California Bioresources Alliance

The drought, bioresources, and nutrient management

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Drought and climate change effects on biomass in California

- A little bit of policy
- Biomass resources in the California
- Urban biomass-BAU
- Forestry (Fire losses likely will be worse, risks increase with time).
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Signing AB 32: The Global Warming Solutions Act

The Low Carbon Fuel Standard requires a 10% reduction in fuel carbon intensity by 2020. The state would also like to encourage in-state biofuel production. CAP & TRADE will affect all aspects of the economy.

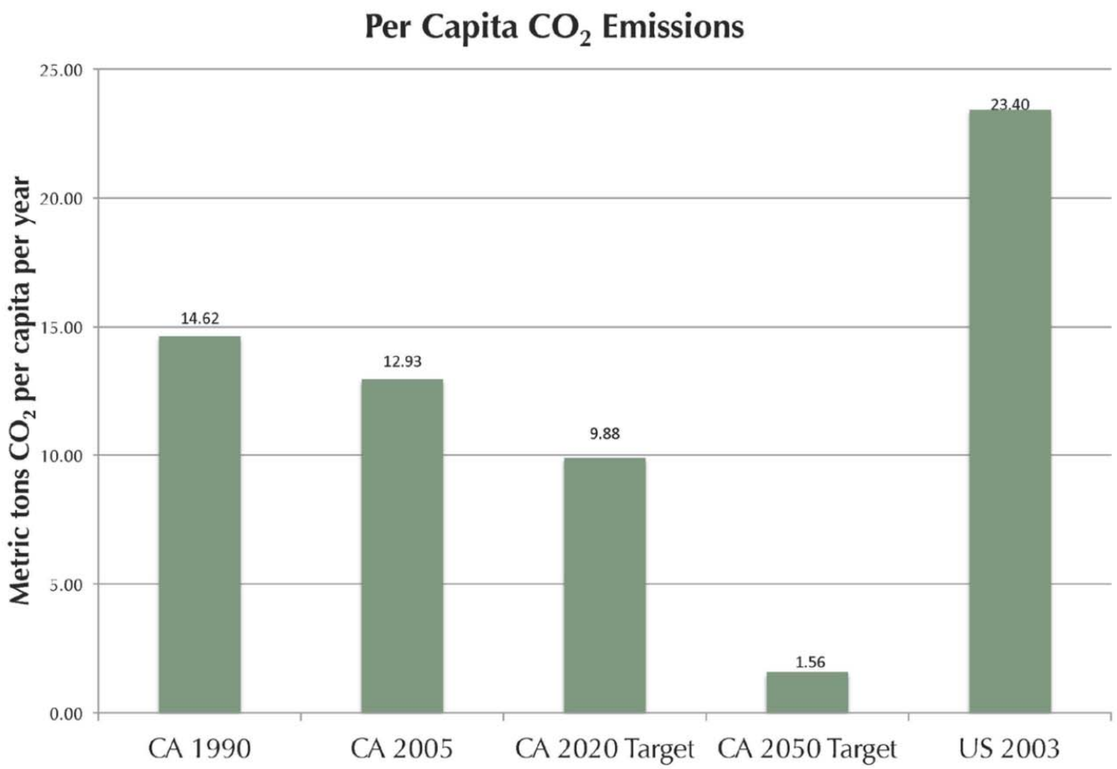
AB 32 is based on the assumption that climate change will cause substantial economic and environmental damage.

CA is particularly vulnerable to the costs associated with unmitigated climate change. A warming climate would generate more smoggy days, ozone, and foster more large brush and forest fires… by late century, CA will loose 90% of the Sierra snow pack, sea level will rise by more than 20 inches, and there will be a 3x to 4X increase in heat wave days. This will lead to increased flood damage, diverse economic losses and substantial public health costs. AB 32 Scoping Plan (Executive Summary).

Annual Damage Estimates in 2006 USD (billions)			
	LOW	HIGH	ASSETS AT RISK
Water	N/A	0.6	5
Energy	2.7	7.5	21
Tourism and Recreation	0.2	7.5	98
Real Estate	0.3	3.9	2500
Agriculture, Forestry, Fisheries	0.3	4.3	113
Transportation	N/A	N/A	500
Public health	3.8	24.0	N/A
TOTAL	7.3	46.6	

Fredrich and Roland-Holst (2008)

California's greenhouse gas reduction targets



Perhaps the most significant and challenging public policy effort ever undertaken.

Like politics, All Biomass Is Local ?

In a diverse state like California, there will be many different optimum solutions for how best to use biomass for energy, depending on where in the state a company is located.

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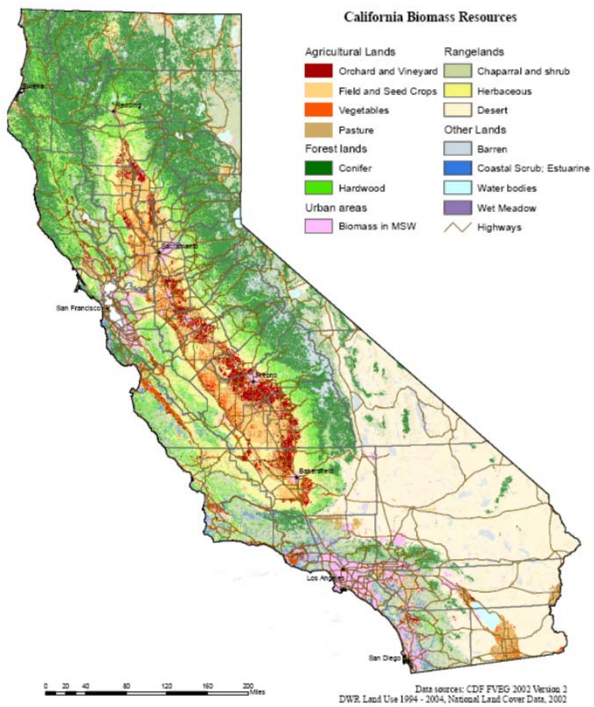
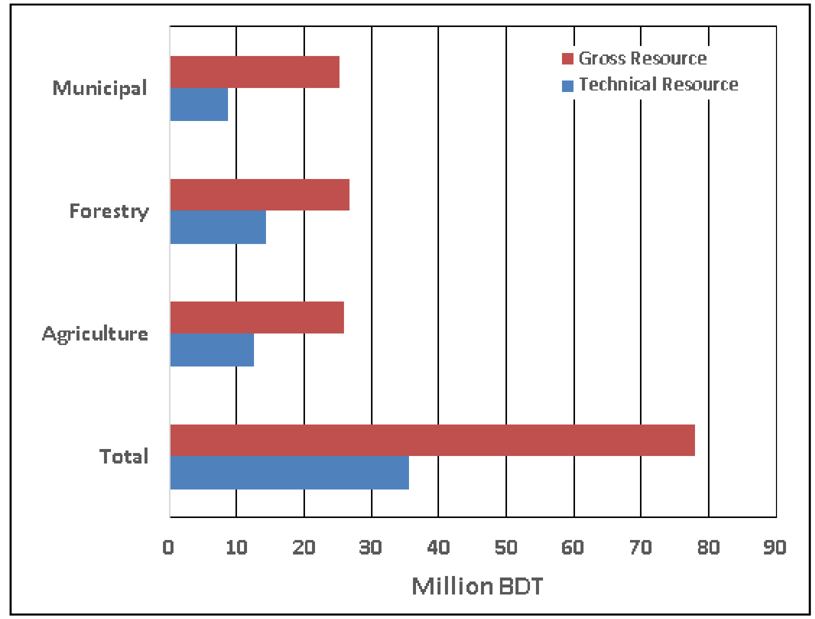
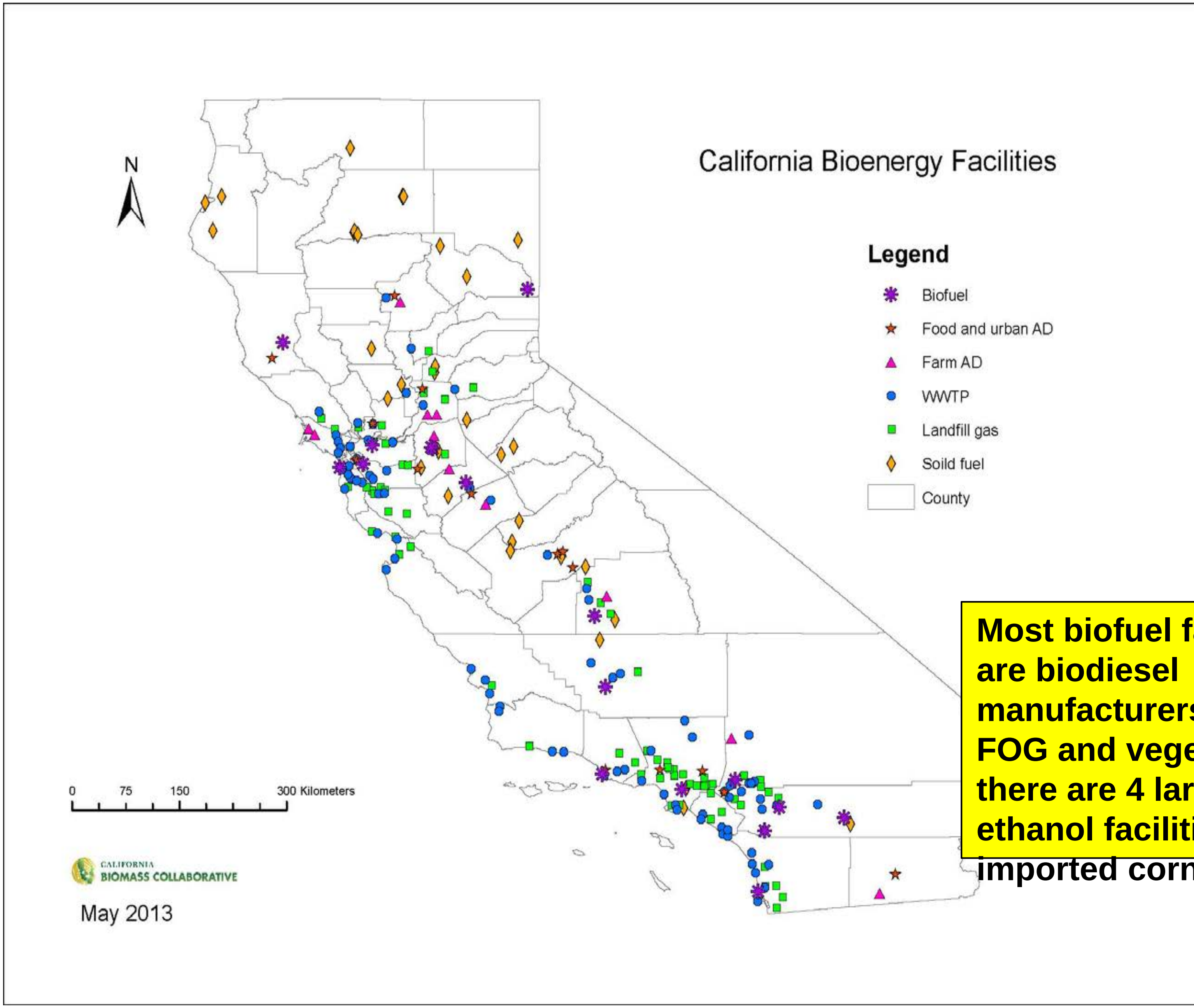




Resources and generation potentials from biomass in CA- 2012

Category	Units	**Agriculture**	**Forestry**	**Municipal Wastes**	**Total**
Gross Resource	Million BDT/y	25.8	27	25	**78**
Technical Resource	Million BDT/y	12.5	14.3	8.6	**35**
Gross Electrical Capacity	MWe	2440	3580	3860	**9,880**
Technical Electrical Capacity	MWe	1015	1907	1712	**4,630**
Gross Electrical Energy	TWh	16	27	29	**71**
Technical Electrical Energy	TWh	8	14	13	**35**

Williams et al., 2014;



Most biofuel facilities are biodiesel manufacturers using FOG and vegetable oil; there are 4 larger ethanol facilities using imported corn grain

Current (2013) biofuel production in California-CBC website.

Biofuel Facilities		
	(MGY)	Facilities
Ethanol	179	4
Biodiesel	62.1	13
Totals	241.1	17

There is in-state demand for vegetables oils and other feedstocks if produced at a price that allows conversion to be profitable. The price biofuel producers can pay depends in-part on the carbon intensity of the feedstock.

