Sustainable Biofuel Crop Production in California?

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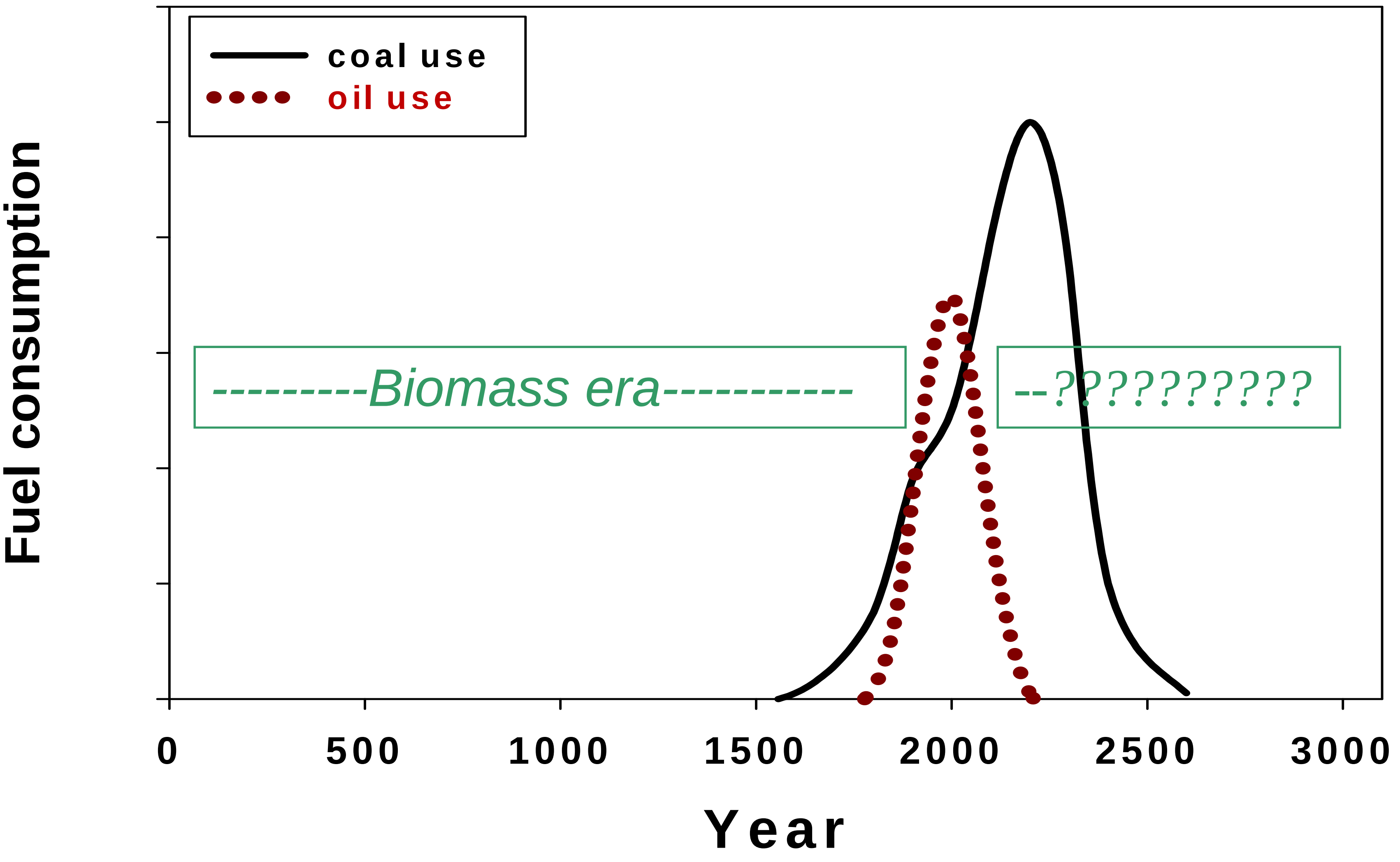
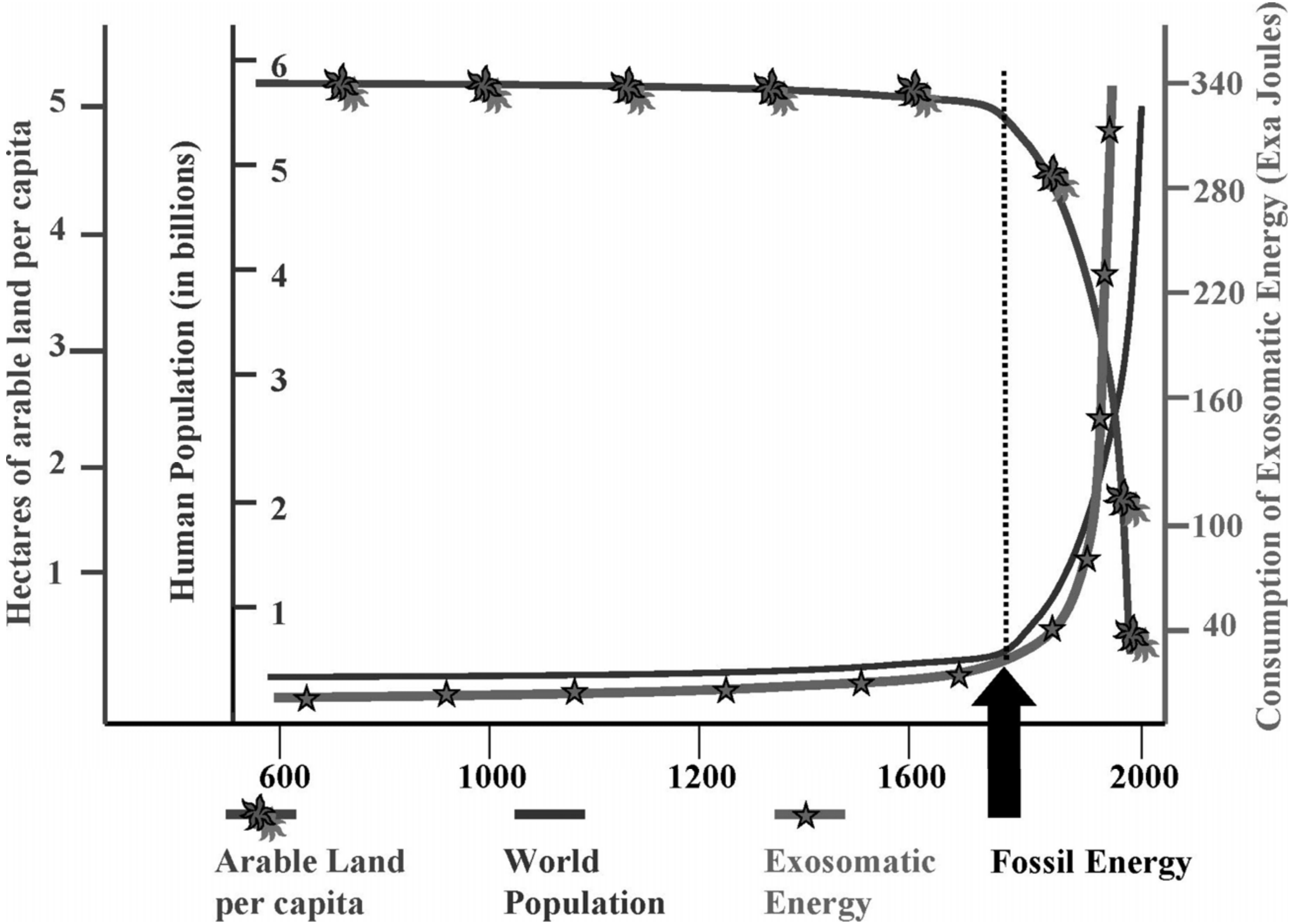
February 10, 2009



