California Biomass Collaborative

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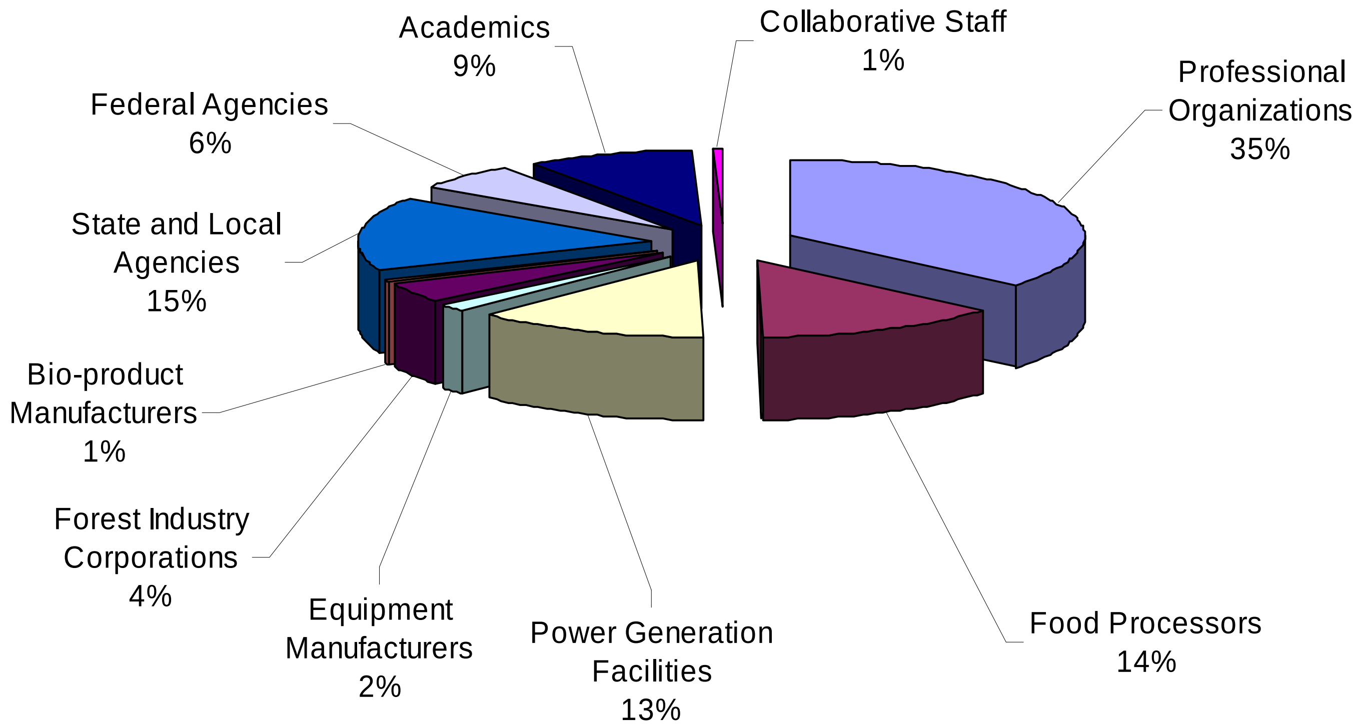
- Established 2003
  - Mission to support the sustainable management and development of biomass in California
  - Addresses multiple aspects of a diverse resource base and industry
    - Electricity generation, biofuels, bio-based products, resource management, infrastructure

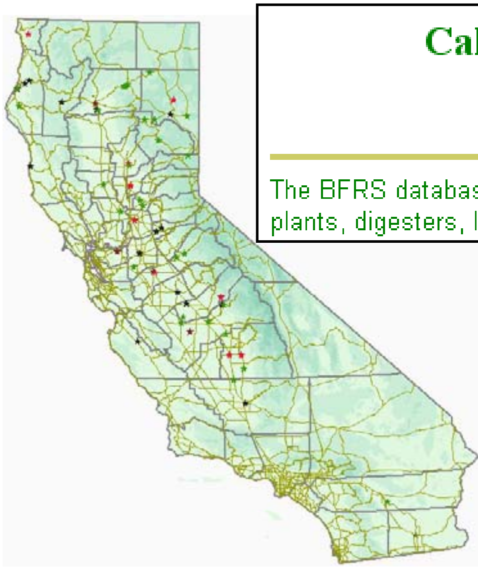
California Biomass Collaborative

- Membership
  - Open membership
    - Currently > 500 members



California Biomass Collaborative

- **Statewide biomass coordinating group**
- **Biomass Facilities Reporting System**
- **Biomass resource assessments**
- **Technology assessments**
- **Planning Functions/Policy**
  - **Needs Assessment**
  - **Roadmap for sustainable biomass development/implementation plan**
  - **Sustainability standards for bioenergy/biofuels**
- **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,

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.

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California Biomass Roadmap

- *Guidance document* providing recommendations on how to develop and use biomass resources in California
- *Audience:* policy makers, law makers, regulators, investors, researchers, developers, the public
- Implementation planning underway
  - Sustainability standards, incentives and markets, permitting and regulation, other areas

California Biomass Collaborative

- Planned Activities—2009 and beyond
- Sustainable biomass development roadmap
  - Implementation plan completion
  - Assessment and improvement of sustainability standards and certification
  - Technical tasks
    - Dedicated energy crop potential
      - Operations research/farm-level LP modeling—expanded model/field validation
    - Food industry survey
      - Statewide survey and assessment
    - Economic assessment of statewide biomass resource potential, including forest wastes
      - Expanded sustainability analysis (joint with USDA/DOE project)
    - Resource update
      - Database and web update
    - Facilities update
      - BFRS web update
    - Conversion technology survey and toolbox (CIWMB)
  - Education, Outreach, Policy
    - Annual forum: Biofuels: Net Environmental and Social Benefits May 12/13, Sacramento
    - Bioenergy shortcourse(s)
    - CSU/Community College coordination
    - Clearinghouse
    - Meetings, reports, briefings
    - Bioenergy Interagency Working Group

