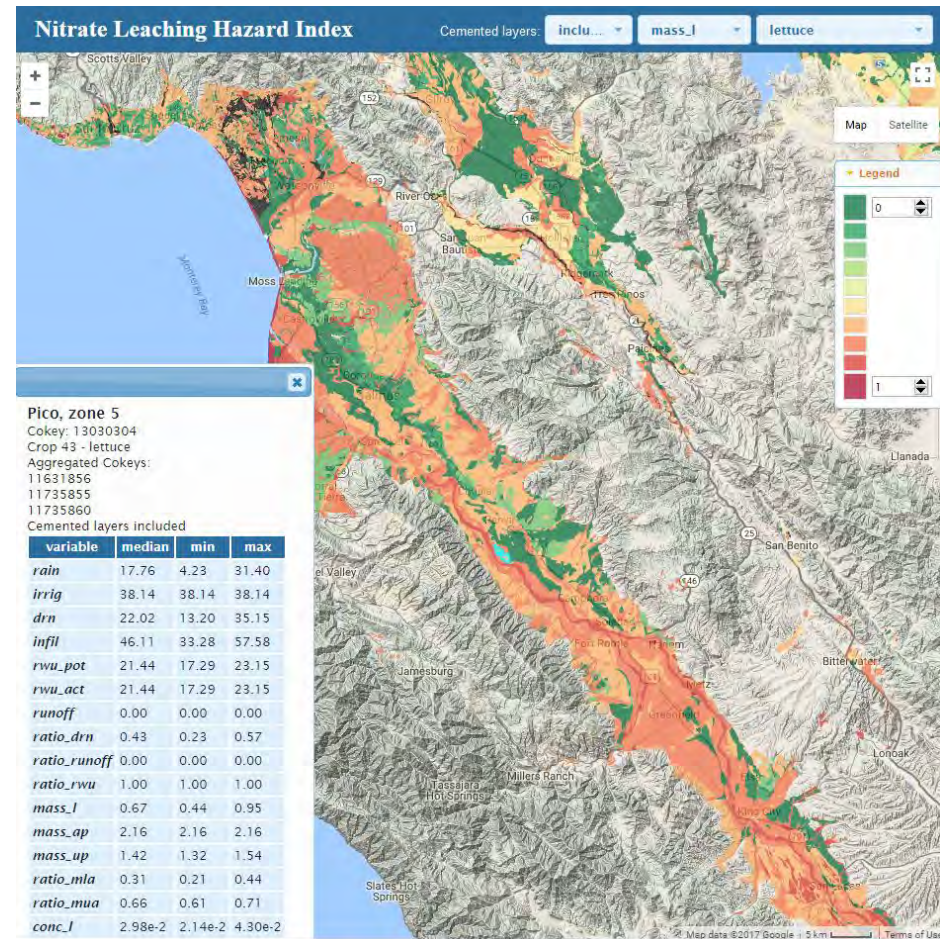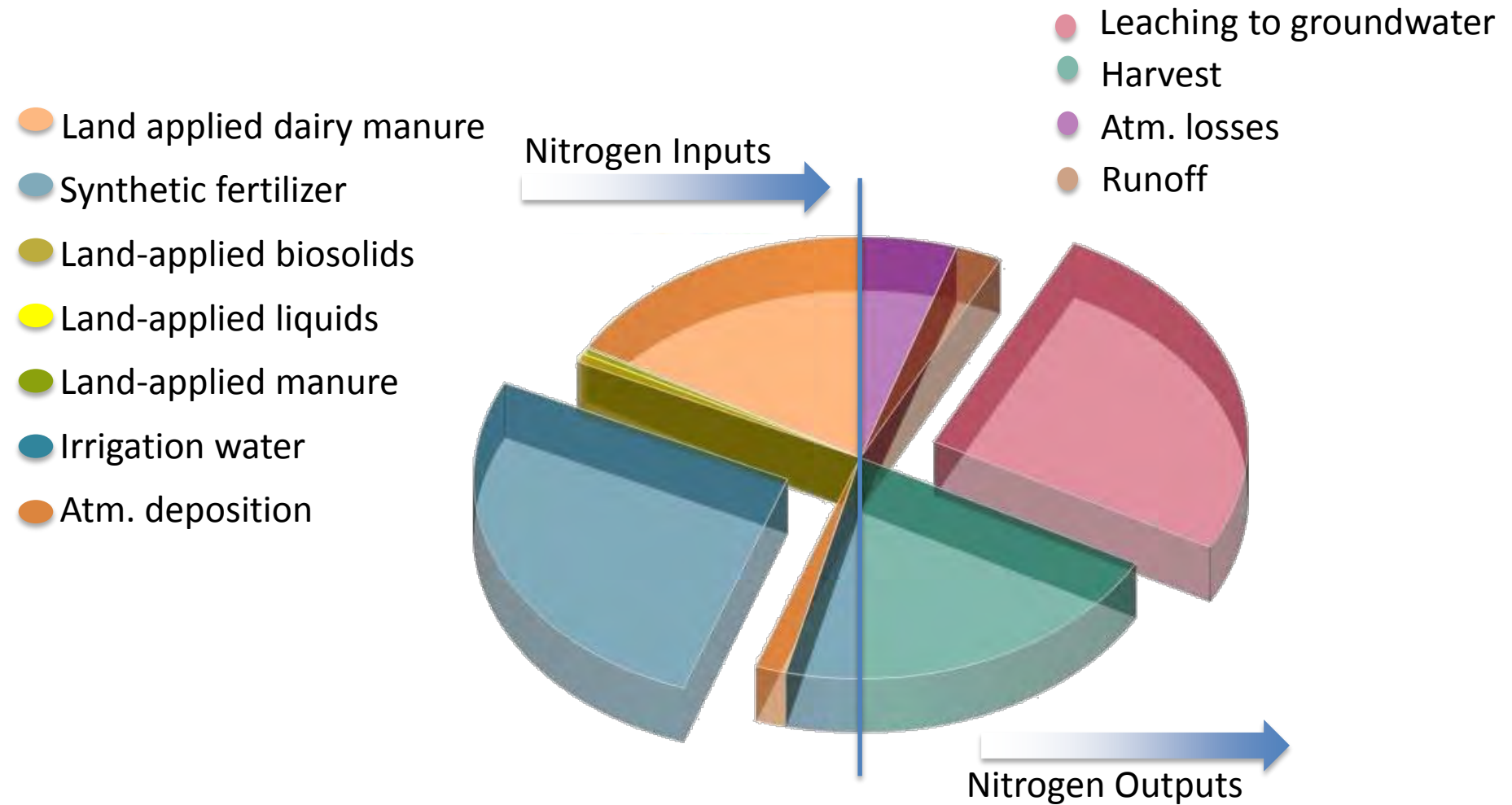# A Data Driven Nitrate Leaching Hazard Index

Toby O'Geen, Stathis Diamantopoulos,

Thomas Harter and

Jan Hopmans

Department of Land, Air and Water Resources University of California, Davis

Nitrogen in California's Cropland

Legend (Inputs):
- Land applied dairy manure
- Synthetic fertilizer
- Land-applied biosolids
- Land-applied liquids
- Land-applied manure
- Irrigation water
- Atm. deposition

Legend (Outputs):
- Leaching to groundwater
- Harvest
- Atm. losses
- Runoff

Nitrogen Inputs

Nitrogen Outputs

Harter and Lund, 2012. Addressing Nitrate in CA's Drinking Water

Project Objectives

-Estimate nitrate leaching potential state-wide with a physically based model using combinations of soil, climate and crop

-Develop an online interactive app for place-based summaries of nitrate leaching potential