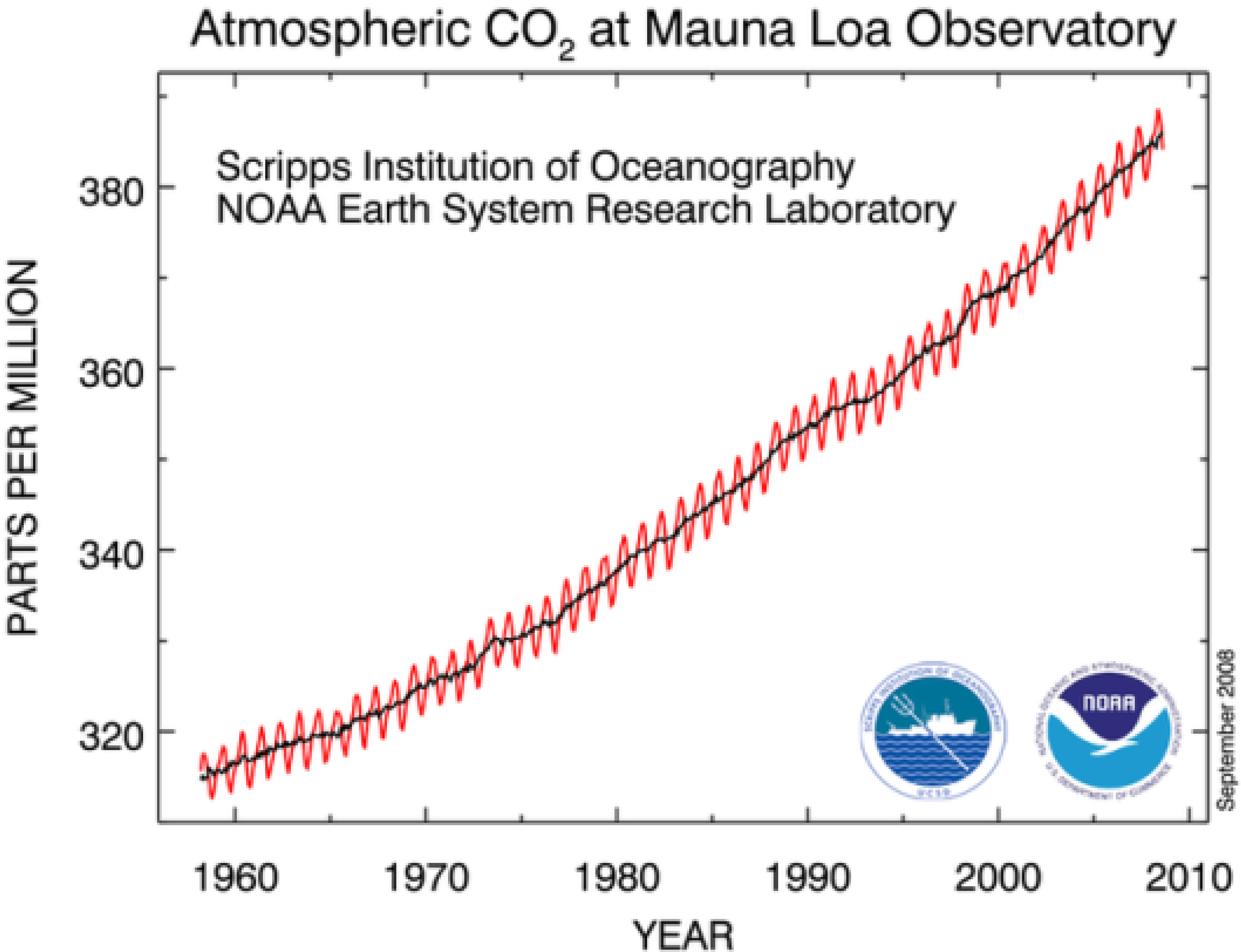
Expected duration of fossil fuels (0 to 3000 AD)

(redrawn from P.E. Hodgson, 1999)



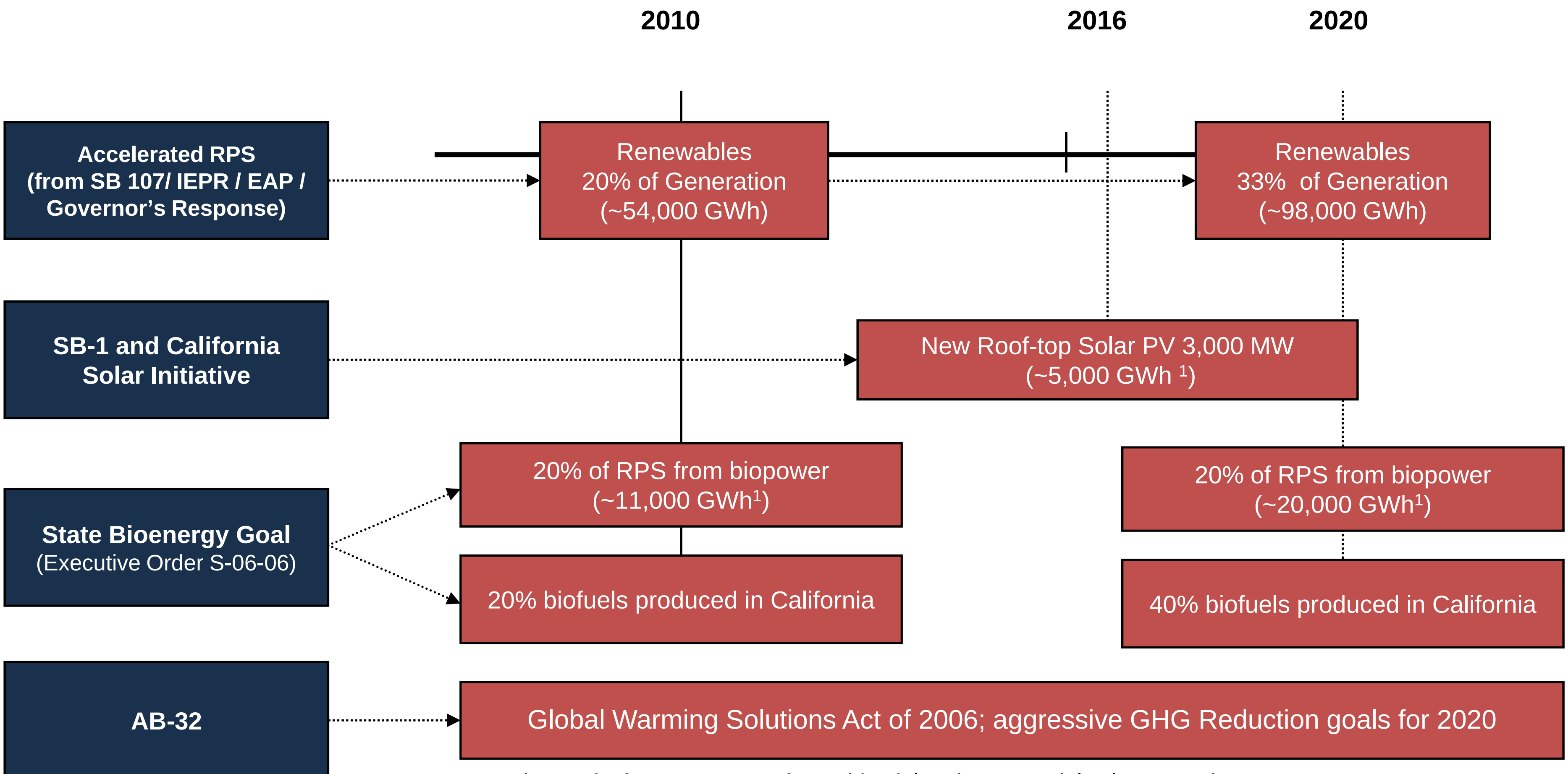
Giampietro and Ugliati 2005

Greg Mitchell slide (UCSD)


Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
320
340
360
380
1960
1970
1980
1990
2000
2010
YEAR
September 2008

