



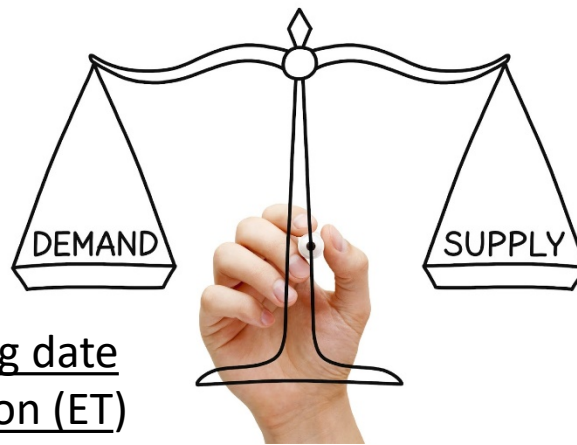
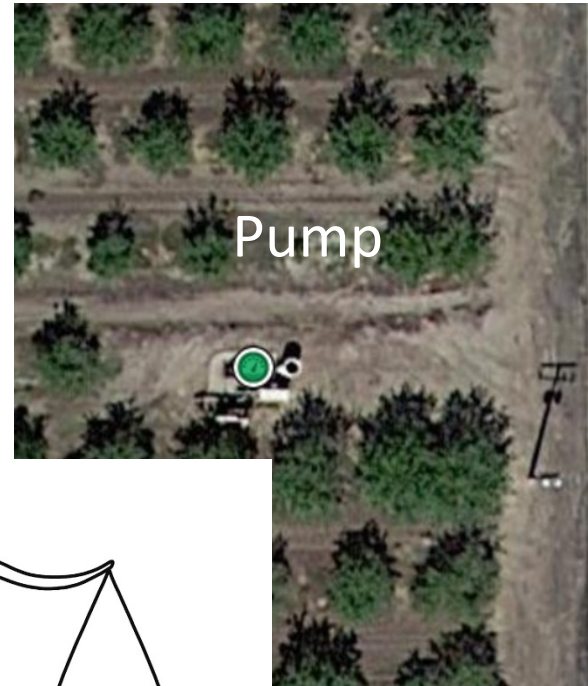
Groundwater management using a combination of supply pump data and demand ET data

Olivier Jerphagnon, PowWow Energy

Don Cameron, Terranova Ranch

Dr. George Paul, Formation Environmental

Challenge: managing supply and demand



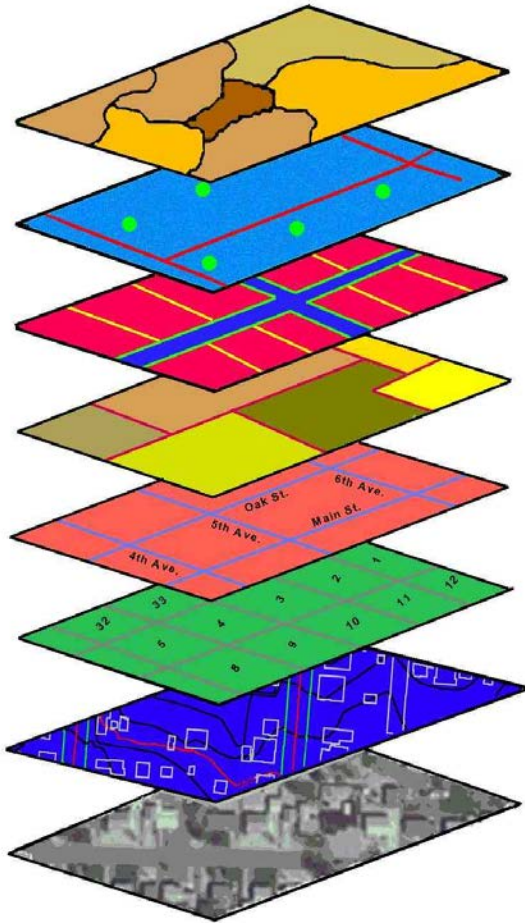
Demand:

- Crop and planting date
- Evapotranspiration (ET)
- Irrigation efficiency

Supply:

