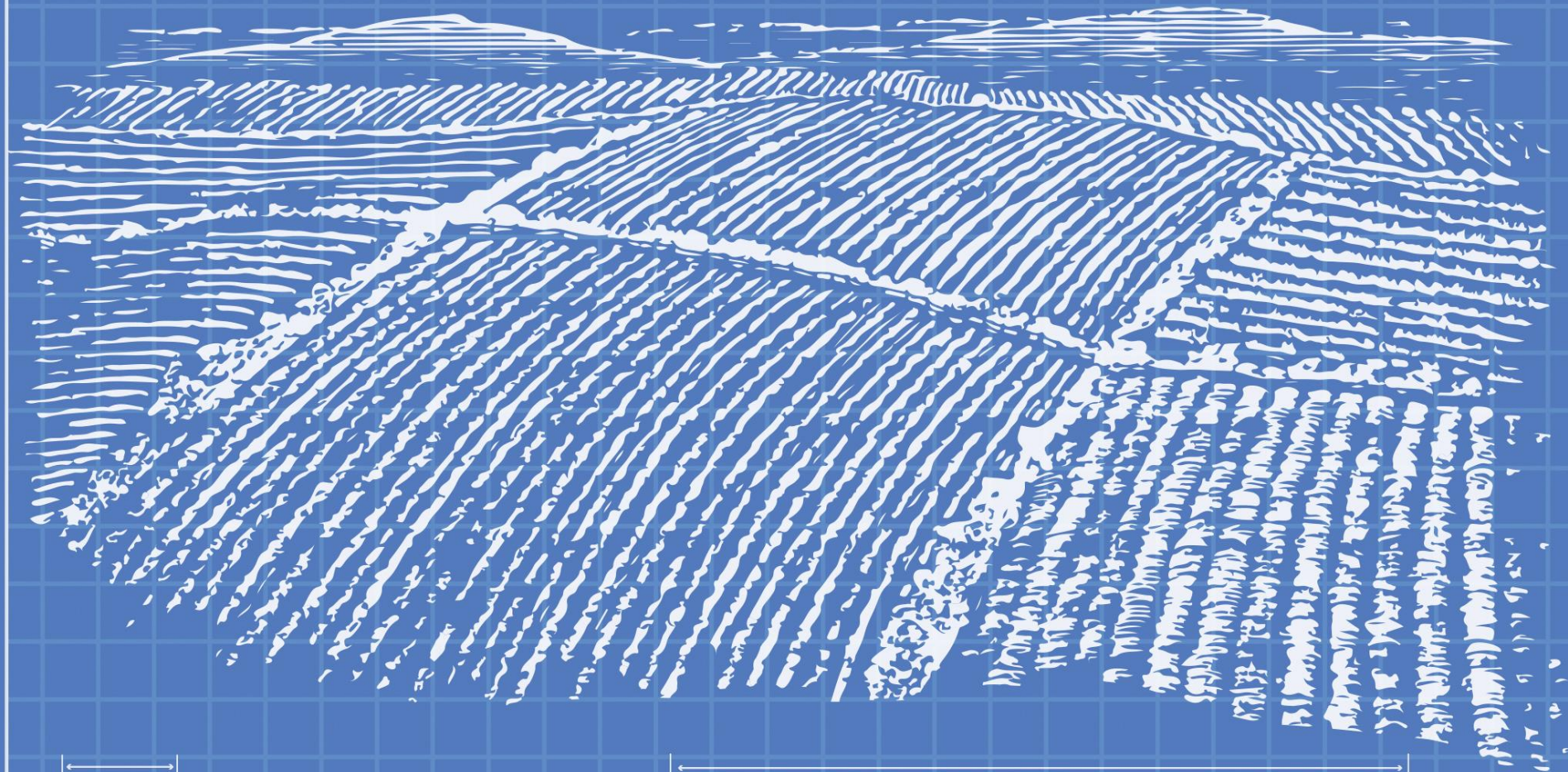

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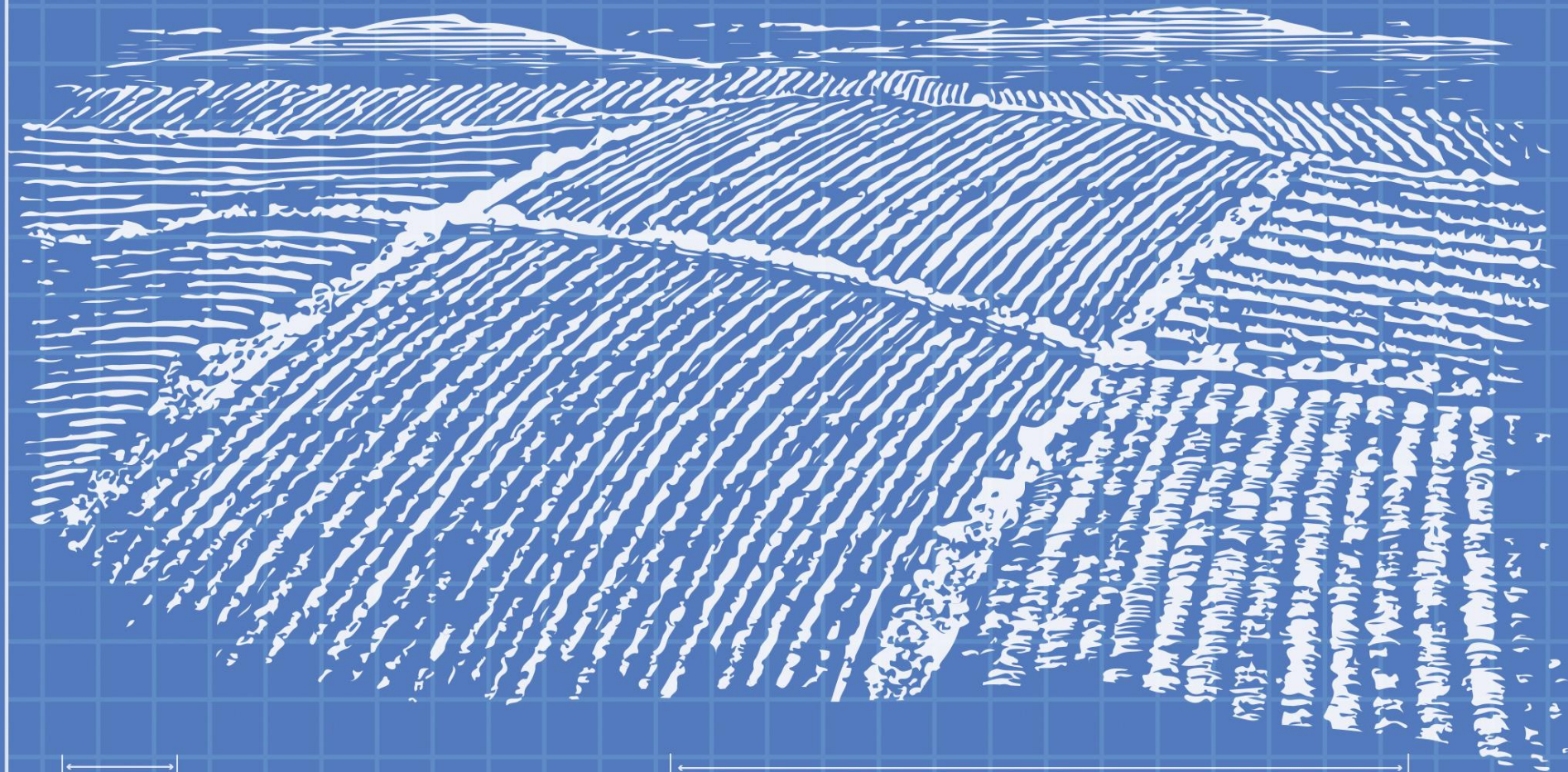
Framing Climate Solutions through Soil Health

Deborah Koons Garcia filmmaker, *Symphony of the Soil*
Louise Jackson UC Davis
Jenny Lester Moffitt California Department of Food and Agriculture
Michelle Buffington Air Resources Board



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Framing Climate Solutions through Soil Health

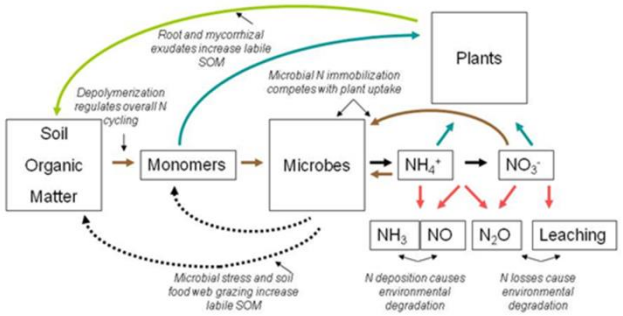
Louise Jackson, Professor and Extension Specialist