Policy Context

Key Renewable Energy Policy Impacting California



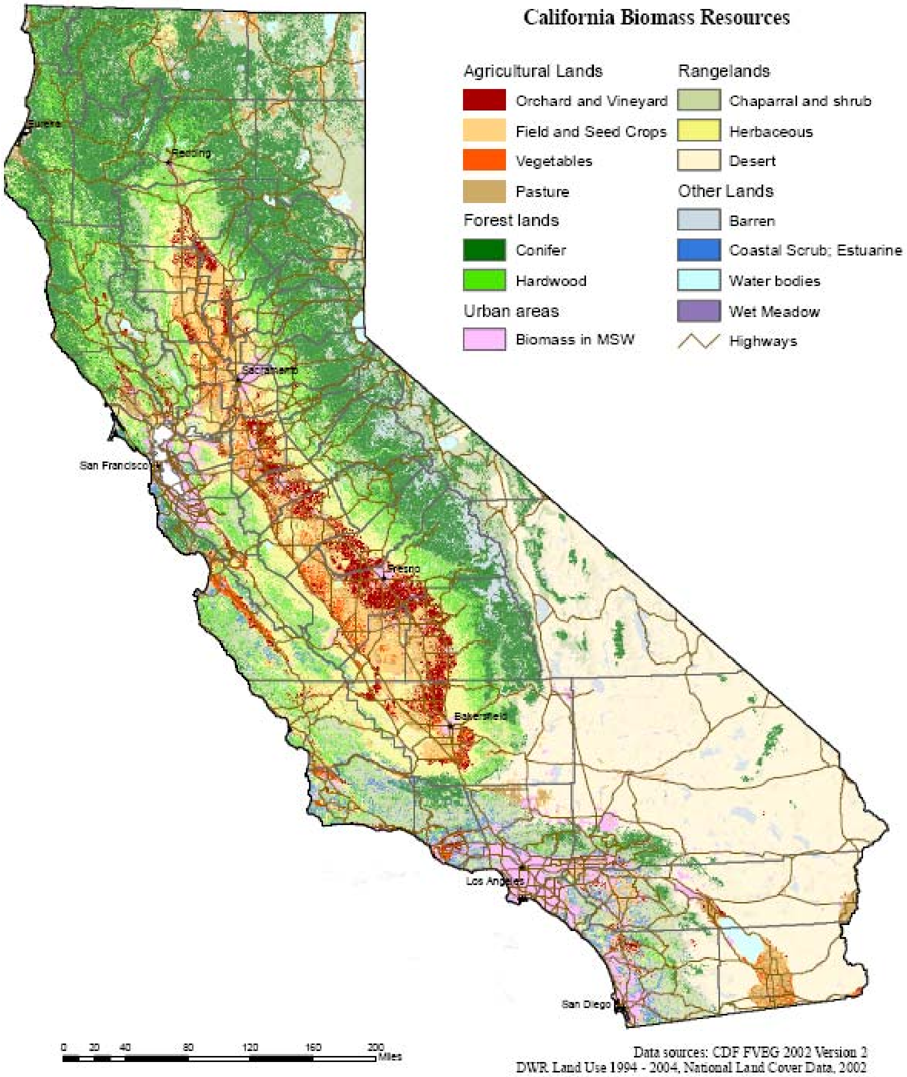
1. Assumed capacity factors are 20% for residential and commercial solar PV and 90% for biopower.

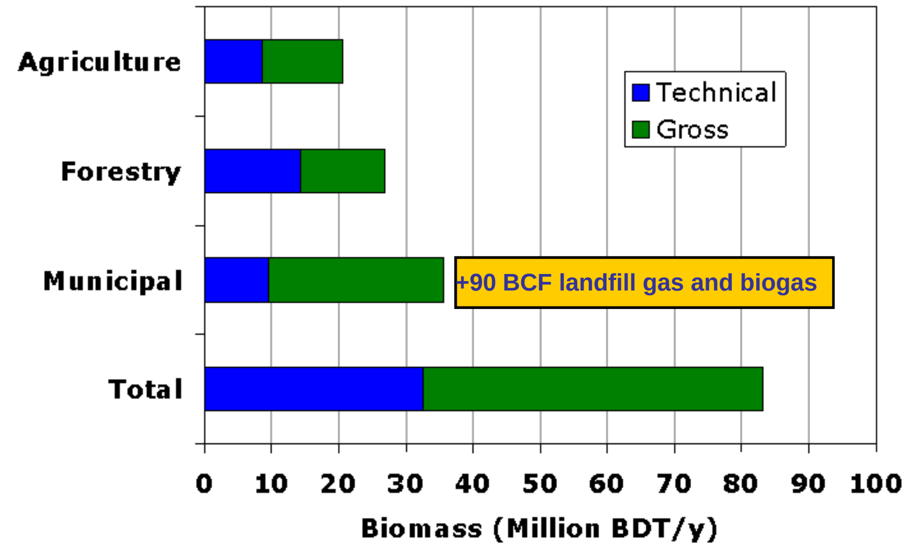
The end of oil?

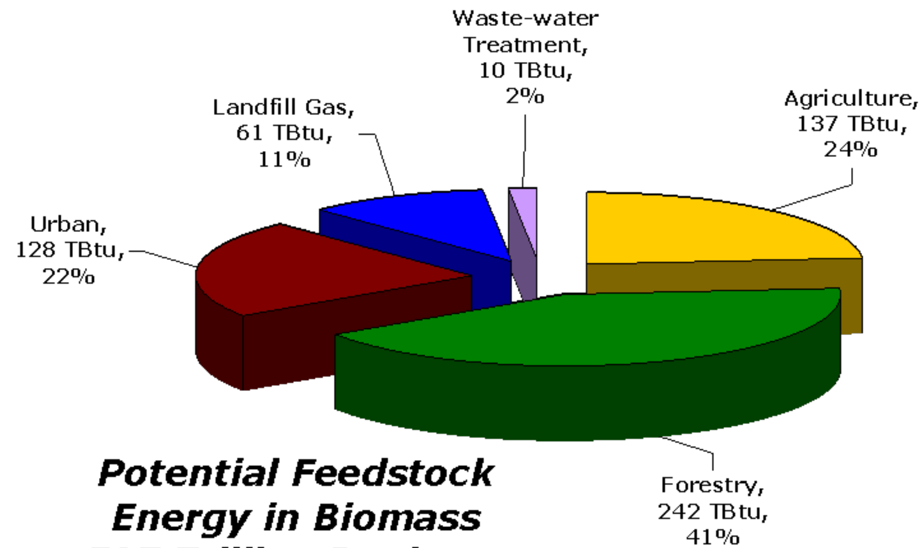
By 2025, every source of energy for transportation fuels will be needed…