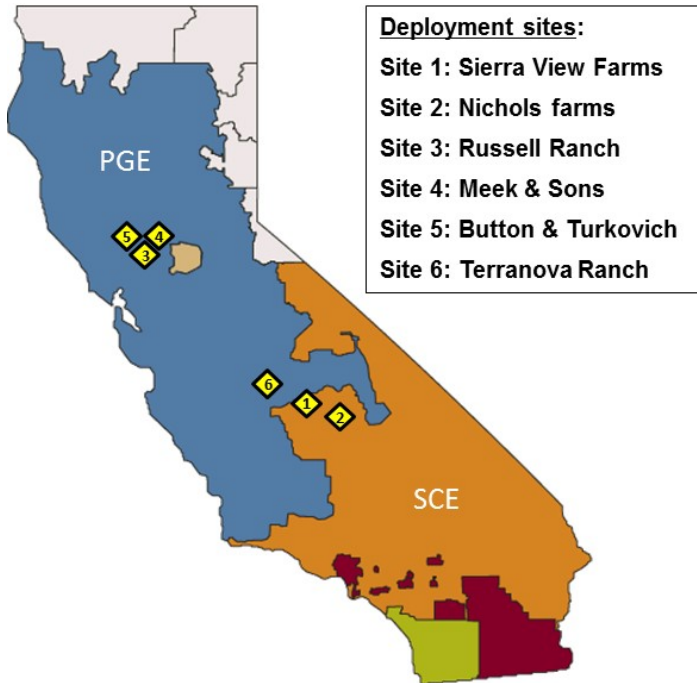
- Rainfall
- Well pumps
- Surface water

Solution: integrating existing data-sets



- Pump energy records from utility (PG&E)
- Weather (NWS, DTN)
- Crop rotation for 2016 (farm) and ETc (CIMIS)
- Actual ET from satellite images (Formation Env)