Feedstock availability and sustainability

1. Are there physical and economic limits to available Biomass in CA?
2. Do results from the Western Governors' Association Biomass Task Force modify estimates of feed stocks for CA?
3. Is there potential for using forest thinning operations to promote forest health and protect against wildfire for biomass energy?
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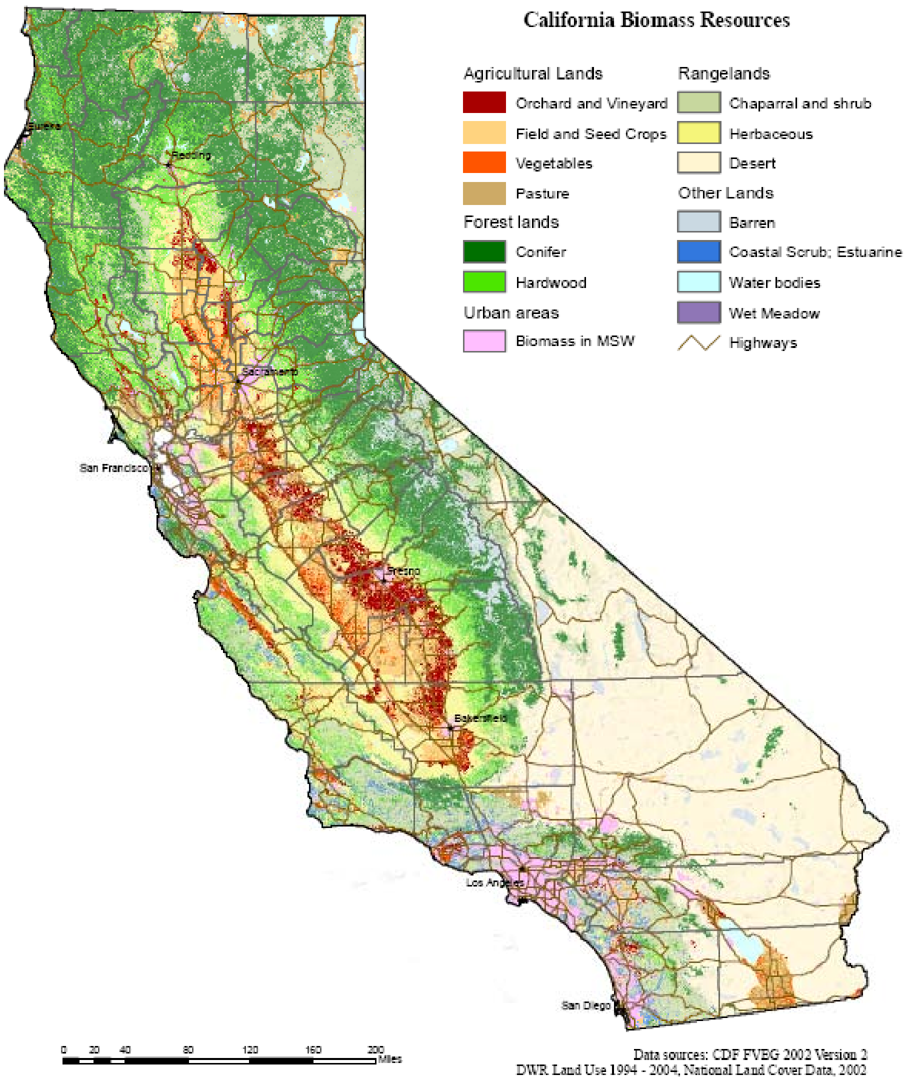
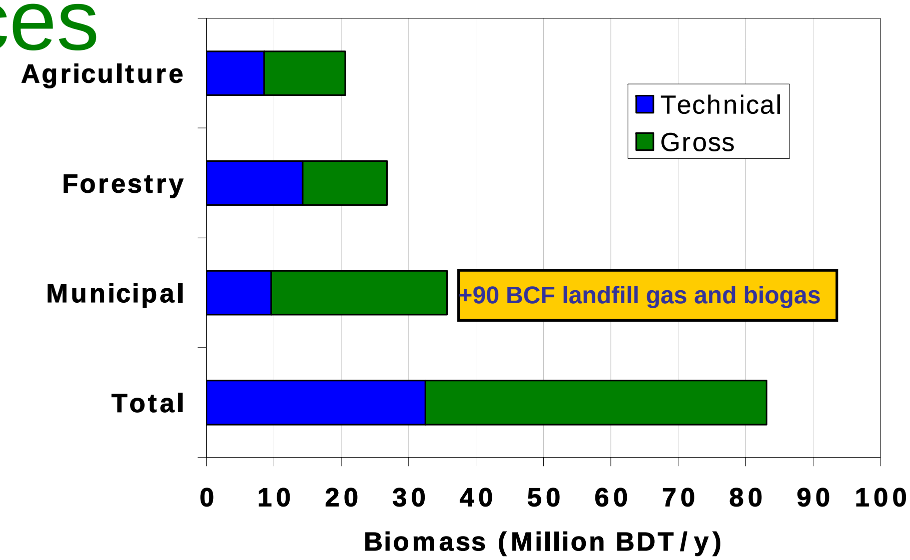
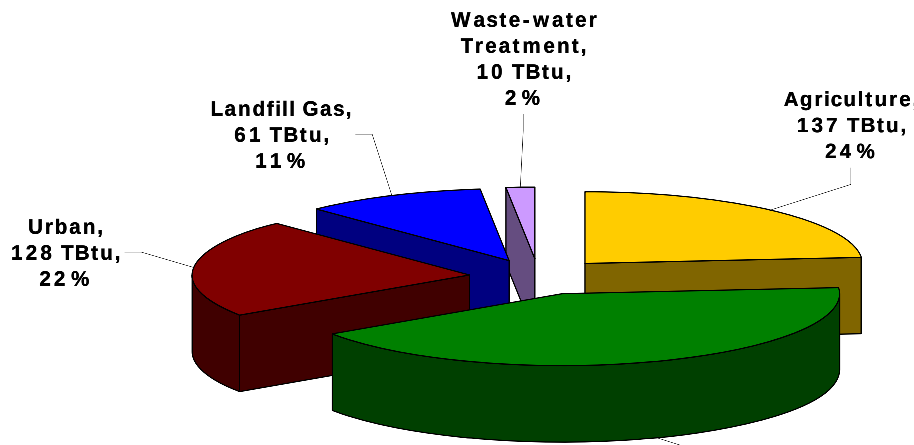
California Residue and In-forest Biomass Resources



Source: California Biomass Collaborative, 2007





Potential Feedstock Energy in Biomass 507 Trillion Btu/year

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 thinning	14.2	990	660
Total estimates	24.9	1,814	1,205*

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

These are not estimates of economically recoverable or sustainable biomass.