---VP for Research, Chevron

California Residue and In-forest Biomass Resources



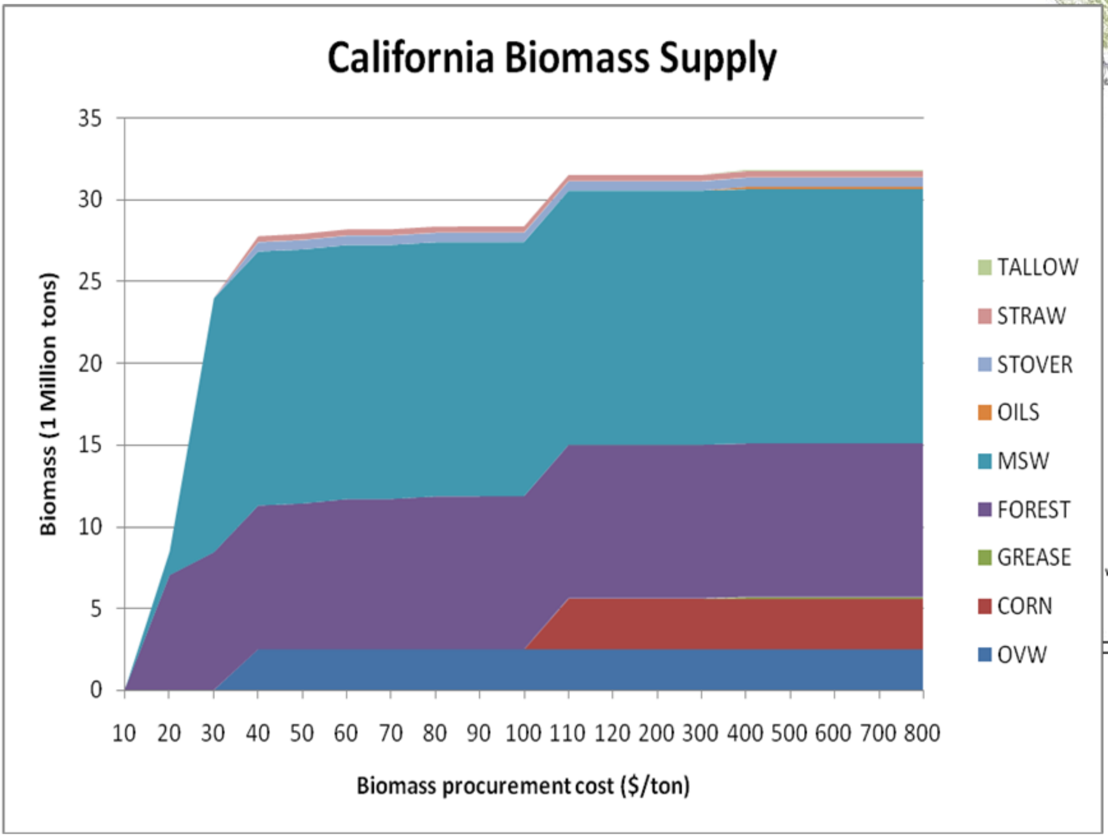


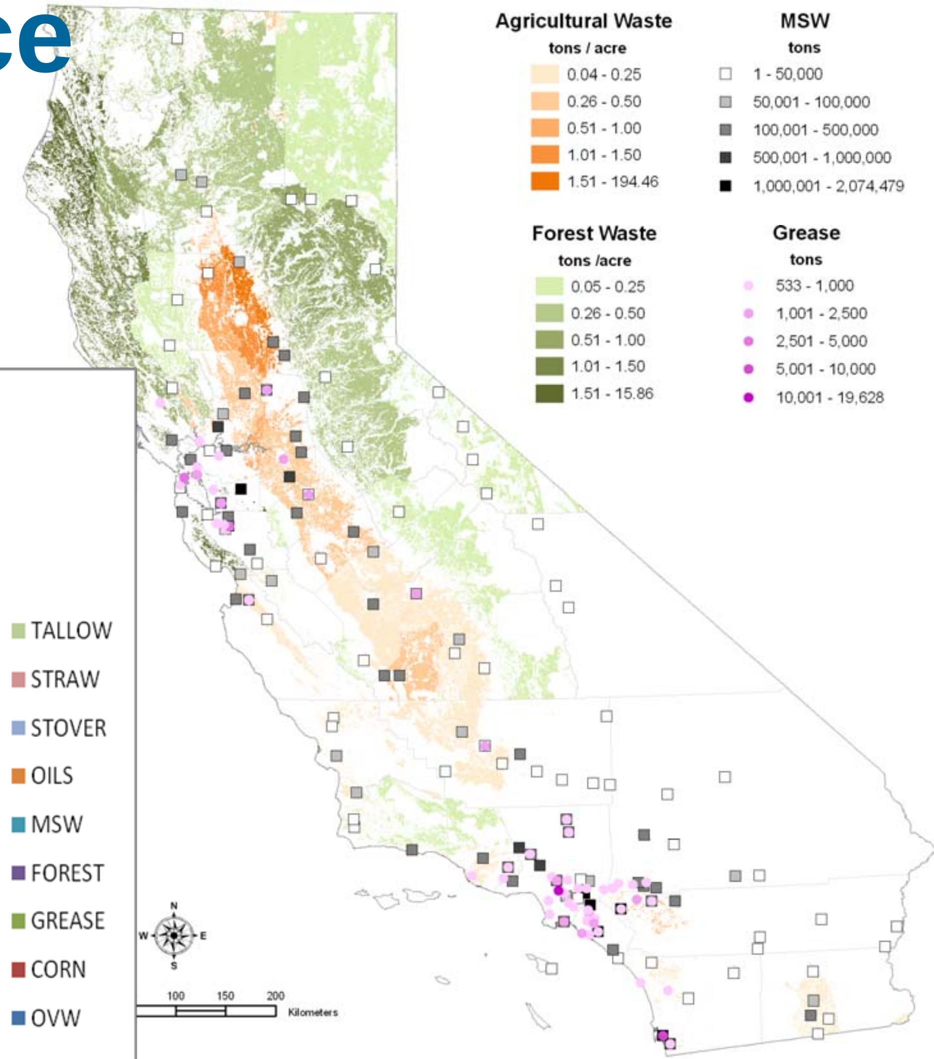


Potential Feedstock Energy in Biomass 507 Trillion Btu/year

Source: California Biomass Collaborative, 2007

Biomass resource distribution





Uncertainties about the future of bioenergy production

- What will be the best feedstocks?
- How will secure supplies of feed stock be contracted at fair price?
- What will be the best manufacturing technology?
- What will be the future public policies governing biofuel production and use?
- What will be the supply and price of oil and natural gas in the future?

Agricultural Biomass for Energy in California

- California is an hydraulic landscape.
- California's agriculture is intensive, high-valued and largely dependent on irrigation.
- Can (should) biofuels be produced in California? If so, where?

California Aqueduct

Biofuel Feed Stocks

The most likely crops for shorter term use in CA are the ones used elsewhere:

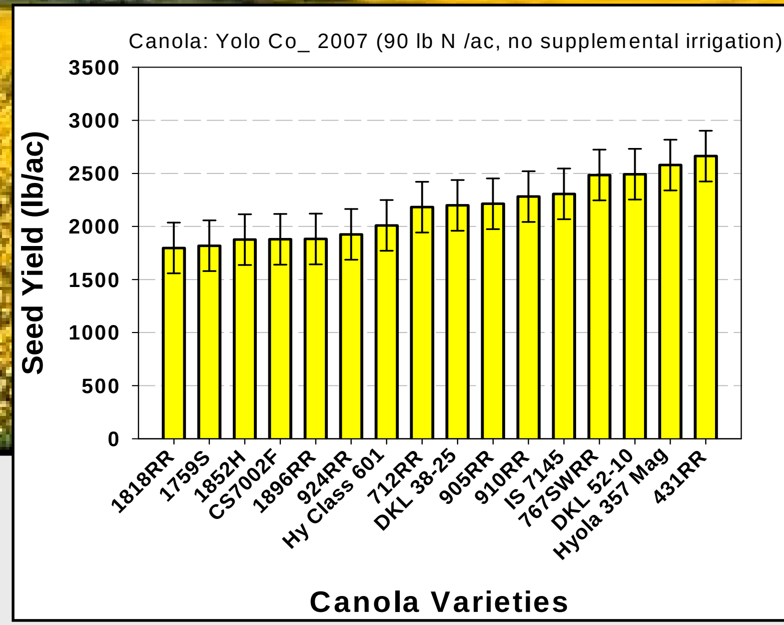
Corn, sorghum, (wheat and other small grains), oilseeds (canola, safflower, camelina, soybean(?)…)

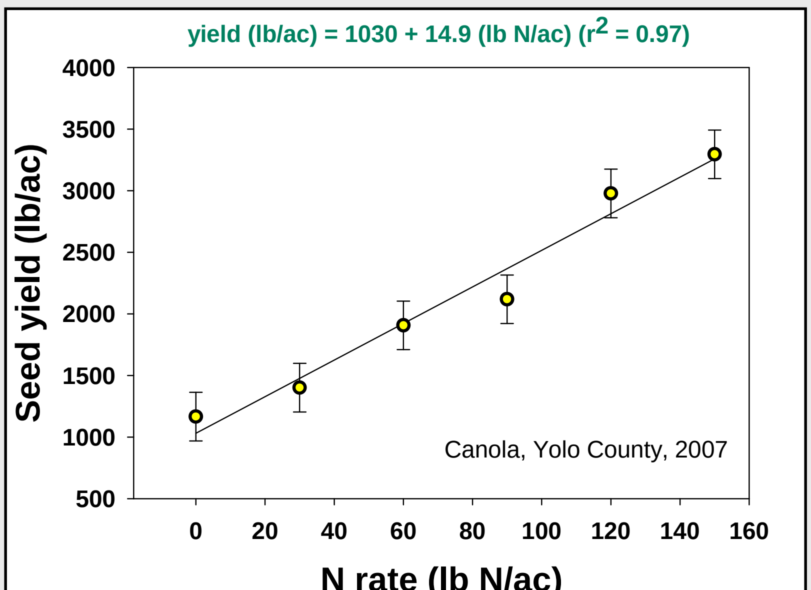
Sugar crops might be viable in the Imperial Valley (sugar cane + beet + sweet sorghum).