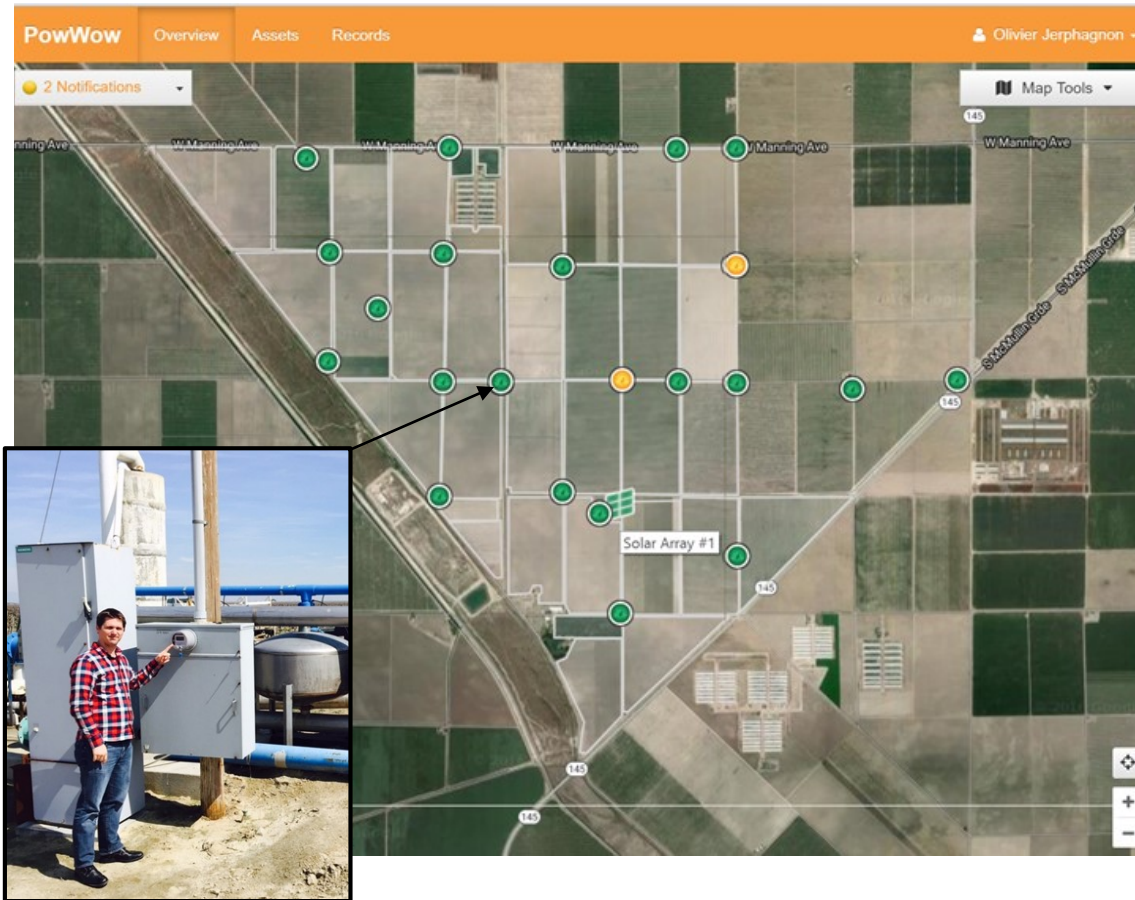
Testing part of project funded by CEC



- Project funded by California Energy Commission (CEC)
- Study from 2015 to 2017 across six sites in 4 counties
- One of the sites is Terranova Ranch:
 - On-farm groundwater recharge project near Helm along Kings River
 - Collaboration with Kings RCD
- We look at different methods to measure water:
 - Water meters and power meters
 - Crop ET from CIMIS and crop model
 - Actual ET from aerial imagery
 - Weather: NWS and DTN data services