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Current Biopower Capacity in California

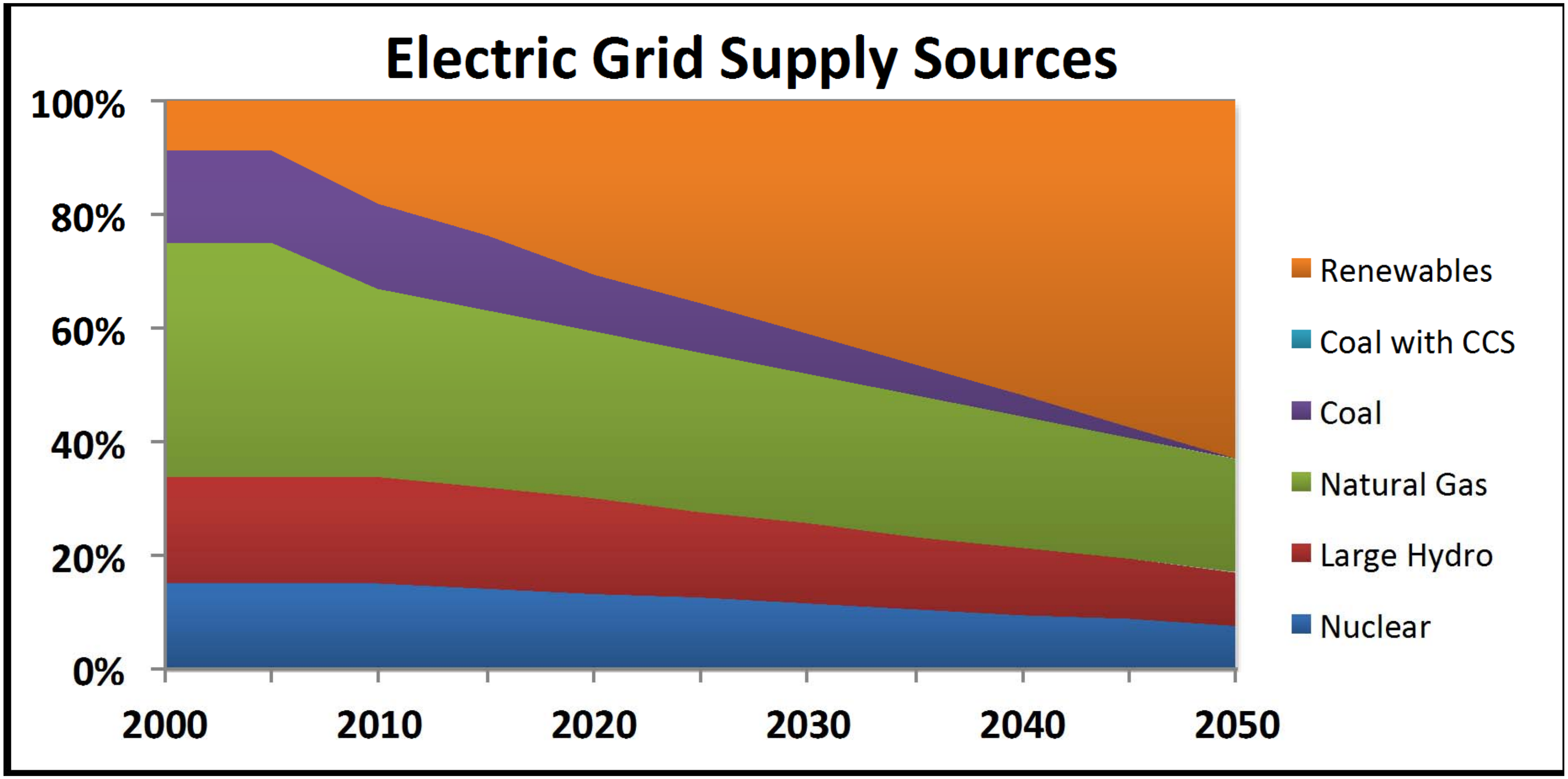
- **5.8 TWh of in-state biopower production (17% of in-state renewable power and 2% of full California power mix)**

Biopower Facilities		
Facility Type	**Net (MW)**	**Facilities**
Solid Fuel (forest, urban & ag)	574.6	27
LFG Projects (a)	371.3	79
Waste Water Treatment Facilities (b)	87.8	56
Farm AD (c)	3.8	11
Food Process/Urban AD (c)	0.7	3-5
Totals	1038	175

Solid Fuel (MSW) (mass burn facilities / organic fraction only)	63	3

* Includes: (a) LFG: 12 direct-use or CNG/LNG facilities; (b) WWTF: 8 heat or pipeline application; (c) AD: 12 Direct-use heat or fuel

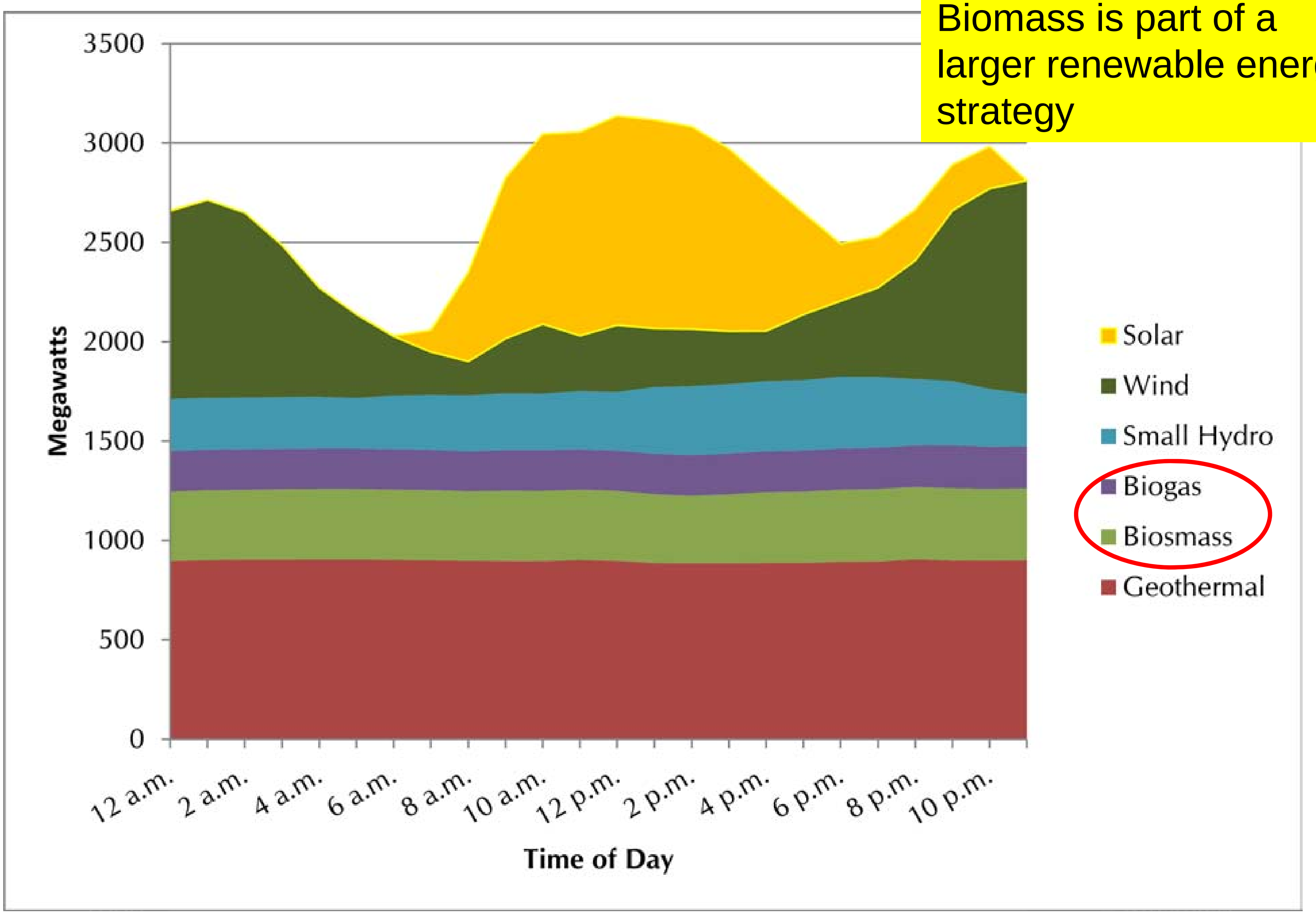
Possible Grid Power Sources in California to comply with AB 32 and LCFS Mandates



CARB projection

Hourly Breakdown of Renewable Resources for Operating Day September 13, 2012

Biomass is part of a larger renewable energy strategy



Source: California Independent System Operator. "Renewables Watch." Website accessed September 13, 2012. http://www.caiso.com/market/Pages/ReportsBulletins/DailyRenewablesWatch.aspx Little Hoover Commission, December 2012

Biomass is complicated. There are many possible feedstocks and biomass Conversion Pathways

- Production
- Collection
- Processing
- Storage
- Transportation

- Thermochemical Conversion
  - Combustion
  - Gasification
  - Pyrolysis
- Bioconversion
  - Anaerobic/Fermentation
  - Aerobic Processing
  - Biophotolysis
- Physicochemical
  - Heat/Pressure/Catalysts
  - Refining
  - Makes e.g. Esters (Biodiesel), Alkanes

- Energy
  - Heat
  - Electricity
- Fuels
  - Solids
  - Liquids
  - Gases
- Products
  - Chemicals
  - Materials

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Estimated Gross Ethanol Potential from Cellulosic Residues in California---Williams et al, (2007)-AB 118 Report

Biomass Source (residues)	Potential Feed stock (MBDT/yr)	Potential Ethanol (Mgal/yr)	Gasoline equivalent (Mgge/yr)
Field and seed crops	2.3	160	105
Orchard/vine prunings	1.8	125	83
Landfills: mixed paper	4.0	320	213
Landfills: wood& green waste with ADC	2.7	216	144
Forest biomass residues	14.2	990	660
Total	24.9	1,814	1,205*

*1.5 M acres of dedicated cellulosic energy crops could add 400 to 900 Mgge to potential.

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These are not estimates of economically recoverable or sustainable biomass.

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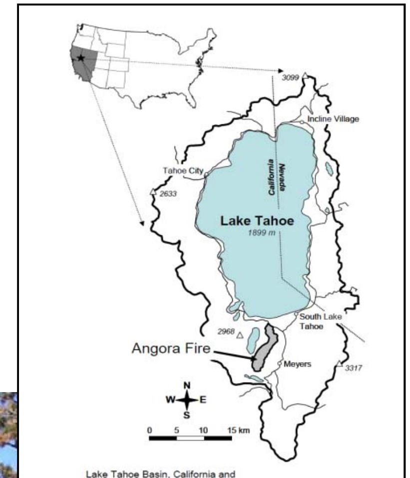
San Marcos Fire near San Diego, May 16, 2014

Chronic forest fires destroy large amounts of biomass annually in California, altering ecosystems, and causing public health problems. **Reducing risk of fire through fuel load reduction is one way to link harvesting biomass for energy with other environmental and economic goods.**

Fuel treatments and their effect: the Angora Fire as a case study. Hugh Safford, USFS, Pacific SW Region; Dept. Env. Science & Policy, UC-Davis
707-562-8934; hughsafford@fs.fed.us