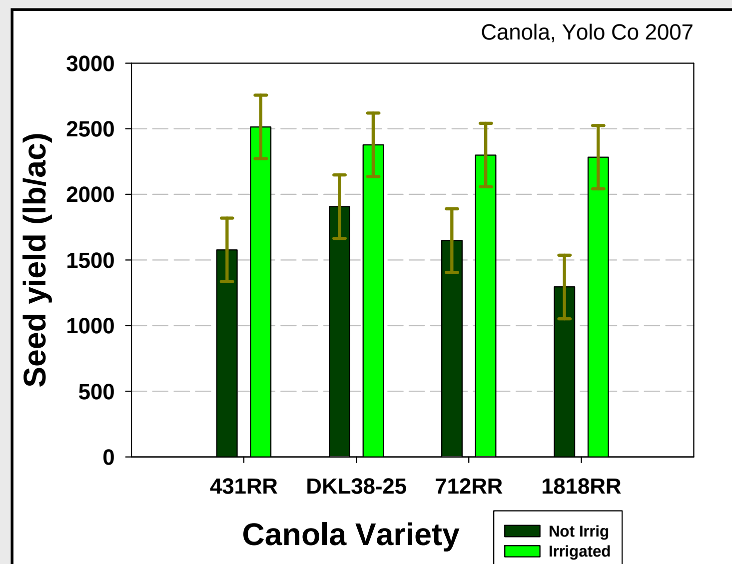
In the longer run, cellulosic sources from crop residues like straw and stover and the production of perennial grasses for biomass may be viable in California; so too may woody crops like Jojoba, Jatropha and Powlonia, and finally algae.

Many growers would like to reduce their input costs for fuel or stabilize its price.

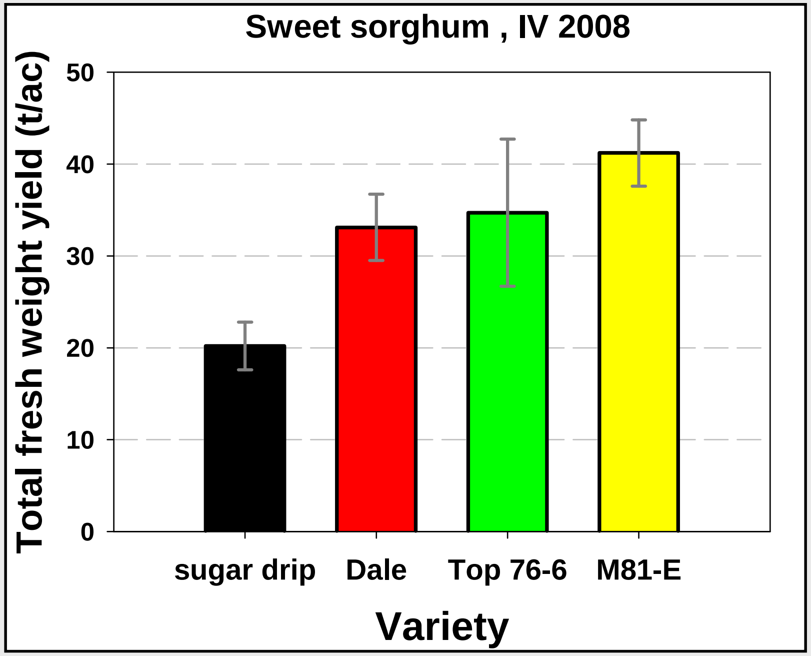
BEWG canola project (2007): Brittan, Hutmacher, Kaffka, Munier , Schmierer

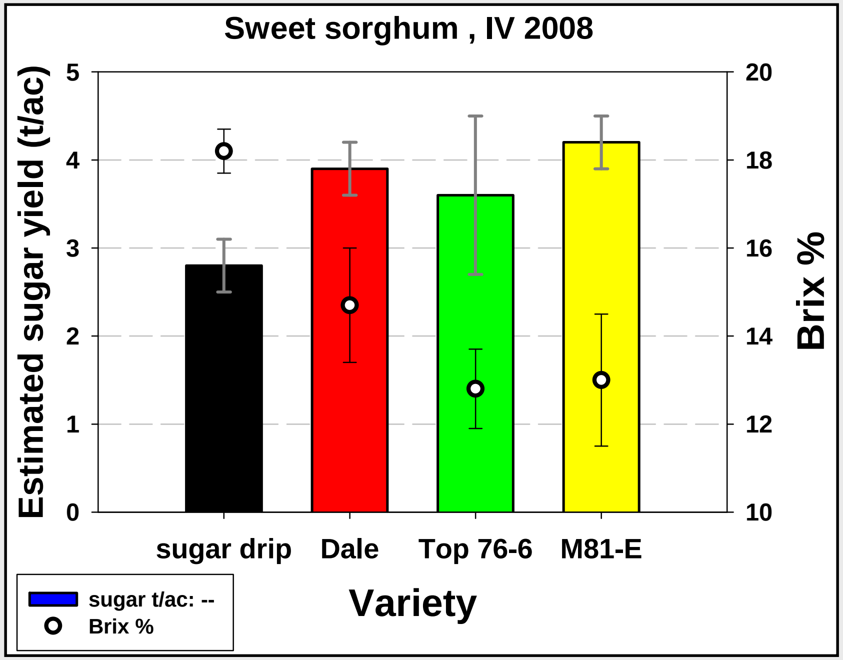







Imperial Valley 2008 sweet sorghum trial at harvest (11-09)/132 days
Sugar drip
M81-E
Top 76-6
Dale


Sweet sorghum , IV 2008
Total fresh weight yield (t/ac)
50
40
30
20
10
0
sugar drip
Dale
Top 76-6
M81-E
Variety


Sweet sorghum , IV 2008
Estimated sugar yield (t/ac)
5
4
3
2
1
0
20
18
16
14
12
10
Brix %
sugar drip
Dale
Top 76-6
M81-E
Variety
sugar t/ac: --
Brix %

Crop rotation optimization modeling of biofuel crop production opportunities for farms in diverse regions of California

Fujin Yi (Agricultural and Resource Economics)
Steve Kaffka (Plant Sciences)

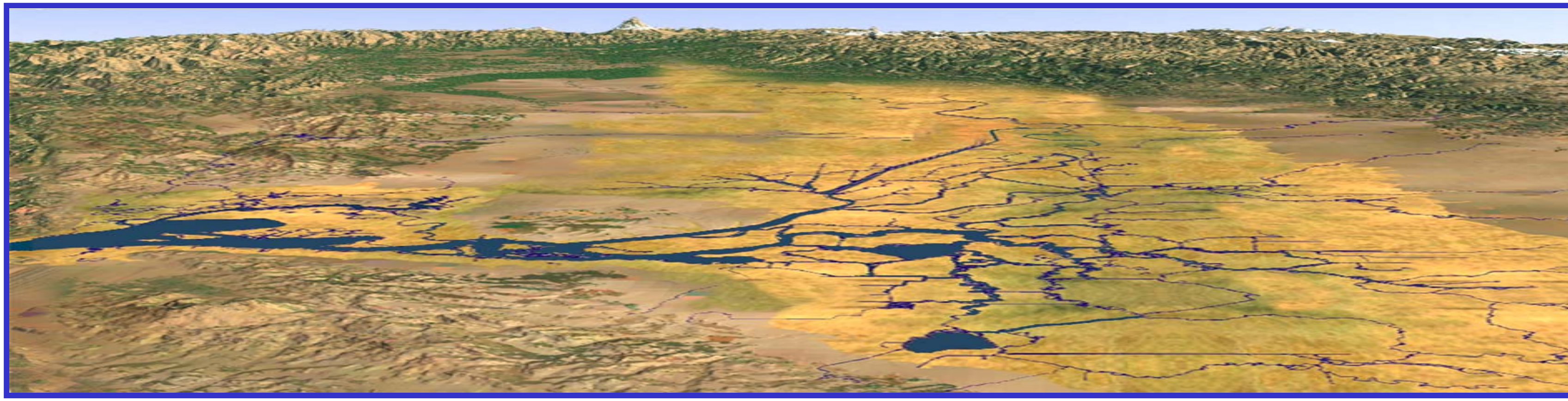
Cooperators: Hossein Farzin, Pierre Merel (ARE)