-Evaluate different fertilization and irrigation practices using this tool

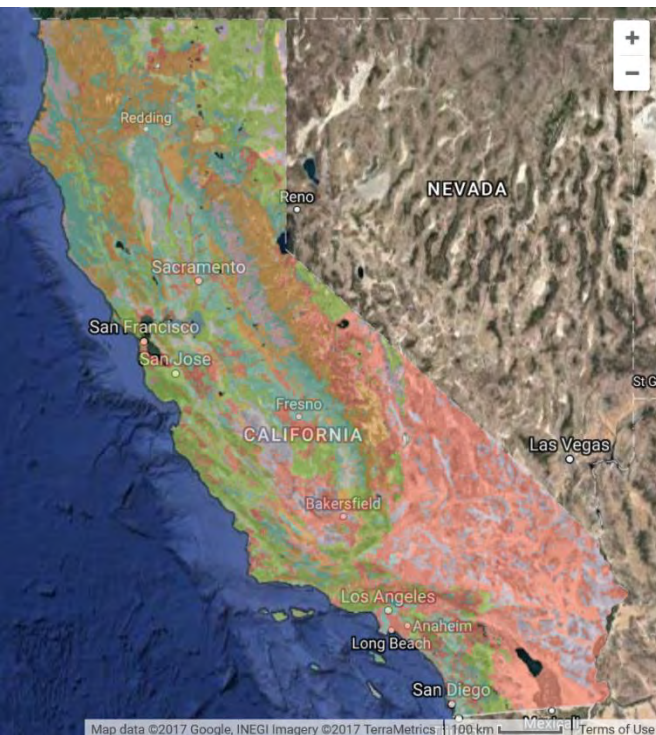# Simulating NO$_3$ Loss by Crop, Soil, & Climate Using HYDRUS-1D

Input data:

6000 unique soils,
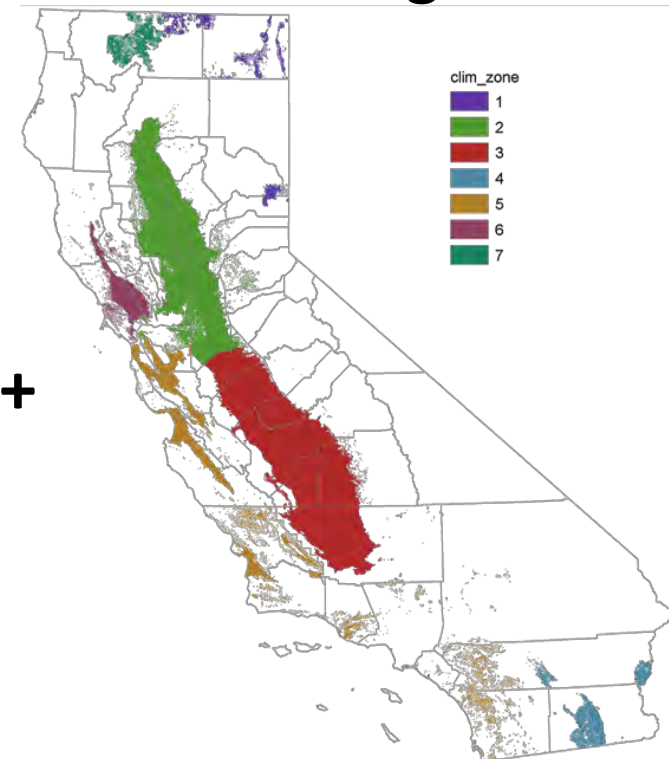22,000 horizons

55 crops

7 climatic zones
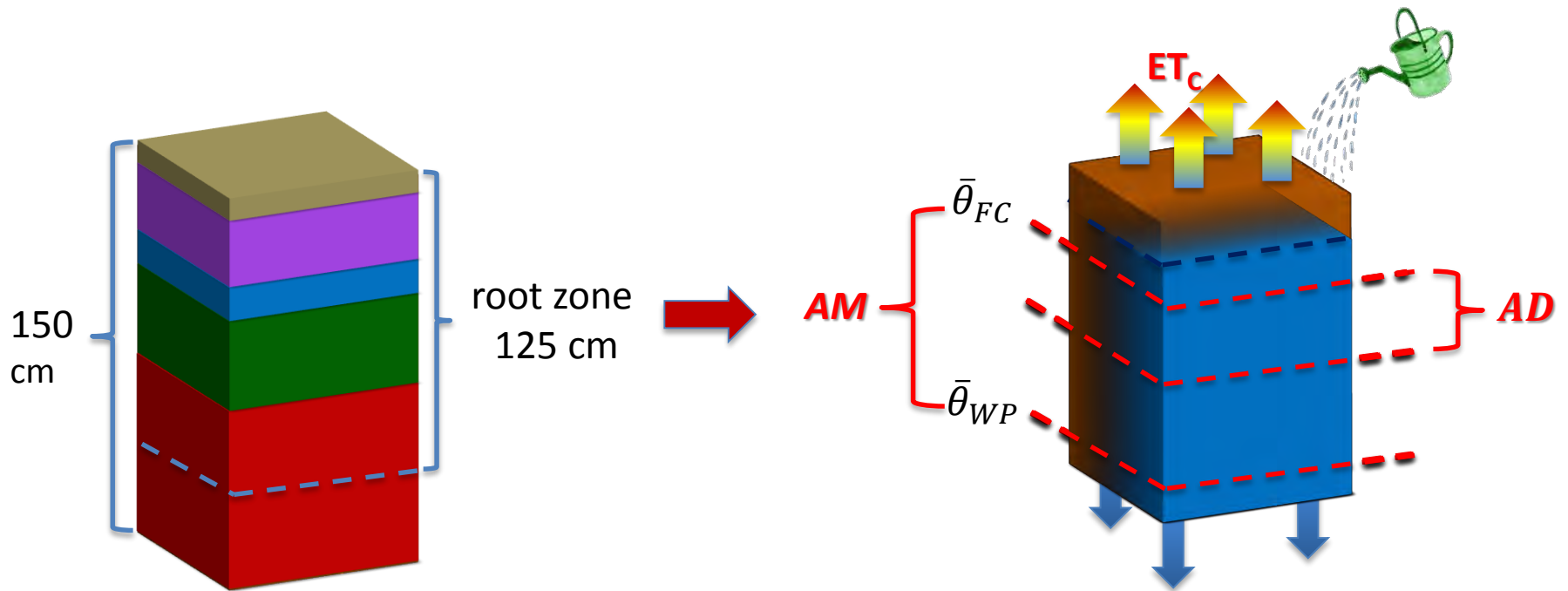21 years (1995 –2015)
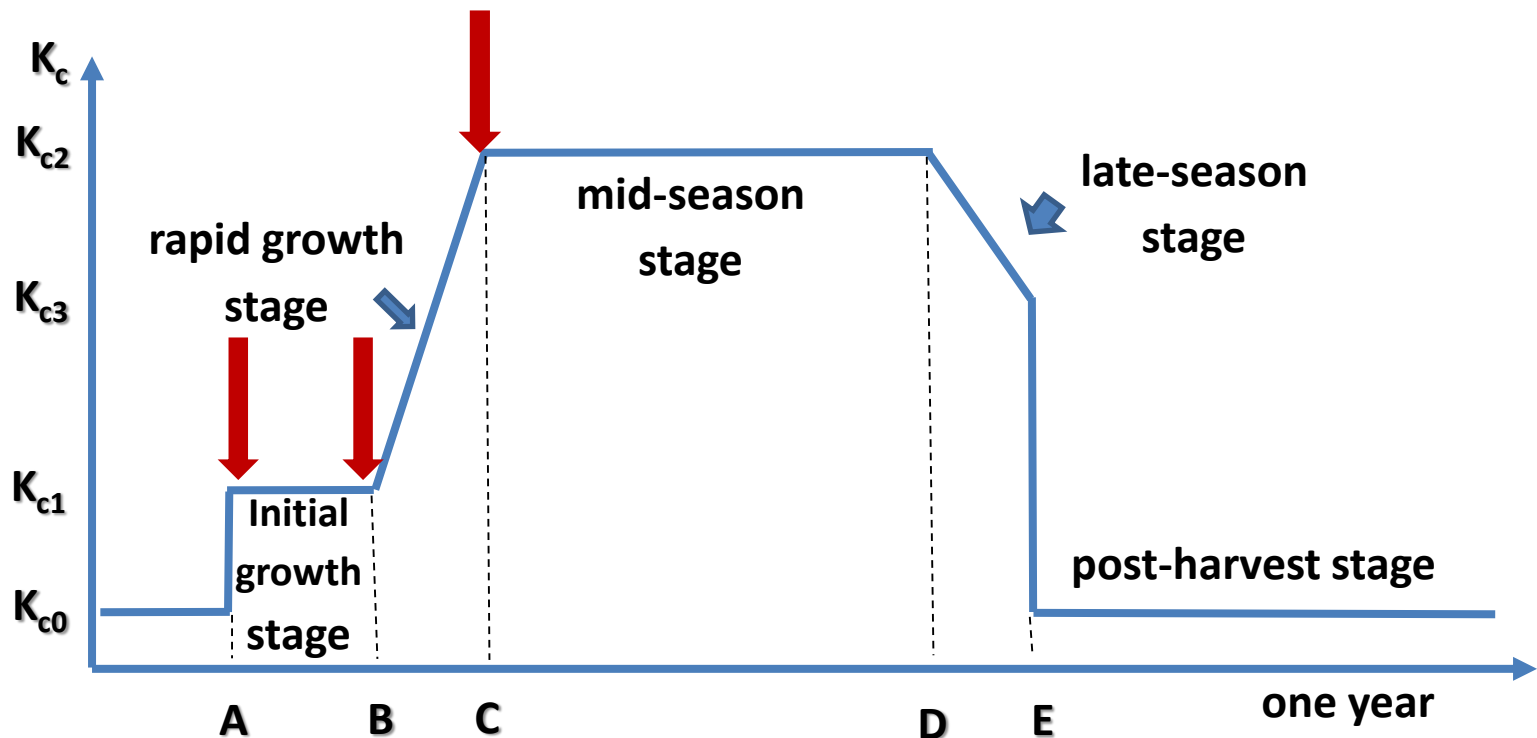winter + irrigation