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

CCOF Annual Meeting, Sacramento
February 29, 2016

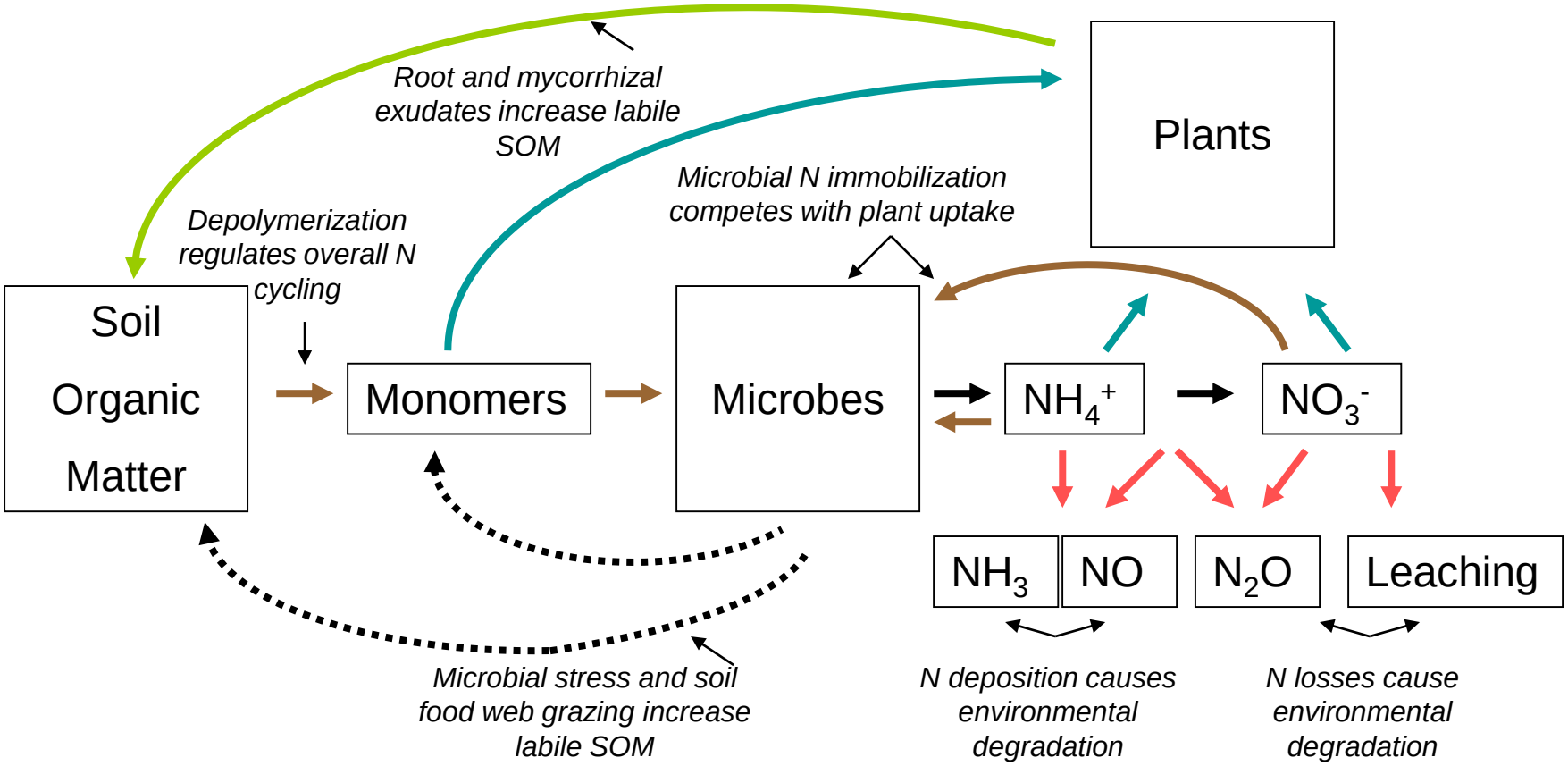
Soil carbon & nitrogen on organic farms

- Organically-farmed soils: increase soil carbon (C)
  - Diverse inputs (*e.g.*, compost, cover crops, manure)
  - Soil C builds slowly; microbial C builds faster
  - Soil organic matter (SOM) benefits: nutrient release, water-holding capacity, infiltration, soil disease suppression
- Organically-farmed crops: susceptible to N limitations
  - Rely on organic matter inputs and microbial activity
  - Timing of inputs difficult to match with crop demand
- Nitrous oxide (N_2O): greenhouse gas emissions with 298x the impact of carbon dioxide (CO_2)
  - Mainly from synthetic fertilizers
  - In California, agricultural soils emit 6.8 MMT (million metric tons) of carbon dioxide equivalents (CO_2E) as N_2O,
  - 23% of agricultural GHG emissions and >1.5 percent of overall GHG emissions
    - This equals the GHG emissions of 1.4 million of California's 20.7 million cars
- How to achieve high yields and low N_2O emissions?

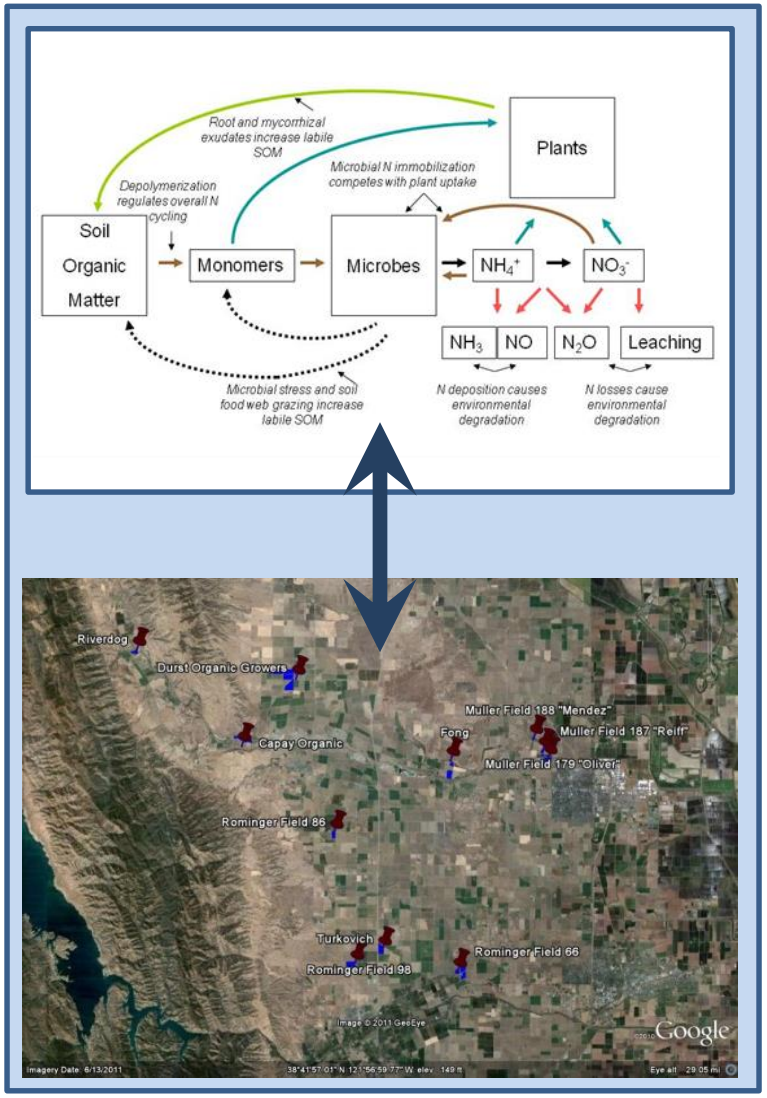


http://ucanr.edu/sites/Nutrient_Management_Solutions/stateofscience/Nitrous_Oxide__In_focus/#N20_basic

Plant-soil-microbe nitrogen cycling



Yolo County comparison of organic farms



- 13 organic farm fields
  - Representative selection of all organic roma tomato fields in Yolo County
- Detailed analysis of plant-soil interactions
  - Soil N and C pools, plant growth and nutrients, soil microbial biomass and enzyme activity, root gene expression of N metabolism genes
- Did any farm fields exhibit tightly-coupled plant-soil nitrogen cycling and good yields?

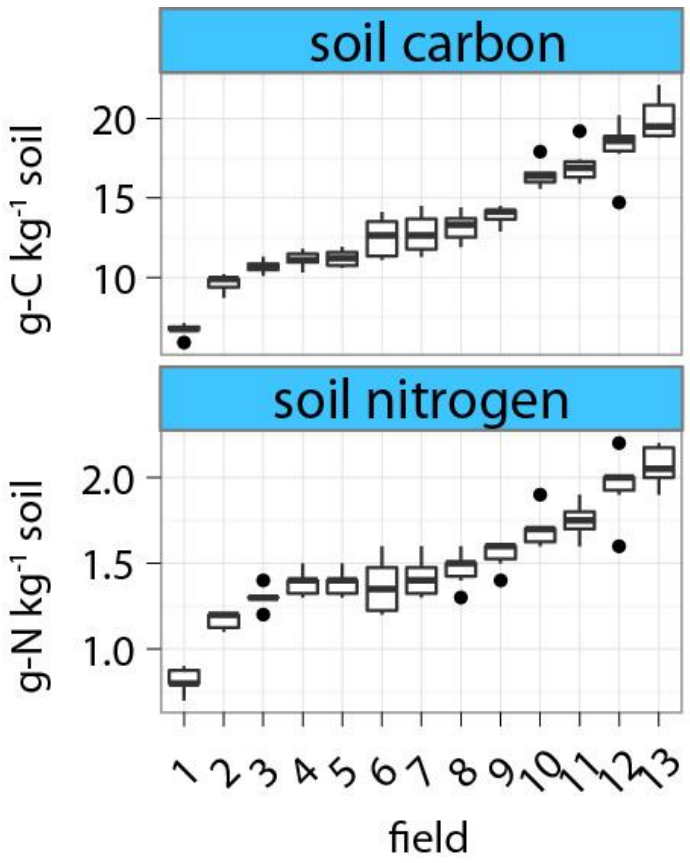
Bowles et al., 2015a, 2015b, 2014

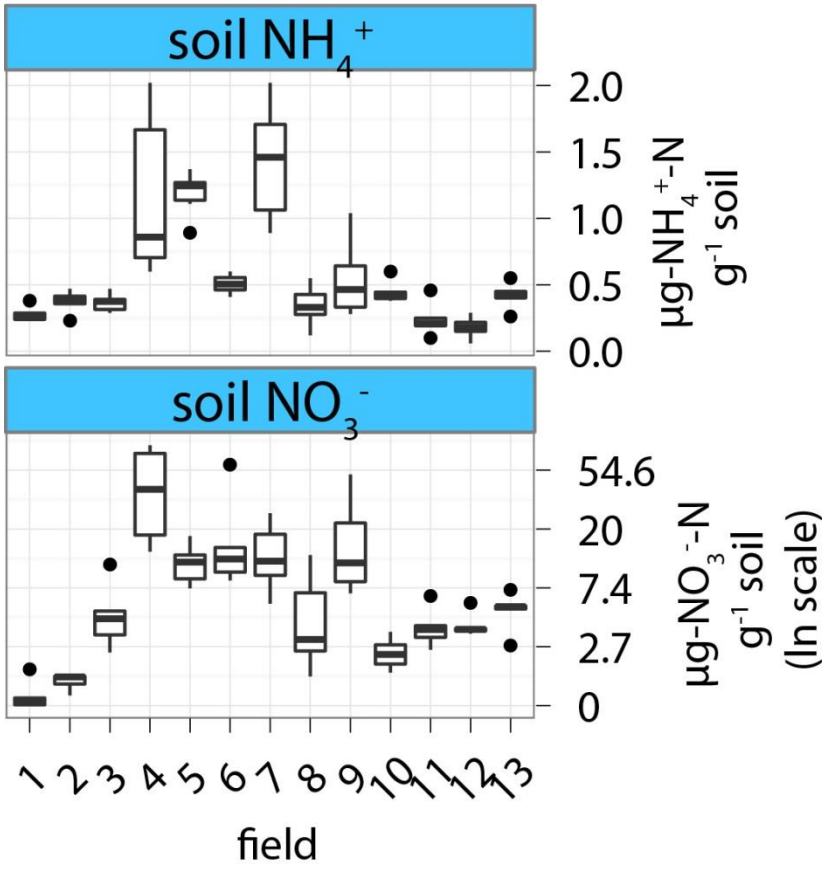
Management practices used on 13 organic Roma-type tomato fields