No treatment: 100% mortality

Treated for fuels 1996-2005: 10% mortality

Fuel treatments and their effect: the Angora Fire as a case study. Hugh Safford, USFS, Pacific SW Region; Dept. Env. Science & Policy, UC-Davis
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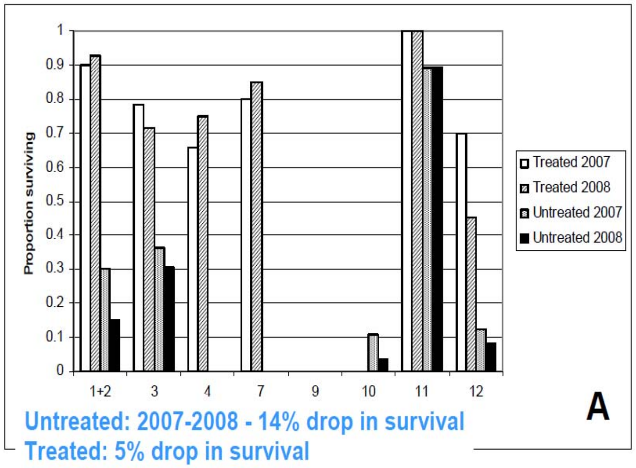
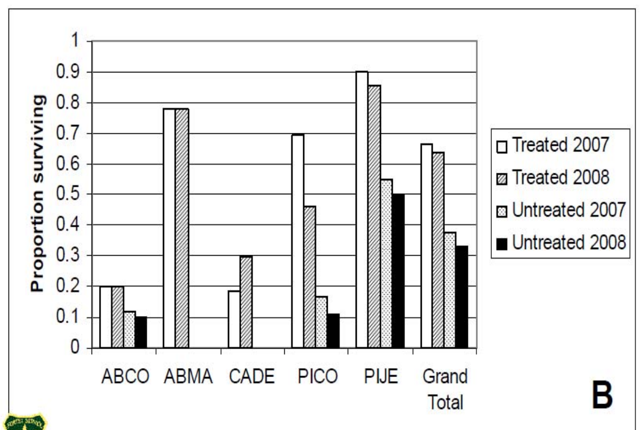
Tree mortality. A: transects; B: species





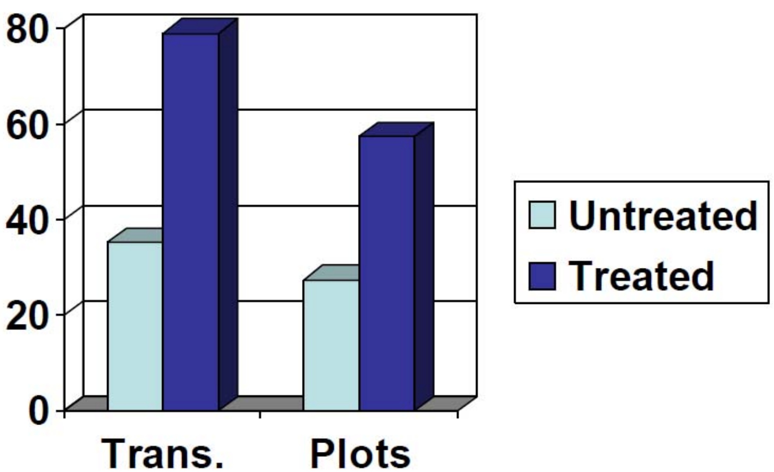
Summary

1. **In almost all cases, completed fuels treatments had a strong effect on fire severity**
   - Fire moved from the tree canopy to the surface
   - Vertical extent of crown torching, crown scorching, and bole char was much greater in the untreated areas
   - Within untreated sample areas, crowns in most trees (66%) were completely scorched, and 40% of trees had $\geq$90% of their crowns combusted by fire
   - Magnitude of effect less where fire weather conditions were less severe and where treatments were not complete
2. **Fuels treatments significantly decreased tree mortality**
   - 2008 tree mortality was 67% in untreated areas vs. 36% in treated areas (excl. Unit 20; 20% if Unit 16 excluded)
   - Additional mortality between 2007 and 2008 much greater in untreated stands
   - Predicted 3-year mortality +/- 2x higher in untreated vs. treated stands
3. **Treated forest has suffered lower rates of turpentine beetle attack**
   - But beetle focus on larger trees is heightened in treated stands

Yellow pine forests (Johansen et al. 2001): major erosion threshold reached at >60% bare ground

Soil cover

Mean litter cover 2008, data from transects and data from CSE plots



Summary (cont.)

5. Major differences in soil litter cover

- Treated stands showed >2x greater litter cover
- Mean litter cover in untreated stands is at or below 30-40% (Johansen et al [2001] threshold for major erosion impacts of heavy rainfall)

6. Understory effects

- One year after fire, treated stands supported much higher understory species diversity than untreated stands
- Live herbaceous cover was low in both areas, but about 70% higher in treated stands
- Shrub seedling density much higher (9x) in untreated forest

7. Forest regeneration

- Few canopy trees in untreated areas are likely to survive in the long-term
- Very low density of living seed trees in untreated stands
- Very few seedlings in fire area due to early fire and coincidence with poor seed crop
- High shrub seedling density in untreated areas will result in chaparral dominance of many of these stands for many decades

Fuel treatments and their effect: the Angora Fire as a case study. Hugh Safford, USFS, Pacific SW Region; Dept. Env. Science & Policy, UC-Davis
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Treatment Priorities

Example treatment priorities map

Fire Threat Treatment Areas

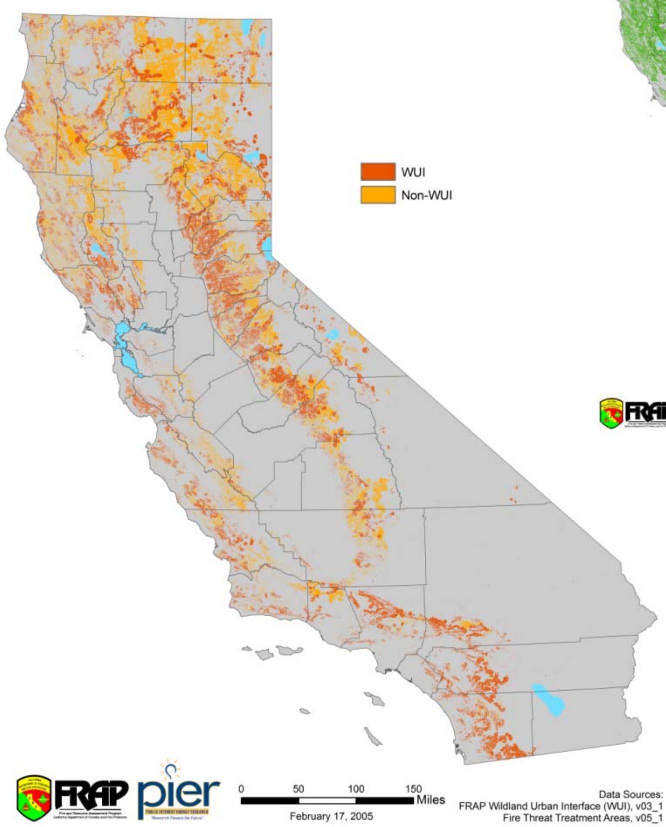
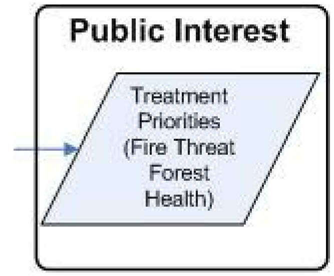


Figure 5. Forest and shrublands technically available for biomass production

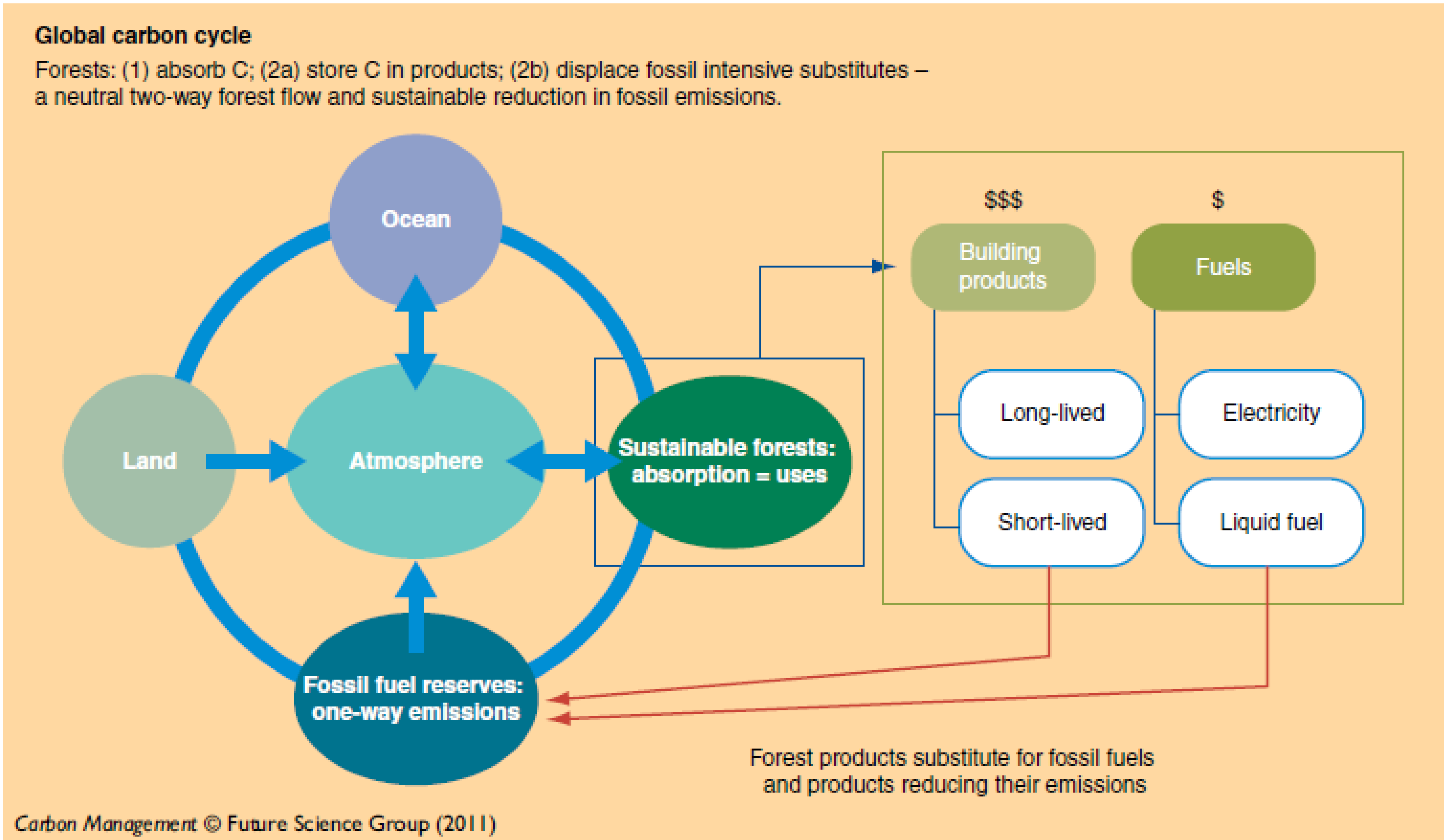


Estimates for treatment priorities are reported within hauling distance

Potential Priority Areas

- Fire Threat
- Forest Health
- Insect and Disease Risk

Use biomass energy to help pay for forest health goals and ecosystem preservation



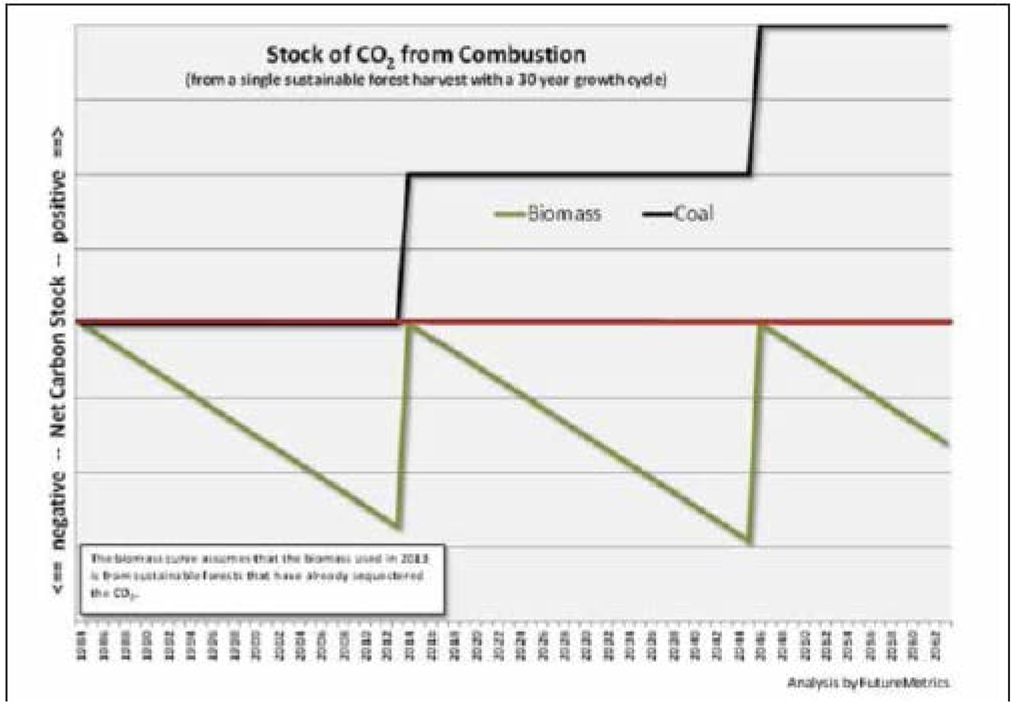
Major global carbon pools and their interactions. Fossil emissions flow one way from deep reserves to the atmosphere, whereas, as forests grow, they absorb atmospheric carbon that is transferred to long-lived product pools, while also displacing fossil fuel emission-intensive products and fuels. Lippke et al. 2011b.