+

+

Methodology – Irrigation Schedule

Over half a million simulations
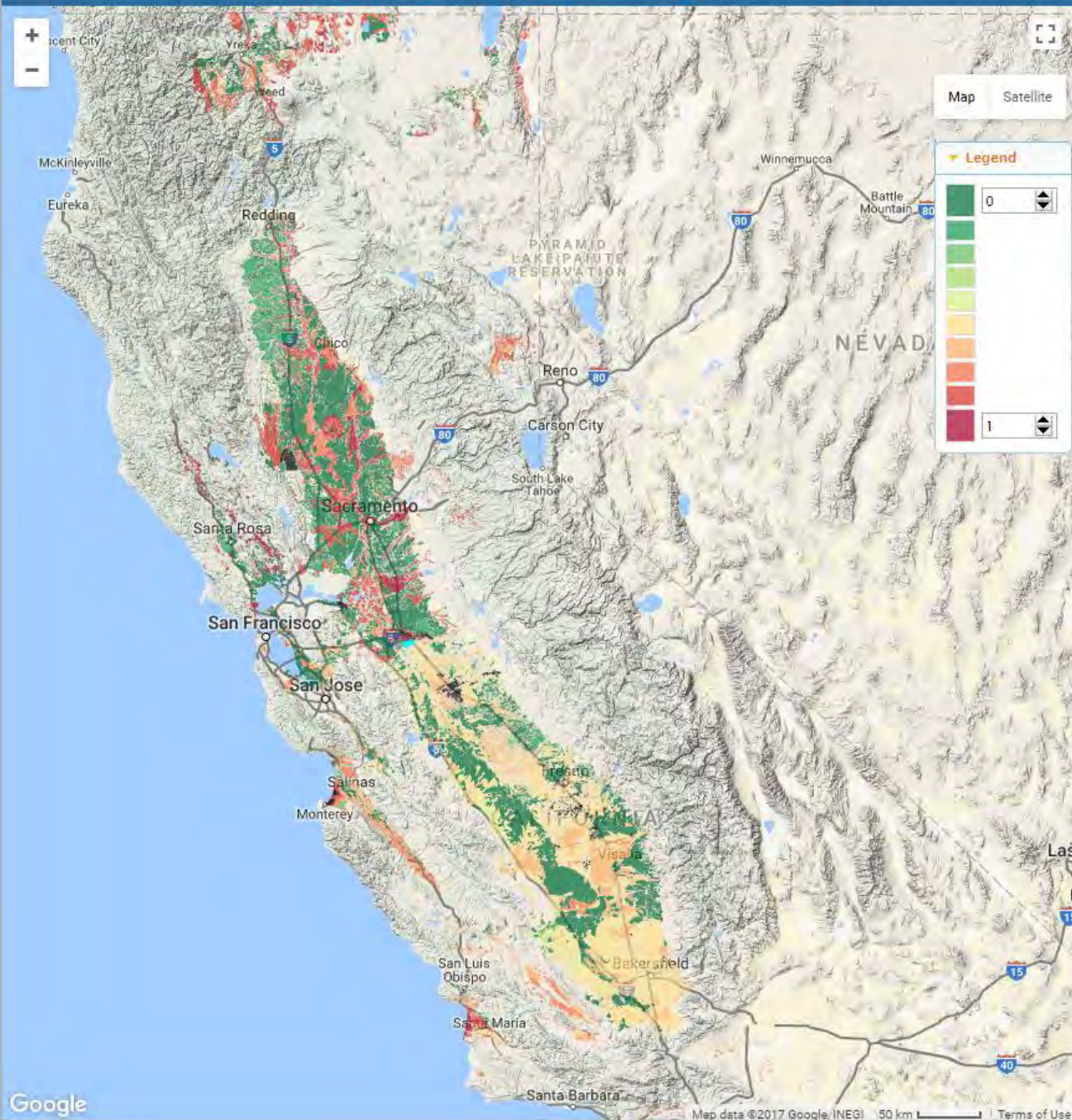
Methodology-Fertilization

Each crop had three early season N applications. Amount and timing was based on crop type.

Administrative Version of App

Maps nitrate leaching for combinations of soil, climate and any <u>one</u> of the 55 crops