Farm	Fields	Certified	Market	Primary organic inputs	Secondary inputs	Irrigation
A	1-3	Mixed	Processing	poultry/cow manure (fall)	none	Furrow
B	4	All	Fresh	vetch winter cover crop	guano, soluble	Drip
C	5	Mixed	Processing	poultry manure (spring)	none	Drip
D	6, 9	All	Processing	poultry litter (fall), vetch winter cover crop	guano	Furrow
E	7	All	Fresh	composted green waste (fall), vetch winter cover crop	pellets, soluble	Drip
F	8	All	Fresh	composted green waste (fall)	pellets, soluble	Drip
G	10,11,13	Mixed	Processing	composted green waste (fall)	Chilean nitrate	Furrow
H	12	All	Fresh	composted green waste (fall)	soluble	Drip

SOM and inorganic N across the farms

- 3-fold range of total soil C (0.67 – 2.0 %) and N (0.08 – 0.21 %)
- Soil NH_4^+ low, but large variability in soil NO_3^- (0.19 – 44.9 µg-N g^{-1} soil)





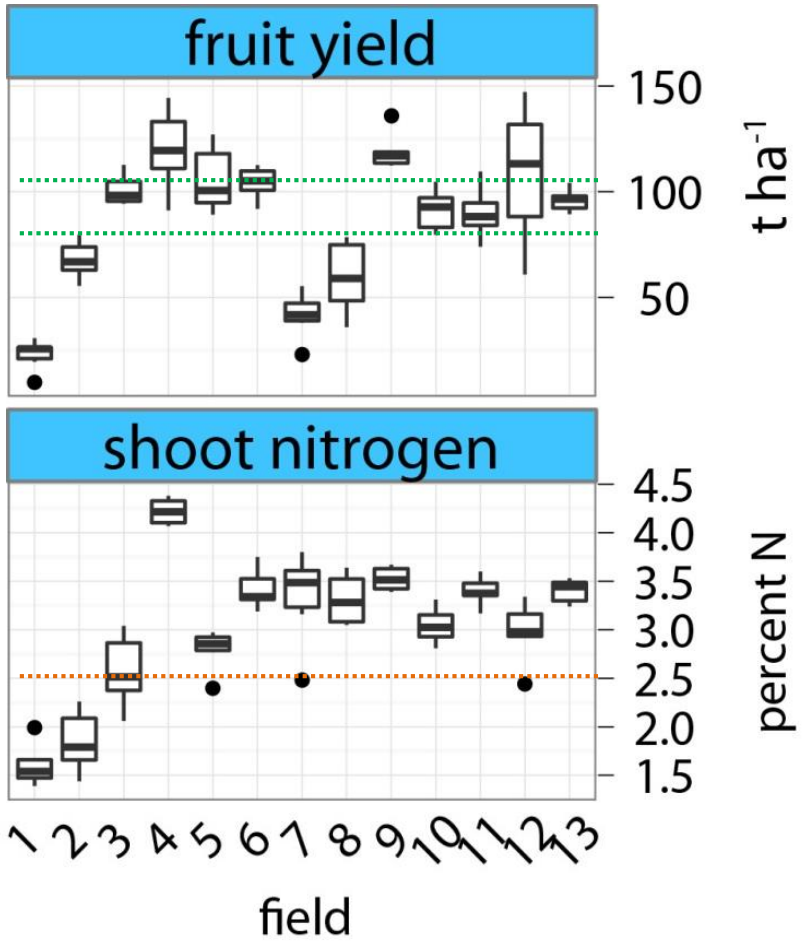
Bowles et al., 2015a, 2015b, 2014

Crop productivity and N

Average 2011 CA production: 107 t/ha (conventional and organic)

Average 2011 Yolo Co production: 86 t/ha (conventional and organic); (38.4 tons/acre)

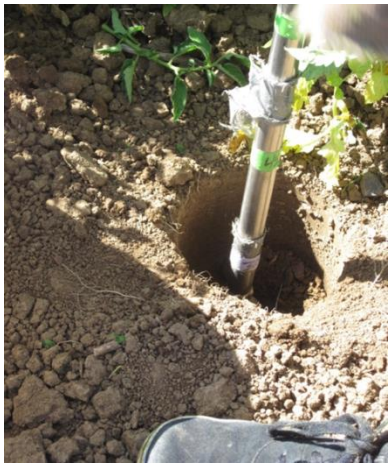
N deficient (<2.5% N)



- 9/13 fields close to overall CA average for processing tomatoes
- 11/13 fields above critical shoot N level
- Thus, overall good yields and adequate N for most fields.

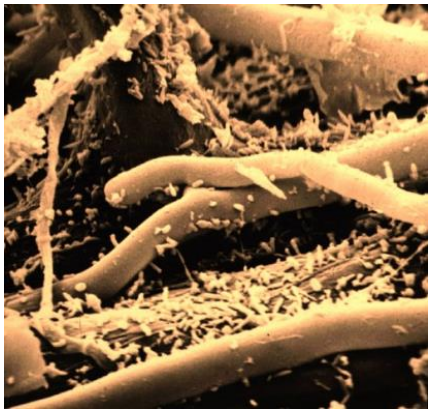
Bowles et al., 2015a, 2015b, 2014

Putting it all together



Plant & soil measurements reveal three scenarios on working farms:

- N deficient
- N saturated
- Tightly-coupled plant-soil N cycling (most desirable)



Tightly-coupled plant-soil N cycling occurs with higher soil C contents, an active soil microbial biomass, and soil enzymes that release N.

Root N uptake is high with tightly-coupled N cycling. Root N metabolism genes show a more positive response to soil microbial bioassays than to inorganic N.

Bowles et al., 2015a, 2015b, 2014

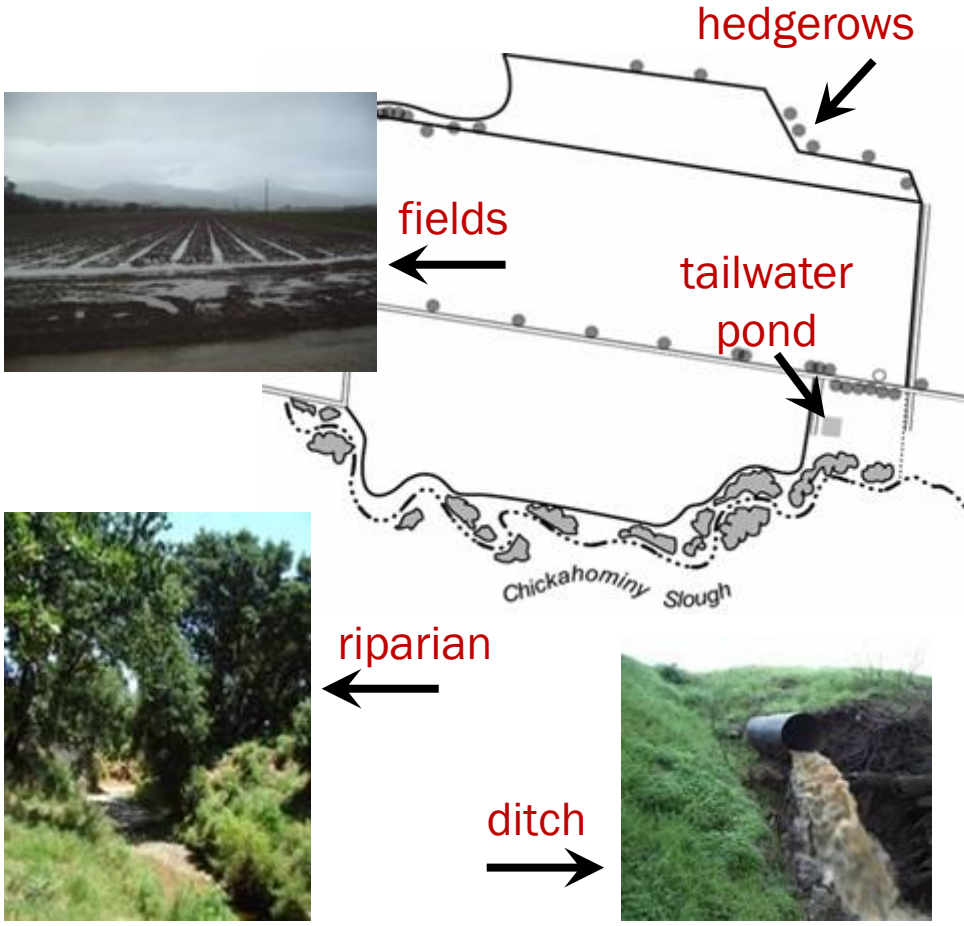
‘Healthy Soils’: N cycling on organic tomato farms