Figure shows the correct frame of reference for a forest that is sustainably managed. The figure shows the carbon-cycle for one harvest. In this model, the forest grows at a rate of one ton per acre per year. The model forest is 100,000 acres, which means that each year there is 100,000 tons of new growth. The figure assumes that this year's 100,000 tons harvest started growing 30 years ago in 1984. Note that the net carbon stock of the atmosphere is reduced over those 30 years as the new growth absorbs carbon. This is shown by the downward sloping green line.

In 2013, when this year's 100,000-ton harvest is combusted as fuel, the previously sequestered carbon is released. The cycle is repeated in 2045. But the carbon does not have to wait until 2045 to be removed from the atmosphere. The new 100,000 tons that grows in 2013 captures all of the carbon released, as long as the net stock of wood on the 100,000 acres of forest is not diminished. In contrast, if the same amount of energy is released from coal in 2013 and 2045, the net stock of atmospheric carbon is permanently increased. This is shown by the black line in the Figure.

Source: Air and Waste Management Association, 2013. W. Strauss, FutureMetrics

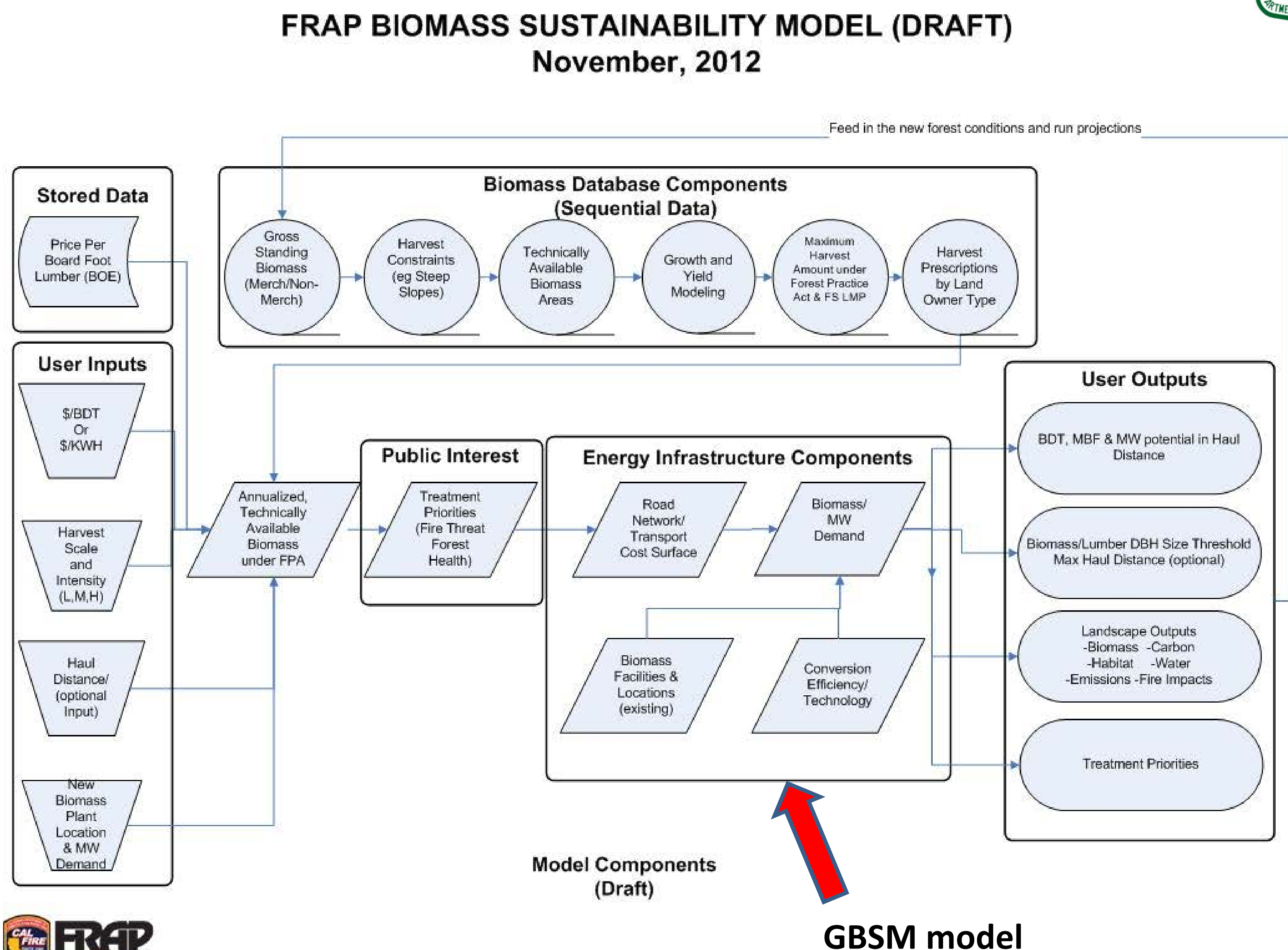
If there is any validity to a model that has carbon cycling from atmosphere into trees and back into the atmosphere, the stock of trees must remain constant or growing. Depleting the forests for energy is not renewable. A shrinking forest is a net carbon source.



FRAP Biomass Sustainability Model

- Address State and Federal policy goals (AB 32, AB 1504, State RPS, Federal RFS etc.)
- Update biomass maps and estimates of potential for California (MW, MBF, BDT)
- Model current and future forests, and wood/energy products
- Model Scale and Intensity of harvest at different price points paid for Biomass material
- Evaluate CA Forest Practice Rules and USFS management plans ability address carbon and ecosystem sustainability issues

Model Diagram



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Aemetis, Keyes, CA; 55mgy


Calgren, Pixley CA; 60 mgy


Stockton; 60 mgy


Madera; 40 mgy

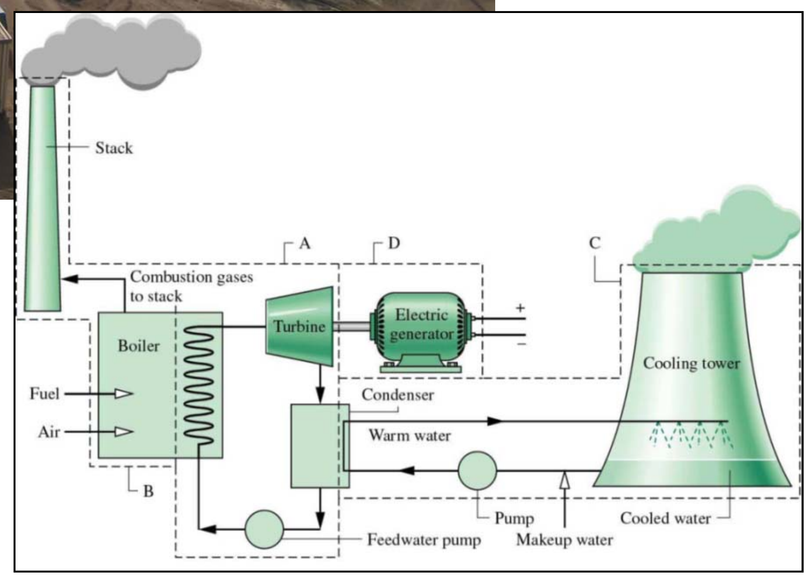
Pacific Ethanol

California Biodiesel Facilities, 30 -40 mgy

Business Name/Location	Contact	Phone	WebSite	BQ9000 Status	RFS Status	Plant Capacity	Last Reported
Baker Commodities Los Angeles 4020 Bandini Blvd Vernon ,CA 90058	Doug Smith	323-200-4659	www.bakercommodities.com				01/2013
Bay Biodiesel, LLC (San Jose) 905 Stockton Ave San Jose ,CA 95110	Pat O""""""""""Keefe	925-228-2222	www.baybiodiesel.com			3,000,000	01/2013
Biodiesel Industries of Ventura, LLC U.S. Naval Base Ventura, National Environmental Test Site Port Hueneme ,CA 93043	Russell Teall, JD	805-683-8103	www.biodico.com			10,000,000	11/2012
Community Fuels 809-C Snedeker Ave. Stockton ,CA 95203	Lisa Mortenson	760-942-9306	www.communityfuels.c			10,000,000	01/2013
Crimson Renewable Energy, LP 17731 Millux Rd. Bakersfield ,CA 93311	Harry Simpson	720-475-5409	www.crimsonrenewabl				12/2012
GeoGreen Biofuels, Inc. 6011 Malburg Way Vernon ,CA 90058	Eric Lauzon	323 826 9753	www.geogreen.com				01/2013
Imperial Western Products 86600 54th Ave Coachella ,CA 92236	Curtis Wright	760-398-0815	www.biotanefuels.com			10,500,000	01/2013
New Leaf Biofuel, LLC San Diego ,CA 92113	Jennifer Case	619-236-8500	www.newleafbiofuel.com			2,000,000	01/2013
Noil Energy Group 4426 East Washington Blvd Commerce ,CA 90040 TERMENDZHYAN	LEVON	323-726-1966					01/2013
North Star Biofuels, LLC 860 W. Beach Street Watsonville ,CA 95076	James Levine	510 350 4102				750,000	01/2013
Simple Fuels Biodiesel, Inc. 93232 Highway 70 Chilcoot ,CA 96105	James Lutch	530-993-6000	www.simplefuels.com			1,000,000	
Yokayo Biofuels, Inc. 350 Orr Springs Road Ukiah ,CA 95482	Kumar Plocher	877-806-0900	www.ybiofuels.org			500,000	01/2013

Drought and policy are having significant short term effects on farming in California. Whether the full potential for agricultural biomass projects can be reached depends on both in the near ter. In the long-term, it depends also on whether Climate Change reduces or increases precipitation, or is neutral.

Agricultural residues



Covanta Biomass to Energy Facility in Mendota. Fuel yard and conversion system. This facility relies on biomass from orchard and vineyard removal and prunings, and other woody waste materials from agriculture. Older technology.

Drought and water policy will led to removal of more acres of almonds and other tree and vine crops in 2014 than normal. This wood will likely go to biomass to energy facilities. This will lower feedstock cost but if facilities re currently operating at capacity, it will not increase power supply.

Fig. 1.7. Location of almond and walnut orchards.

