

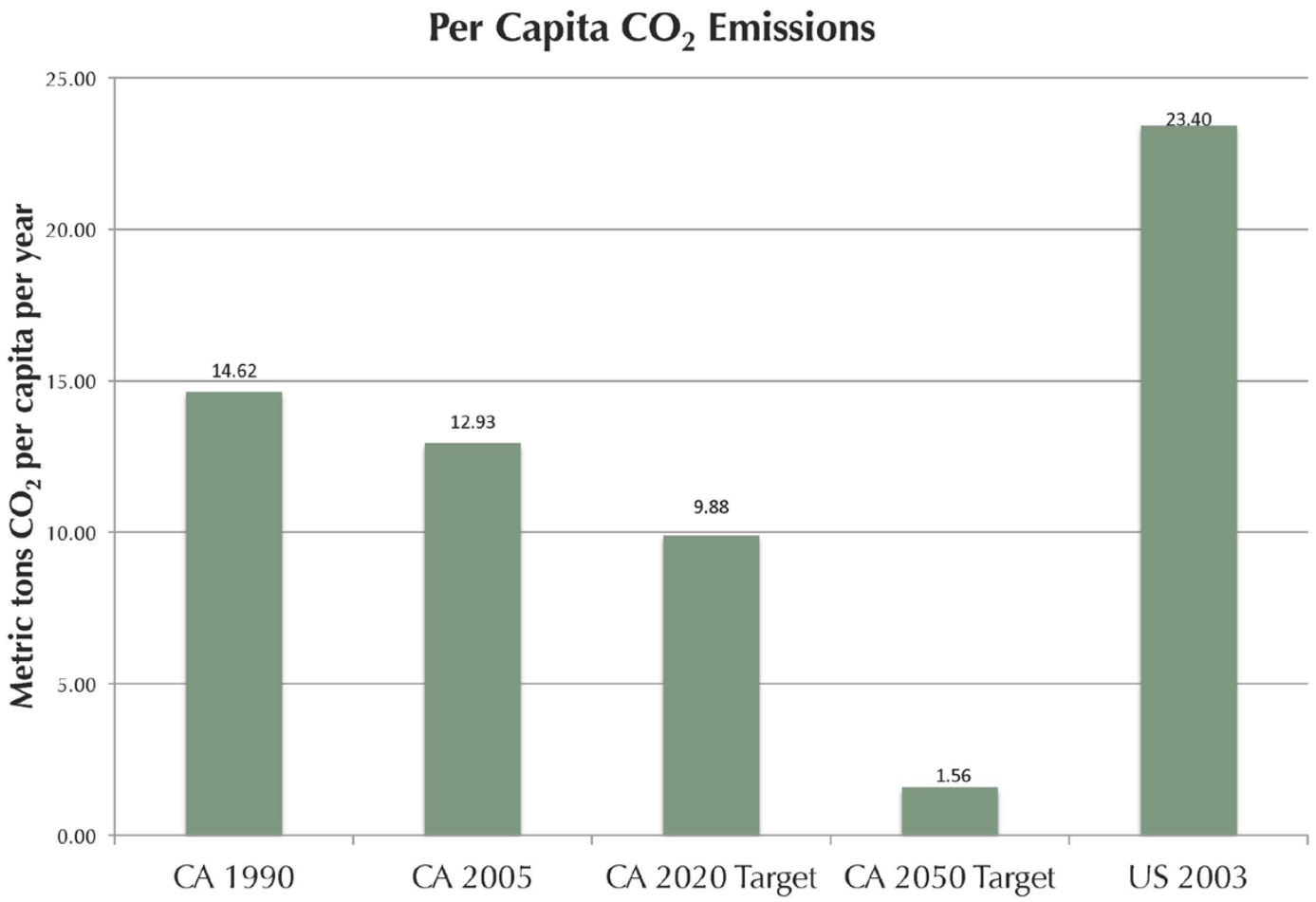
POLICY INSTITUTE FOR ENERGY, ENVIRONMENT AND THE ECONOMY

Overview of Biomass

17 May, 2013

UCDAVIS

California's greenhouse gas reduction targets



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Risks from Climate Change

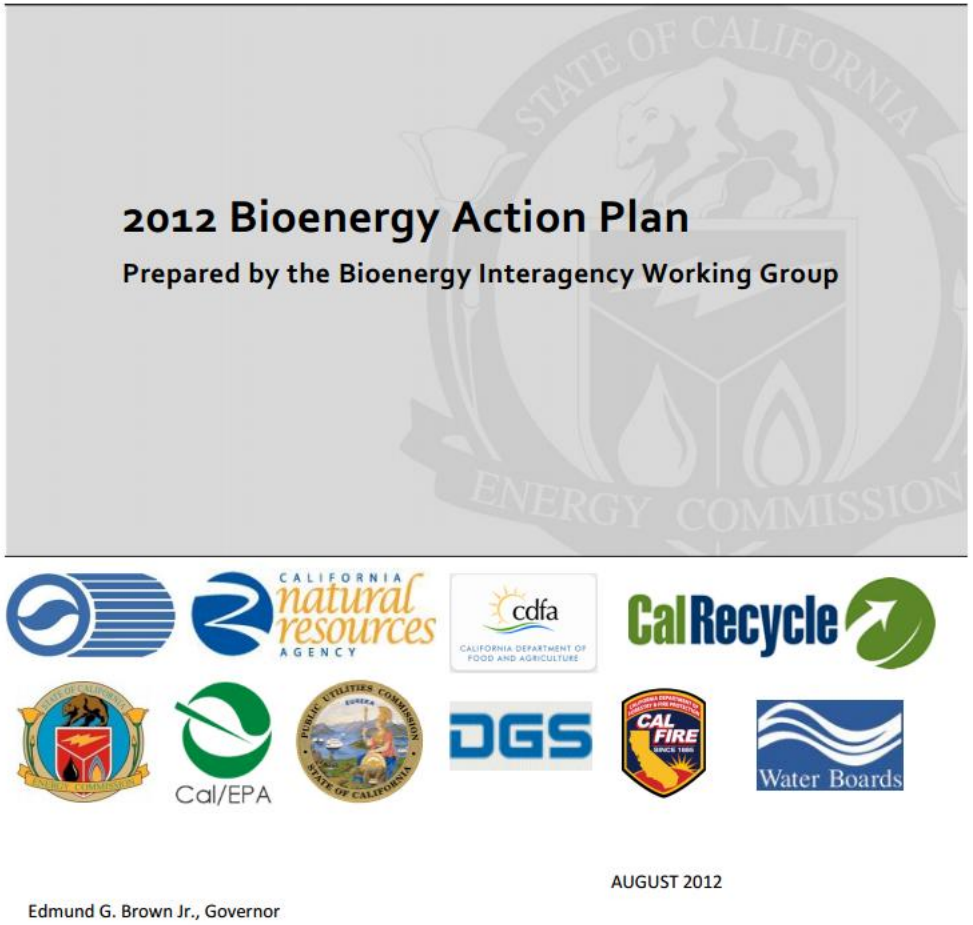
CA is particularly vulnerable to the costs associated with unmitigated climate change. A warming climate would generate more smoggy days, ozone, and foster more large brush and forest fires… by late century, CA will loose 90% of the Sierra snow pack, sea level will rise by more than 20 inches, and there 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 BIOMASS ACTION PLAN

- Increase environmentally and economically sustainable energy production from biomass residues
- Support research and funding mechanisms to stimulate deployment of sustainable bioenergy technologies.
- Stimulate economic development in rural and economically disadvantaged regions of the state.
- Streamline the permitting process through collaboration with stakeholders and local, regional, state, and federal agencies.



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www.resources.ca.gov/docs/2012_Bioenergy_Action_Plan.pdf

WHAT IS BIOMASS?

- **Strict definition:**
  - **living (or recently living) plant or animal material**
- **General Federal statute (Energy Policy Act of 2005):**
  - **"Any organic matter that is available on a renewable or recurring basis, including agricultural crops and trees, wood and wood wastes and residues, plants (including aquatic plants), grasses, residues, fibers, and animal wastes, municipal wastes, and other waste materials." Excludes old-growth timber.**
  - **Many revisions since, but generally similar – (may exclude material from public lands)**

WHAT IS BIOENERGY

- Heat
- Biopower (electricity)
- Biofuels
  - Solid Fuels
    - Wood pellets or cubes for heating or cofiring
    - Torrefied biomass (for cofiring at coal facilities)
    - Char/charcoal for cooking
  - Gaseous Fuels
    - biogas,
    - biomethane,
    - compressed biomethane (like CNG),
    - Renewable synthetic natural gas (RSNG)
  - Liquid Fuels
    - Ethanol (conventional starch/sugar derived, or from lignocellulosic processes)
    - Methanol
    - Butanol
    - Biodiesel (from vegetable or waste oils. Specifically: fatty-acid-methyl-ester (FAME))
    - Renewable diesel and gasoline (e.g., “drop-in” fuels or hydrocarbons, biomass-to-liquid (BTL), Fischer Tropsch liquids, etc.)

DEFINITIONS

- Anaerobic Digestion (AD) – A process by which biomass is sealed in an airtight vessel, which promotes microbial production of methane-rich biogas.
- Billion Cubic Feet (BCF) – Measurement of natural gas or digester gas, when used for natural gas, roughly enough energy to supply 10,000 homes for over one year.
- Landfill Gas (LFG) – Methane-rich gas produced by naturally anaerobic conditions deep in a landfill.
- Wastewater Treatment Plant (WWTP) – Often use anaerobic digesters to help remove organic matter from water, the biogas can be used for heat or power.
- Combined Heat and Power (CHP) – A system which generates electricity and useable heat.

OUR SPEAKER

- Stephen Kaffka PhD
  - Cornell University MS & PhD in Agronomy
  - Extension Specialist – Department of Plant Sciences
  - Director of Biomass Collaborative
  - Extensive experience with potential energy crops

Bioenergy in California

Stephen Kaffka, **Rob Williams**
Department of Plant Sciences, UC Davis &
California Biomass Collaborative; California Biomass Collaborative and Department of Biological and Agricultural Engineering, UC Davis

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May 17, 2013

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CALIFORNIA BIOMASS COLLABORATIVE

Bioenergy in California

Part 1: May 17, 2013 (today).

What is biomass? How much is there in California? Is it being used? Could more be used? How will this come about?

Part 2: (date to be determined)
How is biomass transformed to energy and bio-products? What state policies affect/regulate the use of biomass in California? What are the prospects for increased use of biomass in California?