Nitrate Leached: Lettuce Scenario
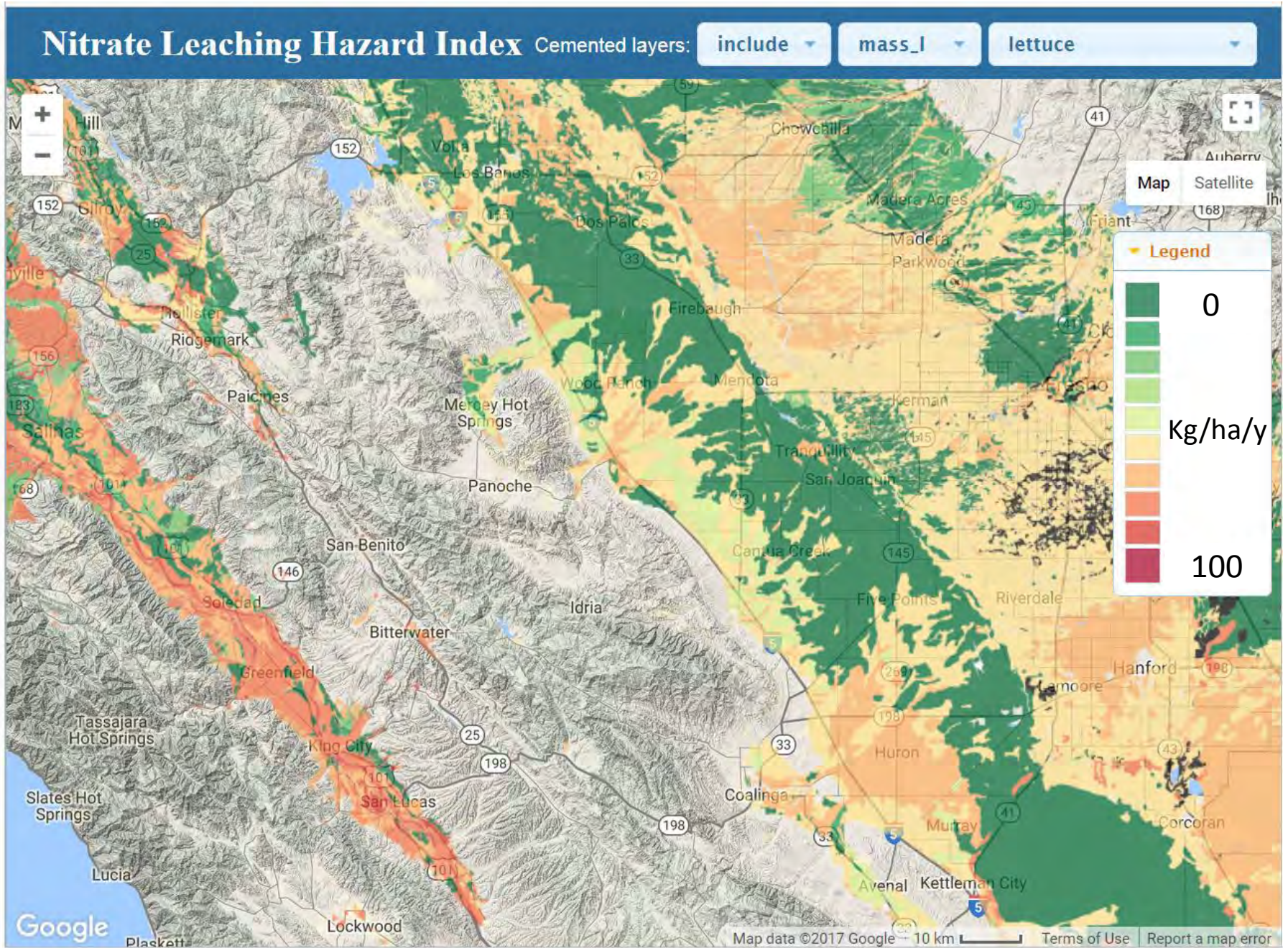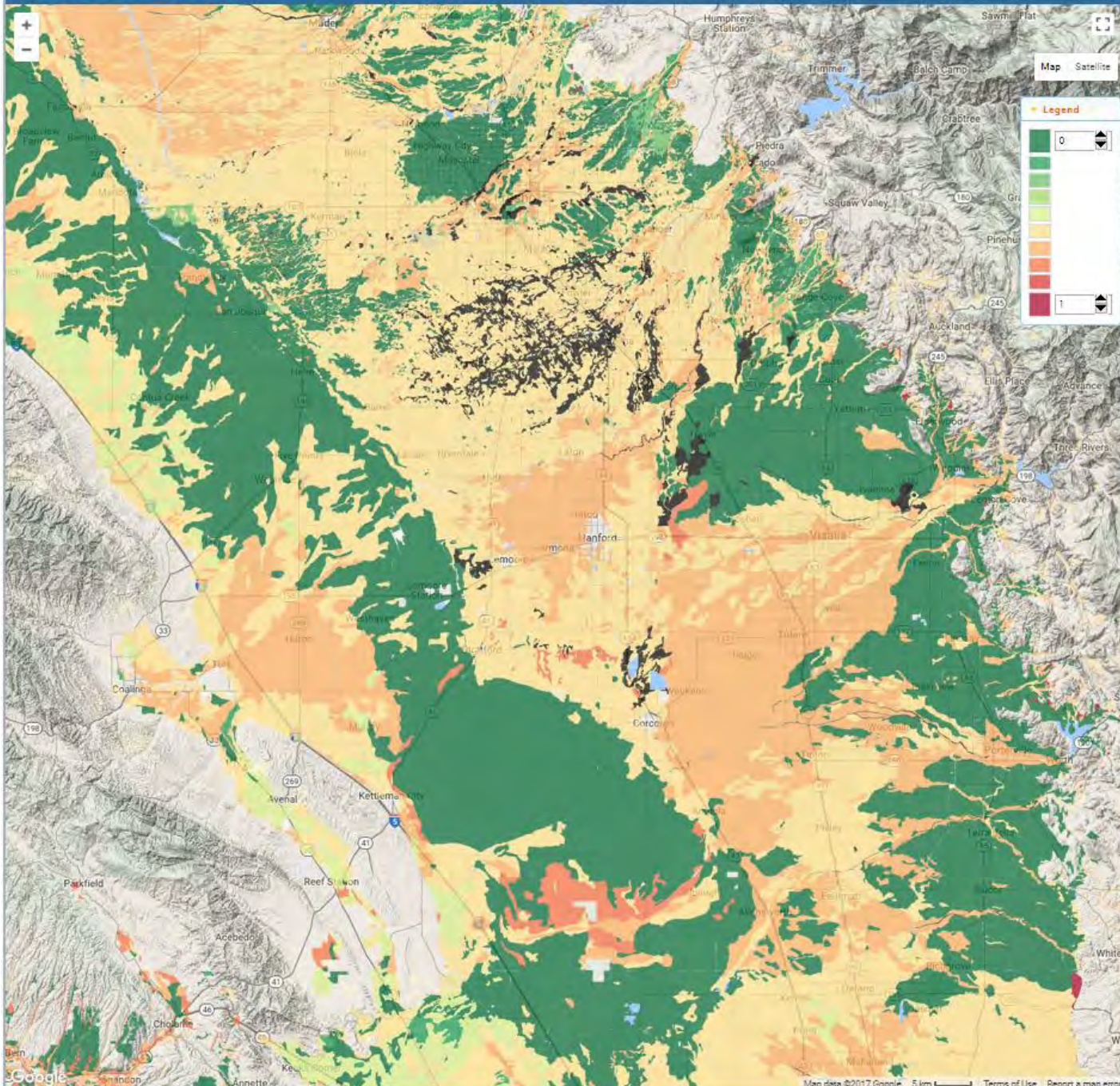
Effects of Hardpans

-No Deep Tillage
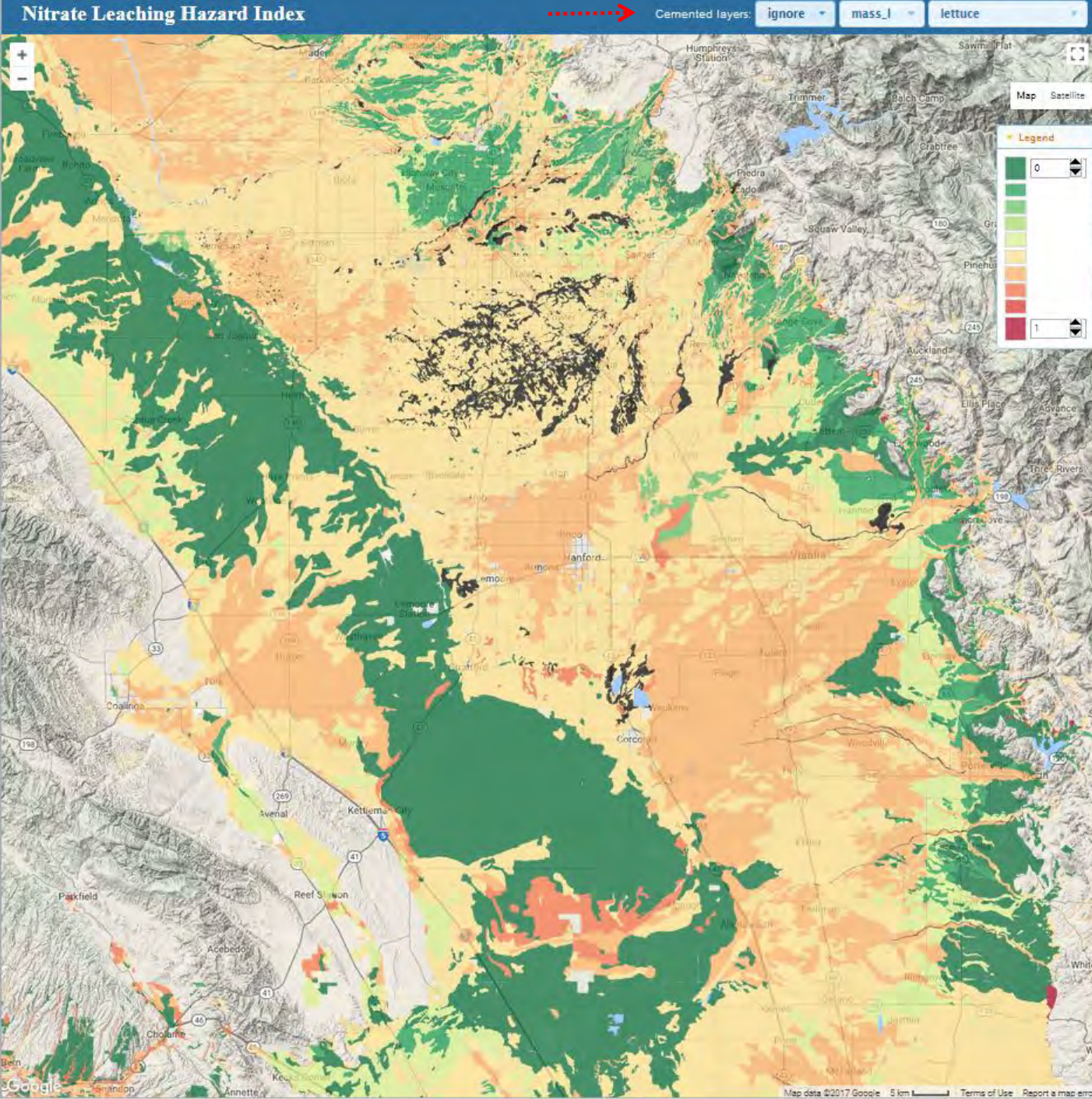
Effects of Hardpans

-With Deep Tillage

Measured vs Modeled N Uptake by Crops, 60% Irrigation Efficiency

Model may under predict uptake for some crops that have high fertilizer rates.