Starch/sugar crop area requirements for in-state ethanol production goals

Year	Corn (acres * 1,000)			Sugarbeets (acres * 1,000)		
	E5.7	E10	E20	E5.7	E10	E20
2010	420	750	1,550	222	395	817
2020	750	1,330	2,755	396	705	1,457
2050	1,270	2,260	4,679	672	1,196	2,474

California Biomass and Biofuels Production Potential---Williams et al, (2007)-AB 118 Report

Oil seed crop requirements to meet in-state production goals for biodiesel (acres*1,000)

Year	B2	B5	B20
2010	180	450	1,800
2020	500	1,243	4,970
2050	1,655	4,139	16,560

California Biomass and Biofuels Production Potential---Williams et al, (2007)-
AB 118 Report

Multi-feed stock scenario for a biofuel industry in California---Williams et al, (2007)-[AB 118 Report]

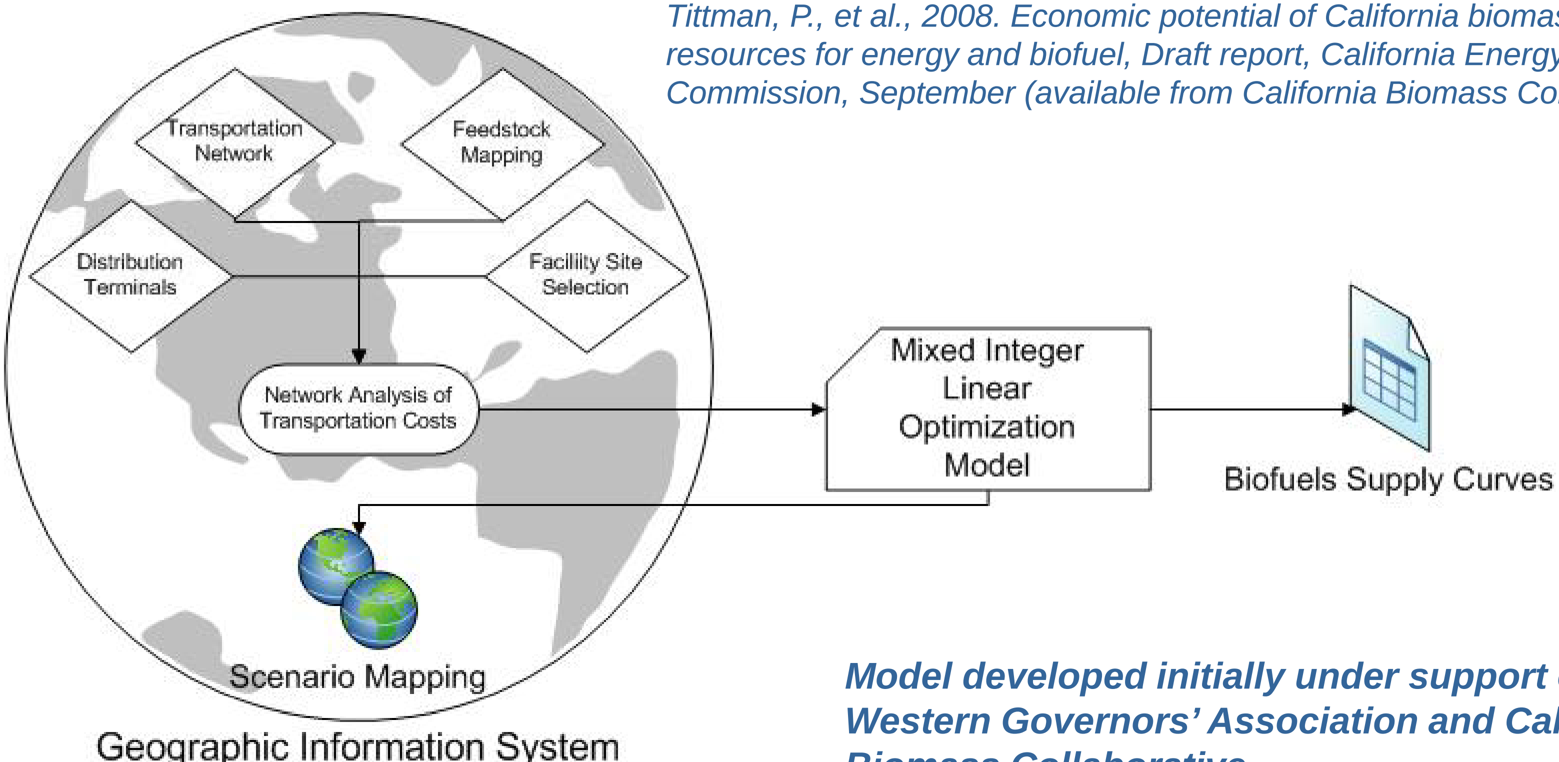
Scenario	Biofuels (M gge*/yr)
10% of current starch/sugar crops for Ethanol	23.4
1/3 of lignocellulosic resides (~8.3 MBDT/yr)	400
200,000 acre energy crops	133
Ethanol total	556†
500,000 acres oilseeds (**FAME biodiesel**)	53.4†