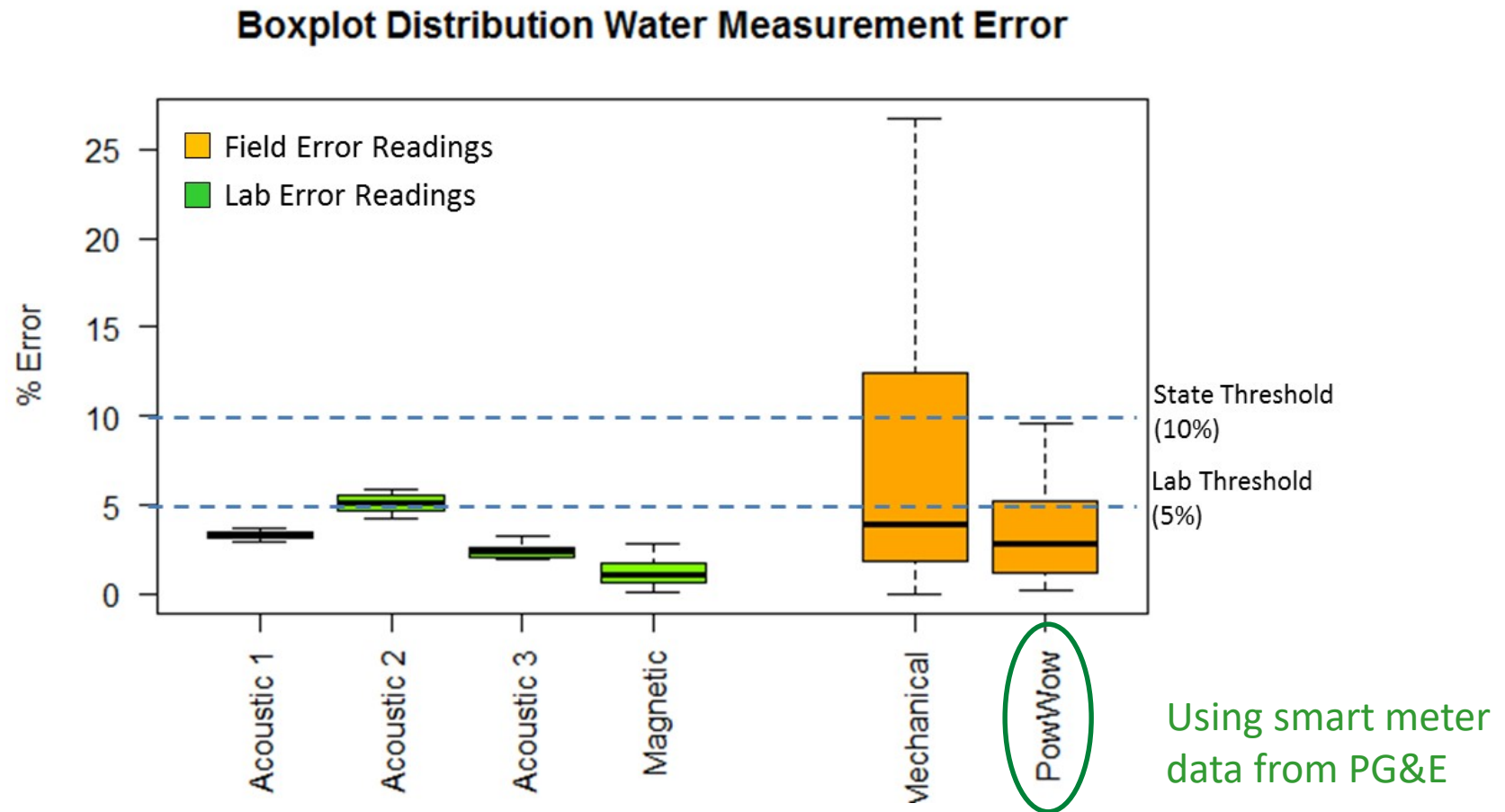
Water supply: ground water extraction



Source: PowWow Energy

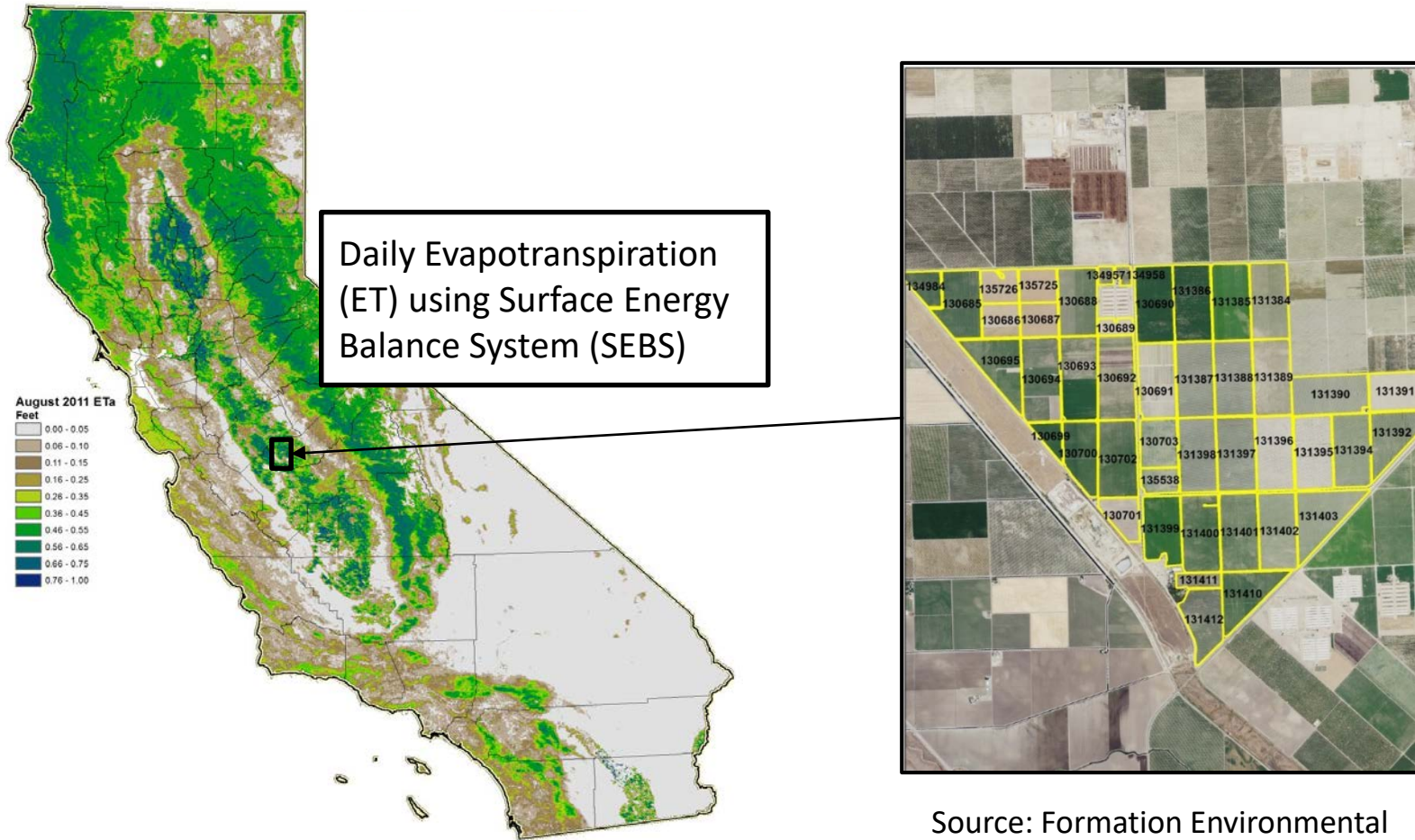
- Sources of water:
 - **Groundwater:**
22 pumps
 - **Rainfall**
 - No surface water
- Daily water records using smart meters powering pumps