- Farms can produce well with tightly-coupled plant-soil N cycling
  - Tight N cycling associated with higher total C and N (SOM)
  - High SOM boosts microbial activity, which stimulates N release from SOM, and thus N meets plant needs
  - Very low SOM contributes to N deficiency
  - Management plays a big role too:
    - Short term: Using N inputs like guano contributes to higher soil NO_3^- and N saturation, especially when SOM is low
    - Longer term: Combination of organic matter inputs (cover crops, compost) may be best to build SOM and tight N cycling
- GHG mitigation: Tightly-coupled plant-soil N cycling decreases soil NO_3^-, so less potential loss by leaching and N_2O emissions
- Other co-benefits of SOM potentially contribute to adaptation and resilience (e.g. water-holding capacity; soil food web)

Biodiversity and ecosystem services across an organic farm

- Several habitats (6) on an organic farm
  - Yields, nutrients, leaching, runoff, GHG emissions, C storage
  - Plant, nematode & soil microbial diversity
- Selecting a farmscape
  - Similar soil in all habitats
  - Participatory research
  - Monitoring for 2 years

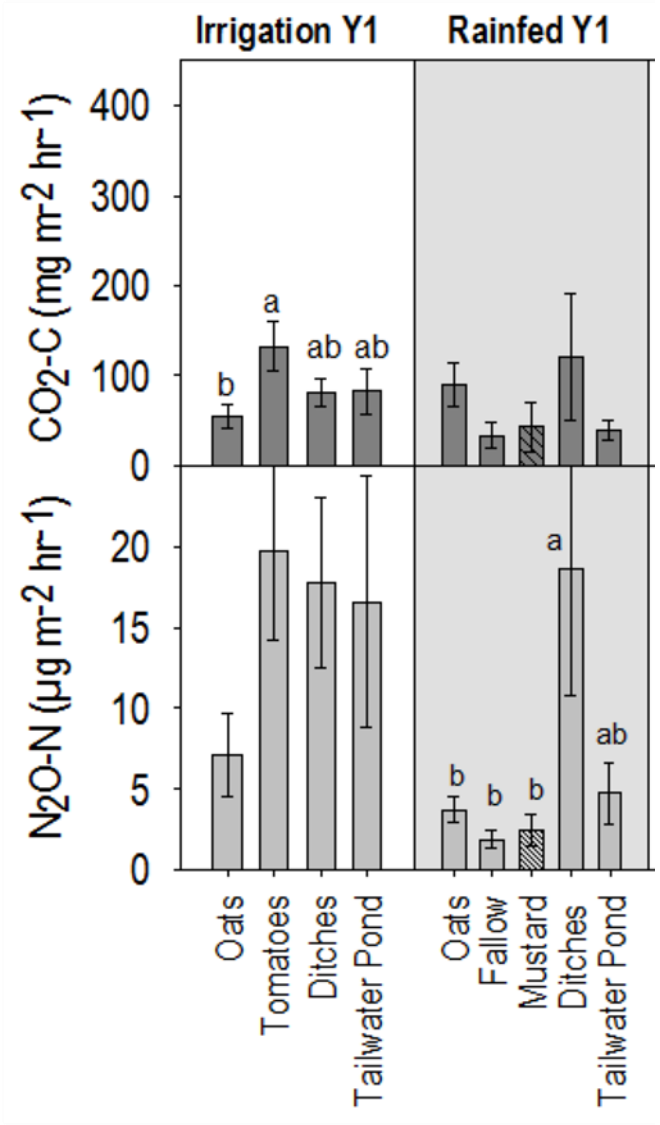
Smukler et al. 2010; 2012



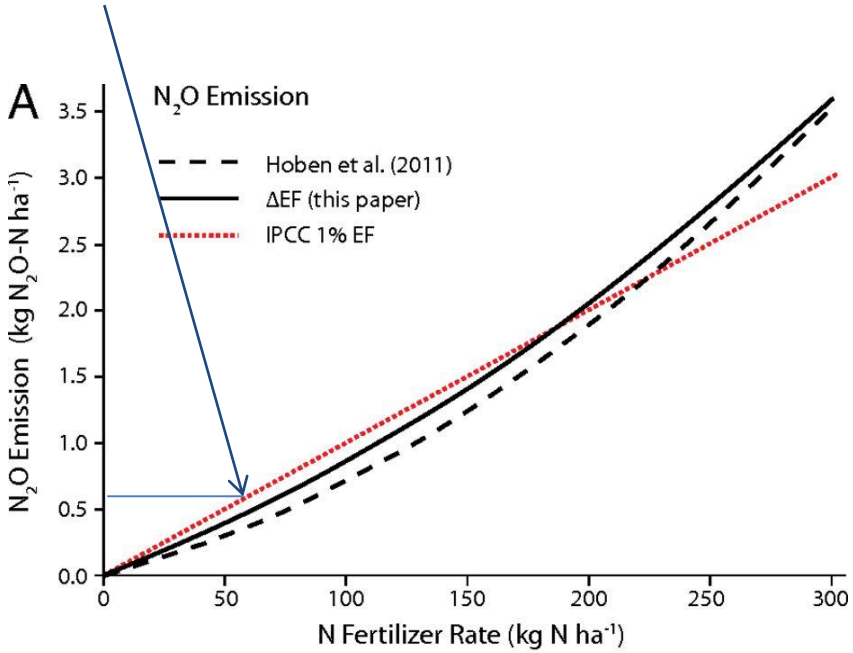
Tomato and grain fields, riparian, hedgerow, drainage ditch and pond habitats at Rominger organic farm in Yolo County, CA

Tracking biota, carbon and nutrients

Greenhouse gas emissions

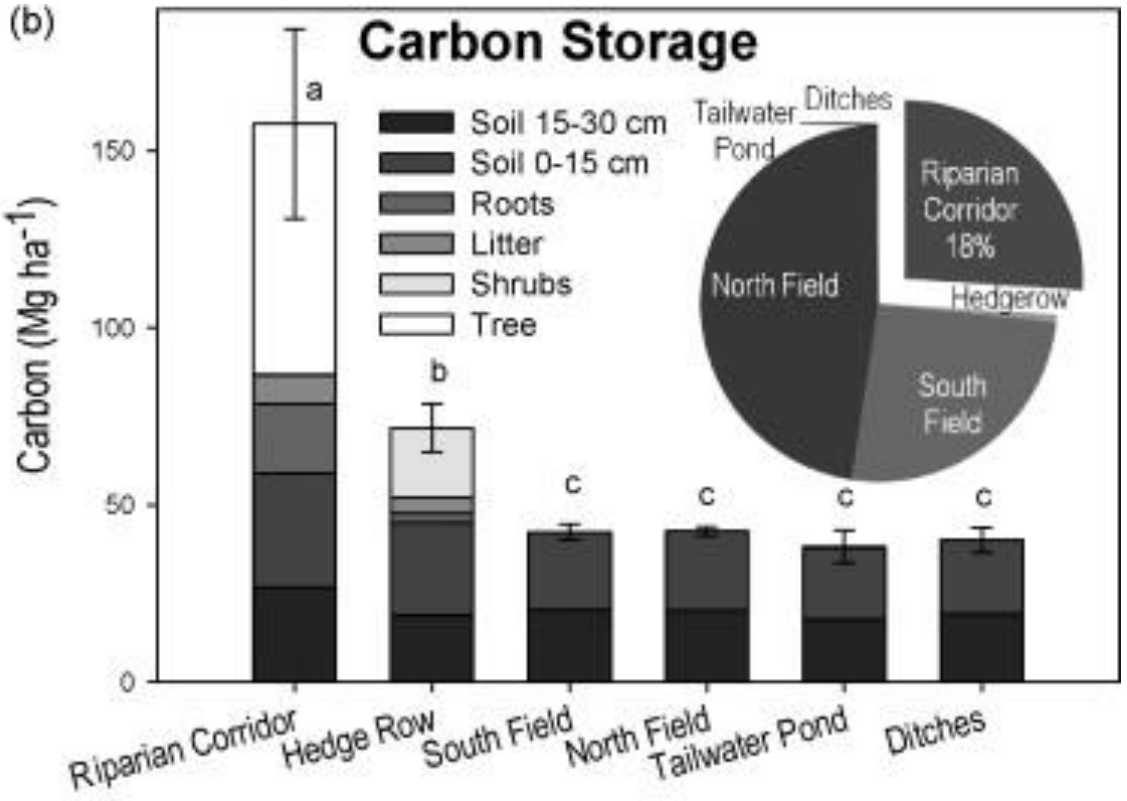


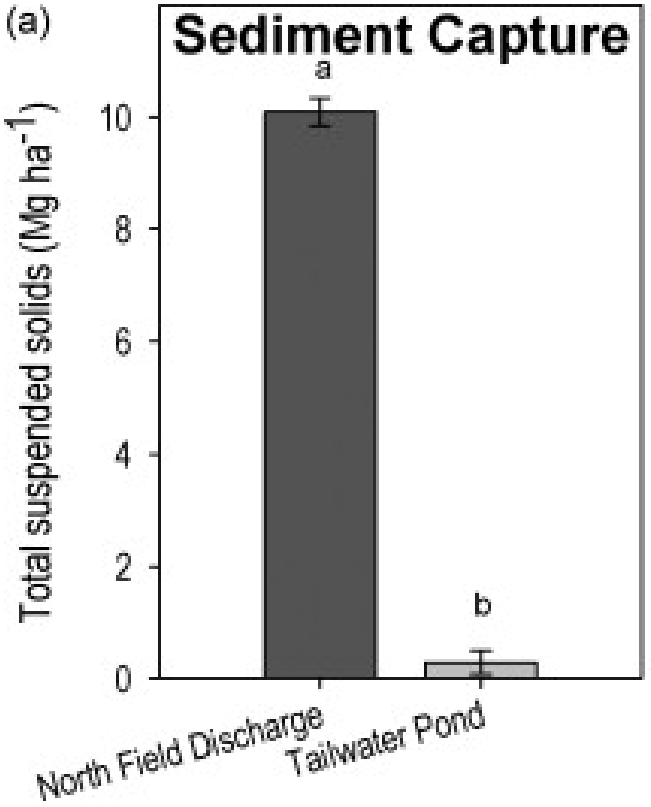
- Mean N_2O emissions <5 g ha^{-1} day^{-1} (0,004 lbs $acre^{-1}$ day^{-1})
- Very low N_2O emissions as compared to synthetic fertilizer studies
  - 0.6 kg N ha^{-1} $season^{-1}$