***gge = gallons of gasoline equivalent (RFG3 @ 118 MJ/gal)**

† Sufficient to meet in state production goals for 2020 E10 and B2 scenarios

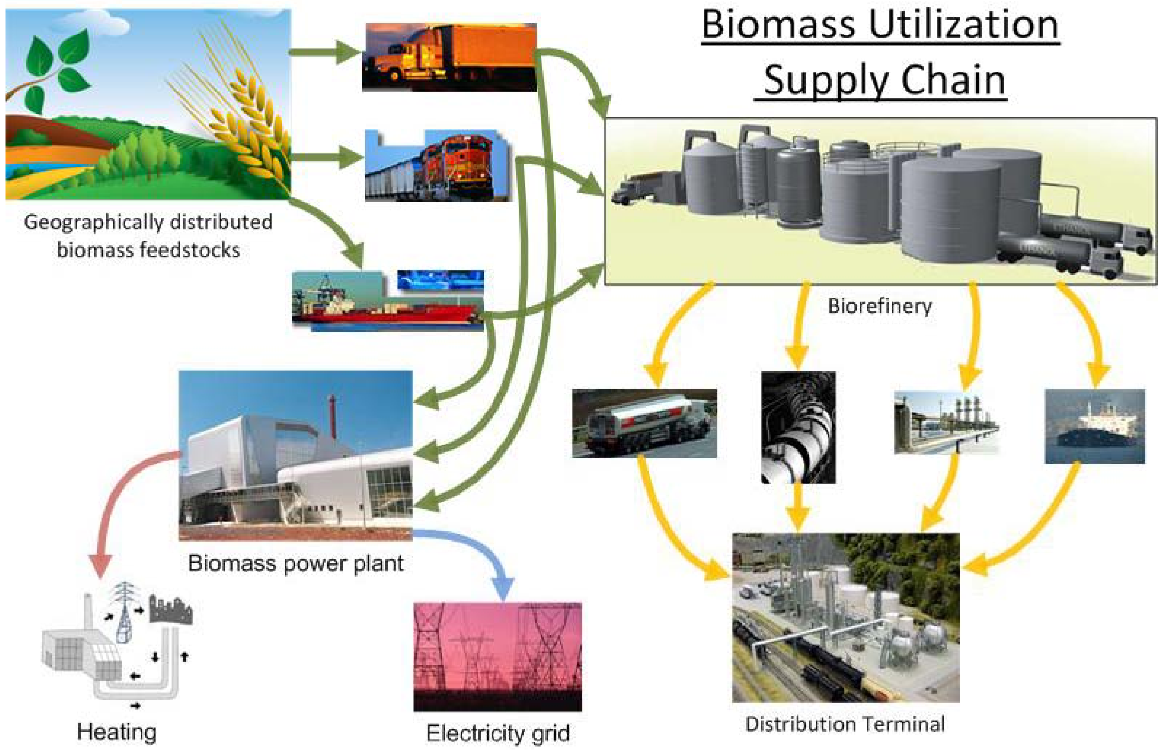
Estimating economically available biomass resource in California: Modeling using GIS with mixed integer linear optimization

Tittman, P., et al., 2008. Economic potential of California biomass resources for energy and biofuel, Draft report, California Energy Commission, September (available from California Biomass Collaborative)



Model developed initially under support of Western Governors' Association and California Biomass Collaborative.

Biomass Supply Chain



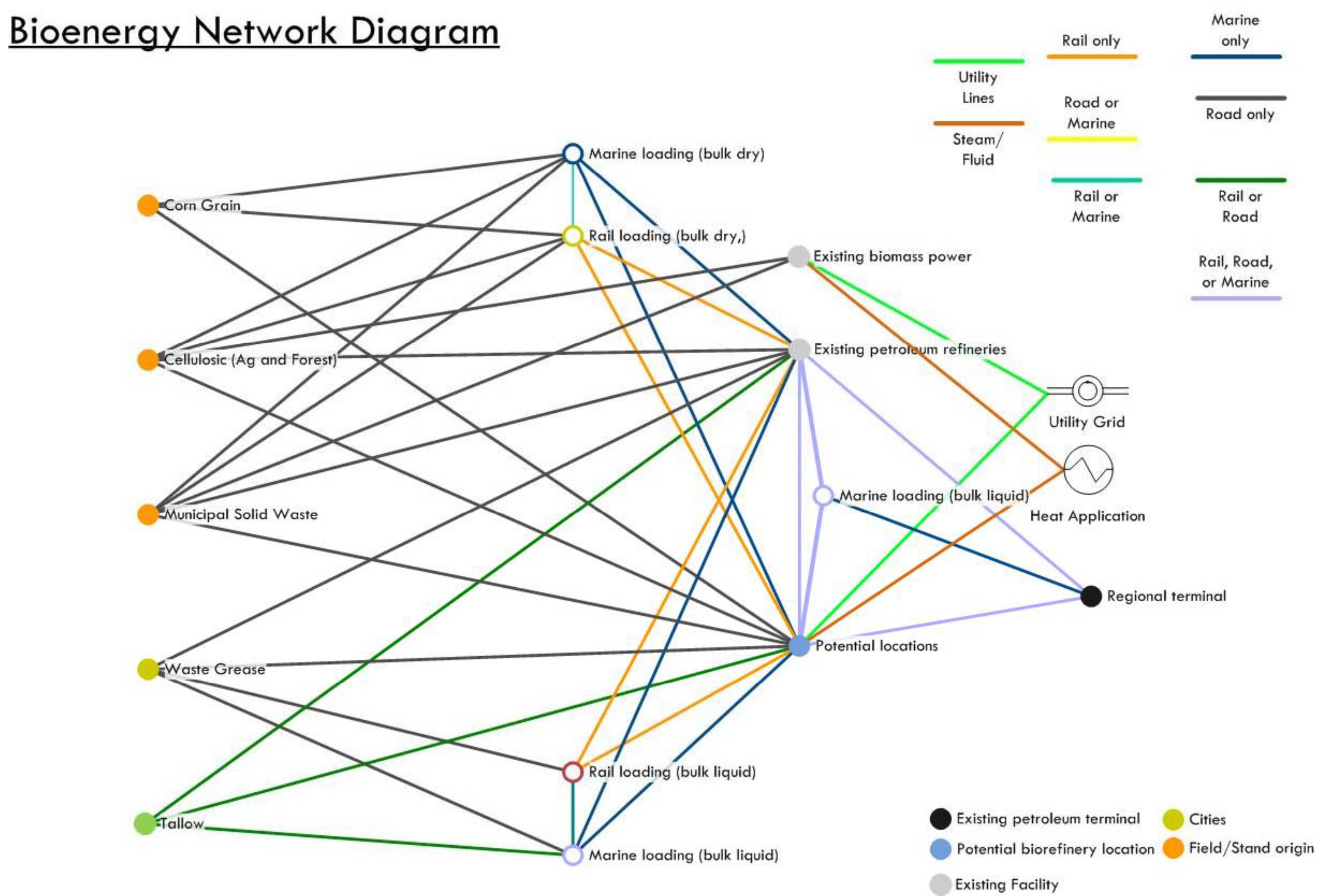
Tittmann, et al., 2008

Modeled Biofuel Pathways

Feedstock Category	Feedstock Type	Conversion Technologies
Clean Lignocellulosics	Forest biomass Straw, Stover, and Vegetable Ag. Residues Dry food processing wastes Orchard/Vineyard Wastes Municipal Solid Wastes (MSW) • Clean Mixed Paper • Clean Wood Wastes • Clean Yard Wastes	LCE LCMD BP CHP
Lignocellulosics	Remainder of Biomass MSW, Remainder from sorting	LCE LCMD BP CHP
Lipids	Yellow Grease Animal Fats	FAME FAHC
Grains	Corn	Dry Mill Ethanol