Measured vs Modeled N Uptake for Different Crops, 75% Irrigation Efficiency

Model may over predict uptake for some crops. Harvest N in tree crops does not account for all N uptake.

Public App

Nitrate Leaching Hazard Index

| About | Nitrate Index | Settings |

Settings

Area of Interest:

[Use My Current Location]

- OR -

Enter a location:

[_____] [Go]

Locations may be entered as:
- City, state
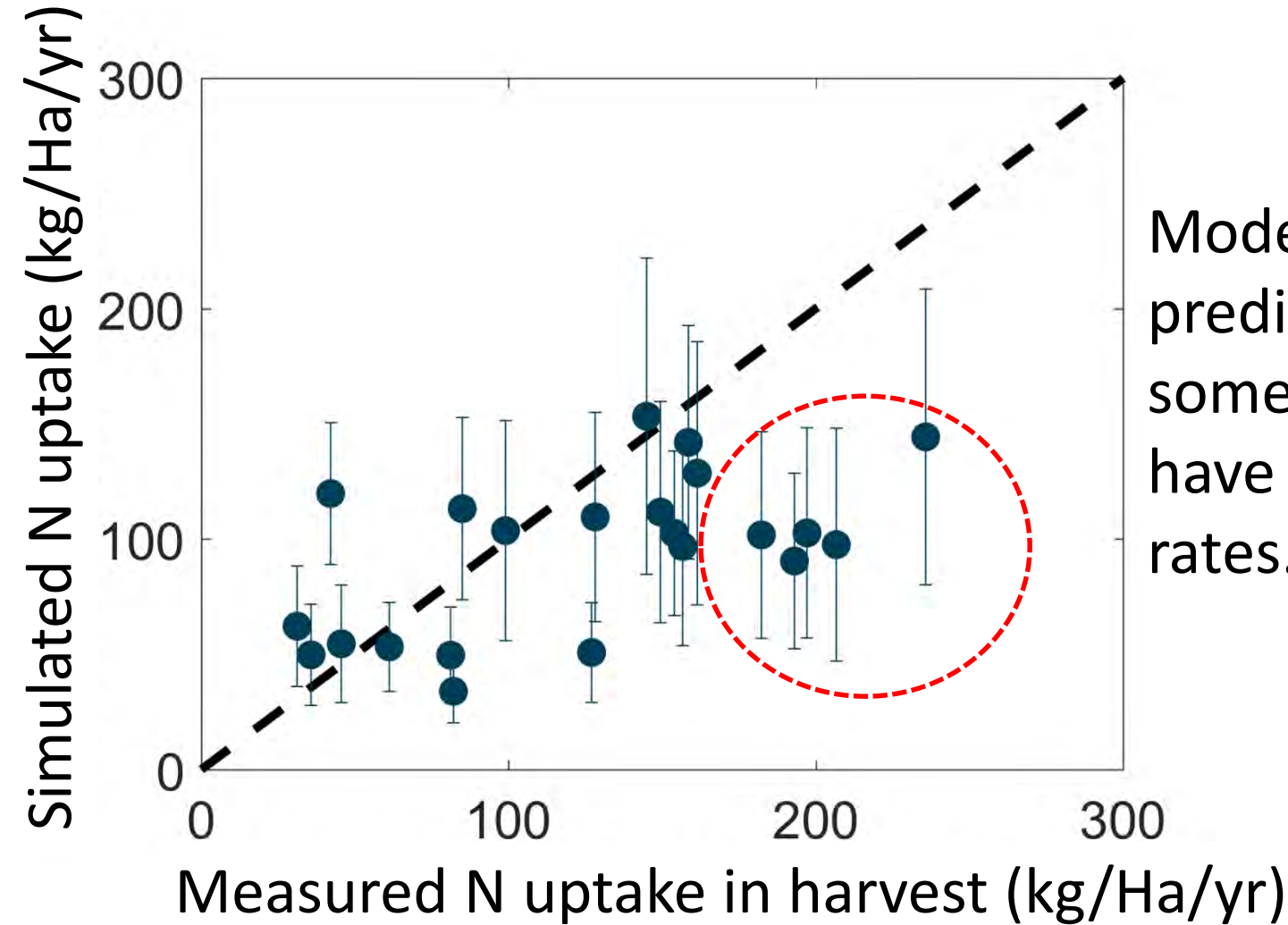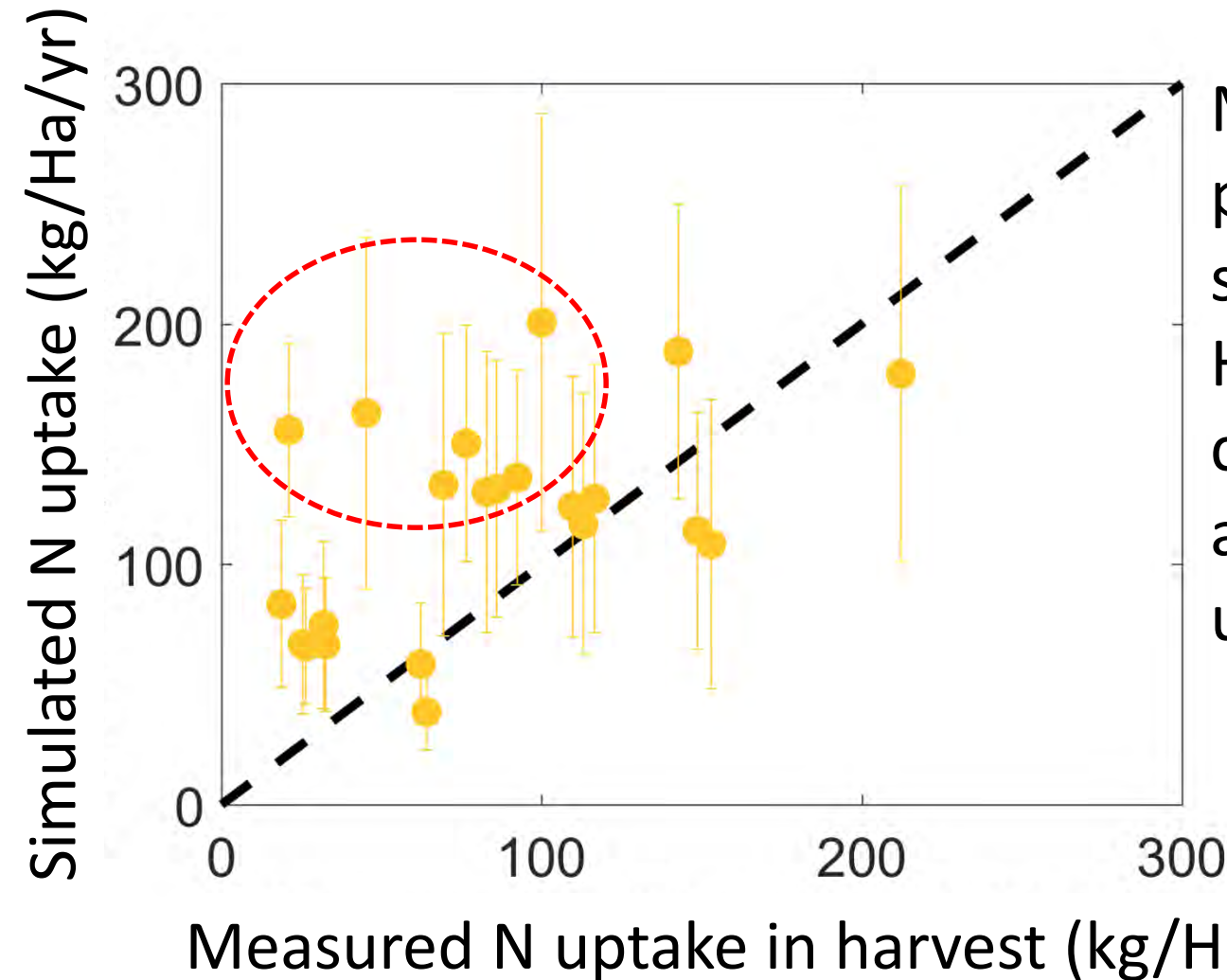- Zip code
- Latitude, longitude (e.g. 38.55, -121.74)

Crop:

[lettuce ▼]

- beans (green)
- carrots
- celery
- **lettuce**
- melons, squash
- garlic, onions
- peas, green
- potatoes
- sweet potatoes
- spinach
- tomatoes, processed
- berries
- strawberries