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Themes/Questions for Part 1: Biomass Energy in California

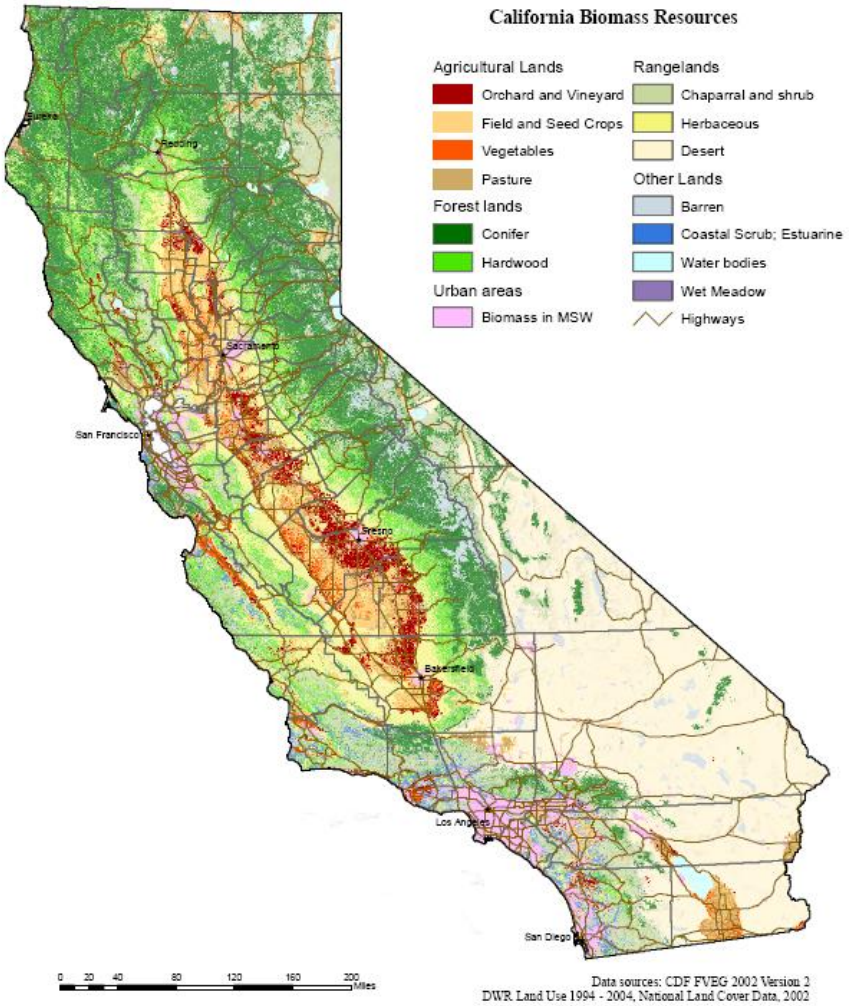
- What do me mean by the term biomass when we discuss the use of biomass for energy?
- How much biomass is there in California?
- How much is being used?
- Where is it being used?
- Could more be used?
- How do state and federal policies affect biomass use in California?

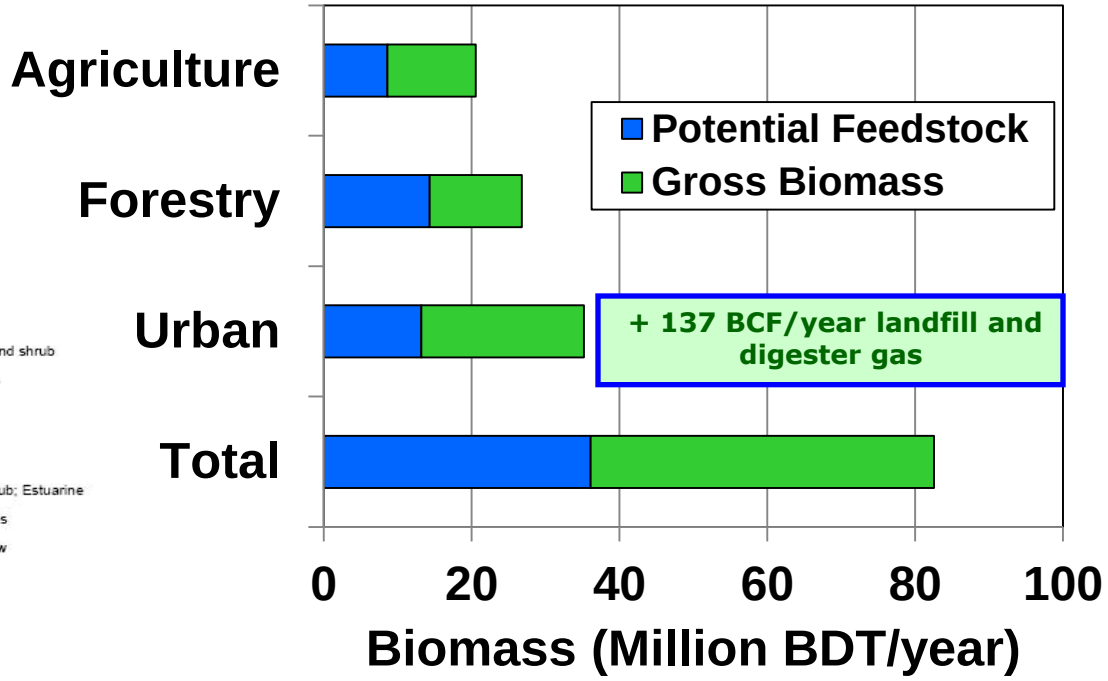
Like politics,

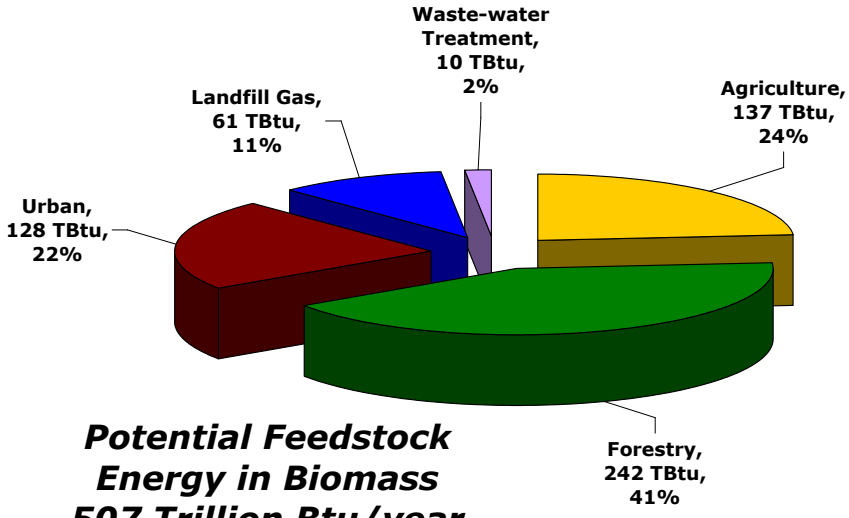
All Biomass Is Local

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, policy incentives, and exogenous economic factors.