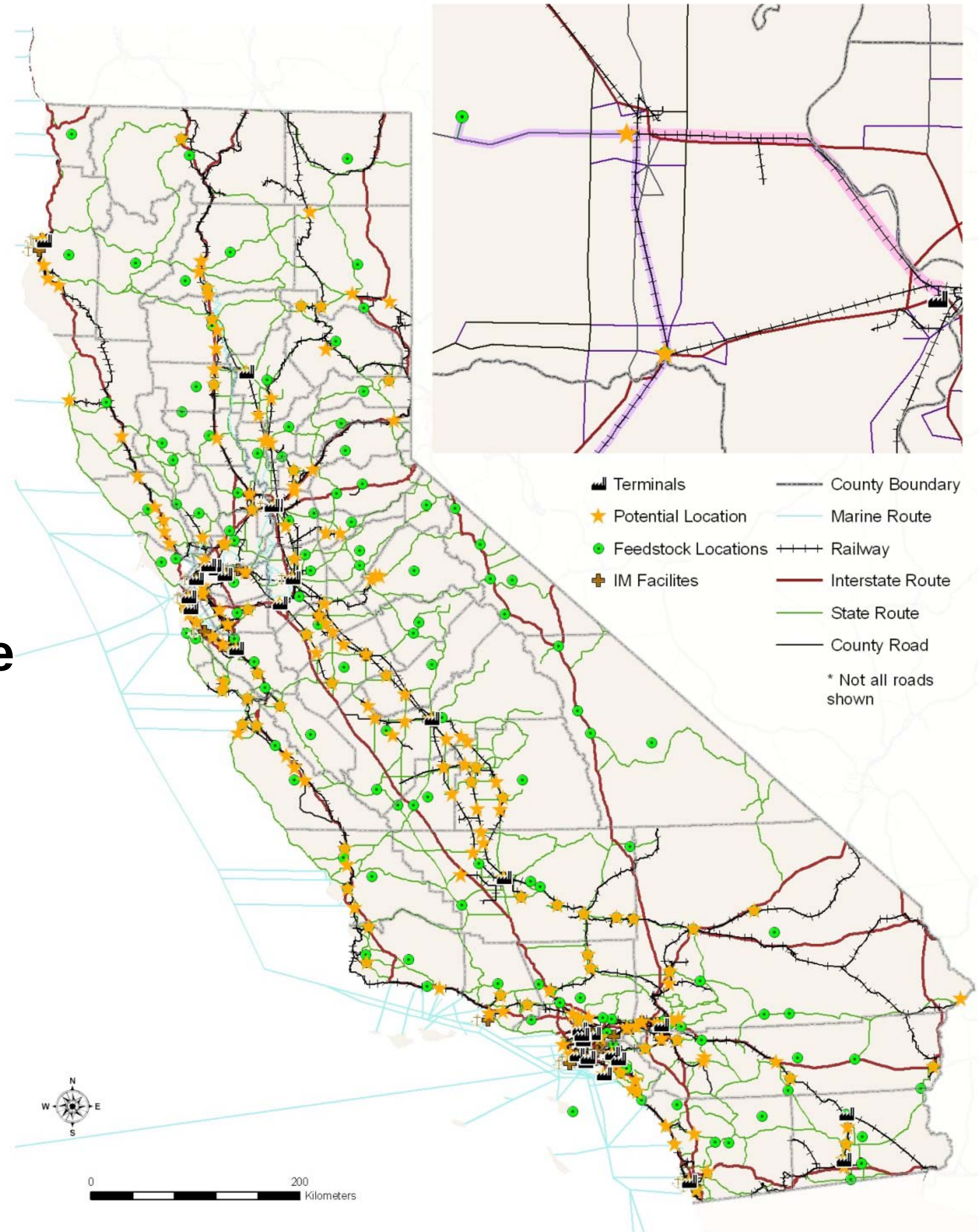
LCE = Lignocellulosic ethanol. LCMD = Lignocellulosic middle distillates (FT diesel). BP = direct combustion for electricity (biopower). CHP = combined heat and power. FAME = fatty acid methyl ester. FAHC = hydrotreated lipids (hydrocarbons). GE = grain ethanol.