Nitrate leaching results

Crop: **lettuce**
Dominant component: **Tujunga**

⦿ Imperial Units   ◯ Metric Units

Water Dynamics

Annual Values	Median	Min	Max
Rainfall (in)	15.9	4.3	21.7
Irrigation water (in)	21.6	21.6	21.6
Deep percolation (in)	21.0	14.8	27.5
Runoff (in)	0.0	0.0	0.0
Leaching fraction (%)	55	48	75
Irrigation efficiency (%)	100	100	100

Nitrate Dynamics

Nitrate applied (lb/ac):   -   193 ⊕   +

Annual Values	Median	Min	Max
Nitrate leached (lb/ac)	105.7	74.9	137.0
Leaching fraction (%)	55	39	71
Nitrate concentration in leaching water (ppm)	22	17	31

Nitrate Leaching Hazard Index

About | Nitrate Index | Settings

Settings

Area of Interest:

Use My Current Location

- OR -

Enter a location:

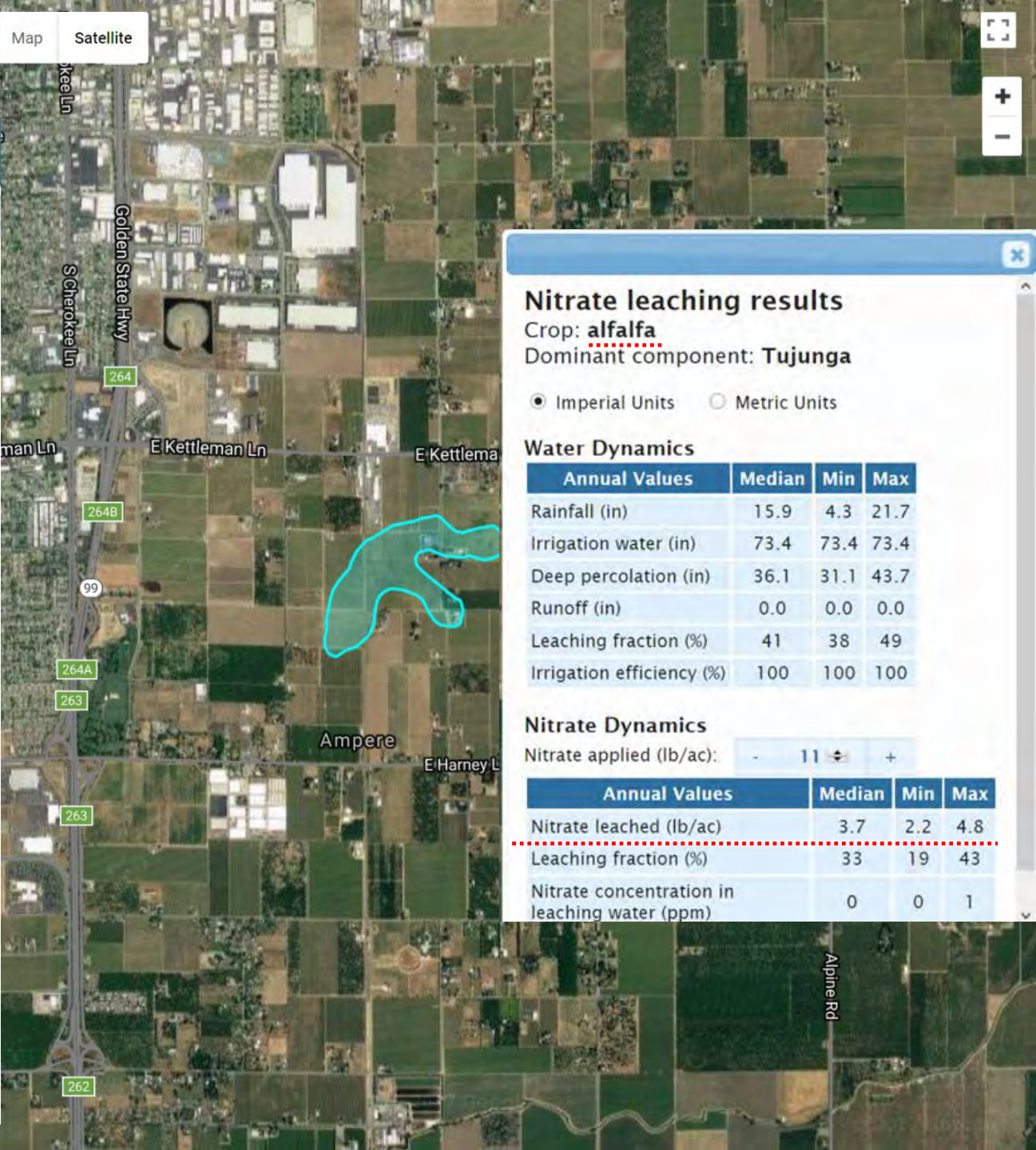[   ] **Go**

Locations may be entered as:
- City, state
- Zip code
- Latitude, longitude (e.g. 38.55, -121.74)

Crop:

lettuce ▼

beans (green)

carrots

celery

lettuce

melons, squash

garlic, onions

peas, green

potatoes

sweet potatoes

spinach

tomatoes, processed

berries

strawberries

Map | Satellite

Nitrate leaching results

Crop: **alfalfa**

Dominant component: **Tujunga**

● Imperial Units   ○ Metric Units

Water Dynamics

Annual Values	Median	Min	Max
Rainfall (in)	15.9	4.3	21.7
Irrigation water (in)	73.4	73.4	73.4
Deep percolation (in)	36.1	31.1	43.7
Runoff (in)	0.0	0.0	0.0
Leaching fraction (%)	41	38	49
Irrigation efficiency (%)	100	100	100

Nitrate Dynamics

Nitrate applied (lb/ac):   −   11 ⇕   +

Annual Values	Median	Min	Max
Nitrate leached (lb/ac)	3.7	2.2	4.8
Leaching fraction (%)	33	19	43
Nitrate concentration in leaching water (ppm)	0	0	1

Nitrate leaching results

Crop: lettuce

Dominant component: San Joaquin

This component contains a cemented layer:

- ● Include cemented layer
- ○ Ignore cemented layer

- ● Imperial Units   ○ Metric Units

Water Dynamics

Annual Values	Median	Min	Max
Rainfall (in)	15.9	4.3	21.7
Irrigation water (in)	21.3	21.3	21.3
Deep percolation (in)	0.0	0.0	0.0
Runoff (in)	30.6	21.9	35.9
Leaching fraction (%)	0	0	0
Irrigation efficiency (%)	0	0	0

Nitrate Dynamics

Nitrate applied (lb/ac):   -   193 ⬍   +

Annual Values	Median	Min	Max
Nitrate leached (lb/ac)	0.0	0.0	0.0
Leaching fraction (%)	0	0	0
Nitrate concentration in leaching water (ppm)	0	0	0
Nitrate leaching hazard index	0.0	0.0	0.0

Nitrate leaching results

Crop: **lettuce**
Dominant component: **San Joaquin**
This component contains a cemented layer:

