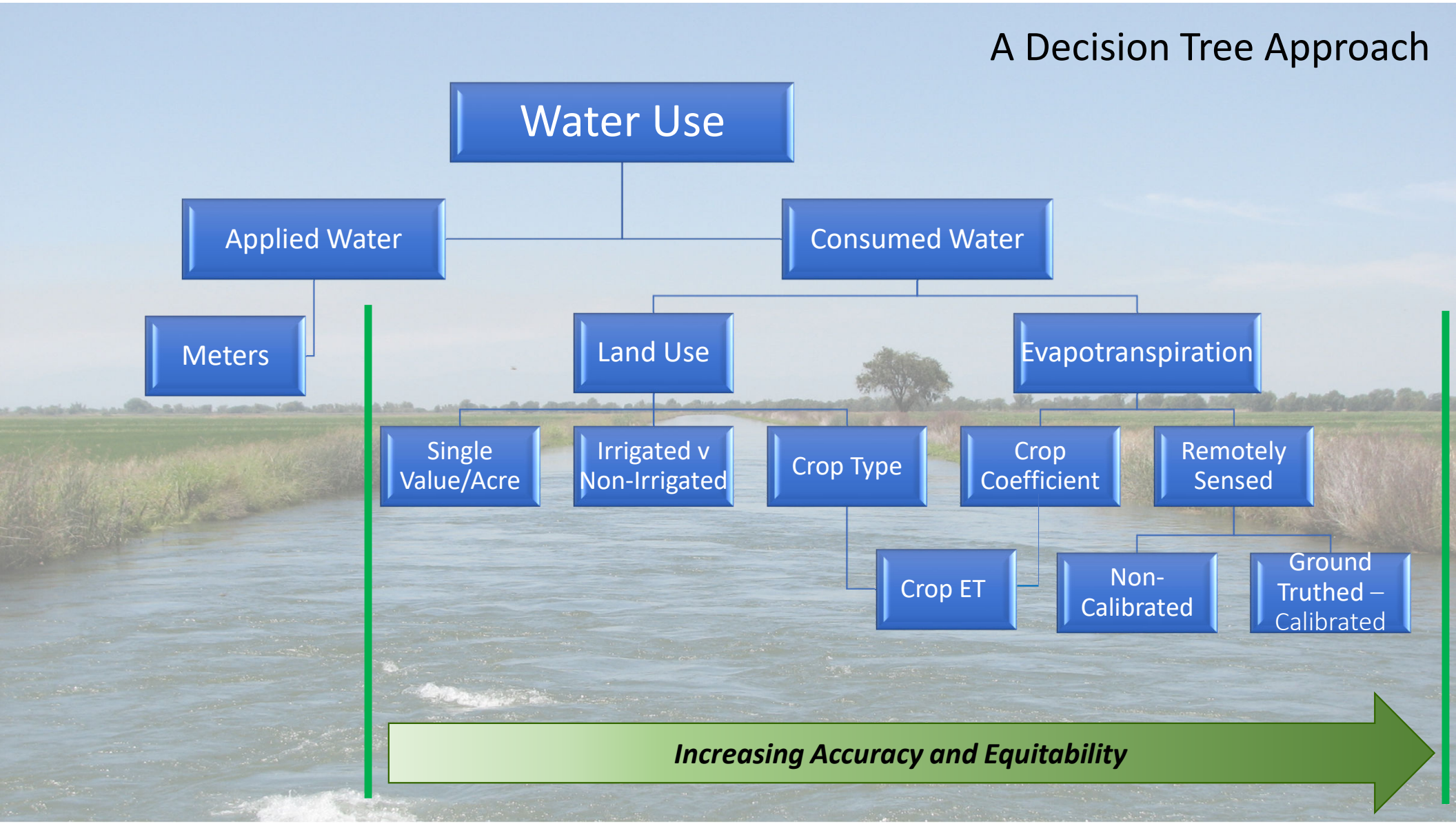
- ET is used to charge growers for their water or regulatory fees
- ET is used to determine pumping allocations
- ET is being integrated into long-term water management planning and decisions
- Few GSAs/Subbasins using meters although some allowing growers the option
- 3.3 million acres delivered each month for approximately 35-40 GSAs/Districts



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, crop management, and allocation management

A Decision Tree Approach



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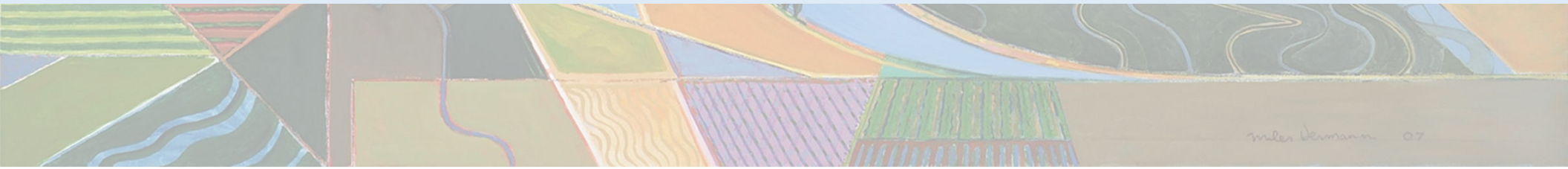

About Land IQ

Land IQ is a specialized **Agricultural, Water Science,** and **Remote Sensing** firm that pairs scientific knowledge of plant, water, and land systems with advanced remote sensing technologies, custom modeling, and analytical methods to develop detailed assessments of land and water resources.

We focus on **large scale land systems** and management applications.