Validation with calibrated water meters



Source: Measurement & Verification by Bren School at UCSB and CIT at Fresno State

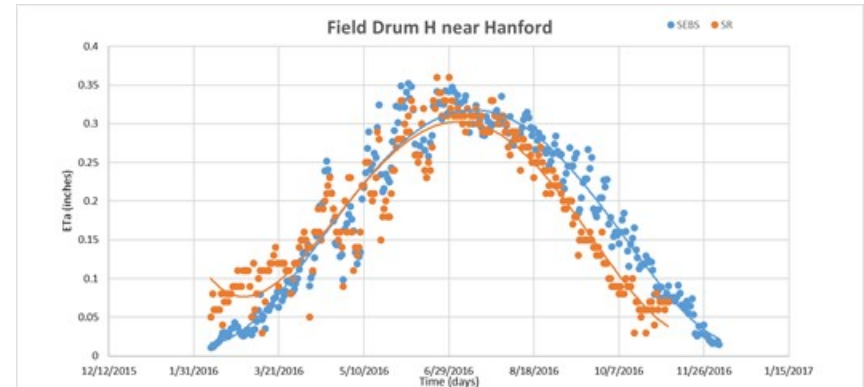
Water demand: ET from satellite images



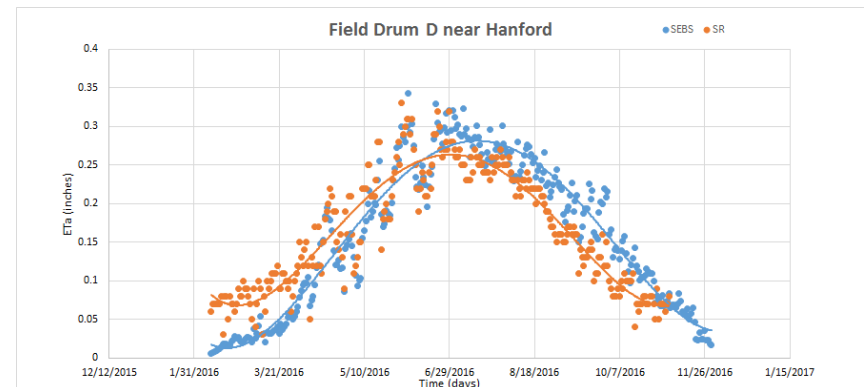
Ground truth testing of actual ET data

- Testing of SEBS method against Surface Renewal (SR) station from Tule:
 - One field with full ET
 - One field with deficit
- Results are similar and pick up difference in water application:

Method	Field Drum D (partial ET)	Field Drum H (full ET)	Difference
Applied water (inches)	34.85	38.34	-4.51
Rainfall (inches)	7.77	7.80	-0.03
Total applied water (inches)	42.6	46.14	-4.54
Actual ET (inches) from SR method	43.8	50.9	-7.1
Actual ET (inches) from SEBS method	40.3	45.3	-5.0