Shcherbak et al. 2014

Some benefits of farmscaping



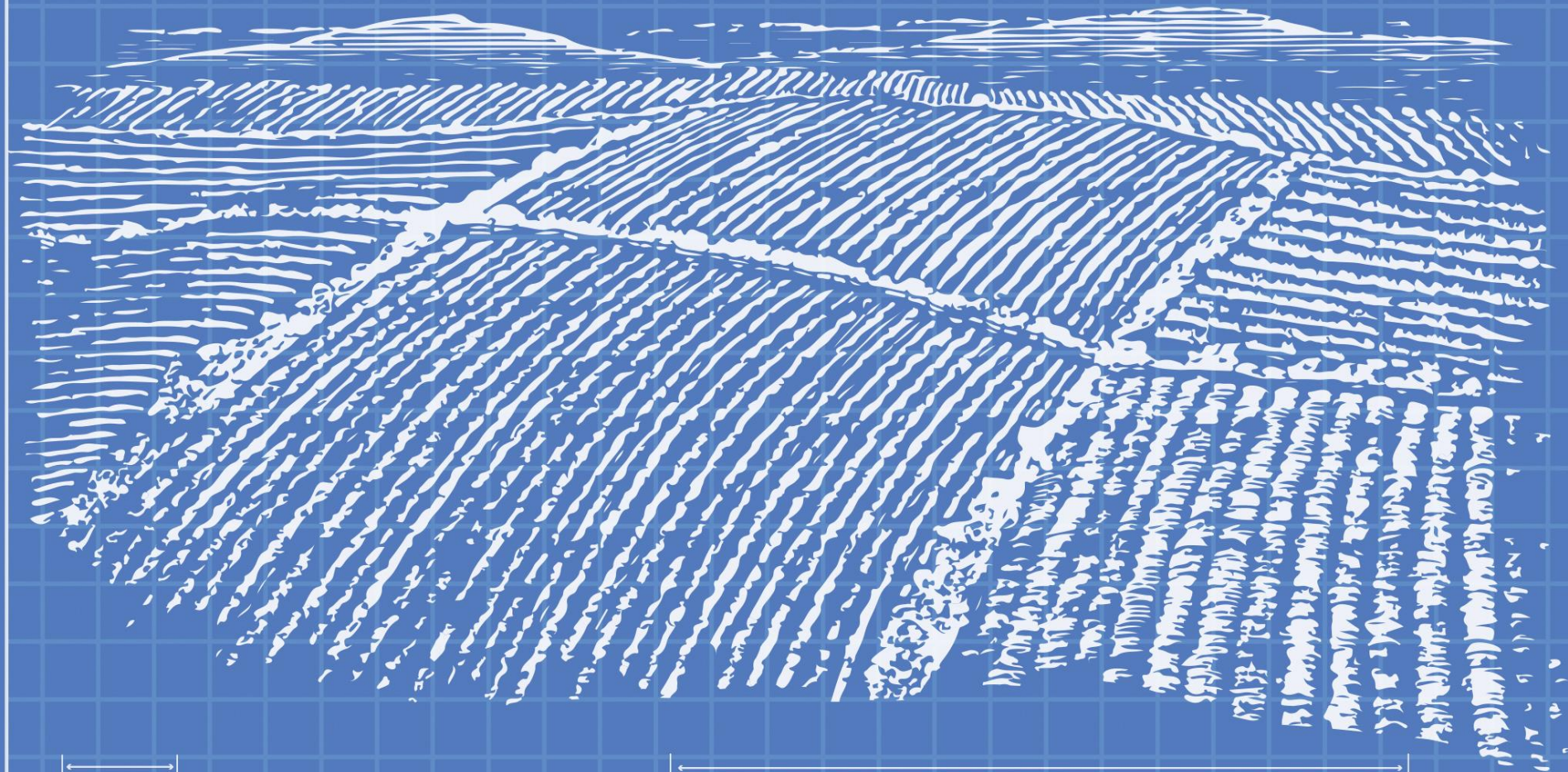


- Tailwater pond was very effective at capturing sediment
- Riparian corridor stores 18% of the farm's carbon (0-12" deep)
  -approx. 10% if calculated to 1 m deep

Smukler et al. 2010; 2012

Conclusions

- Organic management is conducive to building SOM and reducing the accumulation of soil nitrate, resulting in low potential for nitrous oxide emissions and leaching
- Yields of organic roma tomatoes match or exceed county averages for processing tomatoes under tightly-coupled plant-soil N cycling
- Each farmer had a unique approach to soil management, indicating several pathways forward
- Farmscaping with hedgerows and riparian management further contribute to reduction in greenhouse gas emissions.



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CLIMATE SMART AGRICULTURE and HEALTHY SOILS