California Biomass Resources Are Diverse







Potential Feedstock Energy in Biomass 507 Trillion Btu/year

Jenkins et al. (2006) A roadmap for the development of biomass in California

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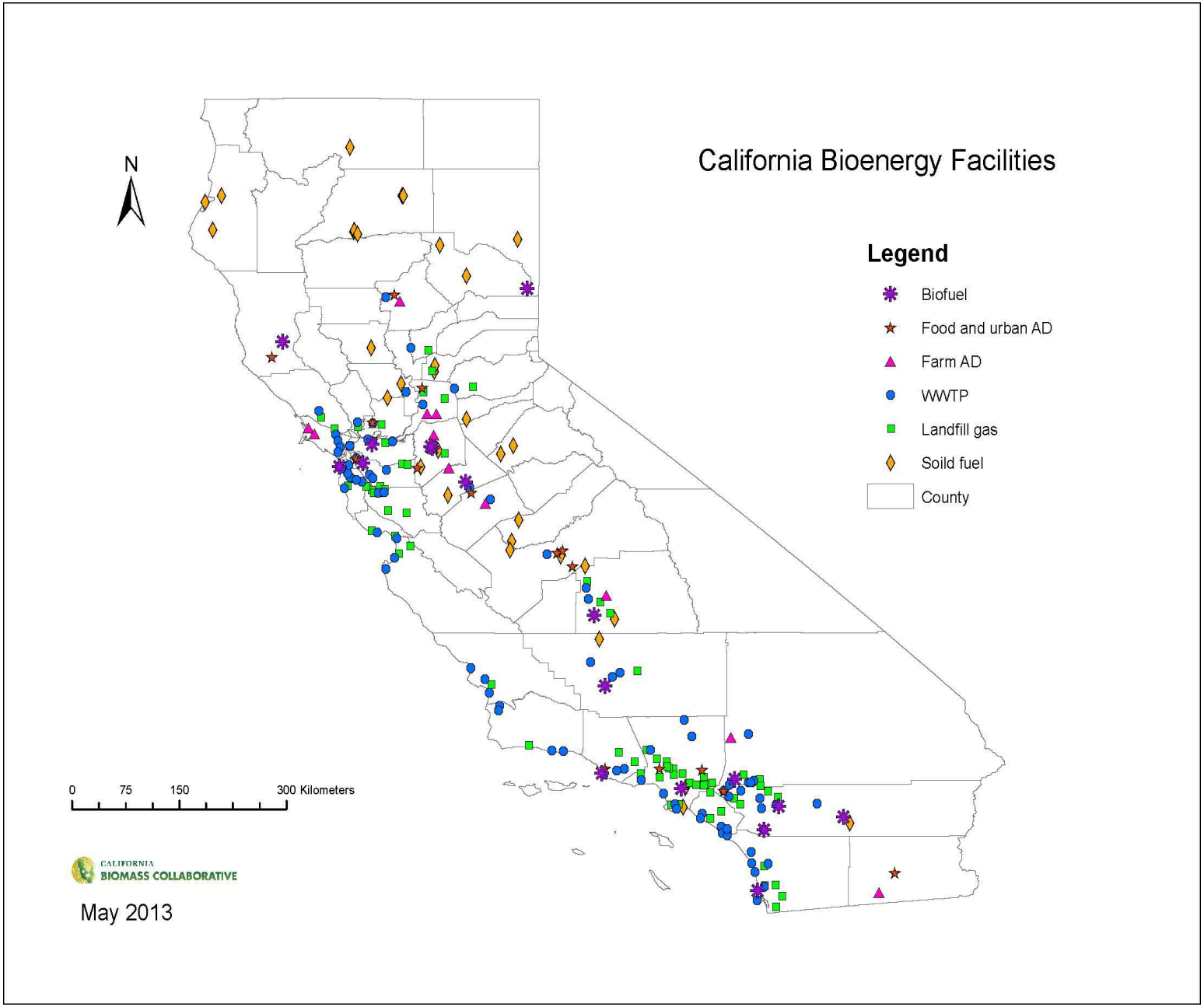
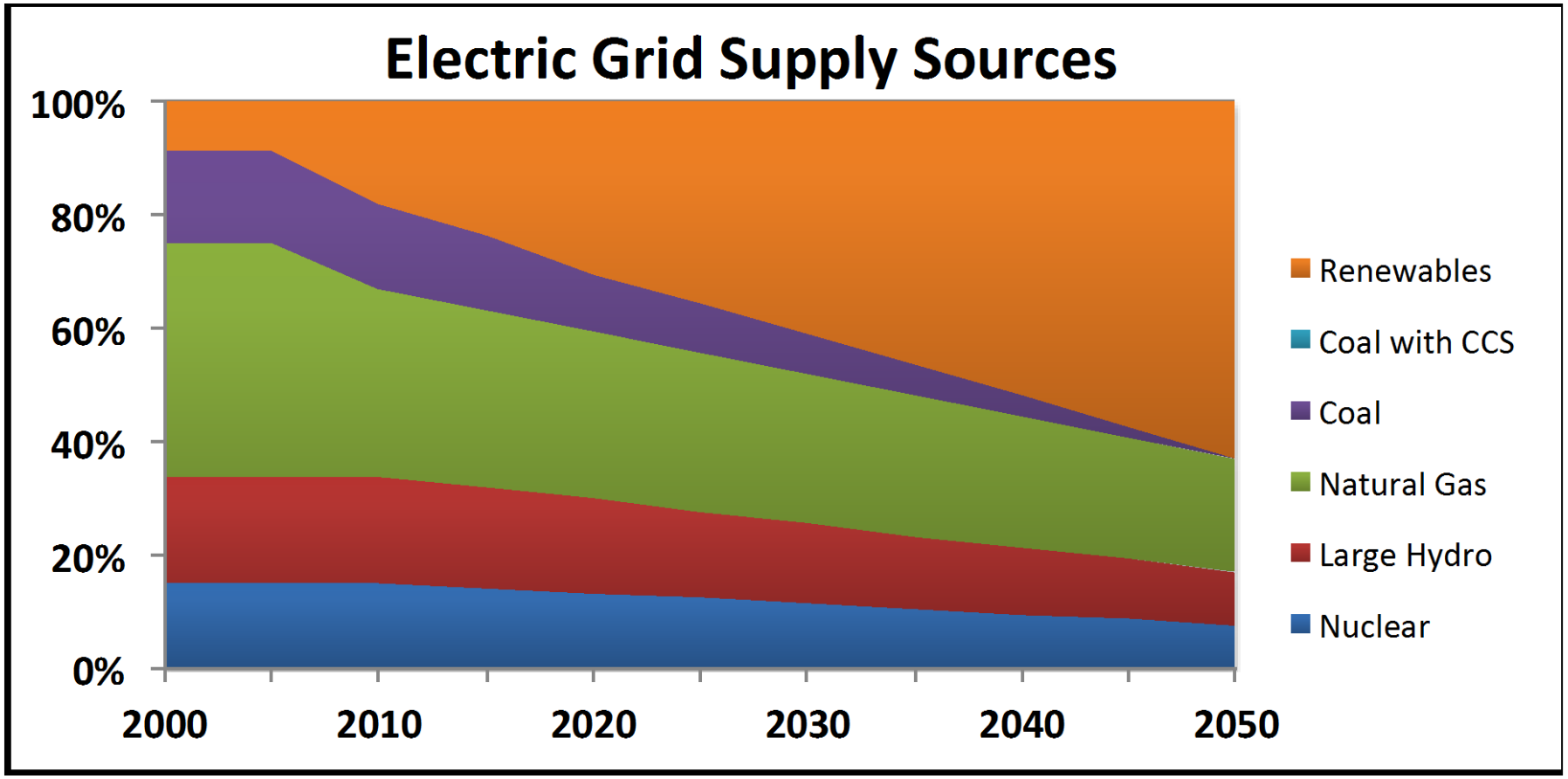

N
California Bioenergy Facilities
Legend
Biofuel
Food and urban AD
Farm AD
WWTP
Landfill gas
Soild fuel
County
0 75 150 300 Kilometers
CALIFORNIA BIOMASS COLLABORATIVE
May 2013

Biopower

Solid biofuel facility using forest biomass and mill wastes to make power.

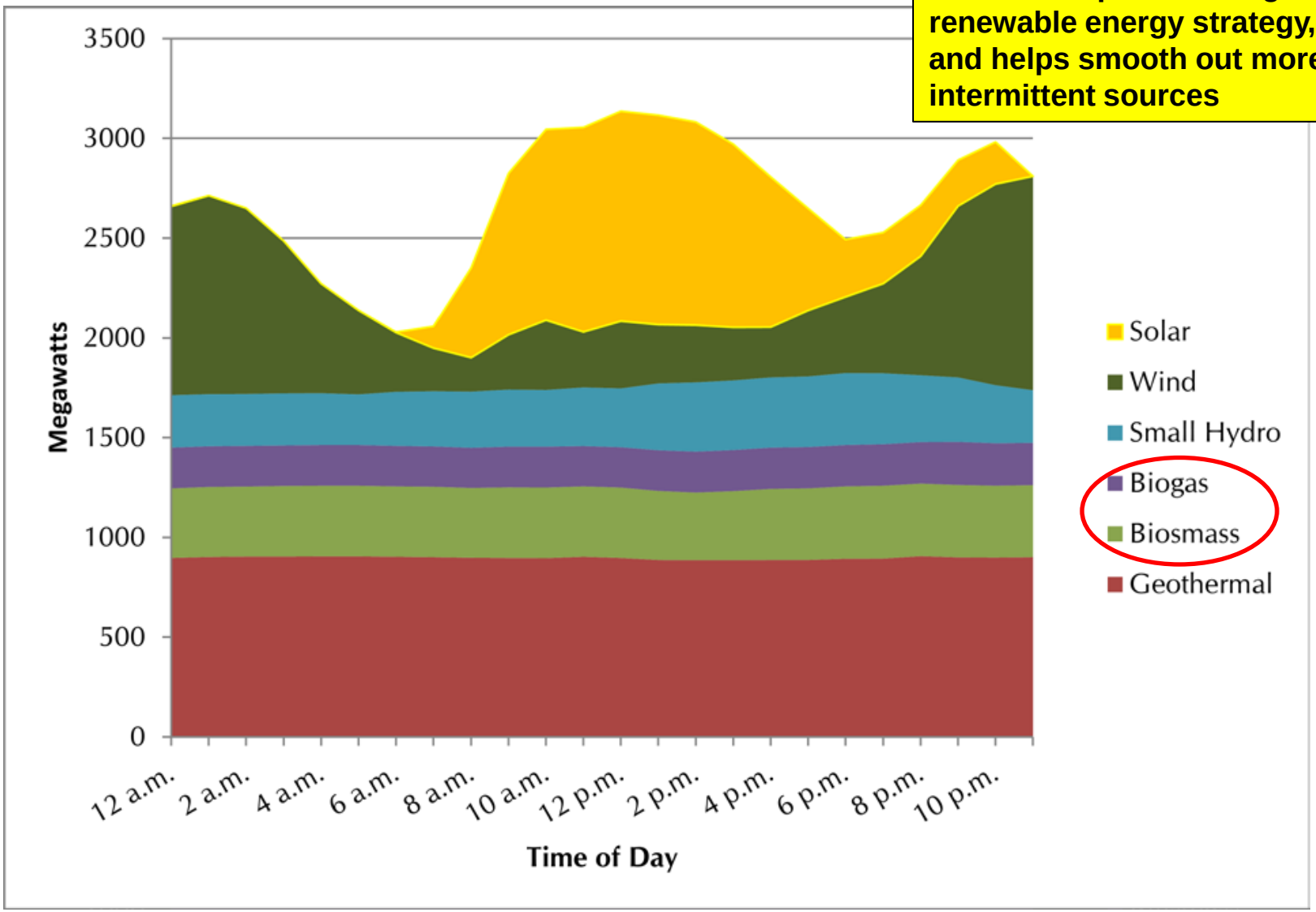
Possible Grid Power Sources in California to comply with AB 32 and LCFS Mandates



CARB projection, 2011

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

Biomass is part of a larger renewable energy strategy, and helps smooth out more intermittent sources