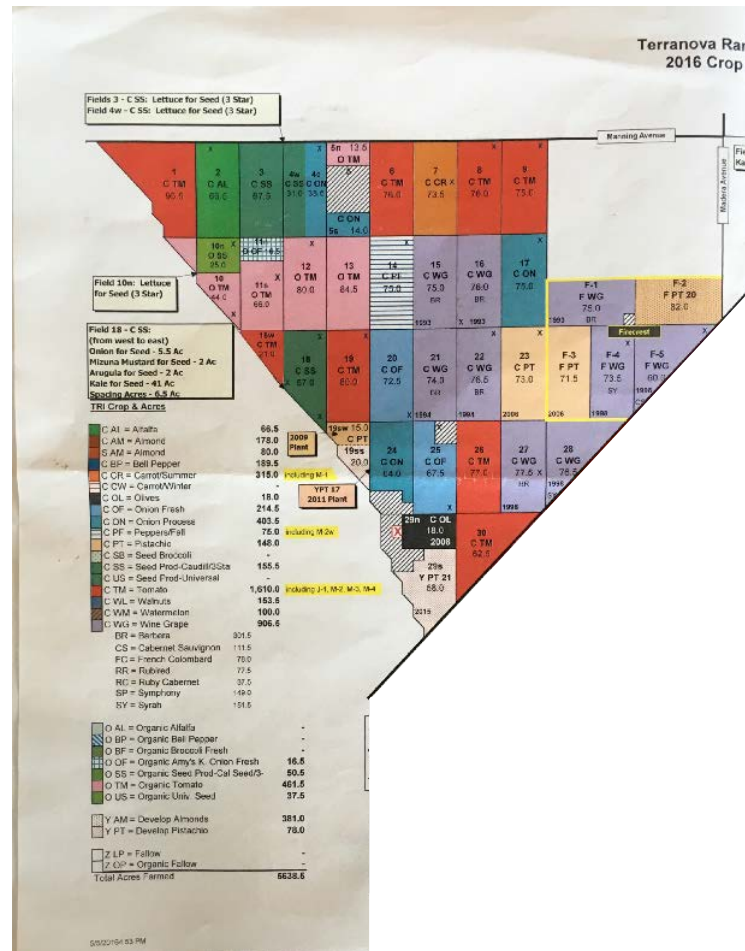


Pistachio field with full ET schedule



Pistachio field with 20% deficit schedule

Water supply and demand at Terranova



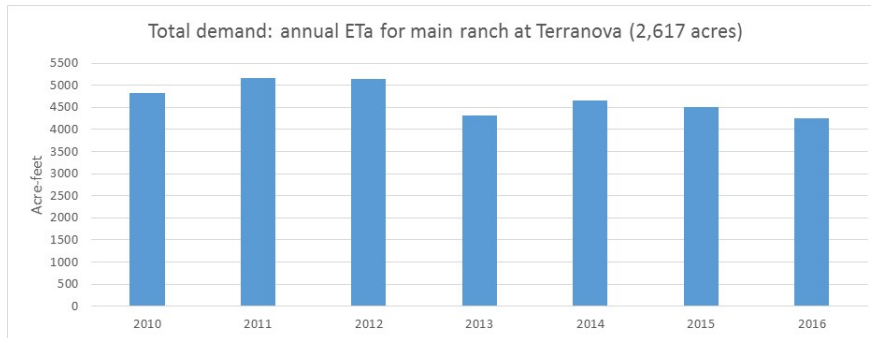
Source: Terranova Ranch

- 8 crops in 2016 (2,617 acres):
 - Alfalfa
 - Carrots
 - Peppers
 - Pistachios
 - Onion, onion fresh
 - Olives for oil
 - Seed production
 - Tomatoes (processing)
 - Wine grapes