BEWG work group cooperators: Kent Brittan, Dan Marcum, Dan Munk, Blake Sanden, Jerry Schmierer, and other members of the BEWG

Funded by California Biomass Collaborative (CEC); STEPS (ARB);

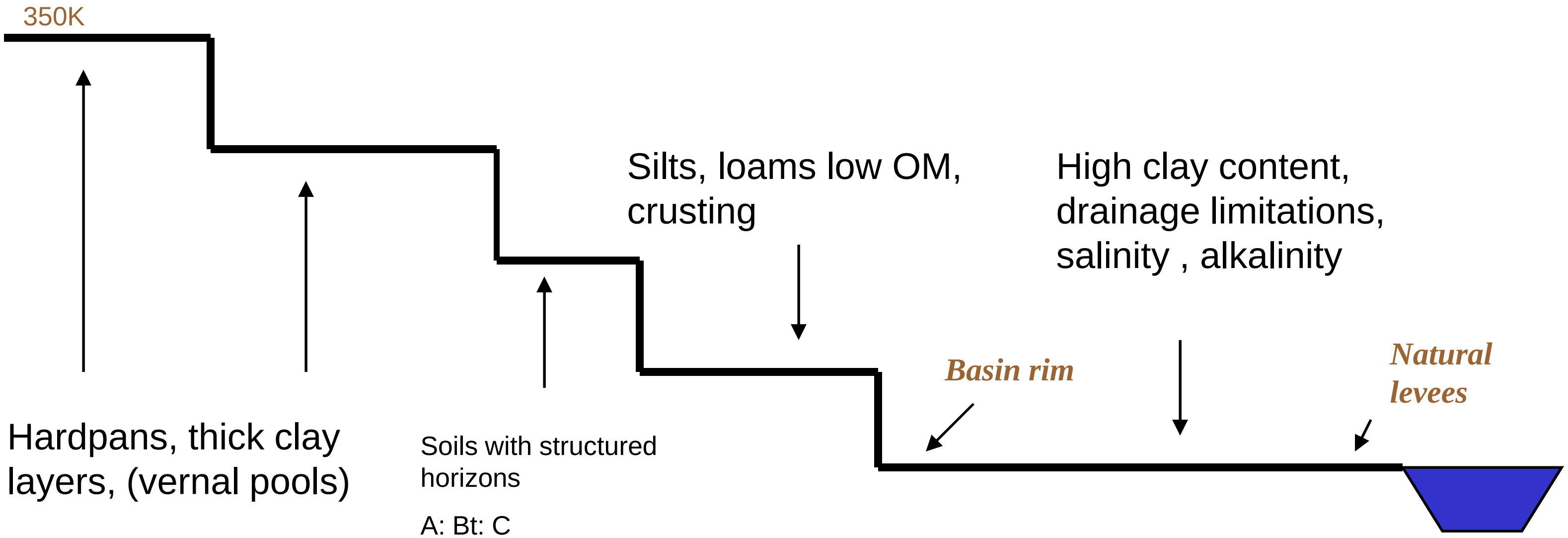
CEC (Bren School-UCSB)

BioEnergy Work Group Project



Soil age:

oldest 100K 30-80K 10K youngest



Oak-savanna/rangelands

rangeland/pasture, some perennials

perennials, annuals

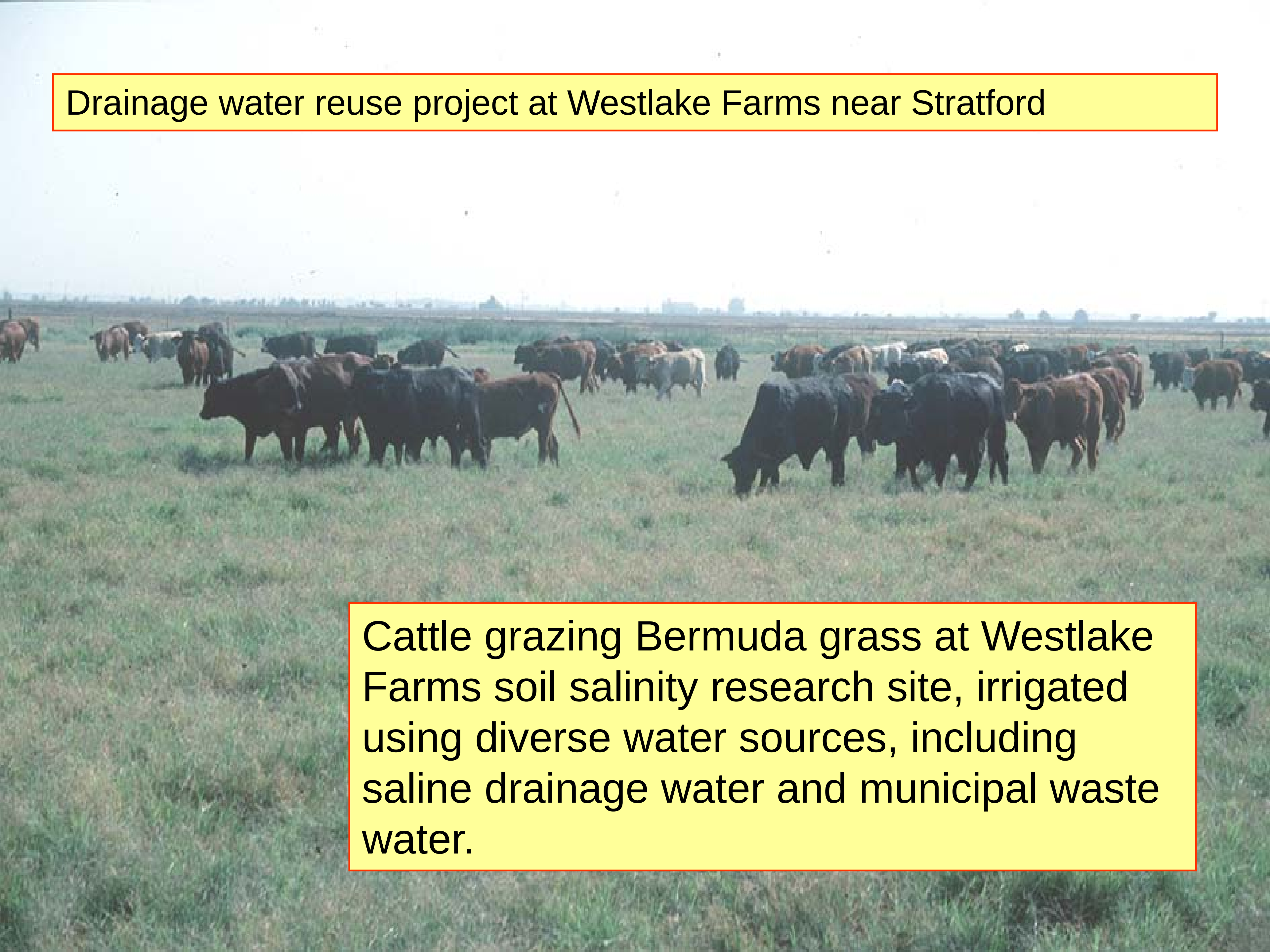
mostly annuals

Soil use

Saline-sodic soil near Stratford

Shallow, saline water table

Drainage water reuse project at Westlake Farms near Stratford



Cattle grazing Bermuda grass at Westlake Farms soil salinity research site, irrigated using diverse water sources, including saline drainage water and municipal waste water.