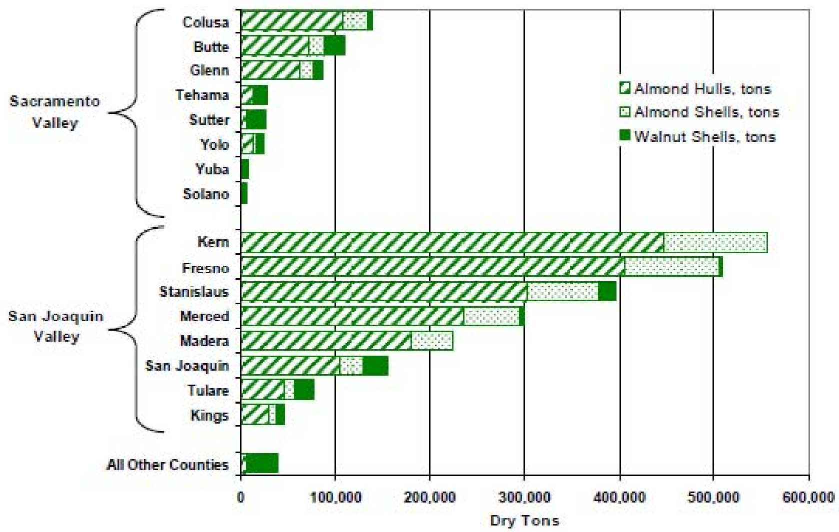
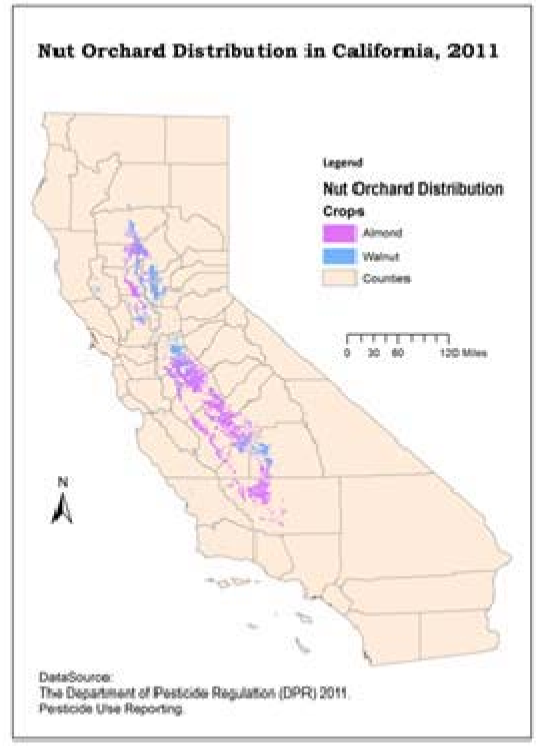


Fig 1.8. Distribution of the production of almond hulls and shells and walnut shells by county and central valley production area.



Dixon Ridge Farm uses 2.0 million pounds of shells for power and heat each year in a 100 kW gasifier provided by Community Power, Inc.

Table 4. 2014 SWAP Estimated Changes in Irrigated Crop Area (acres)

Region	Feed Crops	Vegetables	Trees and Vine	Grain	Other Field	Region total
Sacramento Valley, SD and ED	-83,481	-3,801	-8,931	-40,785	-13,523	-150,521
San Joaquin Valley	-39,269	-2,638	-7,514	-20,105	-55,883	-125,409
Tulare Lake Basin	-23,967	-3,838	-24,483	-35,105	-45,501	-132,894
Central Valley Totals	***-146,718***	***-10,277***	***-40,929***	***-95,995***	***-114,907***	***-408,825***

60% of fallowed area is in the San Joaquin Valley

Preliminary 2014 Drought Economic Impact Estimates in Central Valley Agriculture_CDFA, May 19, 2014 (UC Davis Center for Watershed Sciences, Howitt et al.,)

Table 1. 2014 Drought and Central Valley Agriculture Summary

Drought impact	Loss Quantity	Normal Quantity	Percent Loss
Water delivery reduction	6.5 maf	20 maf	32.5%
Shortage after increased groundwater pumping	1.5 maf	20 maf	7.5%
Fallowed irrigated land	410,000 acres	7,000,000 acres	6%
Crop revenue loss	$740 million	$25 billion	3%
Revenue lost plus additional pumping cost ($450 million)	$1.2 billion	$25 billion	4.8%
Central Valley economic loss	$1.7 billion	N.A.	
Direct crop production job losses (seasonal and full time)	6,400	152,000	4.2%
Direct, indirect and induced job losses	14,500	N.A.	

maf = million acre feet.

Preliminary 2014 Drought Economic Impact Estimates in Central Valley Agriculture_CDFA, May 19, 2014 (UC Davis Center for Watershed Sciences, Howitt et al.,)

Potential to avoid some CH4 emissions from rice fields

Table 2.2. Potential CO_2 Equivalents Offset by AD of Rice Straw at a 140 ton/day Facility

Percent of BMZ Straw	Mg CO_2 (field)	CH_4 Offsets from Natural Gas Generation (Mg CO_2)		CH_4 Offsets from Power Generation (Mg CO_2)		CH_4 Emissions Avoided (Mg CO_2)
		35%	70%	35%	70%	
Facility 1, Biogas Distribution = 70% NG:0% Power						
100%	92,500		9,061			55,311
66%	6,000		5,980			35,980
50%	47,500		4,530			28,280
33%	30,000		2,990			17,990
Facility 2, Biogas Distribution=35% NG:35% Power						
100%	92,500	4,530		3,354		54,135
66%	60,000	2,990		2,214		35,204
50%	47,500	2,265		1,677		27,692
33%	30,000	1,495		1,107		17,602
Facility 3, Biogas Distribution=0% NG:70% Power						
100%	92,500				6,709	52,959
66%	60,000				4,428	34,428
50%	47,500				3,354	27,104
33%	30,000				2,214	17,214

Table 2.3. Estimated benefits from anaerobic digestion of rice straw.

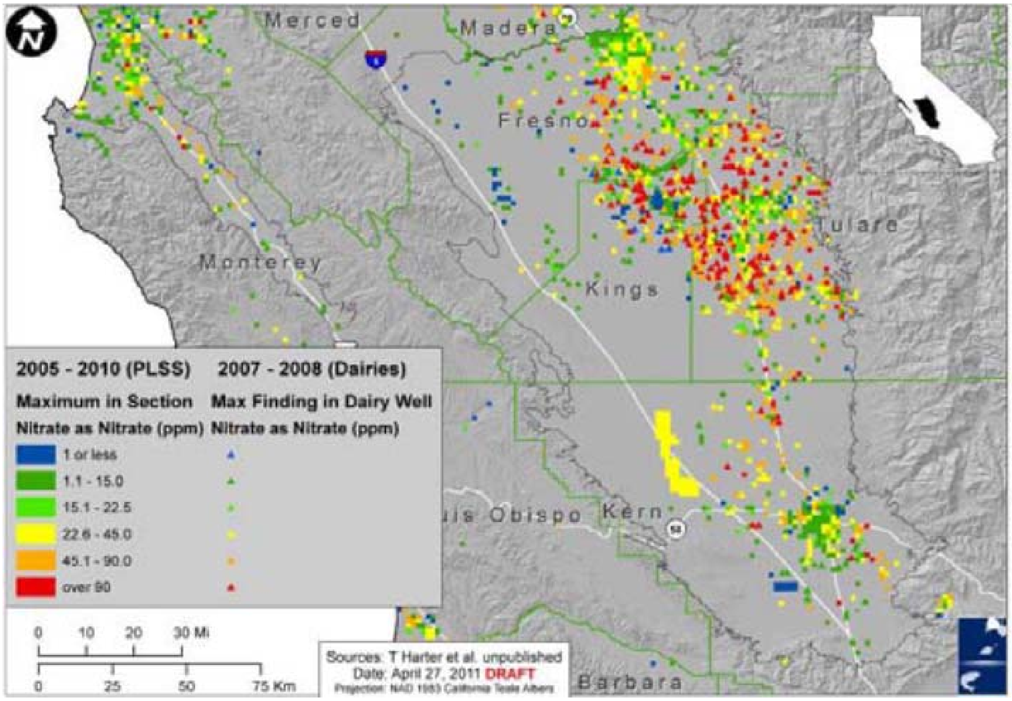
		Feedstock BDT	Power Capacity, MW	Heat Value MMBTU	CH4 Mg CH4
1. Rice Straw AD	Power	50,000	1.9		55,000
140 tons/day	Heat Production	50,000		17,700	53,000
	Power	200,000	7.6		220,500
4.0 AD units	Heat Production	200,000		710,000	220,500

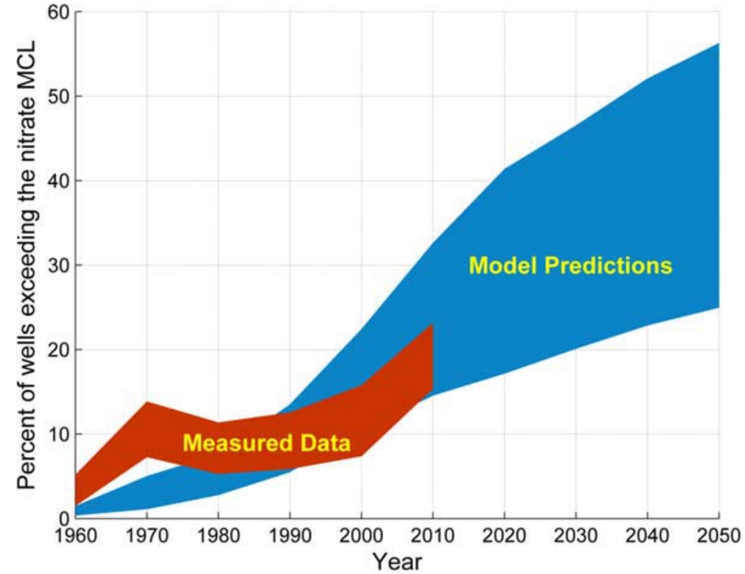
Could anaerobic digestion by-products replace manufactured fertilisers?

- “the digestate application in solid or liquid form could result significant improvement of the quantity and quality of foods through the even nutrient supply harmonizing with the necessity of plants and through its microelement content in the available forms for plants.”

http://www.businessgreen.com/bg/news/2035377/anaerobic-digestion-products-replace-manufactured-fertiliers
Marianna Makádi, Attila Tomócsik and Viktória Orosz (2012). Digestate: A New Nutrient Source - Review, Biogas, Dr. Sunil Kumar (Ed.), ISBN: 978-953-51-0204-5, InTech, Available from: http://www.intechopen.com/books/biogas/digestate-a-new-nutrient-source-review

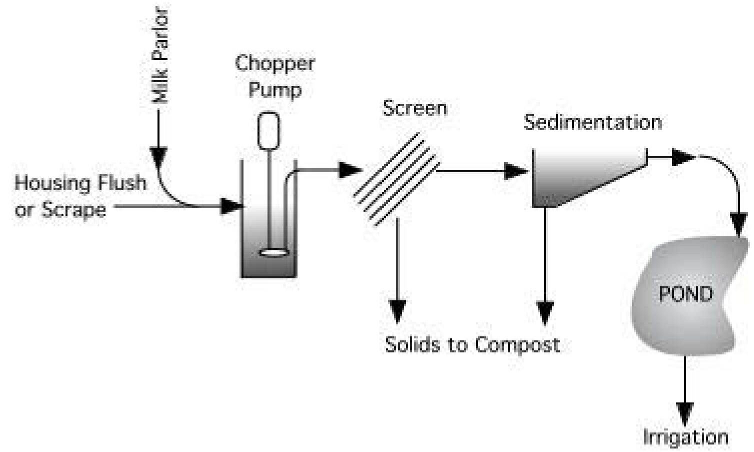
Figure 2.28. Elite Energy thermophilic anaerobic digester at Brazil Dairy in Merced County (3000 cows). Dewatered solid materials from the AD effluent are sold to local bedding plant nurseries. Liquids and most nutrients are returned to fields.