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

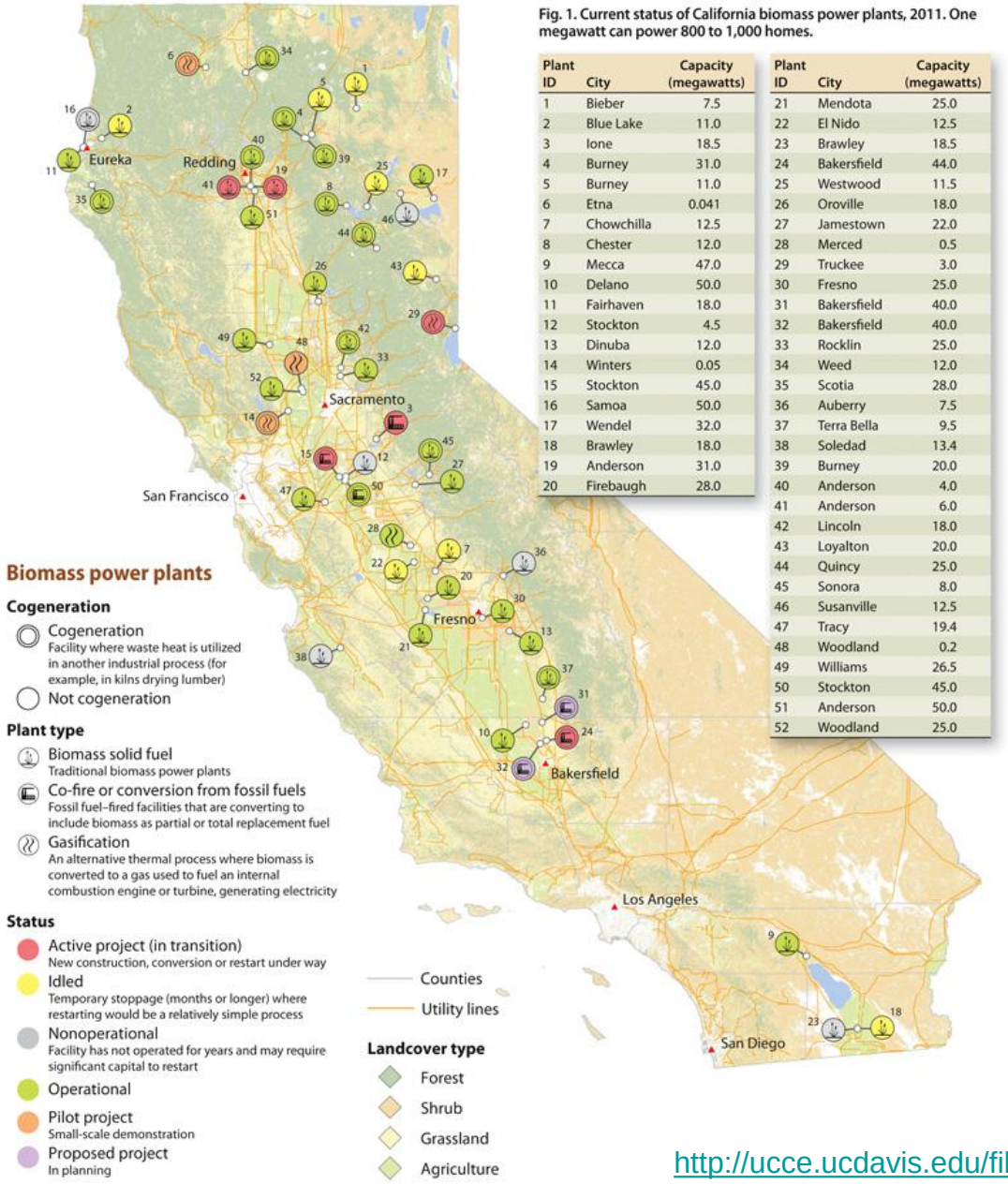


Fig. 1. Current status of California biomass power plants, 2011. One megawatt can power 800 to 1,000 homes.

Plant ID	City	Capacity (megawatts)
1	Bieber	7.5
2	Blue Lake	11.0
3	Ione	18.5
4	Burney	31.0
5	Burney	11.0
6	Etna	0.041
7	Chowchilla	12.5
8	Chester	12.0
9	Mecca	47.0
10	Delano	50.0
11	Fairhaven	18.0
12	Stockton	4.5
13	Dinuba	12.0
14	Winters	0.05
15	Stockton	45.0
16	Samoa	50.0
17	Wendel	32.0
18	Brawley	18.0
19	Anderson	31.0
20	Firebaugh	28.0

Plant ID	City	Capacity (megawatts)
21	Mendota	25.0
22	El Nido	12.5
23	Brawley	18.5
24	Bakersfield	44.0
25	Westwood	11.5
26	Oroville	18.0
27	Jamestown	22.0
28	Merced	0.5
29	Truckee	3.0
30	Fresno	25.0
31	Bakersfield	40.0
32	Bakersfield	40.0
33	Rocklin	25.0
34	Weed	12.0
35	Scotia	28.0
36	Auberry	7.5
37	Terra Bella	9.5
38	Soledad	13.4
39	Burney	20.0
40	Anderson	4.0
41	Anderson	6.0
42	Lincoln	18.0
43	Loyalton	20.0
44	Quincy	25.0
45	Sonora	8.0
46	Susanville	12.5
47	Tracy	19.4
48	Woodland	0.2
49	Williams	26.5
50	Stockton	45.0
51	Anderson	50.0
52	Woodland	25.0

Mayhead and Tittman, California Agriculture, 66(1) Jan-March 2012

http://ucce.ucdavis.edu/files/repository/calag/fig6601p7.jpg

Current Biopower Capacity in California

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

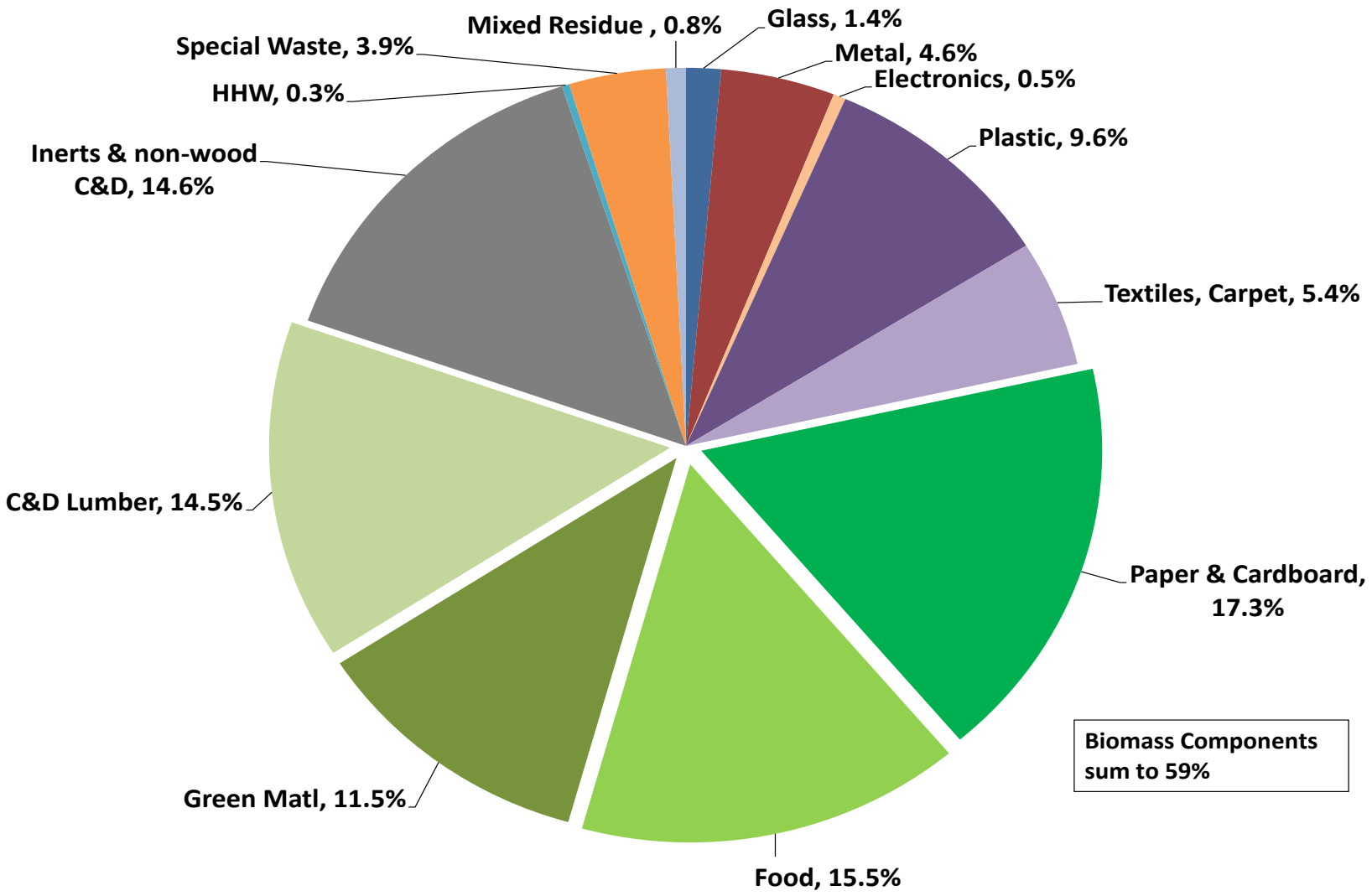
Biopower Facilities		
Facility Type	**Net (MW)**	**Facilities**
Solid Fuel (forest, urban & ag)	574.6	27
LFG Projects (a)	371.3	79
Waste Water Treatment Facilities (b)	87.8	56
Farm AD (c)	3.8	11
Food Process/Urban AD (c)	0.7	3-5
Totals	1038	175

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


Urban residues
(Municipal Solid Waste)

California landfilled waste stream by material type, post recycled (ADC not included)



CALIFORNIA BIOMASS COLLABORATIVE

(adapted from 2008 characterization: (Cascadia 2009))