Why use economic optimization models to study biofuel production?

- To better estimate the actual potential for biofuel crop production and crop residue use in CA.
- To estimate yield and cost goals needed to introduce new biofuel crops into CA farming systems through the estimation of dual values or “shadow costs.”

Why use economic optimization models to study biofuel production?

- To estimate the effects on biofuel crop production of differing policy incentives or constraints (Carbon Credits, N_2O constraints, effects on wildlife, natural resource use, others).

Objectives

- Create realistic, representative cropping system models that reflect the differences in agro-ecological conditions, costs and constraints in different parts of the state.
- The areas to be modeled include: Sacramento Valley (north and south), the Delta, the San Joaquin Valley (west and east sides), Imperial Valley, Intermountain regions.
- Predict the production potential for biofuel crops under diverse cost and policy conditions and evaluate new crops and biofuel technologies.

What is linear programming?

LP models predict the most profitable combination of crops for a farm subject to a series of constraints.

These constraints include water supply, land, soil quality, and other limitations specific to individual farms or for specific locations in the state.

They generate an optimum economic solution and identify the limitations for choices that are left out of the model (dual variables or shadow prices).

Example LP Matrix

$$Max \quad \text{Profit} = [P_{alfalfa} \times Acreage_{alfalfa} \times Yield_{alfalfa} - Cost_{alfalfa}] + [P_{tomato} \times Acreage_{tomato} \times Yield_{tomato} - Cost_{tomato}] + \cdots$$

$s.t.$

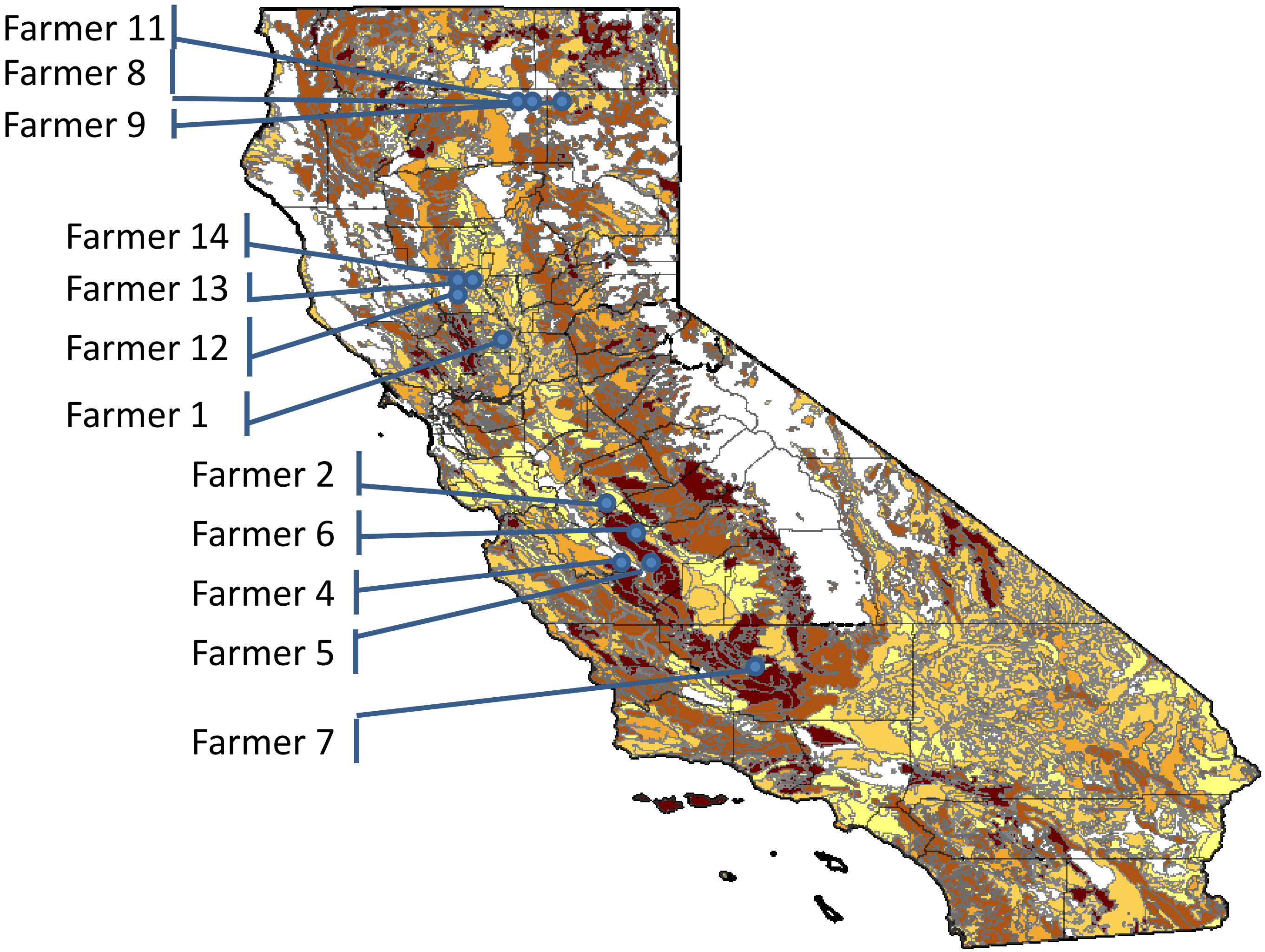
	alfalfa	corn	tomato	$\cdots$	wheat		
Land	1	1	1	$\cdots$	1	$\leq$	Amount of Land
Water	α_1	α_2	α_3	$\cdots$	α_I	$\leq$	Amount of Water

Where, α_i represents the water demand for each crop i per acre.

Methods

- Survey farmers in diverse locations in the state
- Create models with appropriate differences in constraints: soil quality, water, crop limitations, preferences, other…
- Model current production choices of farmers, using PMP
- Use sensitivity analyses for biofuel prices and yields, other factors

CA soil map and farmers' locations



8. Galic		775 (0.40)			–
9. Melon		747 (0.25)			–
11. Spinach		603 (0.21)			–
12. Sugar beet		517 (0.36)			–
13. Tomato		1581 (0.20)	2139 (0.14)		2017 (SCV, 2008)
14 Tomato (fresh			2434 (0.14)		5458 (SJV, 2007)
15. Wheat		420 (0.45)	737 (0.41)	395 (0.18)	488 (SJV, 2008)
16. Winter forage	250				351 (SJV, 2004)
17. Sudan grass				373 (0.33)	501 (INV, 2004)

Notes:(1) SCV-Sacramento Valley; SJV-San Joaquin Valley; IV-Imperial Valley; IM-Intermountain area;

(2) The number in brackets is the percentage of irrigation cost in the total cost