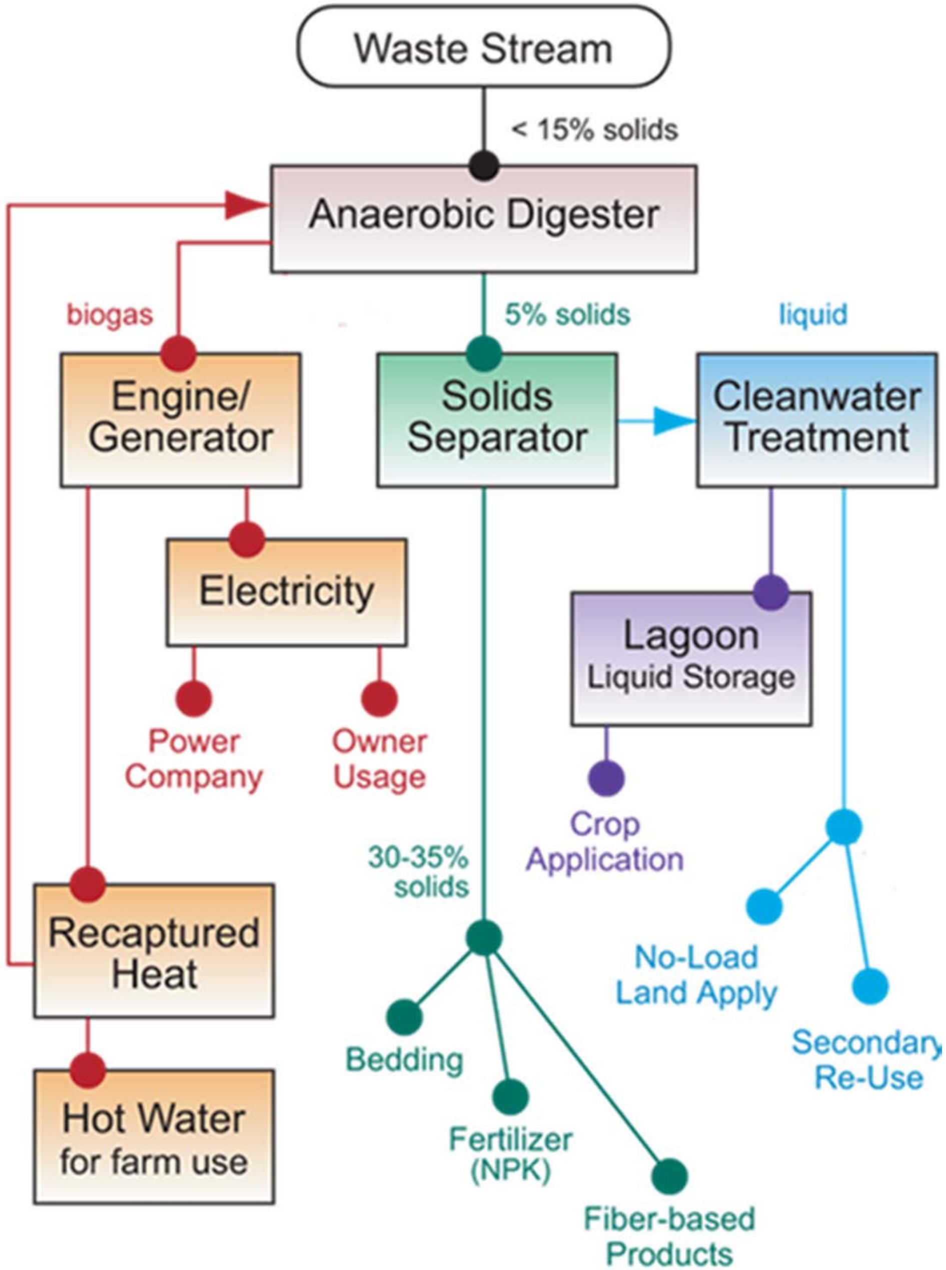




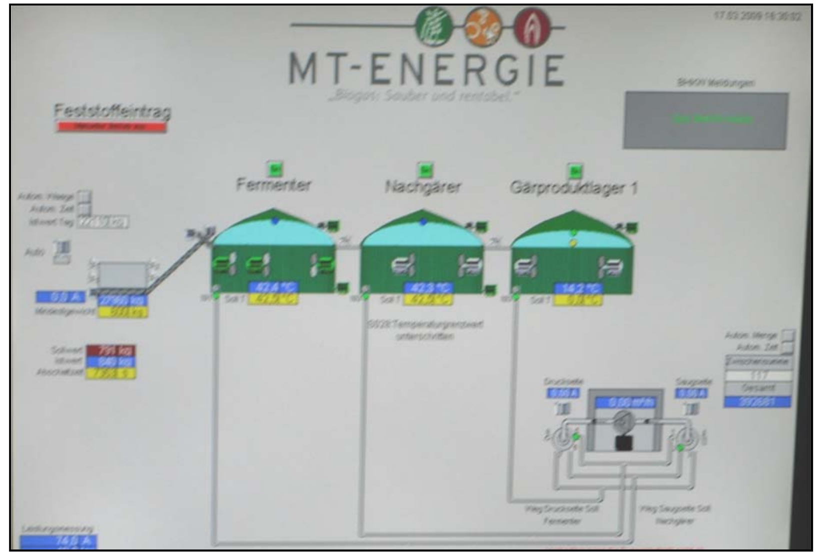
Assessing Nitrate in California's Drinking Water, With a Focus on Tulare Lake Basin and Salinas Valley Groundwater. T. Harter and J. Lund, et al., 2012.
Center for Watershed Sciences, UC Davis; **http://groundwaternitrate.ucdavis.edu**

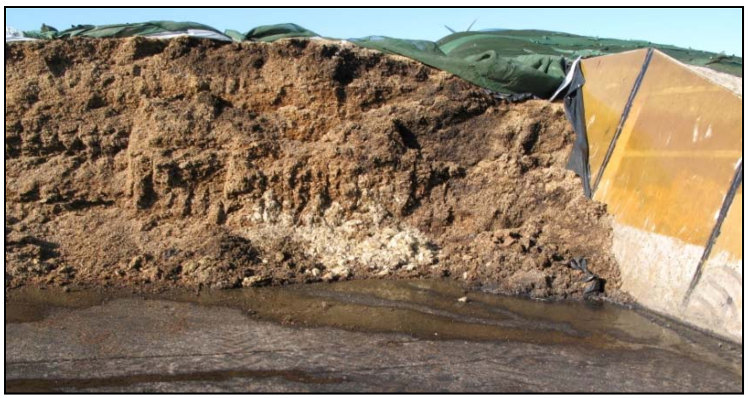

Feed lot near Coalinga

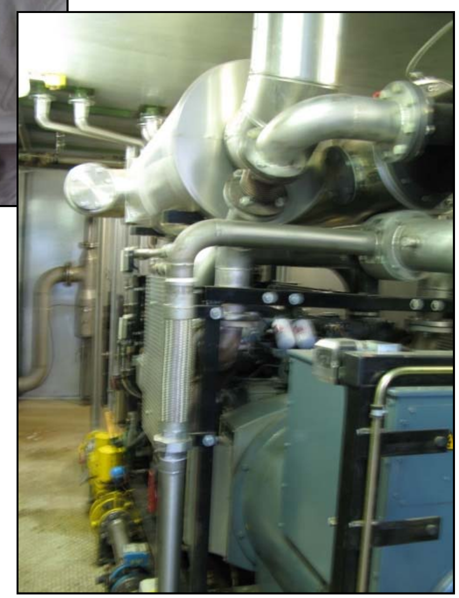

Milk Parlor
Chopper
Pump
Screen
Sedimentation
Housing Flush
or Scrape
POND
Solids to Compost
Irrigation



http://www.dvoinc.net/advantages.php







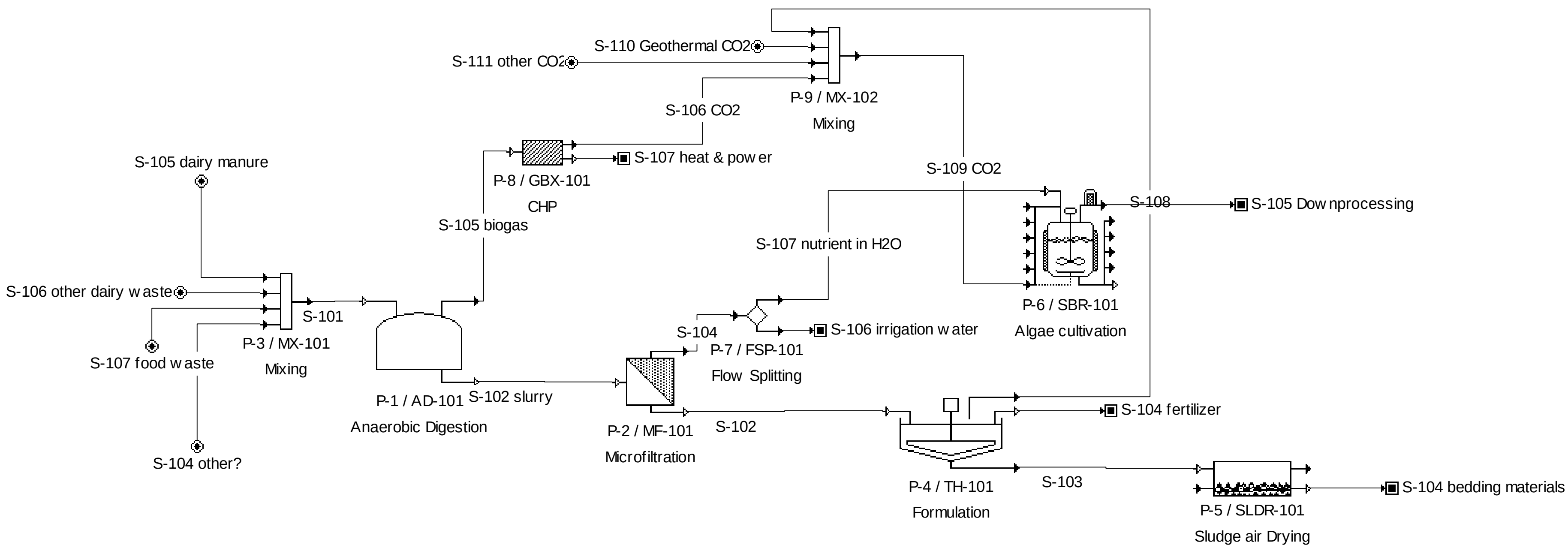
Biogas to electricity facility in Germany, 2009

Effluent is removed daily [7%DM (summer)-8.5 % DM (winter)]. NO3: 5.6%/m3; P: 2.4%/m3; K: 5.6%/m3. It is field spread. They sell it for 12-13 euros/m3.

Reducing N and P losses from CAFOs, (and reducing N losses from agriculture in general) will involve costs, either directly for interventions, or indirectly through higher food prices, or loss of farm businesses.

Integrating nutrient management with energy production and green house gas reduction offers promising opportunities to address several environmental and economic problems in an integrated manner. This may be one way to minimize public costs generally for the environmental improvements desired.

Preliminary scheme



There are many feedstock crop possibilities in California that could provide a basis for bioenergy on an agro-ecological basis. All we need to do is just add water.

Can we have in-state feedstock production for bioenergy in California?

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California Biomass Collaborative

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California Production Differs from Other States

	California $1,000	Iowa $1,000	Texas $1,000	Nebraska $1,000	Illinois $1,000
Food-plant	**$16,490,102**	**$23,681**	**$593,523**	**$66,434**	**$116,780**
Food-animal	**$10,793,300**	**$10,007,347**	**$14,167,468**	**$8,624,935**	**$2,422,917**
Feed	**$2,408,398**	**$10,225,065**	**$3,971,174**	**$6,735,085**	**$10,318,090**
Fiber	$408,272	$32,159	$1,217,333	$8,058	$5,218
Ornamentals	**$3,725,194**	**$107,520**	**$987,533**	**$50,937**	**$458,294**
Other	$58,798	$22,324	$64,042	$20,585	$7,807
Total Value	**$33,885,064**	**$20,418,096**	**$21,001,074**	**$15,506,034**	**$13,329,106**

California farmers tend to produce **food crops** while in other states, more **feed** and industrial crops are produced. **Food crops are higher value and more diverse**.