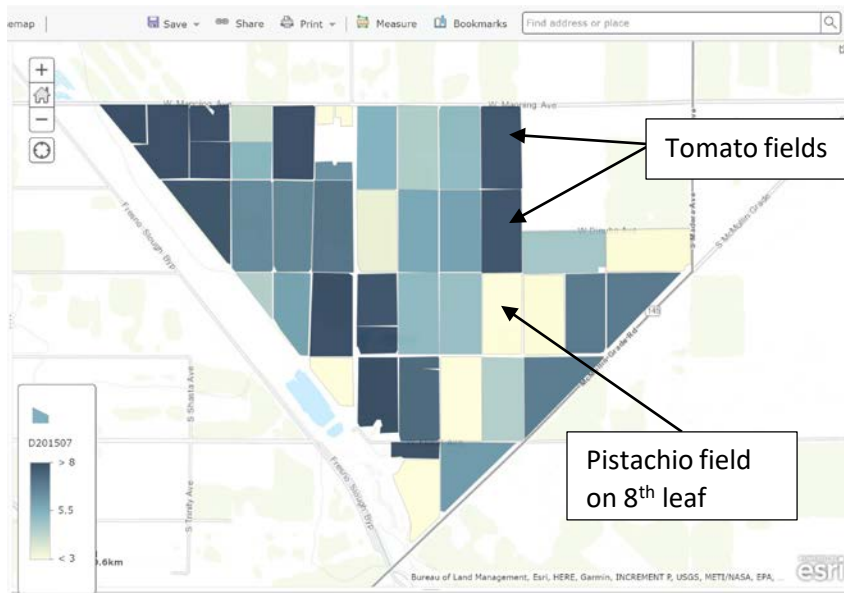
- Results:
 - ETc from fields: - 6,796 ac-ft
 - Groundwater: + 7,110 ac-ft

Difference: 4.4%

Actual ET: zoom on water use efficiency



- Actual usage per data set is 4,263 ac-ft
- Different from 7,031 ac-ft from pump records that are close to ET plan
- What is the difference?



Pump review: zoom on energy efficiency

Pumps	Type	VFD	NEMA	Energy data since	Pump test	2016 energy (kWh)	2016 water (ac-ft)		Energy intensity (MWh/Ac-ft)
2	Well	no		31-Dec-14	3	78,500.04	186.1		0.42
4	Well	no		31-Dec-14	3	41,435.96	82		0.51
7	Well	no		18-Dec-15	1	128,794.72	240.28		0.54
8	Well	no		10-Mar-16	3	201,306.84	400.9		0.50
9	Well	no	YES	19-Nov-15	1	14,836.12	20.4		0.73
10 N	Well	YES		28-May-15	2	351,047.68	589.24		
10 S	Well	YES		21-Aug-16	0	2,272.80	3.81		
11	Well	no		19-Jan-15	1	1,826.99	4.3		0.42
12	Well	no		5-May-16	3	158,424.04	349.31		0.45
14	Well	no	YES	31-Dec-14	1	306,660.96	462.72		0.66
16	Well	no		2-Jul-14	1	460,803.84	585.71		0.79
17	Well	no		25-Jul-16	3	98,384.80	184.68		0.53
18 N	Well	no	YES	18-Jul-15	1	207,237.89	243.37		0.85
18 S	Well	YES		24-Jun-16	3	84,532.96	141.89		
18 W	Well	no	YES	19-Jan-15	1	8,618.49	14.47		
19	Well	YES		31-Dec-13	2	91,917.02	386.94		0.24
20	Well	no		31-Dec-13	3	406,204.07	555.46		0.73
22	Well	no		31-Dec-13	1	0.00	0		
23	Well	no	YES	19-Jan-15	1	165,177.44	160.19		1.03
25 N	Well	no	YES	31-Dec-13	1	242,676.15	379.44		0.64
25 S	Well	no	YES	31-Dec-13	1	52,448.48	108.6		0.48
27	Well	no		31-Dec-13	5	433,947.40	772.71		0.56
F4	Well	no		.	3	590,133.32	1111.47		0.53
F5	Well	no		31-Dec-13	3	88,444.60	126.38		0.70
Total						4,215,633	7,110	Average	0.60

Low efficiency

Low efficiency

Low efficiency

Error: add booster
Low efficiency

Low efficiency

Summary

- Pump records can provide measurement of groundwater use in complement of water meters
- There is a big difference between ETc and ETa
- Review of fields and pumps each year can save significant amount of water and energy
 - Maintain pumps: retro-commissioning
 - Know your fields: adjust to canopy cover
- Satellite images are not a way to measure groundwater extraction but useful for demand