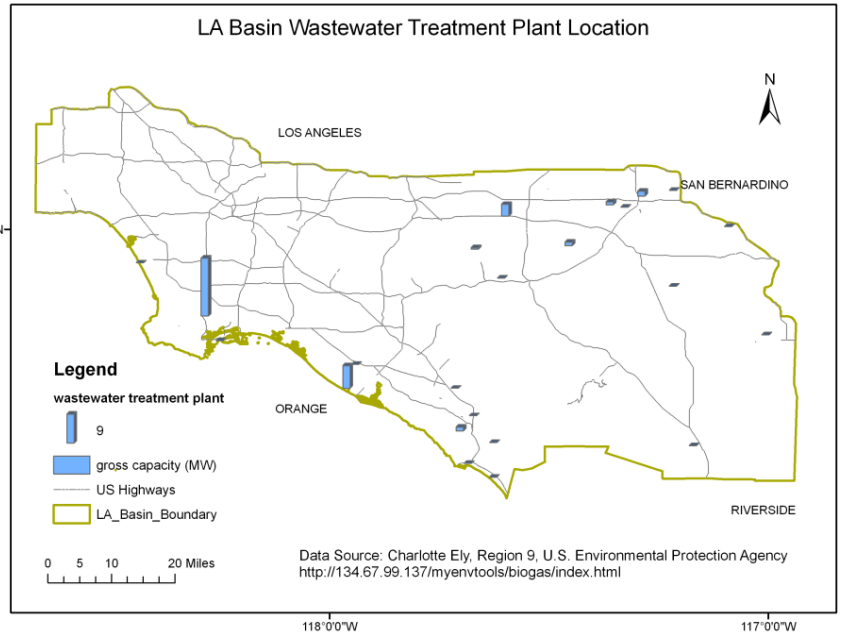
Potential energy from landfill stream

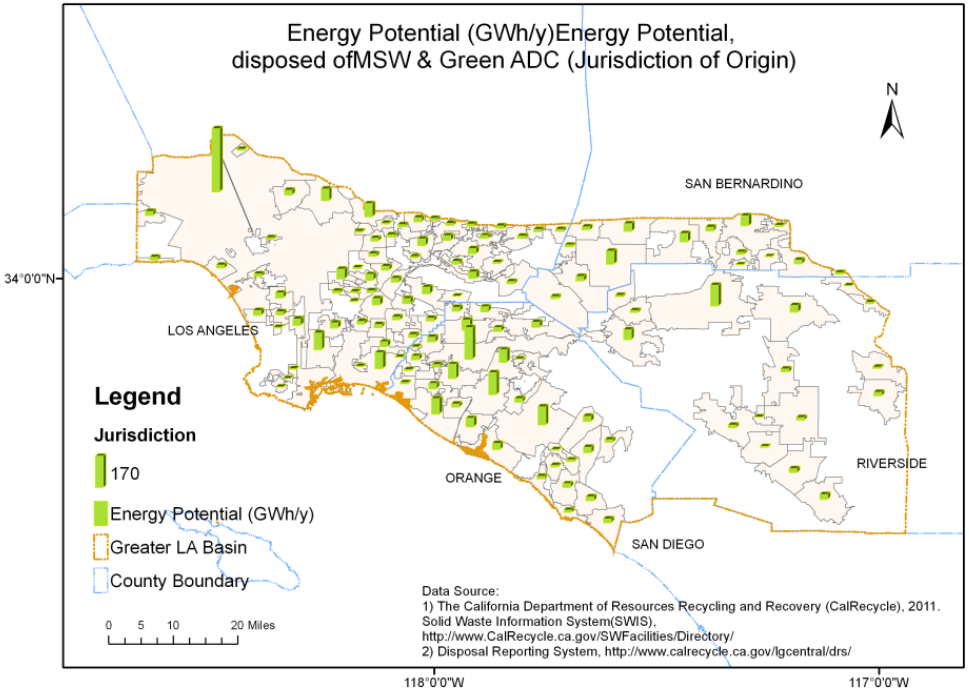
Landfill Stream, California, 2010 (post recycled and black bin)	Million Tons	% of Total	Electricity Potential (MWe)	Electricity Potential ($GWh\ y^{-1}$)	Fuel Potential (MM gge)
Biogenic Material (food, green, C&D wood, paper/cardboard, other)	**17.8**	**59**	**1,230**	**10,800**	**700**
Non-Renewable Carbonaceous (plastics, textiles)	**4.6**	**15**	**670**	**5,900**	**400**
Inert (glass, metal, other C&D and mineralized)	**7.9**	**26**	**-**	**-**	**-**
Totals	**30.3**	**100**	**1,900**	**16,700**	**1,100**

CalRecycle 2010 Disposal, Composition from Cascadia (2009), Energy Characterization adapted from Williams (2003)

CALIFORNIA BIOMASS COLLABORATIVE

A recent assessment of urban residual organics in the greater LA Basin area by local jurisdiction of origin. *(Cal Recycle and other data)*





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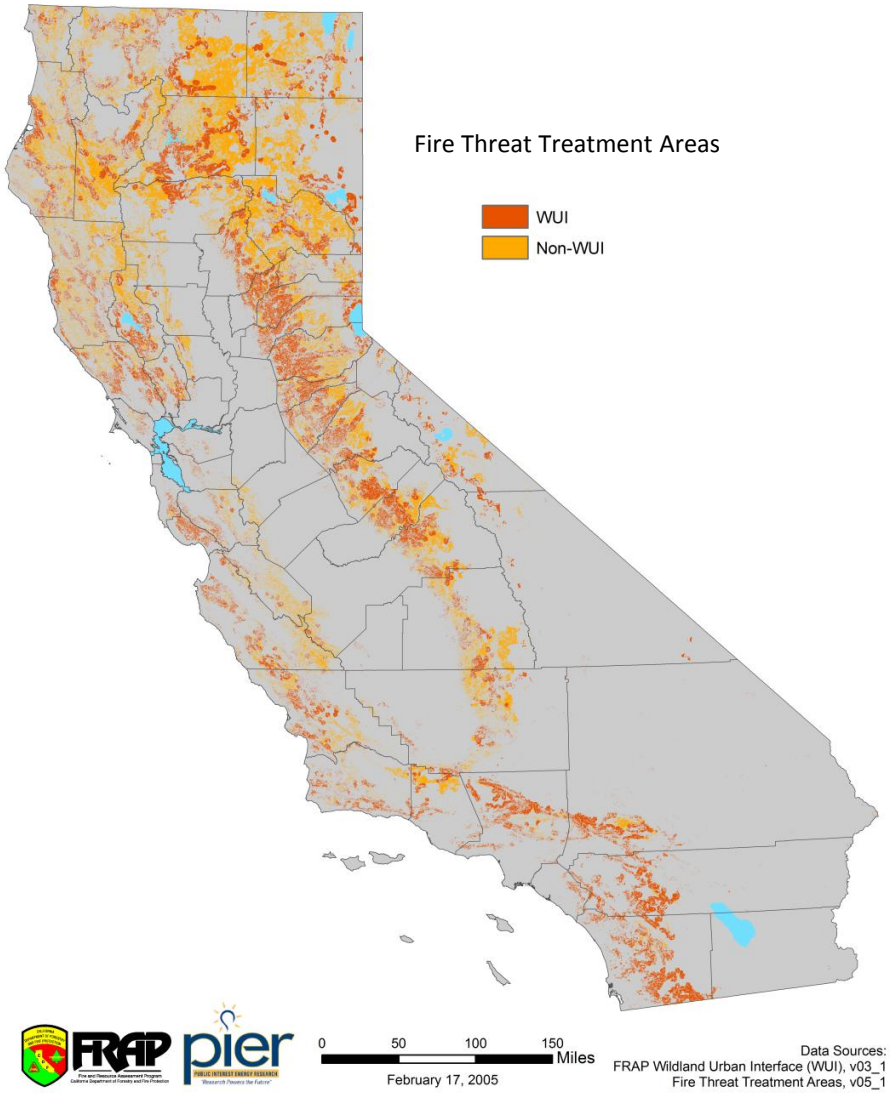
FOREST BIOMASS

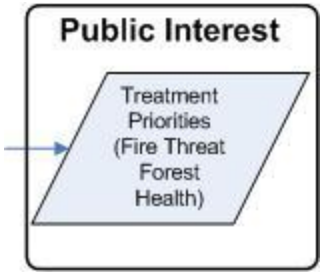
Chronic forest fires destroy large amounts of biomass annually in California, altering ecosystems, causing property loss, public health problems and loss of life.

Reducing risk of fire through fuel load reduction is one way to link harvesting biomass for energy with other environmental, economic and social goods.

Treatment Priorities

Example treatment priorities map





Estimates for treatment priorities are reported within hauling distance

Potential Priority Areas

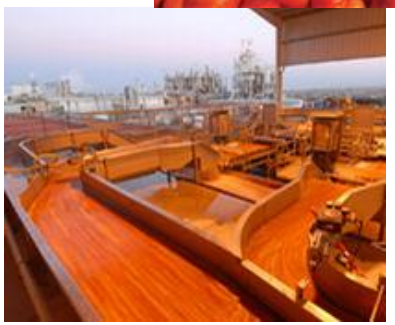
- Fire Threat
- Forest Health
- Insect and Disease Risk

Annual technically available forest biomass in CA*

Ownership	Slash & thinnings (BDT)	Mill Waste (BDT)	Shrub (BDT)	Total (BDT)	%
Private	5,870,000	1,391,611	1,211,457	8,473,069	59.4
Federal	2,385,689	1,907,786	1,296,354	5,589,892	39.2**
State	101,777	29,771	71,905	203,453	1.4
Total	8,357,466	3,329,168	2,579,716	**14,266,351**	100
%	58.6	23.3	18.1%	100	

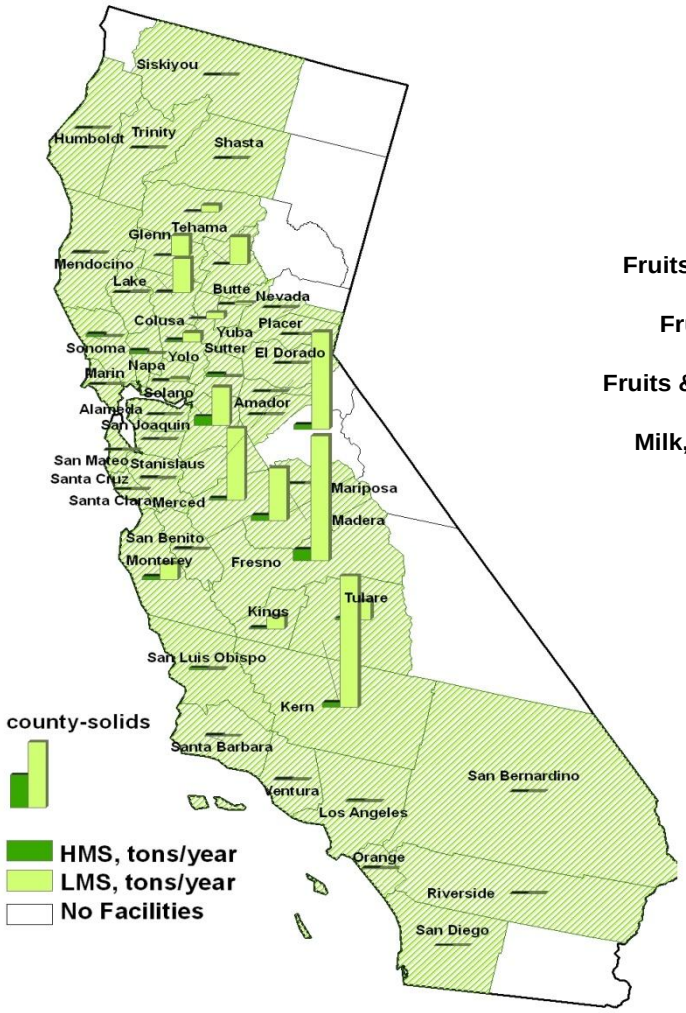
* CBC/CDFFP data and assumptions; **excluding federal reserves, wilderness areas, parks, etc.,