- ○ Include cemented layer
- ● Ignore cemented layer
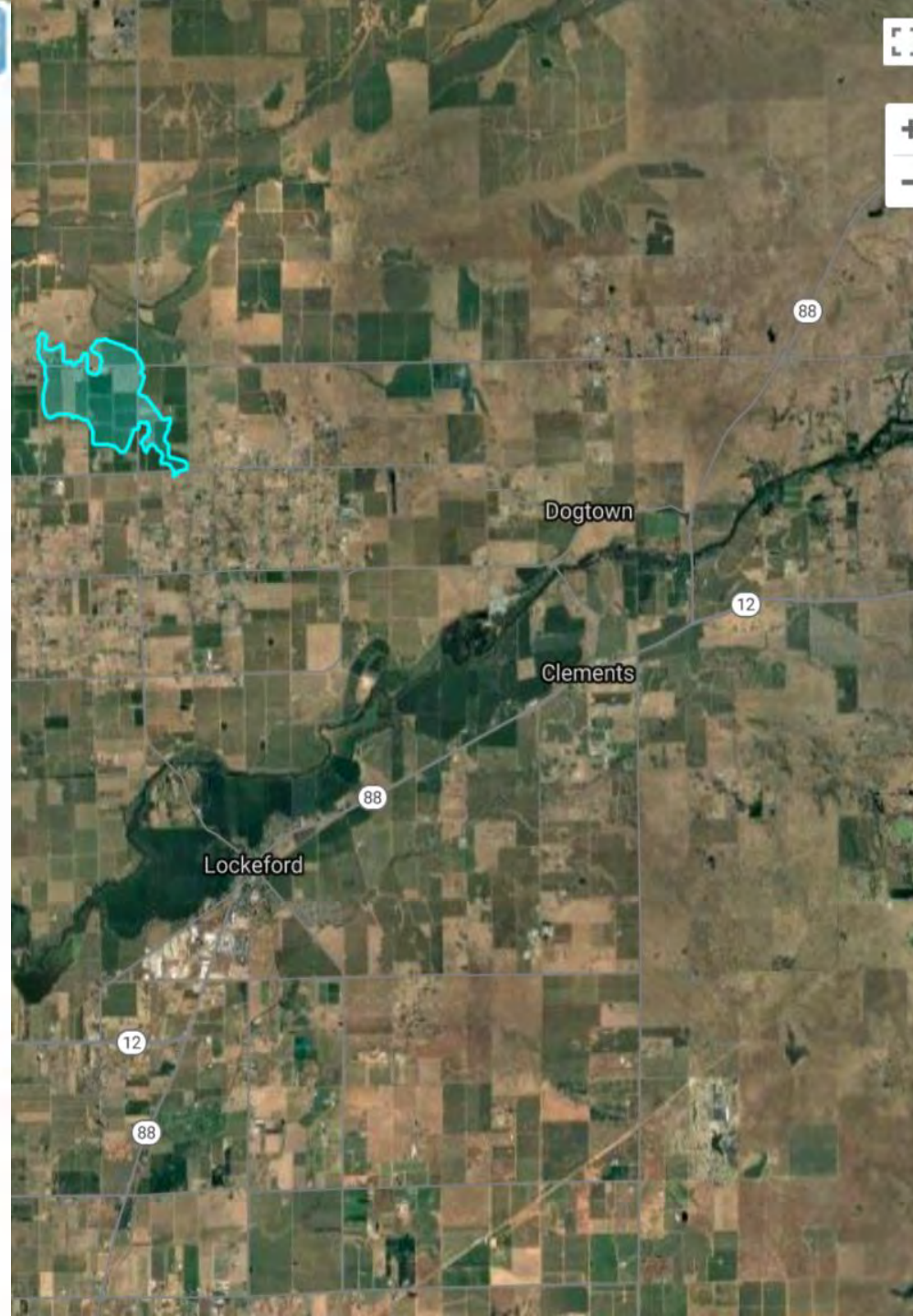
- ● Imperial Units   ○ Metric Units

Water Dynamics

Annual Values	Median	Min	Max
Rainfall (in)	15.9	4.3	21.7
Irrigation water (in)	21.3	21.3	21.3
Deep percolation (in)	12.9	12.8	13.0
Runoff (in)	18.5	10.5	20.9
Leaching fraction (%)	37	31	46
Irrigation efficiency (%)	0	0	0

Nitrate Dynamics

Nitrate applied (lb/ac):   -   193 ⇕   +

Annual Values	Median	Min	Max
Nitrate leached (lb/ac)	71.3	53.0	75.9
Leaching fraction (%)	37	28	39
Nitrate concentration in leaching water (ppm)	24	22	26
Nitrate leaching hazard index	0.0	0.0	0.0
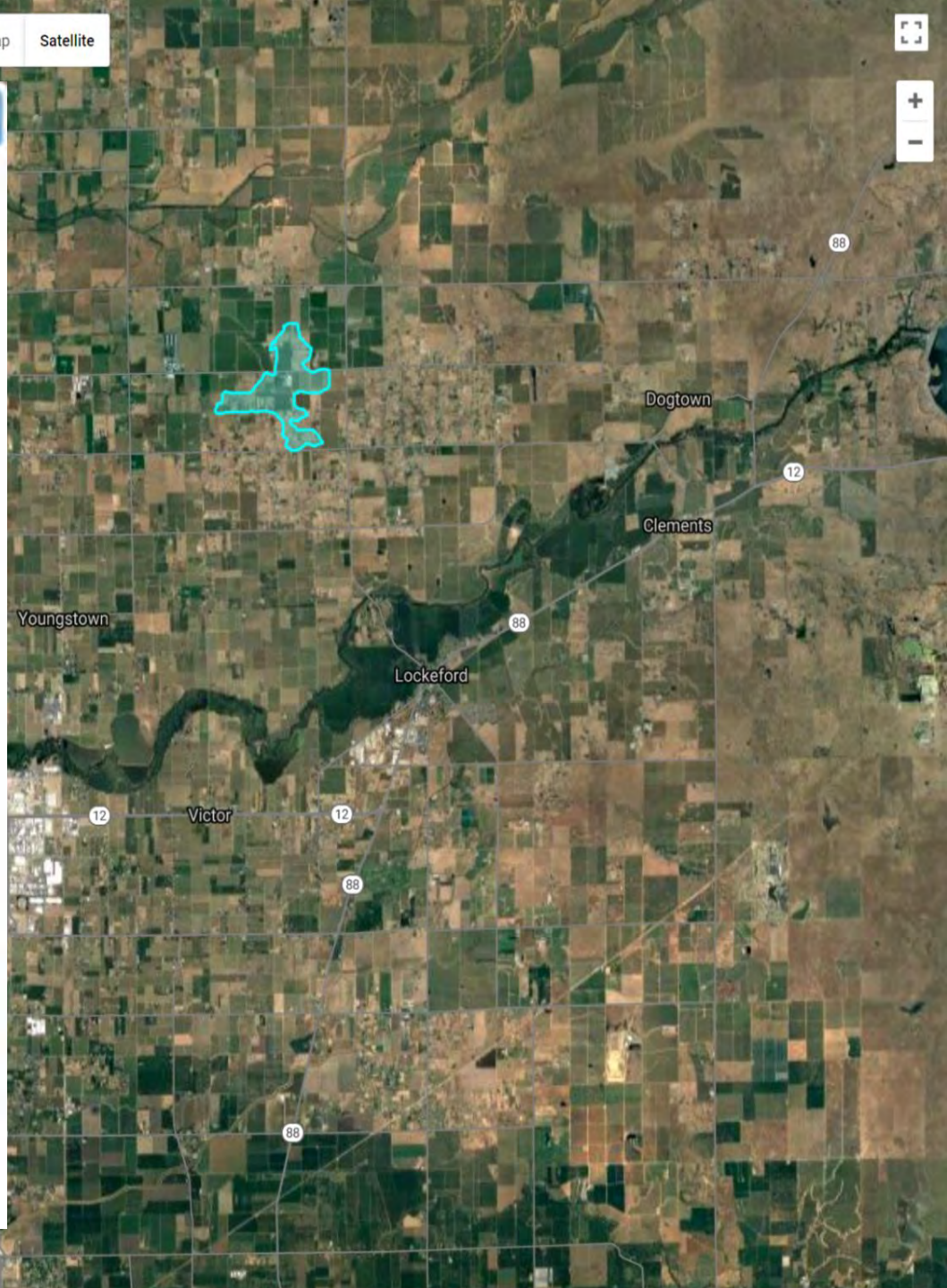
Future Work: Add Other Fertilization Schemes