USDA, NASS, 2007 Census of Agriculture

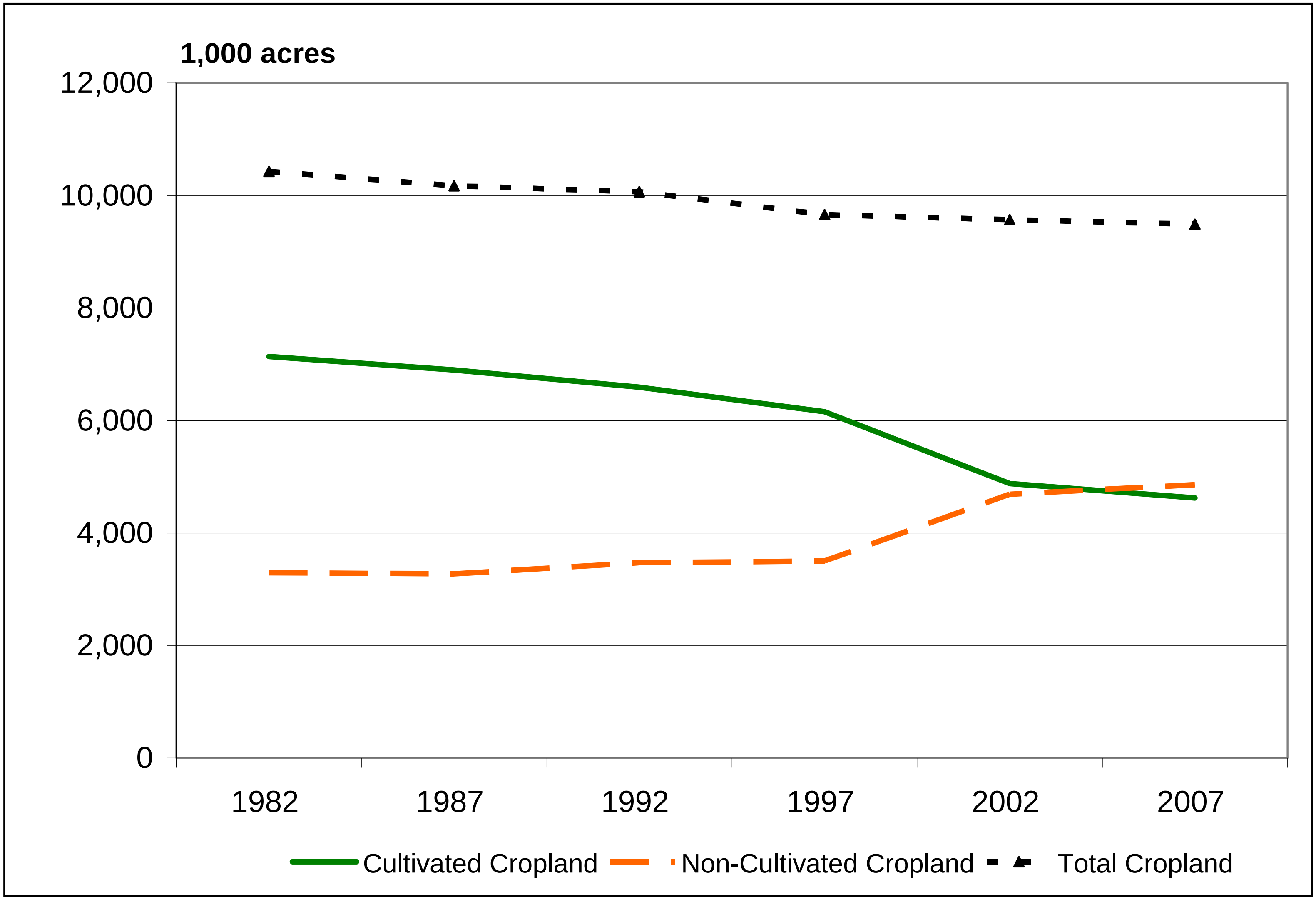
2010 USDA Biofuels Roadmap Estimates

Advanced Biofuel Production from New Capacity (billion gallons)

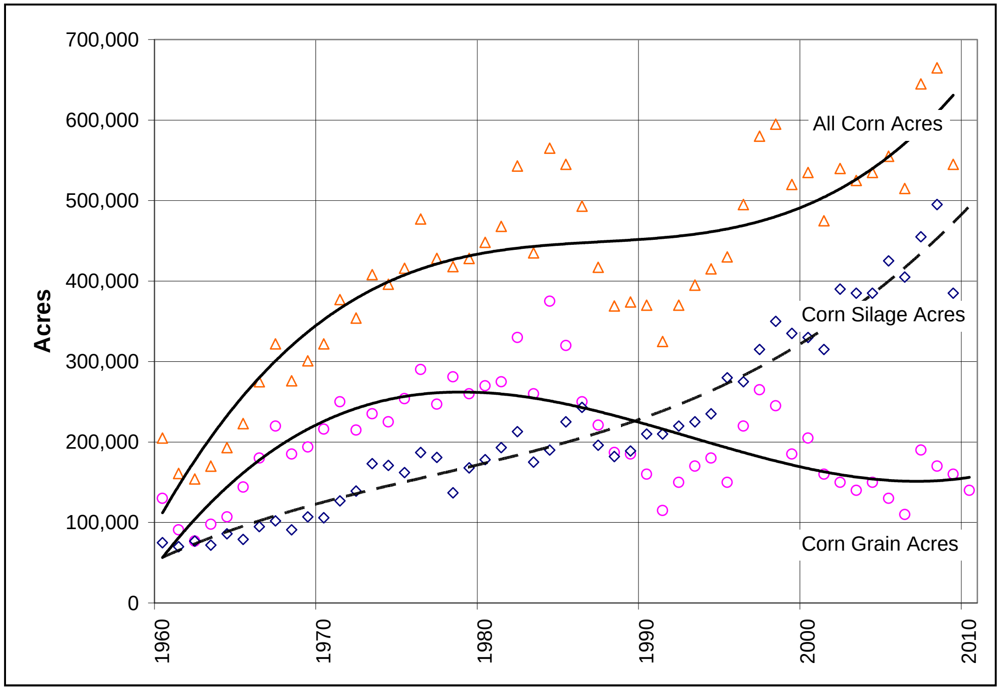
Region	% of Total Advanced Volume	Advanced Biofuels		Total Advanced Volume	Total Advanced RFS2 Basis (1)
		Ethanol	Biodiesel		
Southeast (2)	49.8	10.45	0.01	10.46	10.47
Central East (3)	43.3	8.83	0.26	9.09	9.22
Northeast (4)	2.0	0.42	0.01	0.42	0.43
Northwest (5)	4.6	0.79	0.18	0.96	1.05
West (6)	**<0.3**	**0.06**	**0.00**	**0.06**	**0.06**
United States		20.55	0.45	21.00	21.23

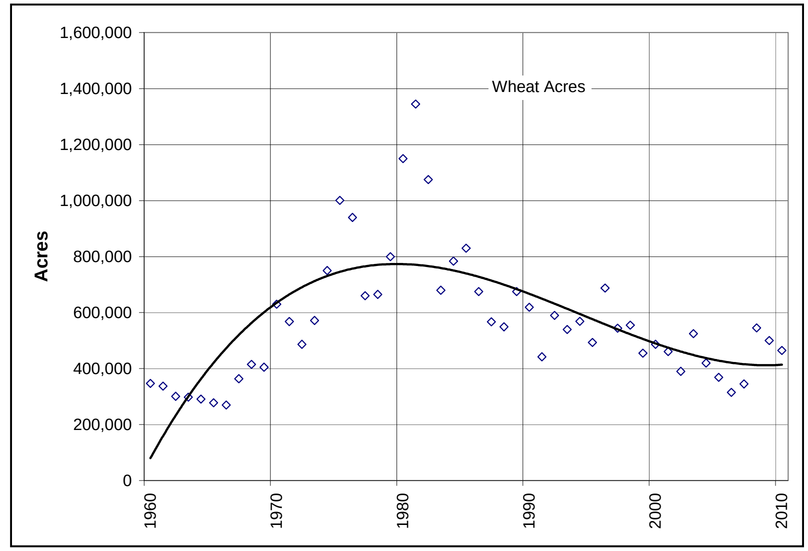
(1) RFS2 Basis - higher density fuels receive higher weighting relative to ethanol. Biodiesel is 1.5
(2) Feedstocks: Perennial grasses, soyoil, energy cane, biomass (sweet) sorghum, logging residues
(3) Feedstocks: Perennial grasses, canola, soyoil, biomass (sweet) sorghum, corn stover, logging residues
(4) Feedstocks: Perennial grasses, soyoil, biomass (sweet) sorghum, corn stover, logging residues
(5) Feedstocks: Canola,straw, logging residues
(6) Feedstocks: Biomass (sweet) sorghum, logging residues

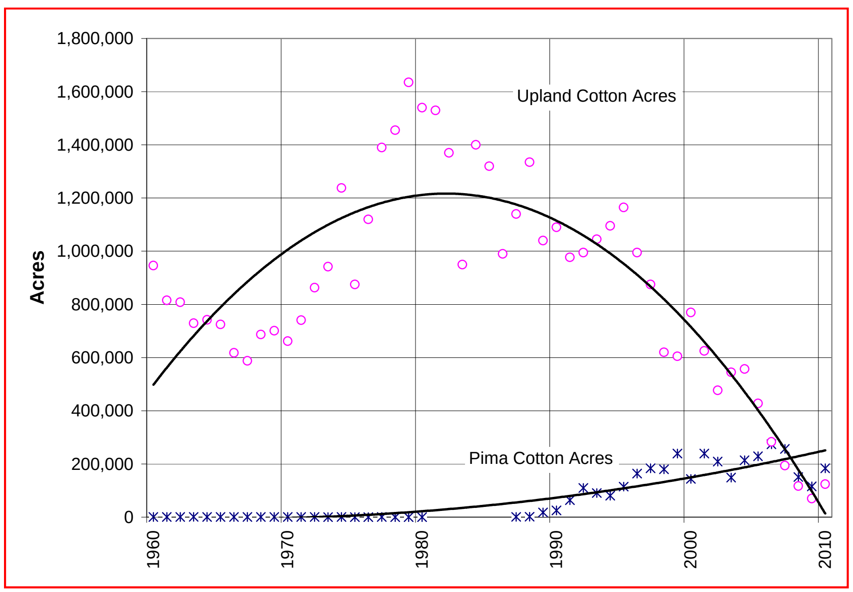
USDA predicts little bioenergy production from crops in California or elsewhere in the western US.

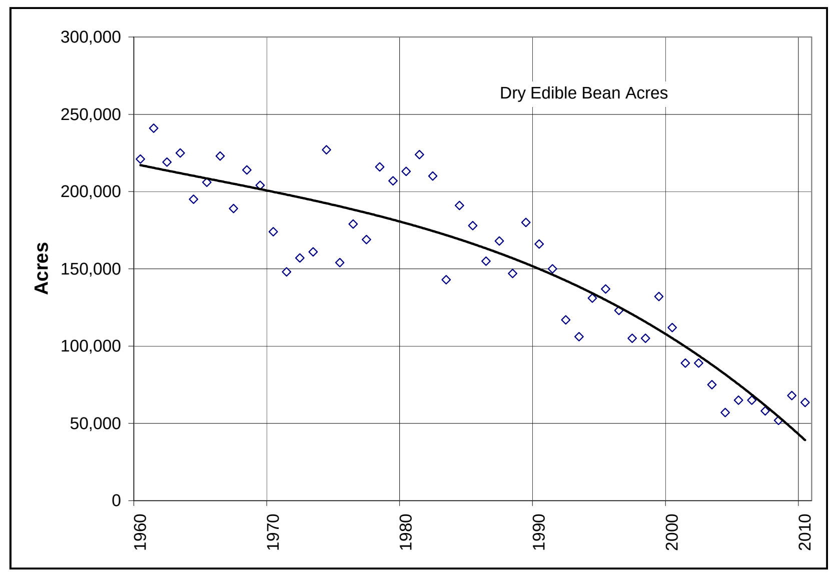


Changes in California cultivated and non-cultivated cropland, 1982-2007 (USDA, NRCS, 2009). Non-cultivated cropland = tree and vine crops predominantly