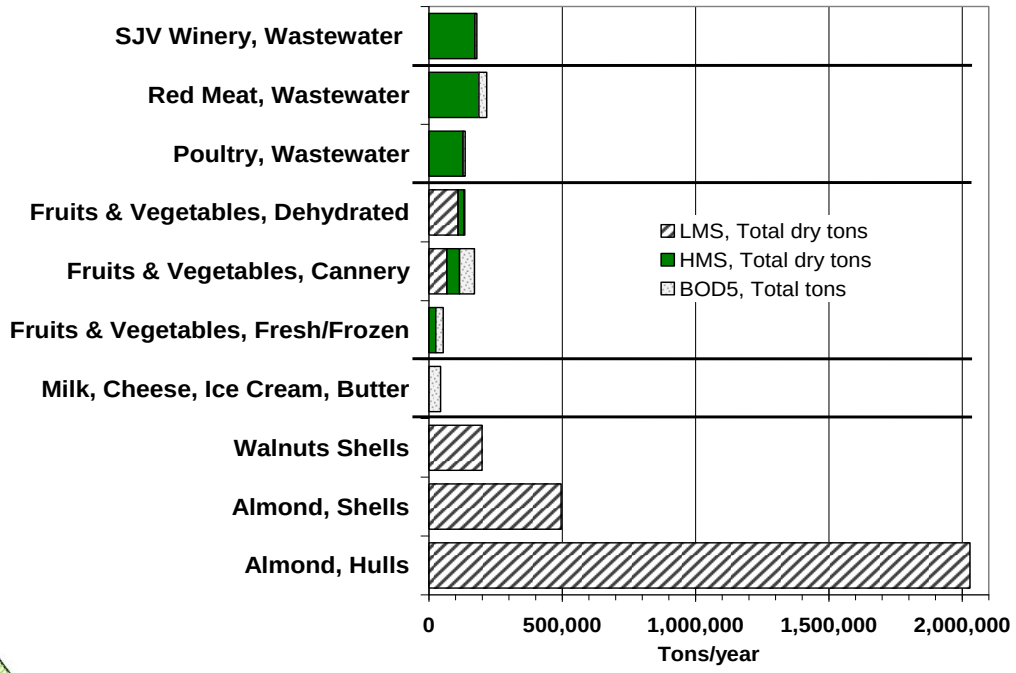
Food Processing



California Food Processing Industry Organic Residue Assessment

Amon et al., 2011





Sources contributing data: canneries (tomatoes, peaches, pears and other fruits and vegetables), dehydrated fruit and vegetable processors (raisins, onions, apricots, plums and other) fresh and frozen fruits and vegetables (includes fresh/frozen packaged vegetables and prepared foods), wine, dairy creameries, meat processing and almond and walnut processors.

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California Food Processing Industry Organic Residue Assessment

(Potential heat and power, not an economic analysis)

Food Processing Sector	BOD_5 Biogas		Solids Biogas		LMS Thermal		Potential Residue Avail-ability
		CHP (MMBtu)	Power (MW)	CHP (MMBtu)	Power (MW)	CHP (MMBtu)	
Cannery F & V	7.2	257,480	11.1	394,600			High
Dehydrated F & V	0.4	12,530	12.7	451,460			High
Fresh/Frozen F & V	3.6	129,500	2.5	88,360			High
Winery	0.9	31,080	16.7	592,960			High
Creamery	5.7	202,770					None
Poultry	1	35,410	12.3	438,590			None
Red Meat	3.8	134,790	18.1	643,670			None
Almonds					427.4	19,545,260	Hulls Low; Shells medium
Walnuts					33.7	1,541,902	High
							Total CHP
Power Total (MW)	22.6		73.3		461.1		557
Recovered Heat (MMBtu)		803,560		2,609,640		21,087,162	24,500,362

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Agricultural sources of biomass in California?

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Current (2013) biofuel production in California-CBC website

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

CALIFORNIA BIOMASS COLLABORATIVE

Calgren, Pixley CA; 60 mgy

Stockton; 60 mgy

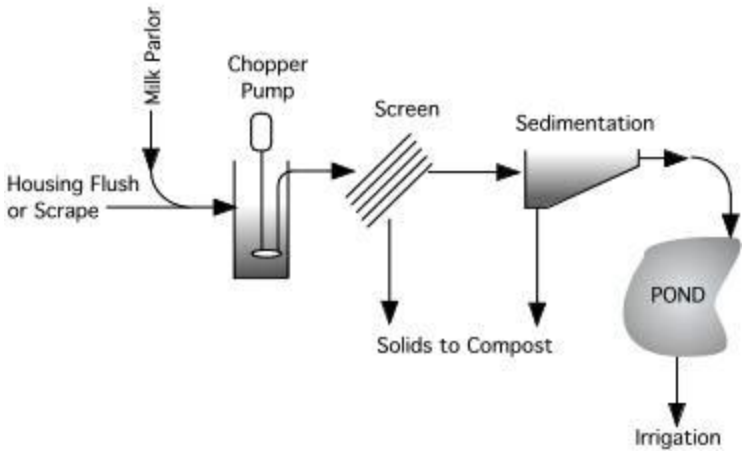
Madera; 40 mgy

Pacific Ethanol

There are 13 facilities making biodiesel in California (30 -40 mgy)

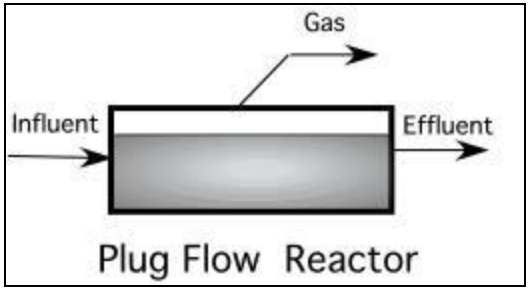
Business Name/Location	Contact	Phone	WebSite	BQ9000 Status	RFS Status	Plant Capacity	Last Reported
Baker Commodities Los Angeles 4020 Bandini Blvd Vernon ,CA 90058	Doug Smith	323-200-4659	www.bakercommodities.com				01/2013
Bay Biodiesel, LLC (San Jose) 905 Stockton Ave San Jose ,CA 95110	Pat O'''''''''''''Keefe	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

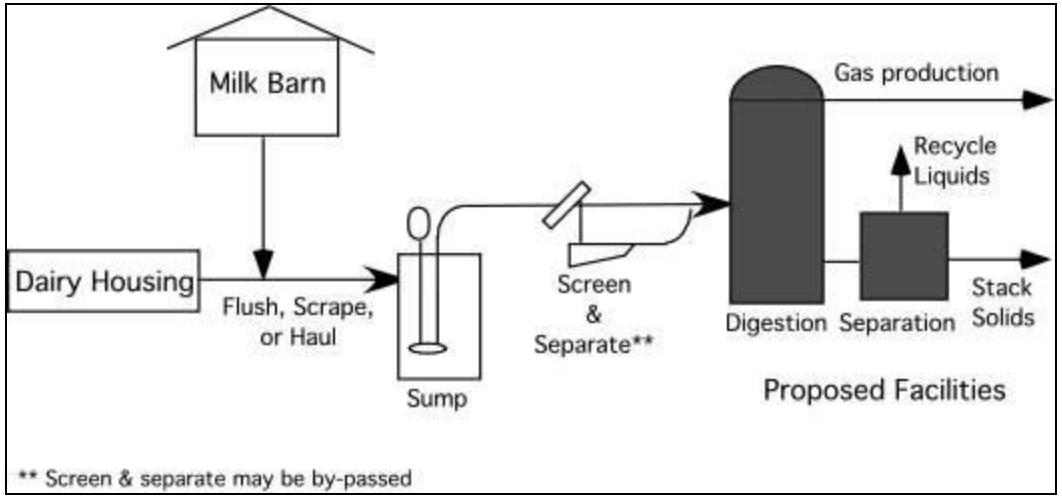
California Biodiesel Alliance

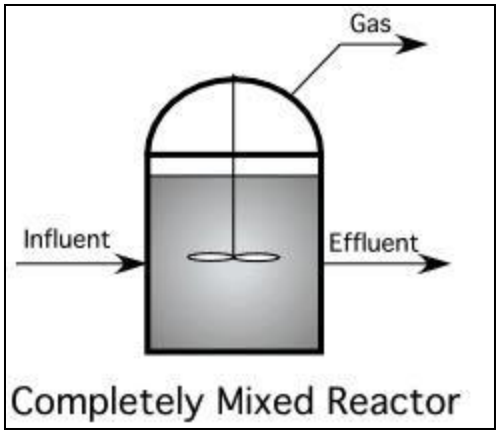


Livestock manure is underutilized as an energy source in California.

Anaerobic Digesters For Biogas

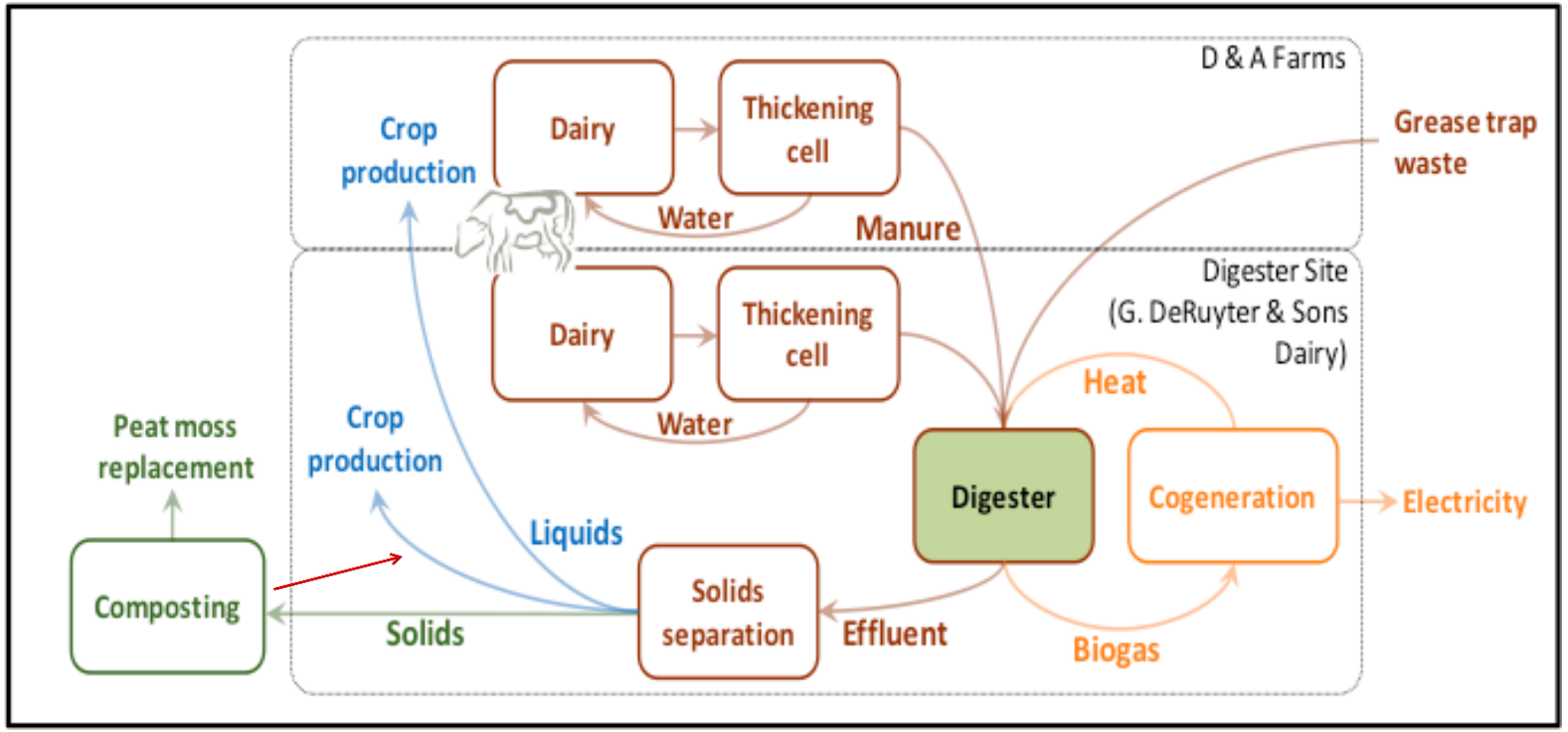






Biogas can be made from dairy and other types of manures, But AD systems do not affect the amount of nutrients that must be managed.