- Pre-plant: 1 time at stage A

- In season: 1 time around B

- Spoon fed: for tomatoes and trees only 6 times A-D.
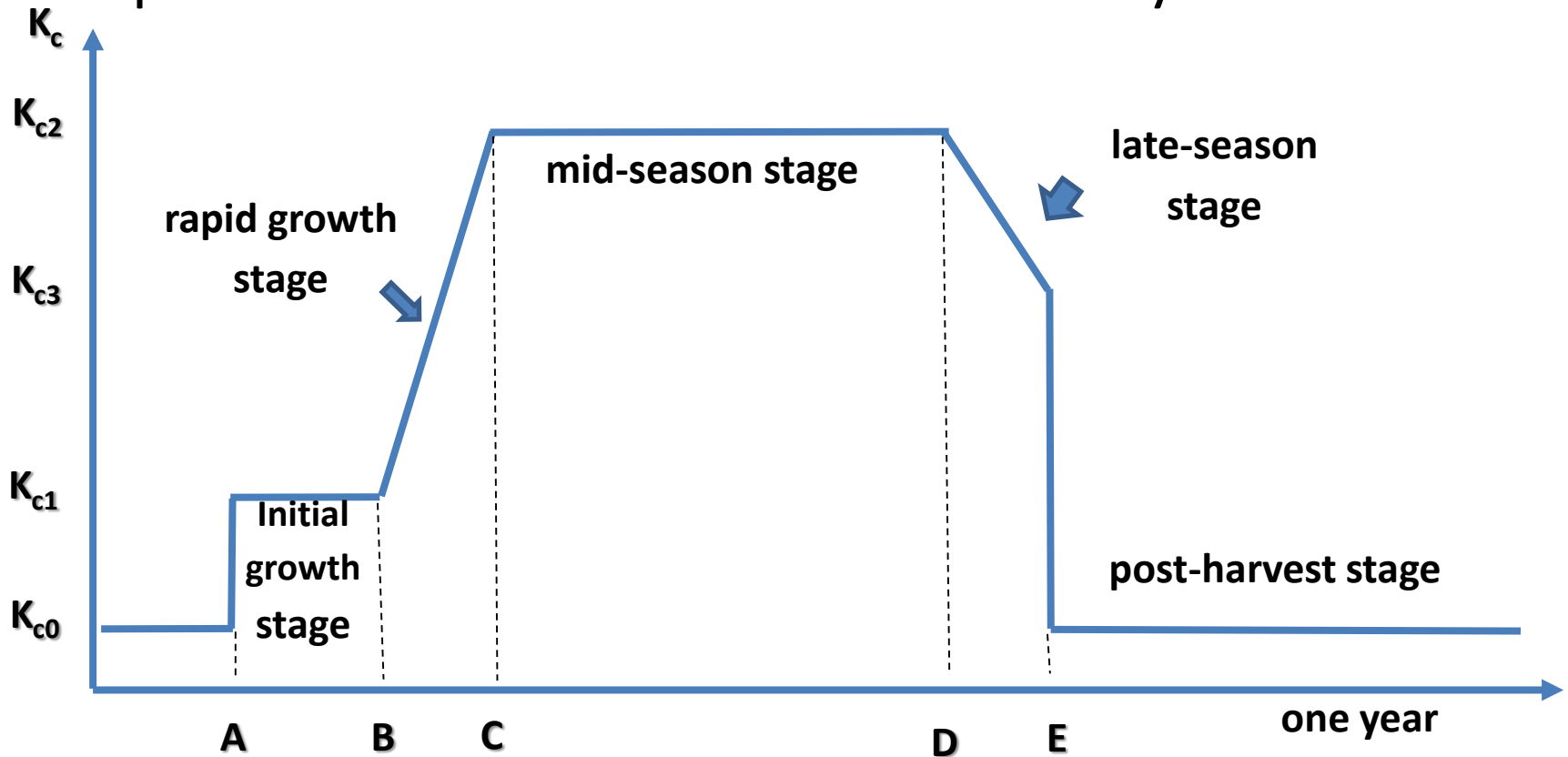
Future Work: Evaluate Irrigation

Simulate nitrate leaching over different irrigation efficiencies to generally reflect different types of irrigation.

Flood - 60% irrigation efficiency

Sprinkler -75% irrigation efficiency

Drip - 90% irrigation efficiency

Use it with Other Apps:
https://casoilresource.lawr.ucdavis.edu/soilweb-apps

Soil Data Explorer - HANFORD

OSD | Lab Data | Component Association | Series Association | Block Diagrams | Map Units | Extent

Competing Series

Lab Data Summary

Aggregate lab data for the HANFORD soil series. This aggregation is based on all pedons with a current taxon name of HANFORD, and applied along 1-cm thick depth slices. Solid lines are the slice-wise median, bounded on either side by the interval defined by the slice-wise 5th and 95th percentiles. The median is the value that splits the data in half. Five percent of the data are less than the 5th percentile, and five percent of the data are greater than the 95th percentile. Values along the right hand side y-axis describe the proportion of pedon data that contribute to aggregate values at this depth. For example, a value of "90%" at 25cm means that 90% of the pedons correlated to HANFORD were used in the calculation. Source: KSSL snapshot as of September 2017. Methods used to assemble the KSSL snapshot used by SoilWeb / SDE
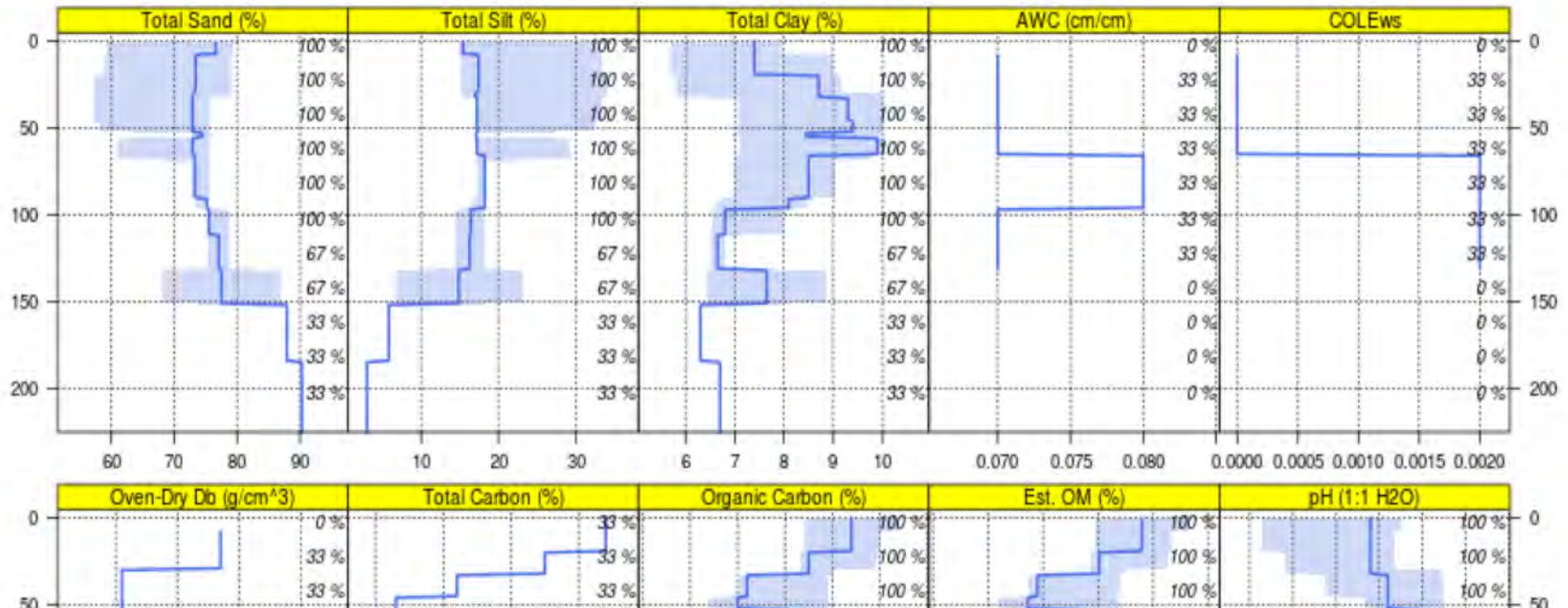
Thank You

Project Funding: CDFA-FREP Grant Program

Key collaborators: Daniel Geissler, Helen Dahlke, Will Horwath

For more information about soil survey apps:

https://casoilresource.lawr.ucdavis.edu/soilweb-apps/

Crops

Category	Number of Crops	Model Parameters
Subtropical	7	
Tree Fruit	9	
Nuts	3	
Cotton	1	• Root Zone
Field crops	8	• Kc function
Grain and Hay	4	• Feddes' parameter
Rice	1	• N Application rates
Vegetables and Berries	22	• Split ET to E and T

Climate

the nitrogen cycle

starts with fixing nitrogen from the air

key
- hydrogen
- carbon
- oxygen
- nitrogen
- NO nitric oxide
- N₂O nitrous oxide
- NO₂ nitrite
- NO₃ nitrate
- NH₃ ammonia
- NH₄ ammonium

bacteria

lightning

Haber-Bosch
NEW

since 1913

methane

3-5% of the world's natural gas

magnetite

iron oxide

THOR of the SOIL

ATP

ammonia volatizes

aminization

ammonification

eutrophication

the atmosphere
78% N₂
21% O₂
<1% Argon

feces
5.5-6.5% N
(dry basis)

urine
15-18% N
(dry basis)

what can you do with N?

nucleotides
require nitrogen

nitrification
part 1   part 2

denitrification

make proteins
like
enzymes,
antibodies,
& hormones
& DNA

clay binds
ammonium

groundwater