Bioenergy network

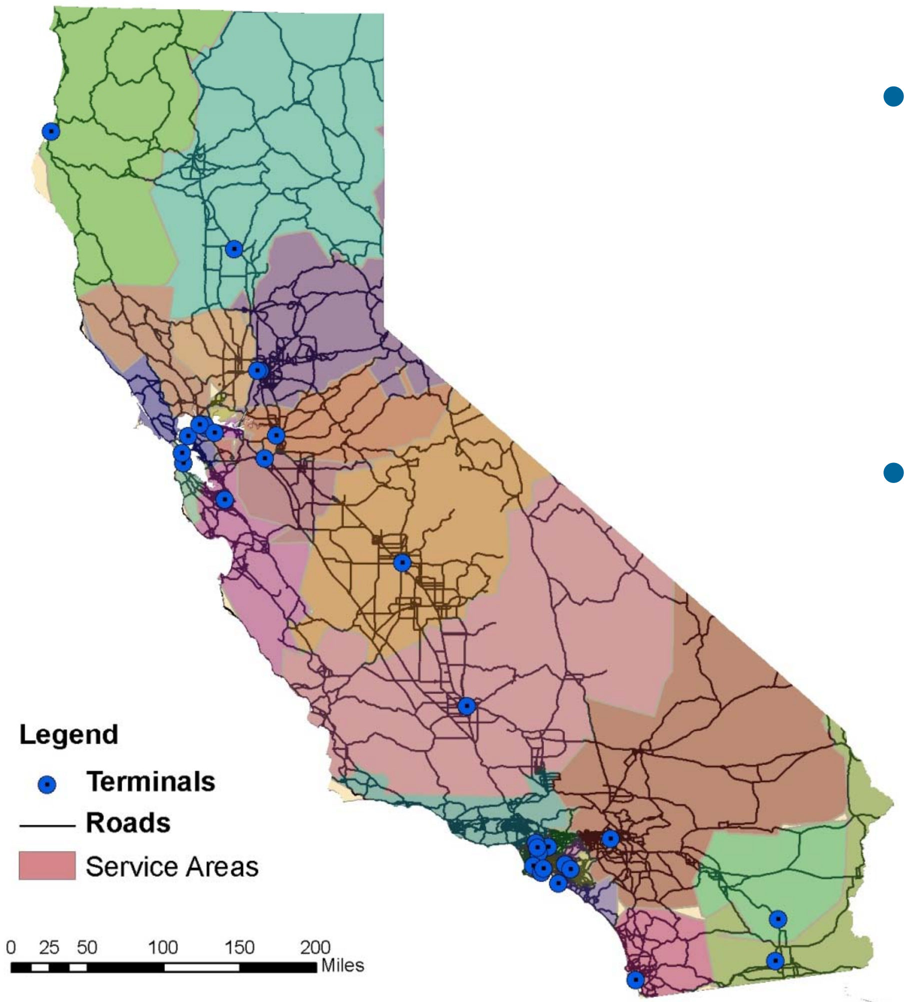


Network modeling results

Overview of California transportation network with network modeling results. The insert figure shows sample feedstock location, travel to the potential biomass facilities via roads or a combination of roads and rail (in purple), and then travel to petroleum refineries via rail or marine (in pink).



Fuel/Energy Demand Modeling



- Fuel allocated to existing fuel terminals within service territories
- Terminal limitations
  - Biofuel limited to max of 20% of gasoline
  - Full diesel replacement

Feedstock availability and sustainability

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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.,

Assumptions behind forest biomass estimates:

There are 40 million acres of forest lands in CA (46% national forest, 12 % other public forests, and 42% private lands.

Forestry biomass includes:

1. logging slash (tops, branches, bark),
2. forest thinnings (non-merchantable materials extracted during stand improvement/fuel reduction), to reduce the threat of catastrophic wildfire,
3. mill residues (bark, sawdust, shavings, trim ends),
4. shrubs and chapparel, for fire prevention.

Data from: Calif. Biomass Collaborative; California Department of Forestry and Fire Protection, Shih (2004); Yang and Jenkins (2005); Morris, 2003 and others.

Both nationally and in California, the amount of forest land burning each year and the intensity of forest fires is increasing.