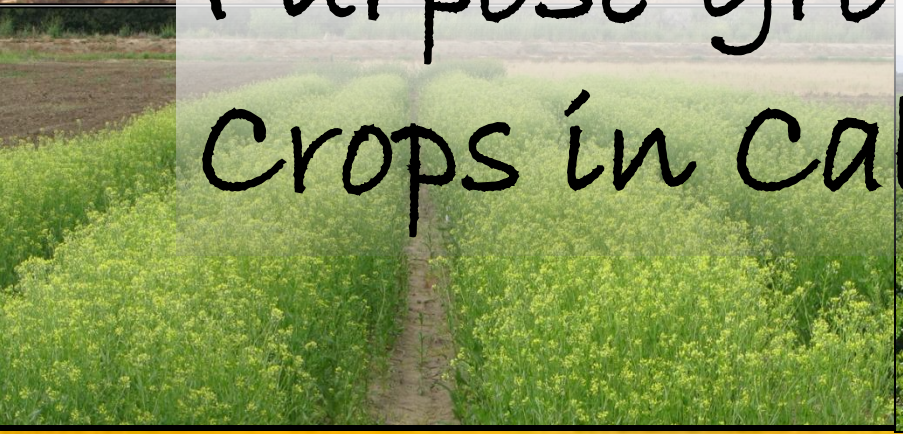
Schematic of one possible set of pathways for nutrient removal from a Washington State Dairy (Nutrient recovery targets: 70% NH3, 80% P, 20% K). Nutrients recovered can replace fertilizers used on other farms.



The cost of treating AD effluents and concentrating their fertilizer nutrients can be reduced by selling power or using biogas as a transportation fuel.

C. Frear (Washington State University); EPA Technology Market Summit, Washington DC, May 14, 2012

Purpose-grown bioenergy Crops in California?



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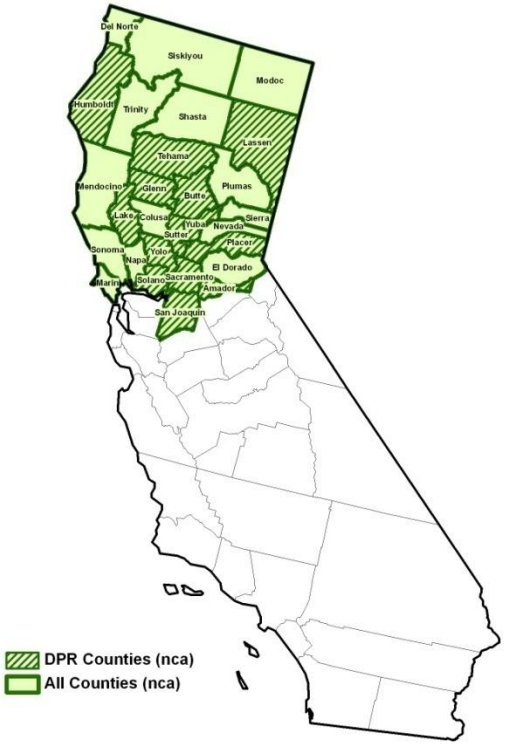
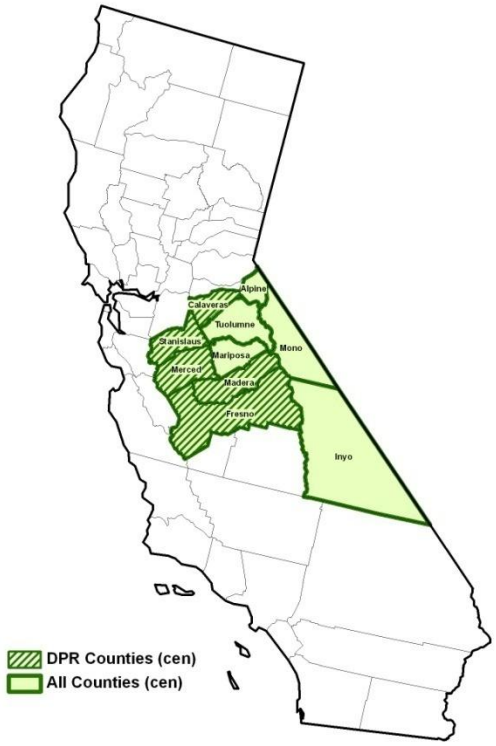
Counties in Analysis Regions



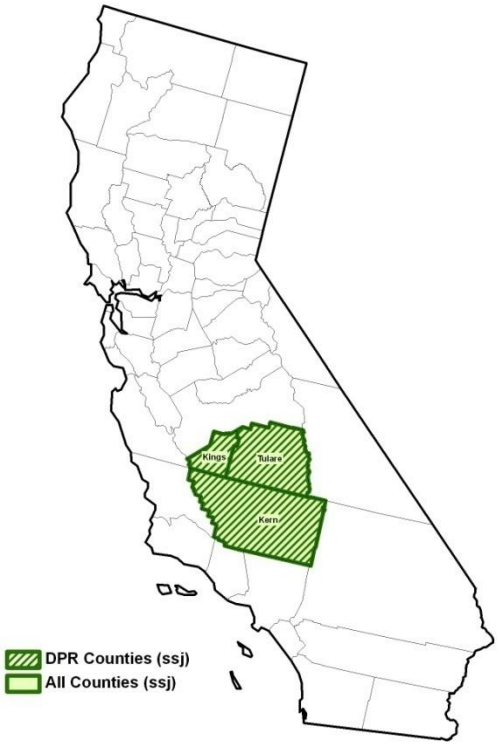
Northern California (NCA)

9 Cropping Clusters



Central California (CEN)

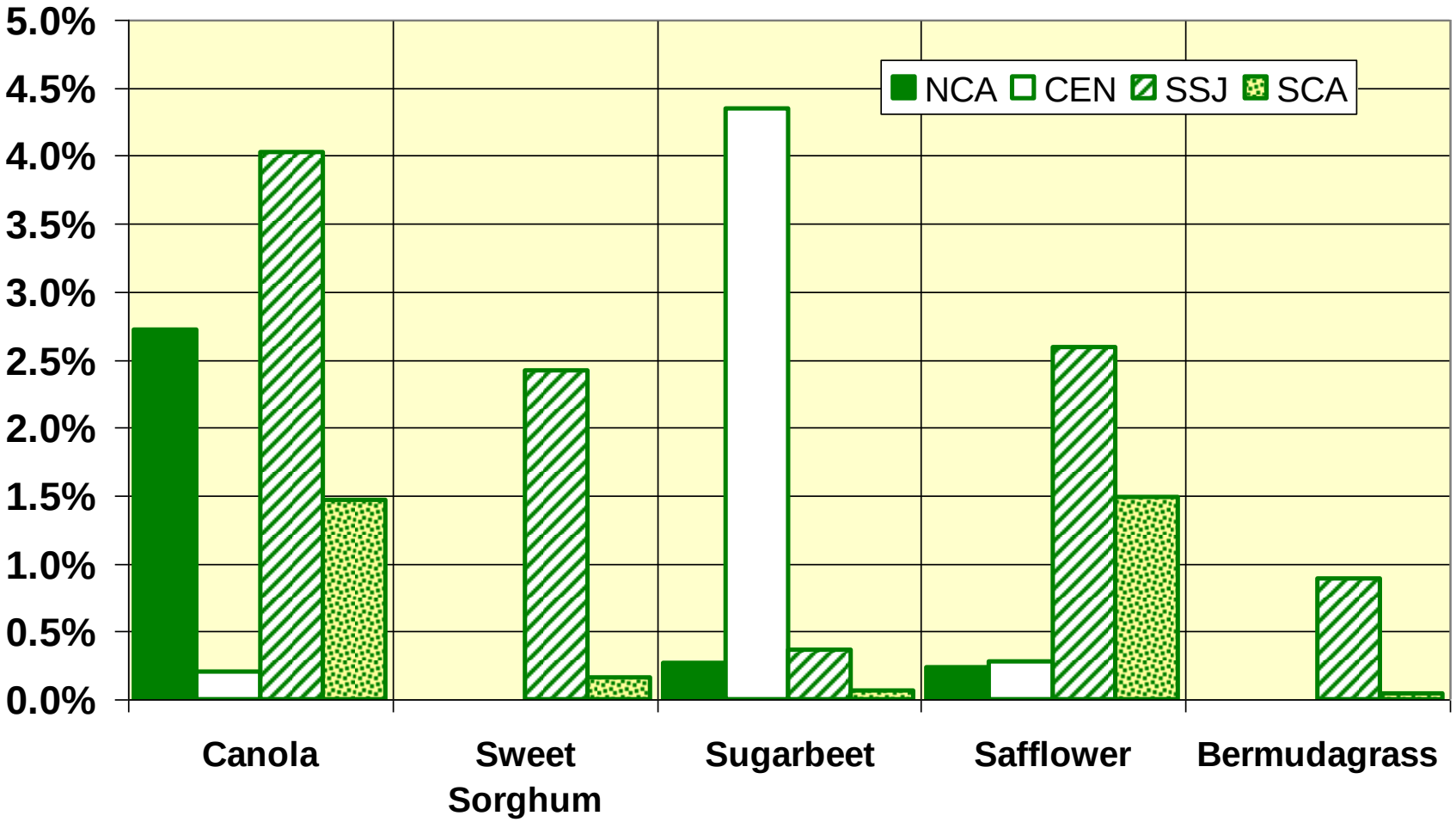
9 Cropping Clusters



South San Joaquin (SSJ)