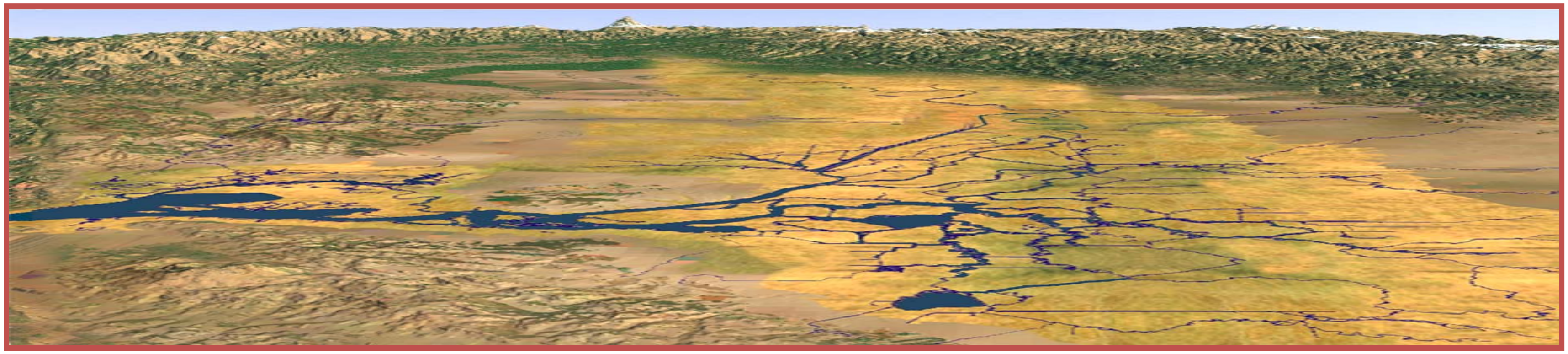




Changes in agronomic crop acres in CA. USDA data,

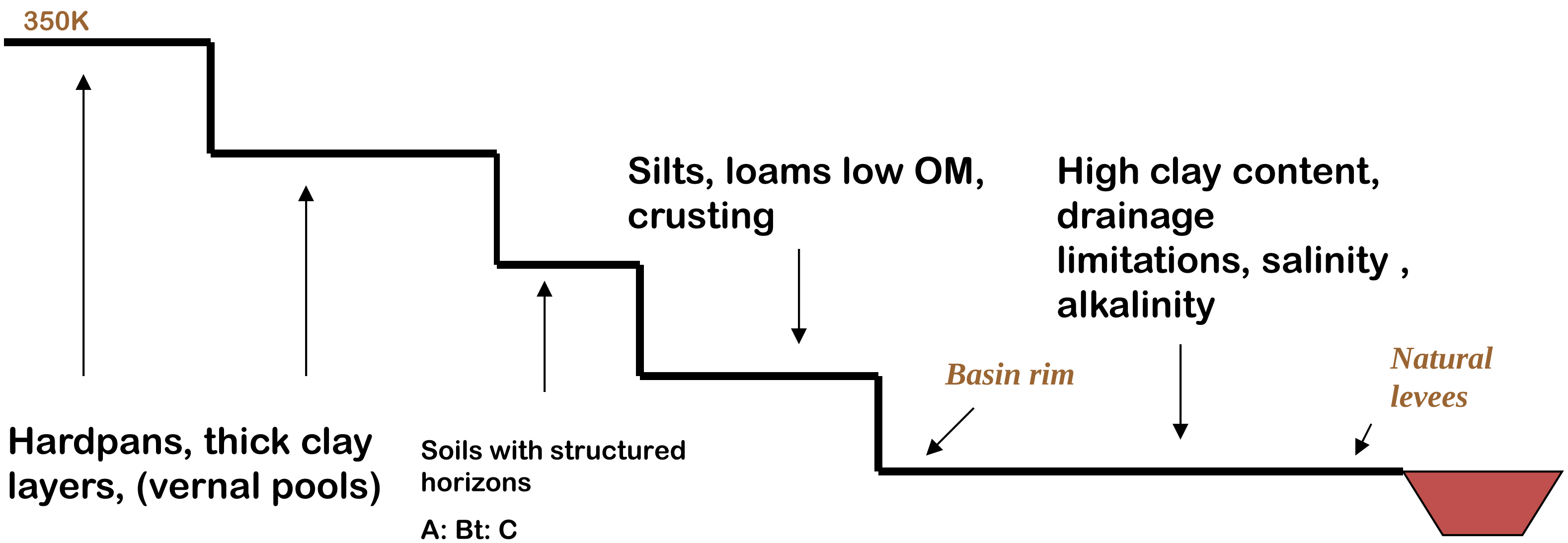
In California's varied landscape, the challenge will be to achieve high yields, low production costs, and low LCA CO2eq values for feedstocks.

Diverse soils and landscapes lead to differing cropping systems in CA



Soil age: - →

oldest 100K 30-80K 10K youngest

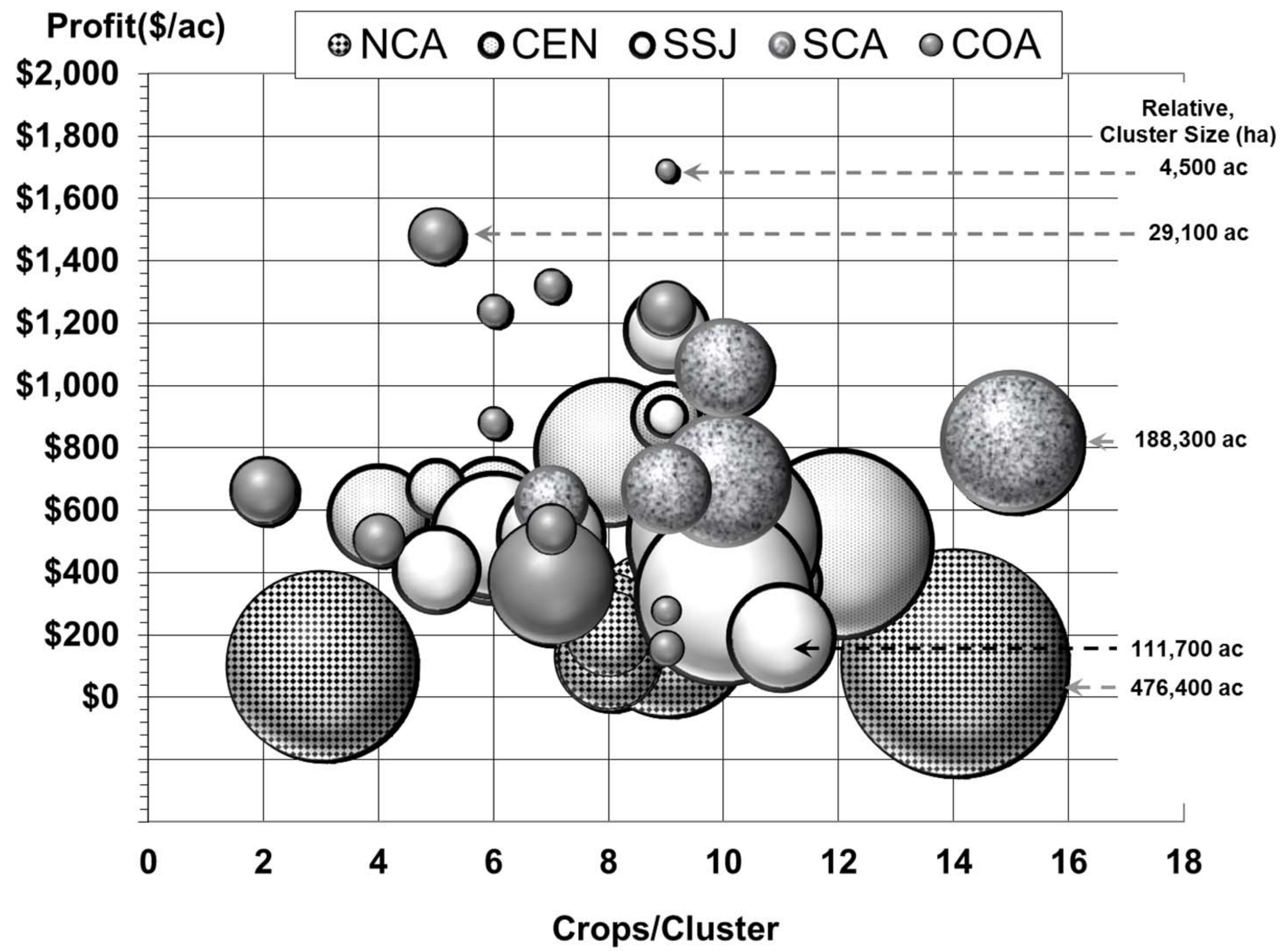


Oak-savanna/rangelands

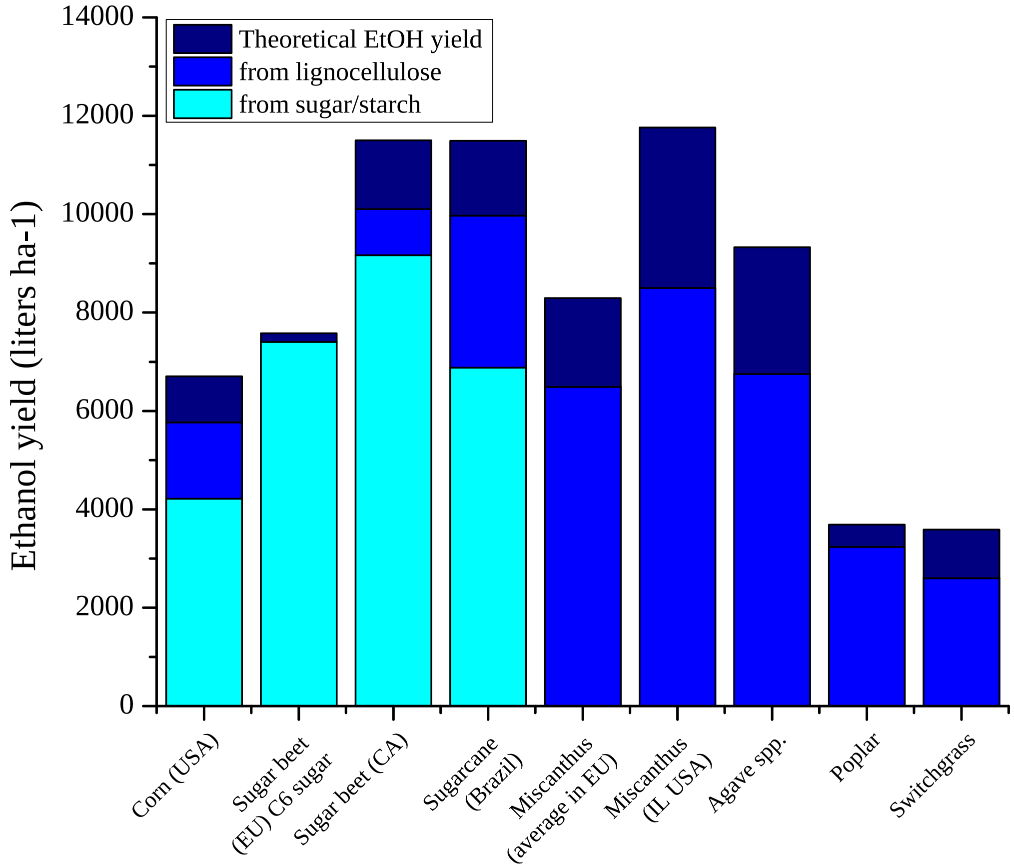
rangeland/pasture, some perennials

Soil use → perennials, annuals mostly annuals

Per Acre Profit for 45 Regional Farming Systems (2007 data)



NCA: Sacramento Valley; CEN: Delta and northern SJV; SCA: Tulare, Kings, Kern; SCA: Imperial Valley, Palo Verde, San Diego; COA: Salinas Valley, Santa Maria, Ventura



Potential ethanol yields from selected feedstocks. Crops like beets can be produced with high yields and efficiency using current or near –term technology. Cellulosic or low quality feedstock sources have been slow to enter the market, and are less likely to be produced in California. Light blue, current or simple technology, mid-blue (new of pilot-scale technology) and dark blue (no current technology available-the theoretical conversion limit). Data from diverse sources.

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Likely near term crop based biofuel opportunities in California

Crop	Commodity	Current Price (2013-14)	BCAM entry price (2007)	Location with most likely adoption	Estimated acres (thousands)	Fuel type	Yield (as harvested)	Feedstock cost			In-state potential	Assumptions#		
	$/t	$/t	$/t				gal/t	$/gge	gge/ac	gge/ton	Mgge/y	lb/ac	t/ac	Quality
Canola	seed	475	385	SAC.SJV	100	biodiesel	129.15	2.85	169	135.22	16.90	2500	1.25	43% oil
	meal													
Camelina	seed	340*	525	SAC.SJV	0	biodiesel	96.11	5.22		100.63	0.00	1600	0.8	32% oil
	meal													
Sorghum	grain		134-139	SAC,SJV	100	ethanol	110.95	1.81-1.88	296	73.97	29.59	8000	4	
Sorghum	sugar*		23.75	SJV/IV	15	ethanol	21.54	1.65		14.36	8.62		40	13% brix
	livestock feed													
	biogas					CNG								
Beets	sugar**	65	40	SJV	30	ethanol	25.20	2.38	672	16.80	20.16		40	16% sucrose
	livestock feed													
	biogas					CNG								
Sugarcane	sugar***		45	IV	60	ethanol	21.54	3.13	646	14.36	38.78		45	13% brix
	bagasse					electricity								
	biogas					CNG								
Energy cane##	bagasse		45	IV	40	ethanol	63--79.2	0.85-1.07	622-781	42-52.8	31.9-40.1		45###	
	biogas					electricity								

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