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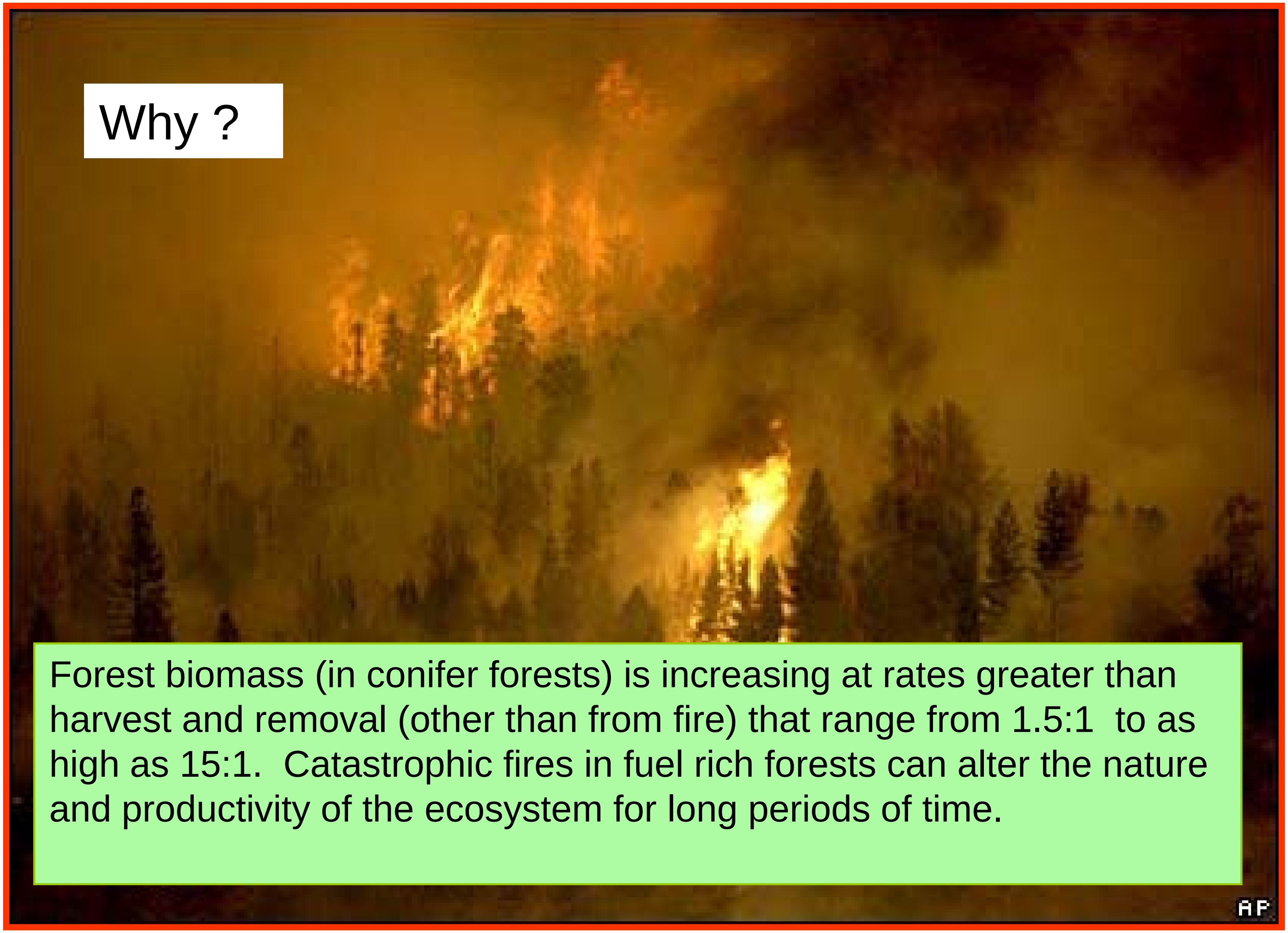
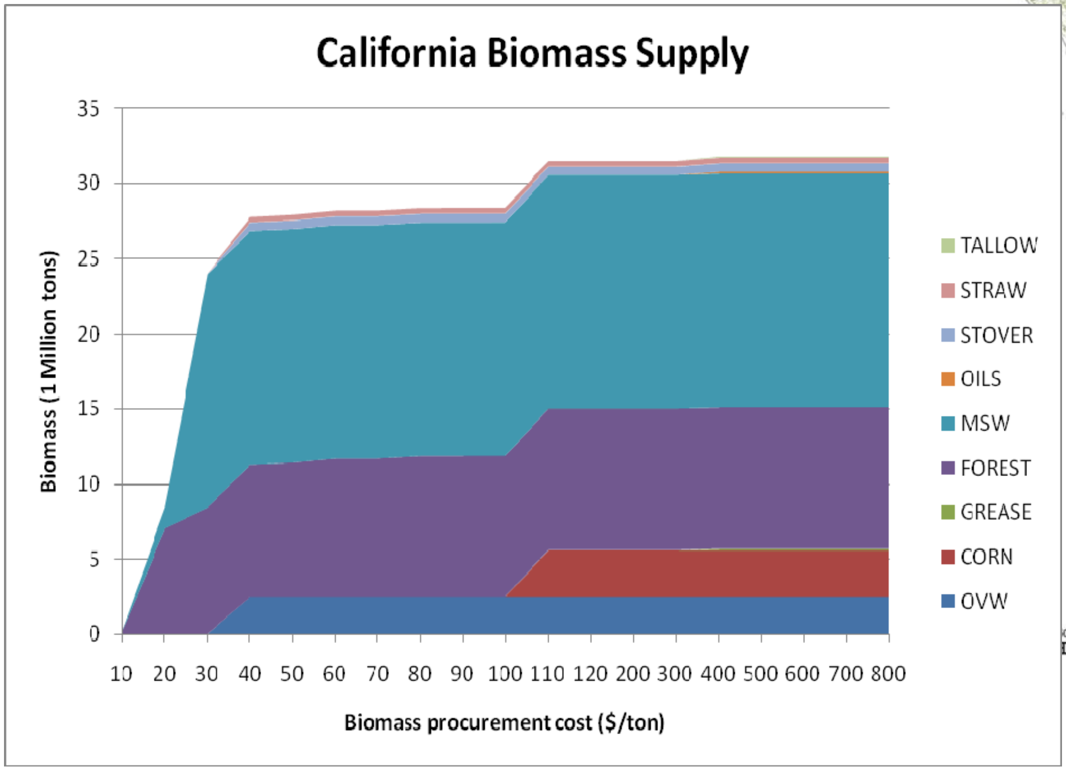
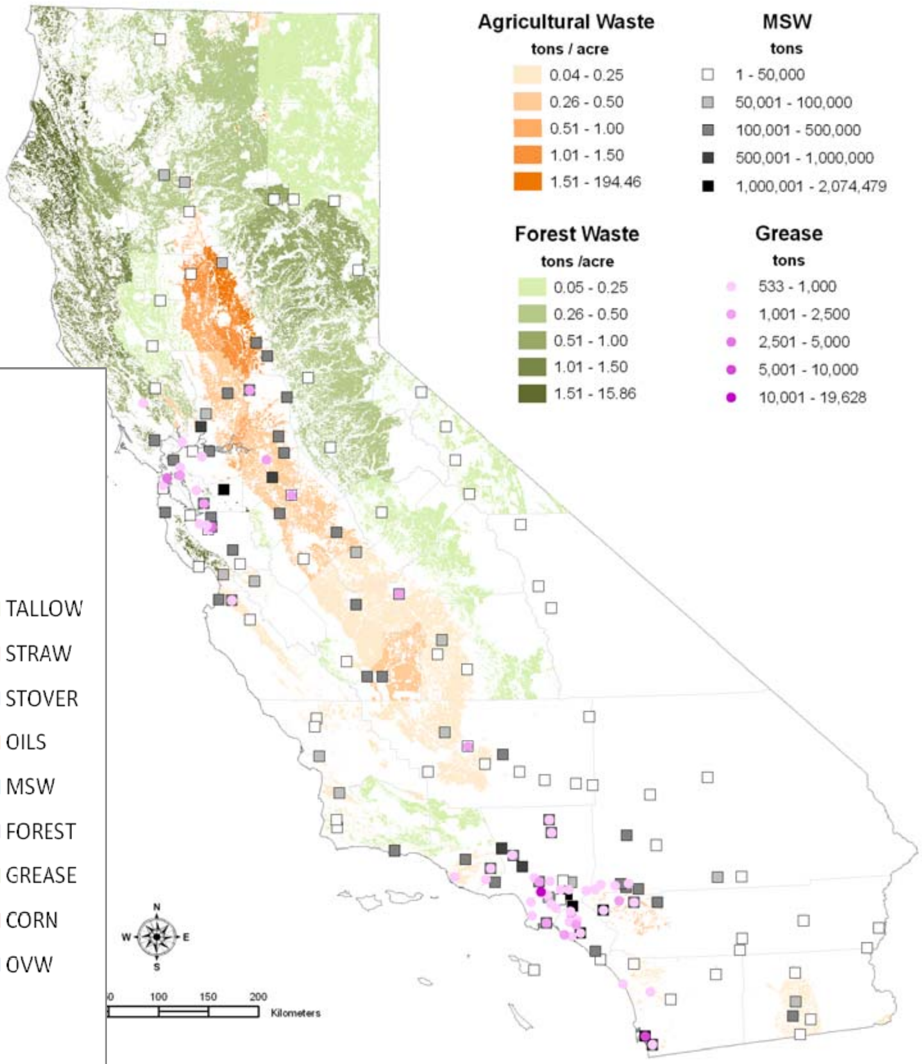


Why ?