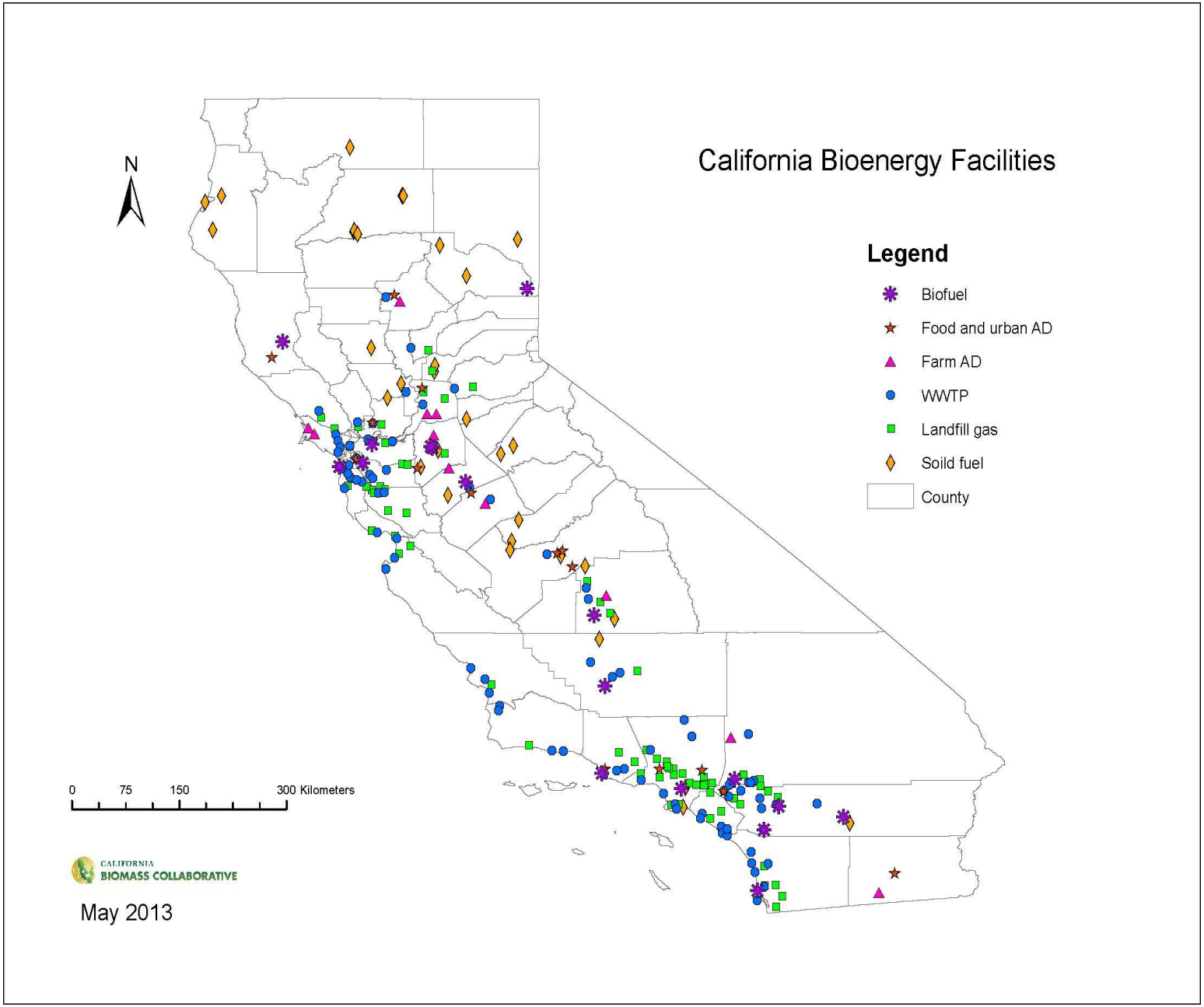
8 Cropping Clusters

Potential crop use for energy with favorable prices in different regions of the state (% of land in each region)



Multiple iterations of the Biomass Crop Adoption Model suggest that certain crops will be preferentially adopted in different parts of the state.

CALIFORNIA BIOMASS COLLABORATIVE


N
California Bioenergy Facilities
Legend
Biofuel
Food and urban AD
Farm AD
WWTP
Landfill gas
Soild fuel
County
0 75 150 300 Kilometers
CALIFORNIA BIOMASS COLLABORATIVE
May 2013

Estimated Fuel Potential from California biomass residues*

(*not its economic potential)

Feedstock	Amount Technically Available	Biomethane Potential (billion cubic feet)	Biofuel Potential (million gge)
Agricultural Residue (Lignocellulosic)	3.5 M BDT[a]	-	175[h]
Animal Manure	3.8 M BDT[a]	14.6[a]	125[i]
Fats, Oils and Greases	207,000 tons[b]	(assume conversion to biodiesel)	56[j]
Forestry and Forest Product Residue	14.2 M BDT[a]	-	710[h]
Landfill Gas	110 BCF[a]	55[f]	474[i]
Municipal Solid Waste (food waste fraction)	1.2 M BDT[c]	13.1[g]	113[i]
Municipal Solid Waste (lignocellulosic fraction)	9.5 M BDT[d]	-	475[h]
Waste Water Treatment Plants	9.6 BCF (gas)[e]	4.8[f]	41[i]
Total			**2,169**

a. Williams, R. B., Gildart, M., & Jenkins, B. M. (2008). An Assessment of Biomass Resources in California, 2007. CEC PIER Contract 500-01-016: California Biomass Collaborative.
b. From: Wiltsee, G. (1999). Urban Waste Grease Resource Assessment: NREL/SR-570-26141. Appel Consultants, Inc. 11.2 lbs./ca-y FOG and California population of 36.96 million. Biodiesel has ~9% less energy per gallon than petroleum diesel.
c. Technical potential assumed to be 67% of amount disposed in landfill (2007). Reference (a) uses a 50% technical recovery factor for MSW stream going to landfill, however it is not unreasonable to assume higher recovery factors as market value of bioenergy product increases or for cases where biomass does not need to be separated before conversion. (waste characterization and disposal amounts are from: http://www.calrecycle.ca.gov/Publications/General/2009023.pdf)
d. 67% of mixed paper, woody and green waste and other non-food organics disposed in landfill (2007). Note (c) discusses rational for using a higher technical recovery factor than that assumed for MSW in reference (a). (waste characterization and disposal amounts are from: http://www.calrecycle.ca.gov/Publications/General/2009023.pdf)
e. From EPA Region 9; Database for Waste Treatment Plants
f. Assumes 50% methane in gas
g. Assumes VS/TS= 0.83 and biomethane potential of 0.29g CH4/g VS
h. Using 50 gge per dry ton (75 gallons EtOH per dry ton) yield. See, for example: Anex, R. P., et al. (2010). Techno-economic comparison of biomass-to-transportation fuels via pyrolysis, gasification, and biochemical pathways. [Article]. *Fuel, 89*, S29-S35. doi: 10.1016/j.fuel.2010.07.015
i. ~116 ft^3 methane is equivalent to 1 gge (983 Btu/scf methane and 114,000 Btu/gallon gasoline, lower heating value basis)
j. 7.5 lbs FOG/ gallon biodiesel. Biodiesel has ~9% less energy per gallon than petroleum diesel, gives 50 M gallons diesel equivalent. 1 dge = 1.12 gge

Themes/Questions for Part 1: Biomass Energy in California

- What do me mean by the term biomass when we discuss the use of biomass for energy?
- How much biomass is there in California?
- How much is being used?
- Where is it being used?
- Could more be used?
- **How do state and federal policies affect biomass use in California?**

How do state and federal policies affect biomass use in California?

- Prescriptive technology choices in state statute rather than performance standards hinder MSW conversion technology development (favors landfilling of biomass).
- Not including energy recovery in the “Waste Hierarchy” favors continued landfilling.
- Bioenergy is expensive - monetizing societal and environmental benefits of biopower could help pay for its use – reducing the cost to ratepayers/drivers.
- The Low Carbon Fuel Standard is a performance-based regulation and could stimulate new fuels and businesses in California.

2012 Bioenergy Action Plan

Bioenergy Interagency Working Group

Ann Chan, Chair, Bioenergy Interagency Working Group
Deputy Secretary, California Natural Resources Agency

Cliff Rechtschaffen
Senior Advisor to Governor Edmund G. Brown
Karen Ross
Secretary, Department of Food and Agriculture
Matthew Rodriquez
Secretary, California Environmental Protection Agency
Mary Nichols
Chair, California Air Resources Board
Mark Ferron
Commissioner, California Public Utilities Commission
Carla Peterman
Commissioner, California Energy Commission
Ken Pimlott
Director, Department of Forestry and Fire Protection
Caroll Mortensen
Director, Department of Resources Recycling and Recovery
Pamela Creedon
Executive Officer, Central Valley Regional Water Quality Control Board
Stephen Kaffka
Director, California Biomass Collaborative

2012 Bioenergy Action Plan
prepared by the Bioenergy Interagency Workgroup

California has an abundance of biomass residues from the state's agricultural, forest, and urban waste streams. Sustainably collected biomass can be used to produce renewable energy, such as transportation fuels, methane, or electricity. Using biomass to produce energy reduces the need for traditional disposal options for biomass such as landfill disposal or burning in place, while reducing dependence on fossil energy sources.

The 2012 Bioenergy Action Plan is a coordinated state agency approach to addressing challenges and maximizing opportunities for the development of bioenergy projects that promote economic development and provide the greatest environmental benefit.

2012 Bioenergy Action Plan
prepared by the Bioenergy Interagency Workgroup

The plan outlines state agency actions that:

1) stimulate cost-effective utilization of the state's diverse biomass resources for conversion to "low-carbon" biofuels, biogas, and renewable electricity;
2) increase research, development and demonstration of bioenergy toward commercializing new technologies;
3) streamline the regulatory and permitting processes; and
4) quantify and monetize the benefits of bioenergy.

For more information:

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