February 29, 2016

CCOF Annual Meeting

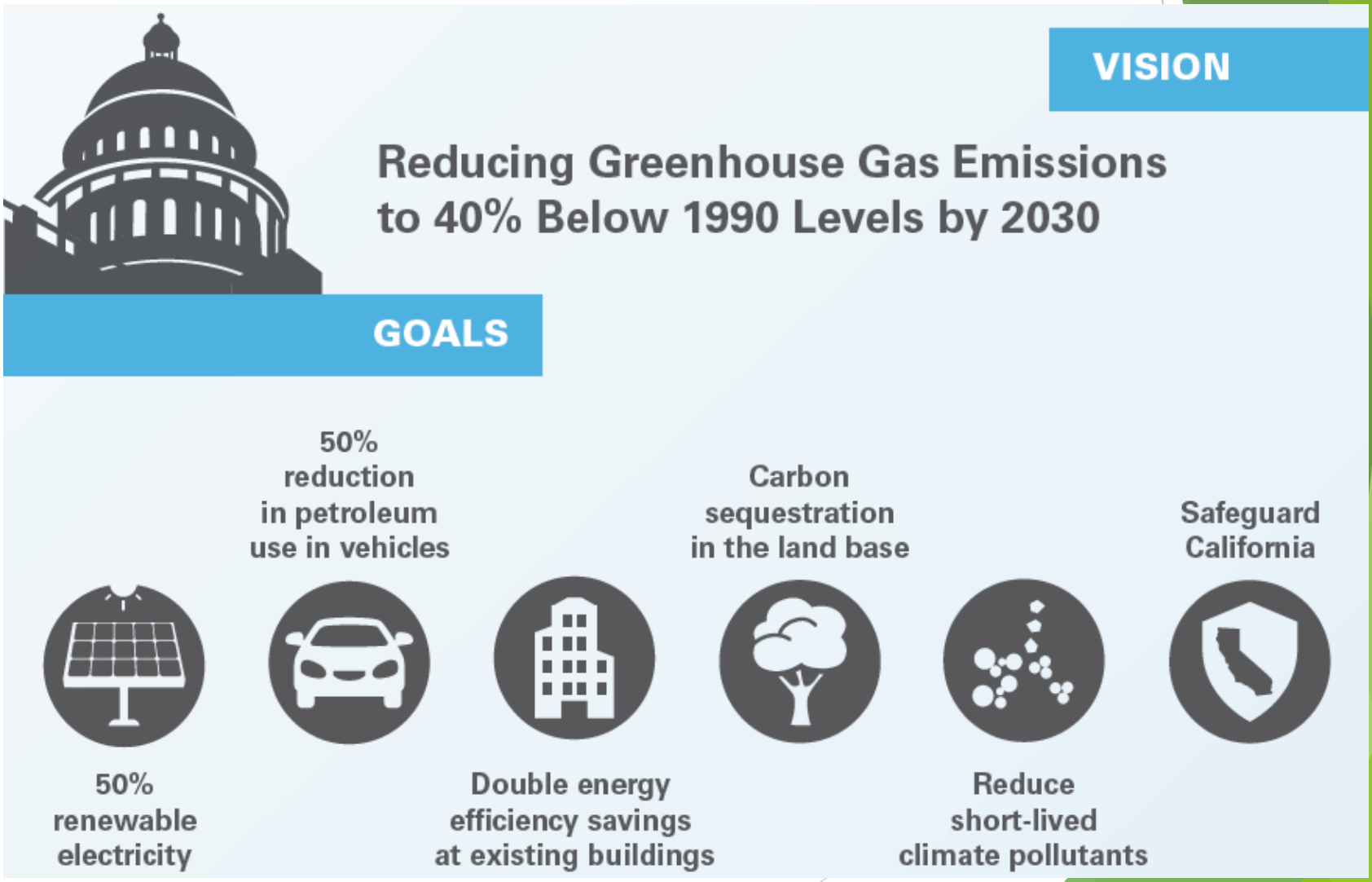
Jenny Lester Moffitt

Deputy Secretary

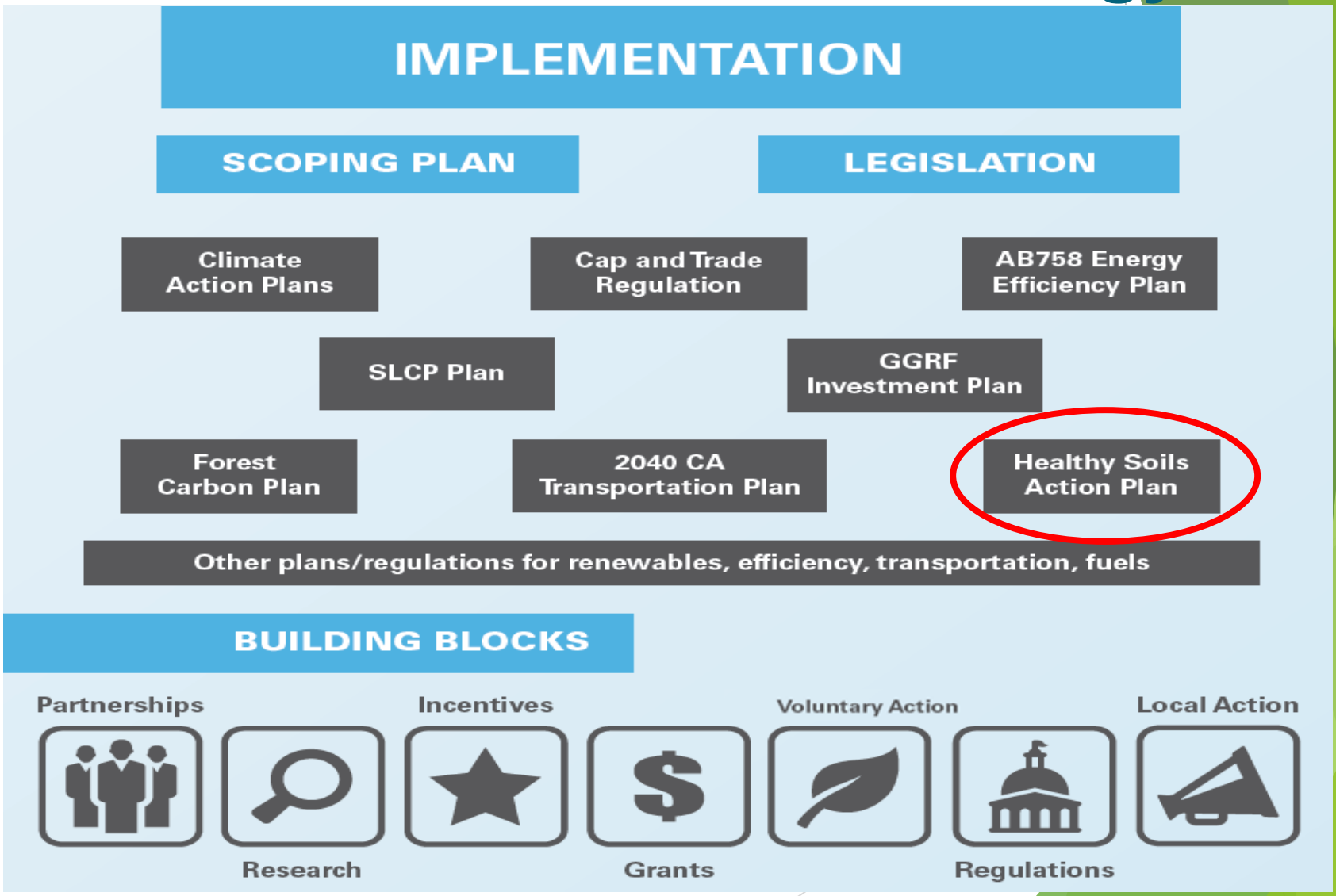
cdfa

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California's Climate Strategy



California's Climate Strategy



Climate Smart Agriculture

Climate Smart Agriculture is an integrated approach to achieving greenhouse gas (GHG) reductions while also ensuring food security in the face of climate change. .

The concept is defined by three main pillars:

- Sustainably increasing farm productivity and incomes.
- Adapting and building resilience to climate change.
- Reducing/removing greenhouse gas emissions, where possible.

California's working lands offer substantial opportunities to reduce GHG emissions while building resilience to maintain our food and economic security.

California's Climate Smart Ag Practices

- **Soil Carbon Sequestration** - Healthy Soils
- **Manure Management** - Dairy Digester Research and Development
- **Water Management** - State Water Energy and Enhancement Program (SWEEP)
- **Pollinators and Biocontrol** – Perennial plantings to support pollinators
- **Fine-tuning Fertilizers**
- **On-farm Renewable Energy** – Solar, wind, biomass and digesters
- **Agricultural Land Conservation**

Milestones: Investments & Achievements

Healthy Soils Initiative: Governor Brown incorporated this initiative into his most recent budget directing agencies to expedite efforts contributing to soil health and appointing CDFA as lead agency for this effort.

State Water Efficiency and Enhancement Program (SWEEP): $20 million invested to improve irrigation practices that save water, reduce energy use and reduce greenhouse gas emissions. An additional $40 million has been allocated through the state's Greenhouse Gas Reduction Fund.

Dairy Digester Research and Development Program: $12 million invested to develop and install dairy digester technology to turn emissions into energy.

Healthy Soils Initiative

An Interagency Plan to Reduce Greenhouse Gases and Improve Drought Resiliency by Innovating Farm and Ranchland Practices.

- **Climate Benefit**: Sequester and Reduce Greenhouse Gases
- Co-benefits
  - Increase water retention
  - Improve plant health and yields
  - Reduce sediment erosion and dust
  - Improve water and air quality
  - Improve biological diversity and wildlife habitat

cdfa CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

CALIFORNIA CONSERVATION

AIR RESOURCES BOARD

dpr

CalRecycle

CALIFORNIA Water Boards

DEPARTMENT OF WATER RESOURCES STATE OF CALIFORNIA

Land-base

Actions for the Healthy Soils Initiative

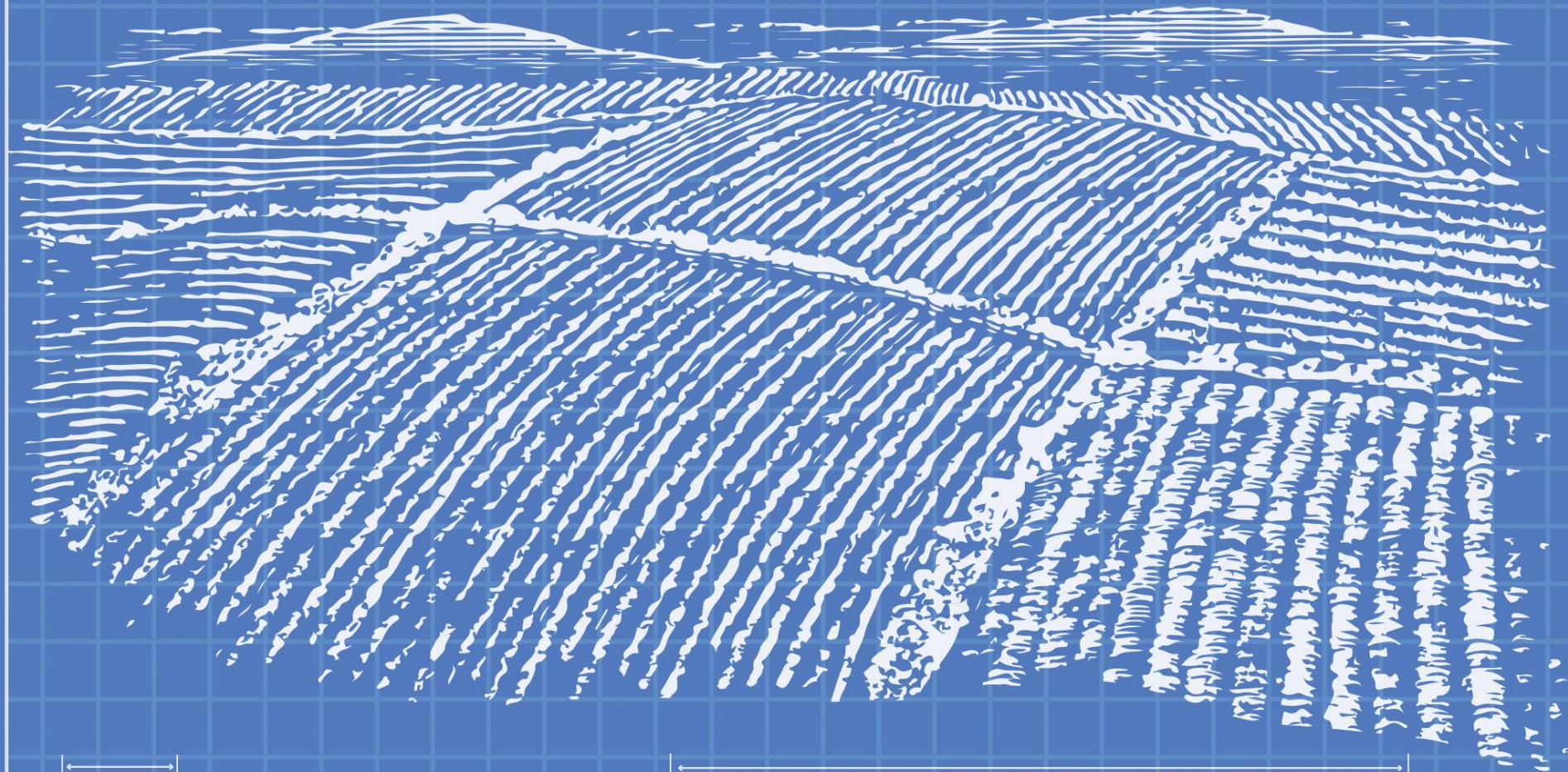
- **Protect and restore soil organic matter in California's soil**
  - Set goals for building soil organic matter
- **Identify sustainable and integrated financing opportunities**
  - To incentivize voluntary on-farm management practices
  - Governor 2016-17 Budget Proposal Healthy Soils: $20 million
- **Provide for research, education and technical support**
- **Increase governmental efficiencies to enhance soil health on public and private lands**
- **Promote interagency coordination and collaboration**

Land-base

Organic Systems and Soil Health

- **CFR §205.203 Soil fertility and crop nutrient management practice standard.**
  - (a) The producer must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion.
  - (b) The producer must manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials.
  - (c) The producer must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances

Thank you



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AB 32 and Agriculture

California Certified Organic Farmers Annual Conference
February 29, 2016

CALIFORNIA CLIMATE STRATEGY

An Integrated Plan for Addressing Climate Change

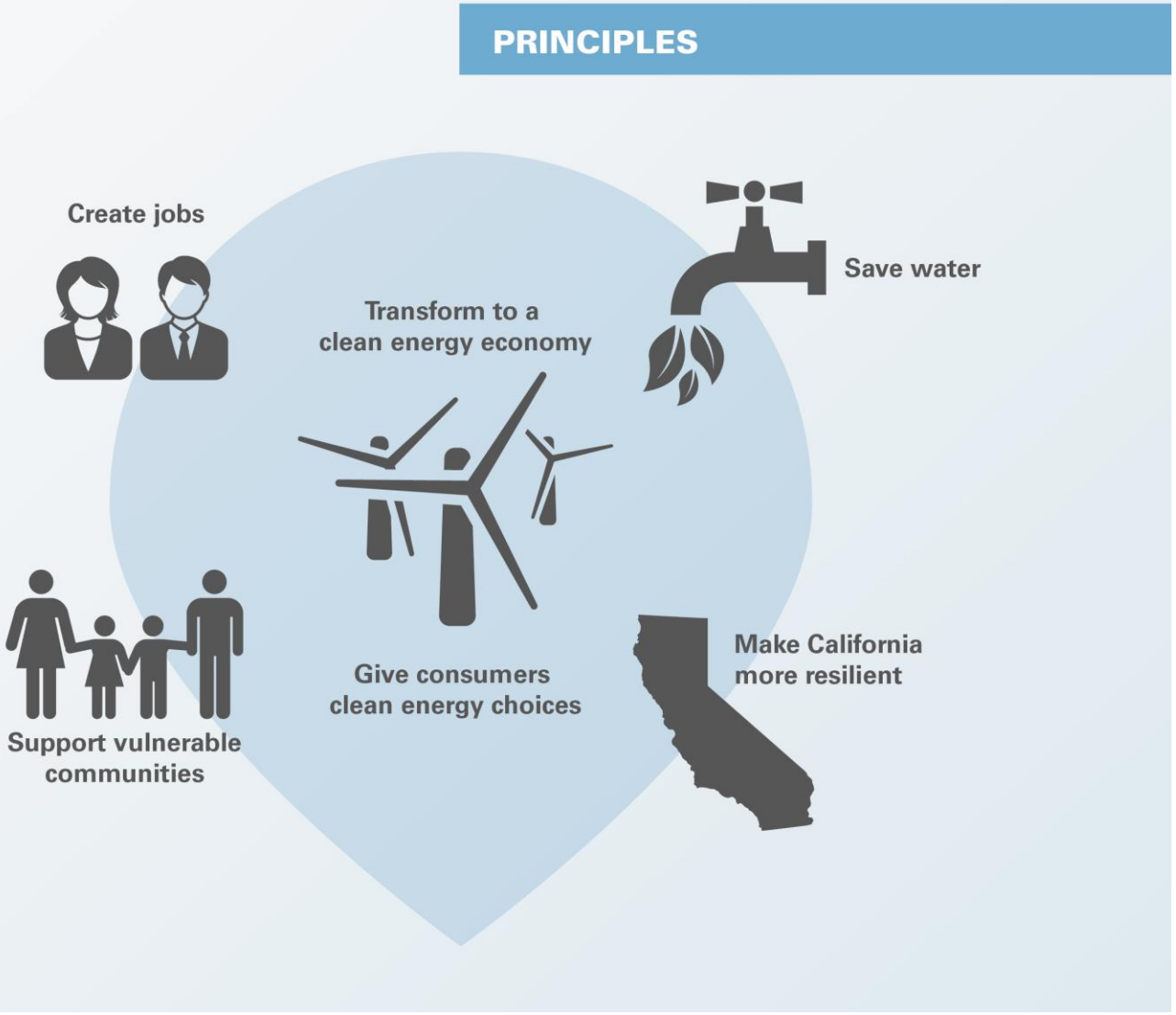
VISION

Reducing Greenhouse Gas Emissions to 40% Below 1990 Levels by 2030

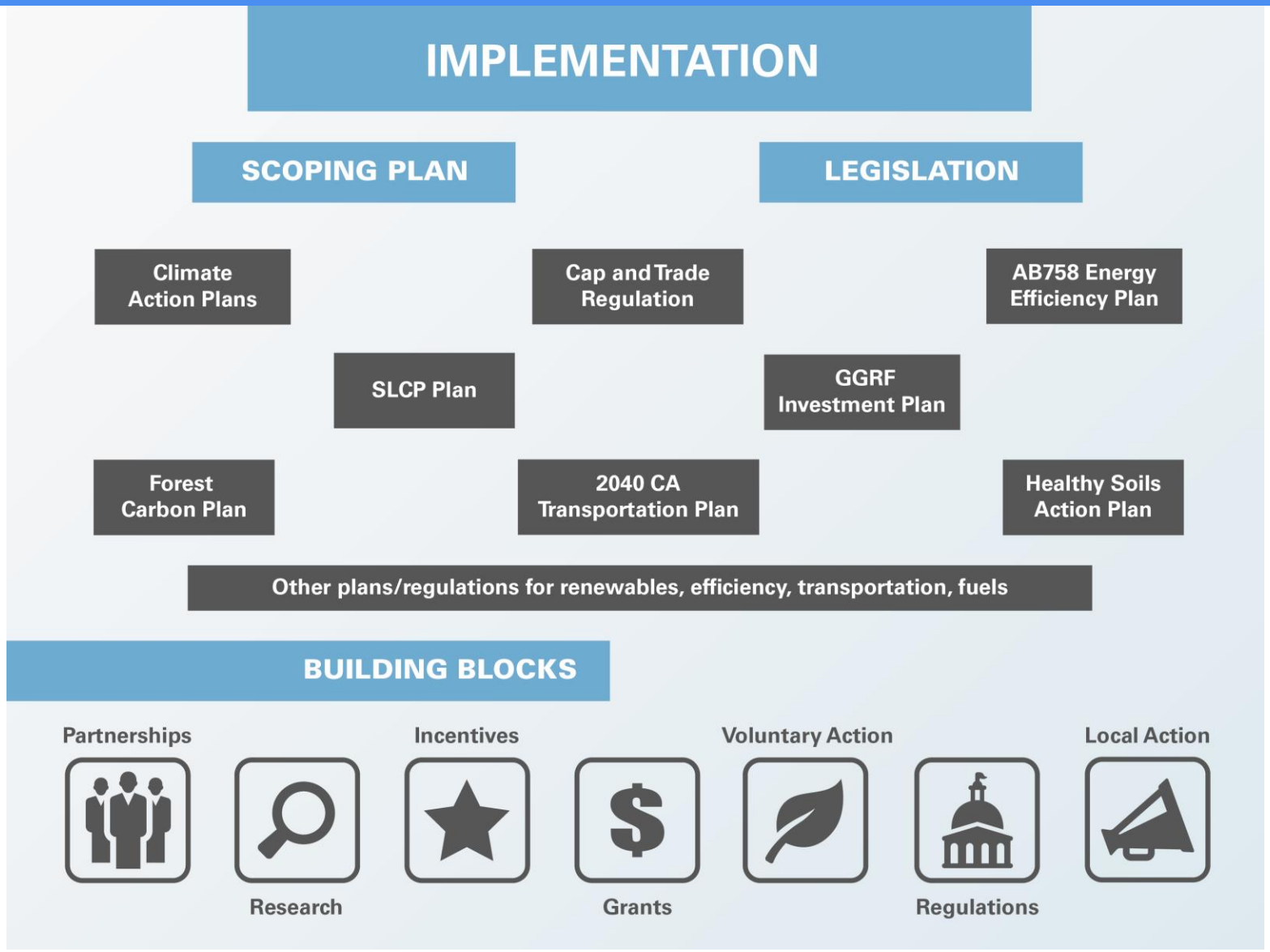
GOALS

- 50% renewable electricity
- 50% reduction in petroleum use in vehicles
- Double energy efficiency savings at existing buildings
- Carbon sequestration in the land base
- Reduce short-lived climate pollutants
- Safeguard California

CALIFORNIA CLIMATE STRATEGY



CALIFORNIA CLIMATE STRATEGY



AB 32 Objectives

- Develop a balanced approach to address climate change
- Improve air quality and public health
- Provide a consistent policy approach to drive investment in clean technology
- Provide a model for future national and international climate change efforts
- Achieve 1990 emissions by 2020; maintain and continue reductions past 2020 to achieve 2030 and 2050 goals
- Coordinate efforts across government agencies

Agency Perspectives
GHG Reduction Focus Areas

- Short-Lived Climate Pollutants
- Energy Efficiency
- Natural and Working Lands
- Electricity
- Transportation and Land Use

Scope

Forests

Wetlands

Rangeland

Farmland

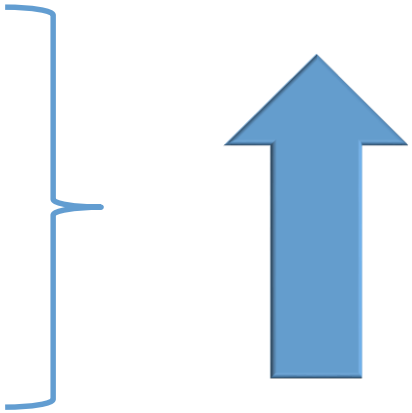
Photo Credits: USDA NRCS, USDA forest Service

The Value

- **California's land base stores carbon** below ground, in soil and root systems, and above ground, in trees, shrubs, grasses and other plant biomass
- **Healthy and resilient natural and working lands provide sustainable public benefits in addition to carbon sequestration,** such as water filtration, improved air quality, wildlife habitat, temperature moderation through shading, and soil fertility that supports food production
- **Conservation of natural and working lands supports sustainable communities**
- **Natural and working lands provide jobs, support regional economies and improve quality of life for all California residents**.