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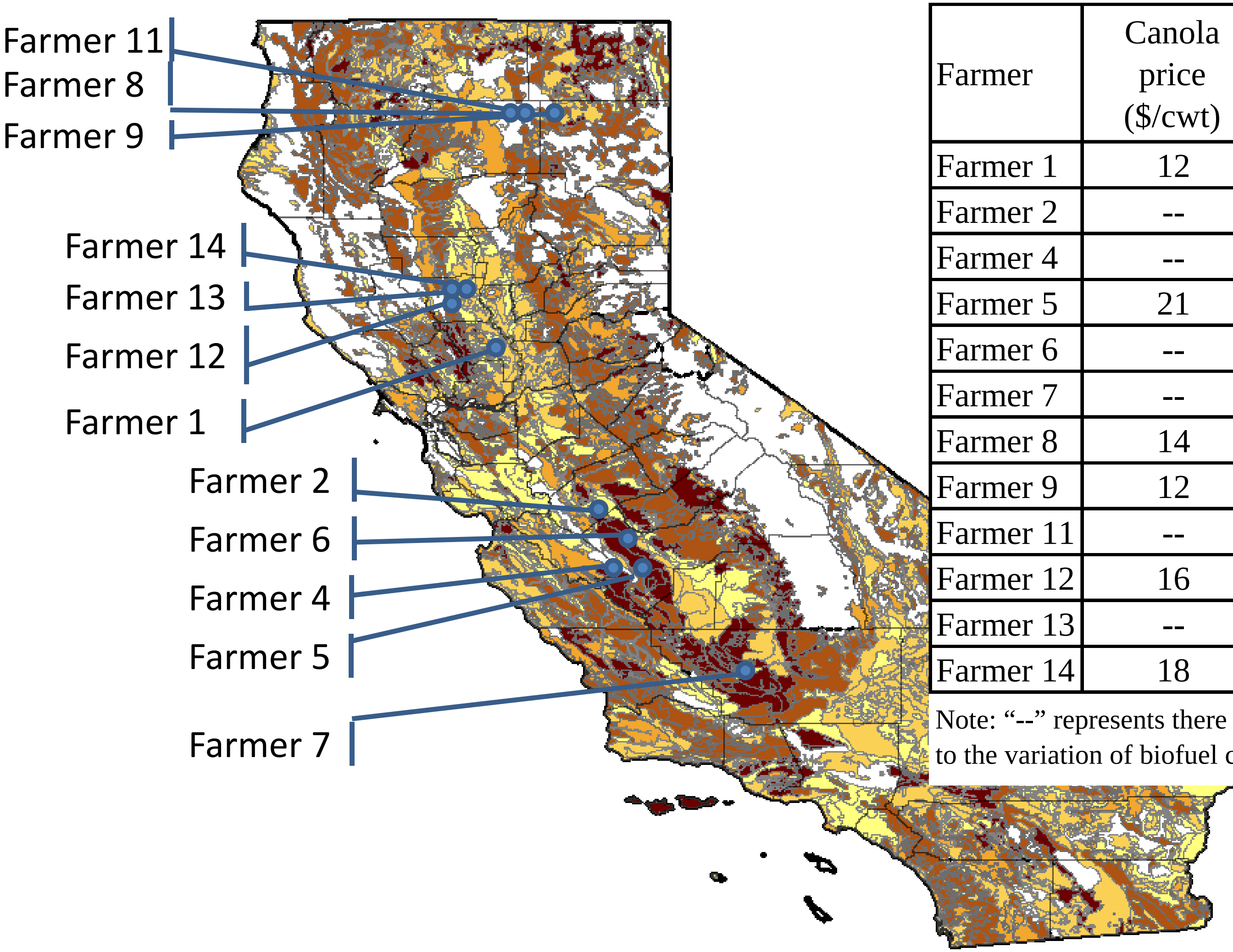
Simulation with respect to biofuel crop price and yield changes

- Biofuel crop price:
  - Canola price increases from 0 to 30 $/cwt
  - Sweet sorghum price increases from 10 to 60 $/ton.
- Biofuel crop yield:
  - Canola yield varies from 10 to 30 cwt/ac;
  - Sweet sorghum yield varies from 20 to 40 ton/ac.

- Trigger prices for the surveyed farmers



Farmer	Canola price ($/cwt)	Sweet sorghum price ($/ton)
Farmer 1	12	16
Farmer 2	--	30
Farmer 4	--	28
Farmer 5	21	22
Farmer 6	--	28
Farmer 7	--	44
Farmer 8	14	18
Farmer 9	12	18
Farmer 11	--	32
Farmer 12	16	20
Farmer 13	--	30
Farmer 14	18	20

Note: "--" represents there is no change due to the variation of biofuel crop price

The economic returns from energy crop production are not limited to the on-farm value of the biomass only. Other products like electricity generation or by product sales also can be derived from biomass.

Based on interviews, some growers would be willing to sacrifice some profit for stabile income projections.

Some growers see cropping system benefits from the use of certain biofuel crops that could not be identified except through interviews.

We intend to continue with interviews and add current land use cover estimates to our means of evaluating farmers’ current preferences.

Can we produce biofuels from crops sustainably?

S. Kaffka, 2008; *California Agric.*, submitted

"Most simply, sustainability means the ability to continue over time. To assess and monitor the sustainability of agricultural biomass use for energy, well validated simulation models linked to long-term research are necessary to predict some of the biophysical consequences of biofuel production, and to improve the accuracy of life-cycle assessments of net benefits from agricultural biomass use.

Agreement about other aspects of sustainability that are primarily social and value-based can only come from a process that embodies procedural rationality."

Francis et al., Developing and Extending Sustainable Agriculture (2006)

John Ikerd : "… The issue of sustainability is rooted in a worldview that is fundamentally different from the mechanistic worldview that has dominated the modern era of science and industrial development.

… One's worldview is a matter of personal belief, and reflects how we believe the world works and what we believe about our place within it.

… Long run ecological issues are fundamentally ethical or moral in nature. Such issues cannot be decided in the marketplace or by majority vote; they must be resolved by consensus."

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Can we produce biofuels in California from crops and crop residues?

- We should consider the sustainability of biofuel production from the start.
- We will know most about in-state conditions and can have the greatest confidence about our assumptions for CA feed stocks. This might provide an additional value for feed stocks produced within CA.
- CA should not export its pollution.

Oil production from tar sands in Alberta

An alternative to biomass use for energy

BEWG: BioEnergy Work Group

What is a UC ANR work group?

Work groups facilitate the application of agricultural research (from basic to applied) to important issues or problems affecting farming in CA

Work groups identify, communicate, and help focus research on emerging issues

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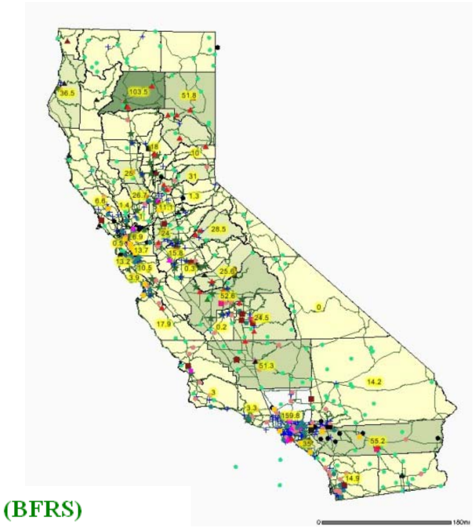
California Biomass Collaborative

- Statewide biomass coordinating group
- Biomass Facilities Reporting System
- Biomass resource assessments
- Technology assessments
- Planning Functions/Policy
  - Needs Assessment
  - Roadmap for biomass development
- Coordination with State Bioenergy Interagency Working Group



California Biomass Facilities Reporting System (BFRS)
Power Generation Assessments

The BFRS database contains Biomass power plants and related facilities, including thermal station power plants, digesters, landfill gas systems, fermentation plants, bio refineries, other biomass energy converters, material handling and processing operations, and storage units with technical and environmental performance. Gross and technical resources, estimates of electricity capacity and energy from biomass for year 2003, 2005,2007, 2010 and 2017 are included in this database.

Specific information can be retrieved by following steps.

Data Query

Select Category :
Select County :
Select Year :

Retrieve data | View Map

California Biomass Facilities Reporting System (BFRS)
Resource Assessments

The BFRS database contains Biomass power plants and related facilities, including thermal station power plants, digesters, landfill gas systems, fermentation plants, bio refineries, other biomass energy converters, material handling and processing operations, and storage units with technical and environmental performance. Gross and technical resources, estimates of electricity capacity and energy from biomass for year 2003, 2005,2007, 2010 and 2017 are included in this database.

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http://biomass.ucdavis.edu
Email: biomass@ucdavis.edu

UCDAVIS
pier
SMUD
SACRAMENTO MUNICIPAL UTILITY DISTRICT
The Power To Do More.
Integrated Waste Management Board