These Values are Threatened

- Land Conversion for Development
- Degradation
- Drought
- Sustained Heat
- Fire



2020 Status Update

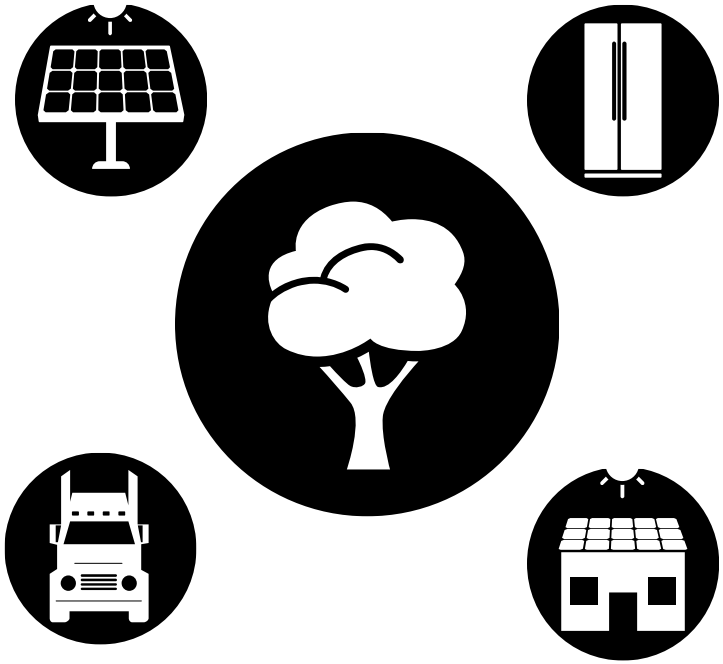
- Investments
- Planning
- Collaboration

Vision 2030 and 2050

- **Protect** Minimize Conversion
- **Enhance** Carbon Sequestration Potential
- **Innovate** Across Sectors
- **Develop** Sequestration Targets
- **Align** Climate Targets with Co-Benefits

Biomass Diversion
& SLCP Reductions

Forest
Management
& Bioenergy



Land Protection
& Avoided VMT;
Urban Greening

Ag & Forest Waste
Diversion to Biofuels





CalEPA
California Environmental Protection Agency

GOVERNOR'S OFFICE OF PLANNING AND RESEARCH
STATE OF CALIFORNIA

CALIFORNIA natural resources AGENCY

CALIFORNIA ENERGY COMMISSION

CalSTA
CALIFORNIA STATE TRANSPORTATION AGENCY

cdfa
CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

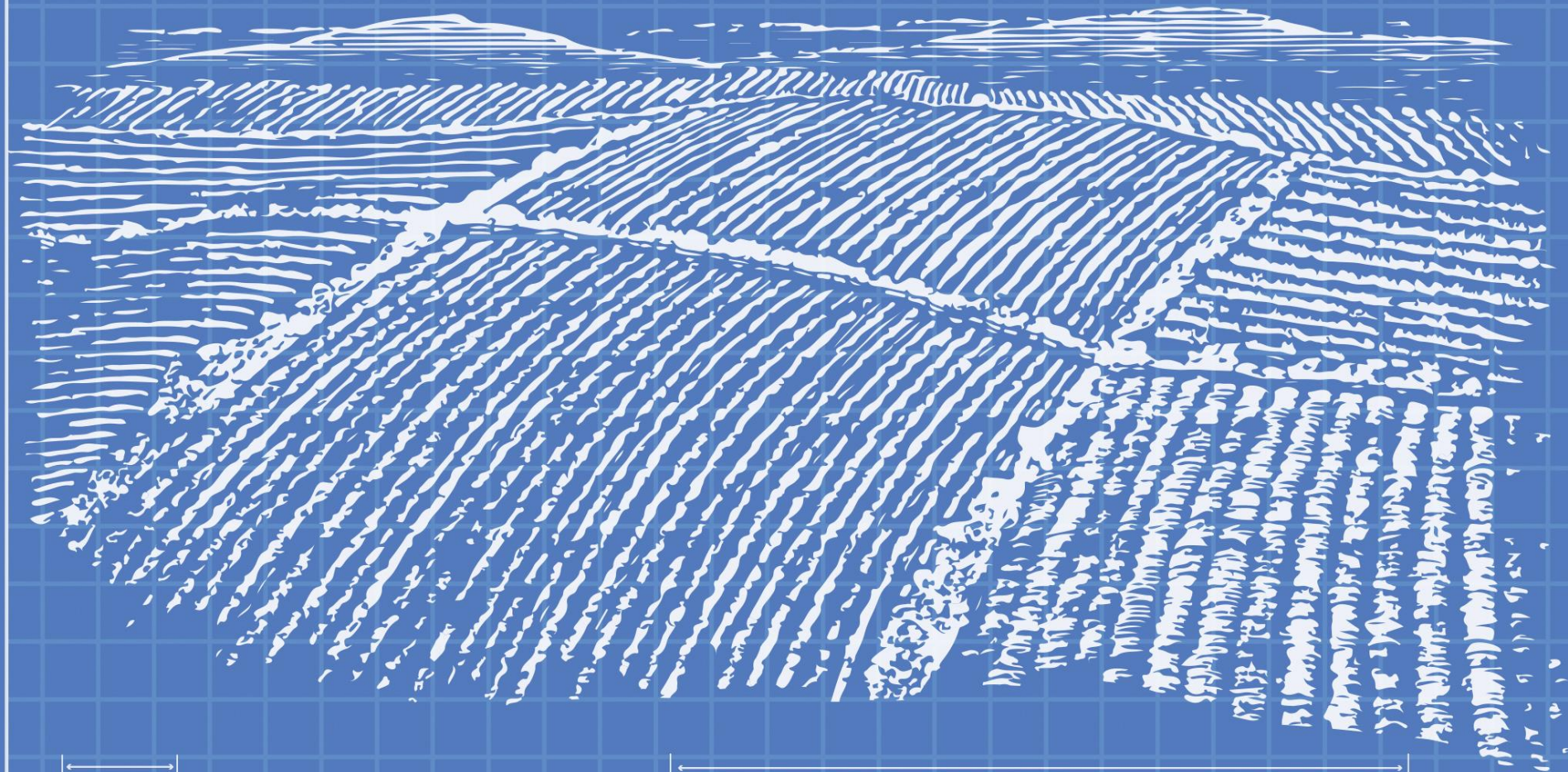
California Public Utilities Commission

Caltrans

California Environmental Protection Agency
Air Resources Board

CalRecycle

California Strategic Growth Council



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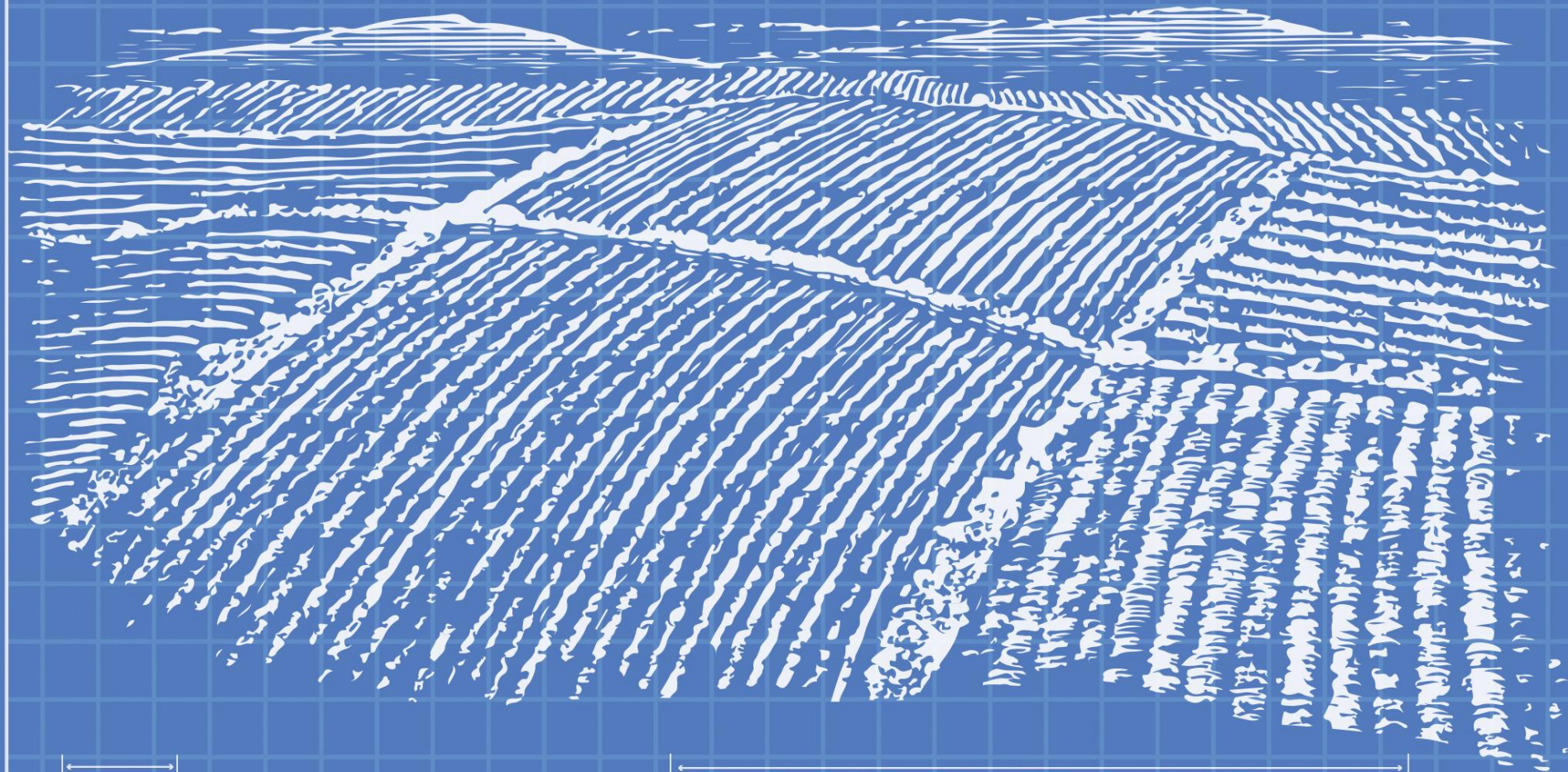
Questions?



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