Forest biomass (in conifer forests) is increasing at rates greater than harvest and removal (other than from fire) that range from 1.5:1 to as high as 15:1. Catastrophic fires in fuel rich forests can alter the nature and productivity of the ecosystem for long periods of time.

Biomass resource distribution

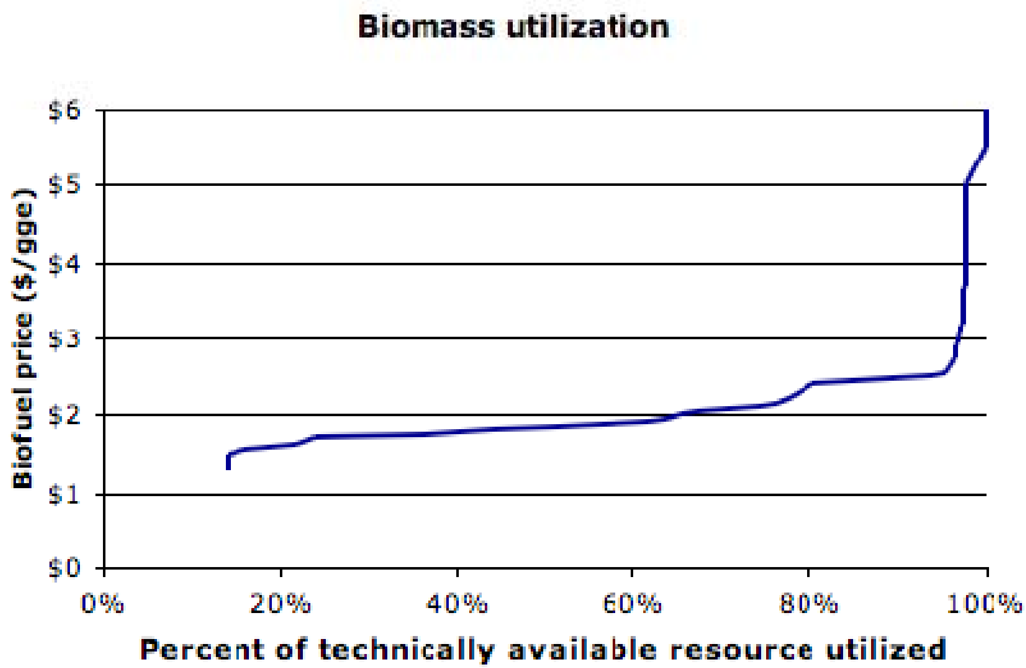




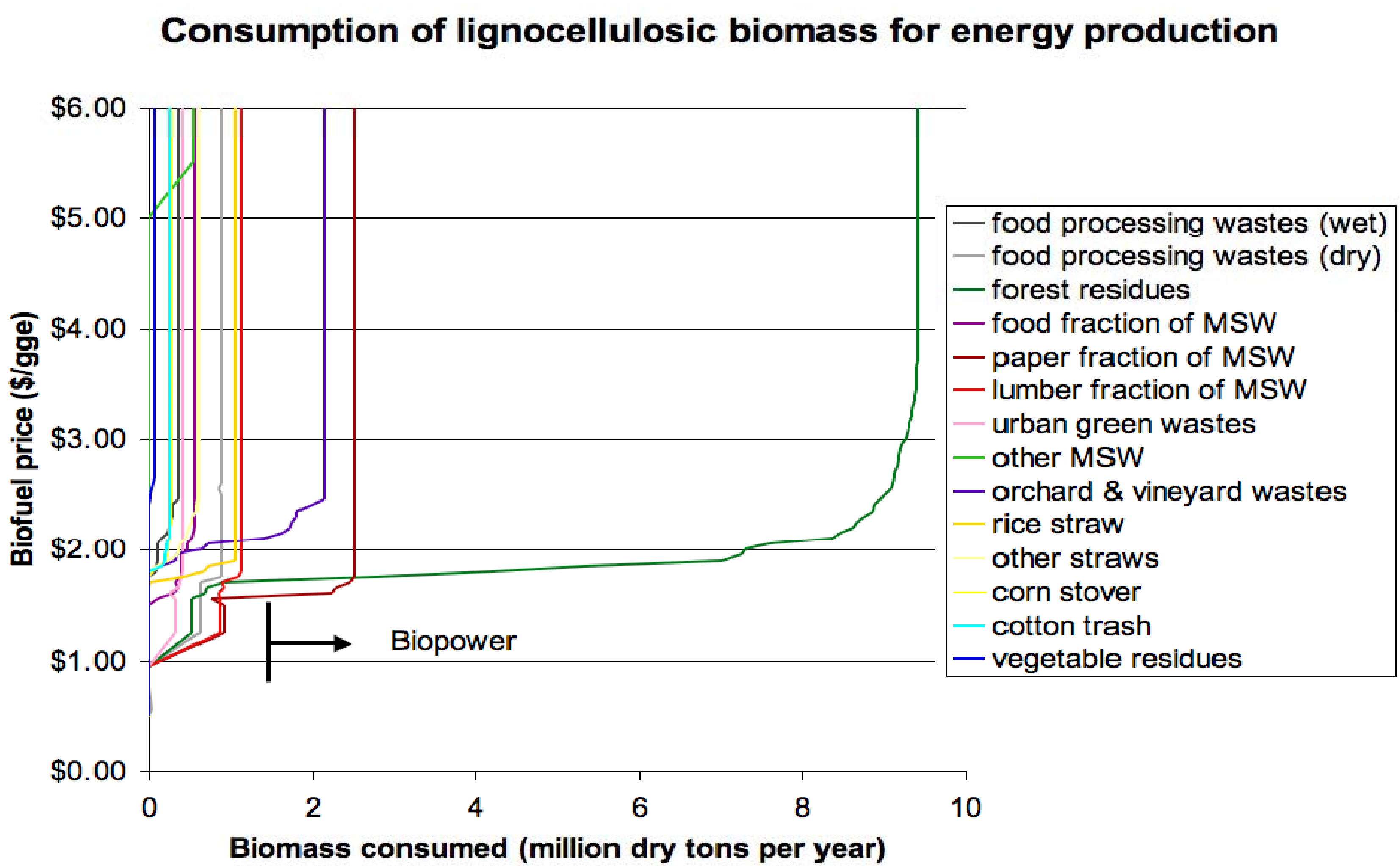
Feedstock utilization

Biofuel markets

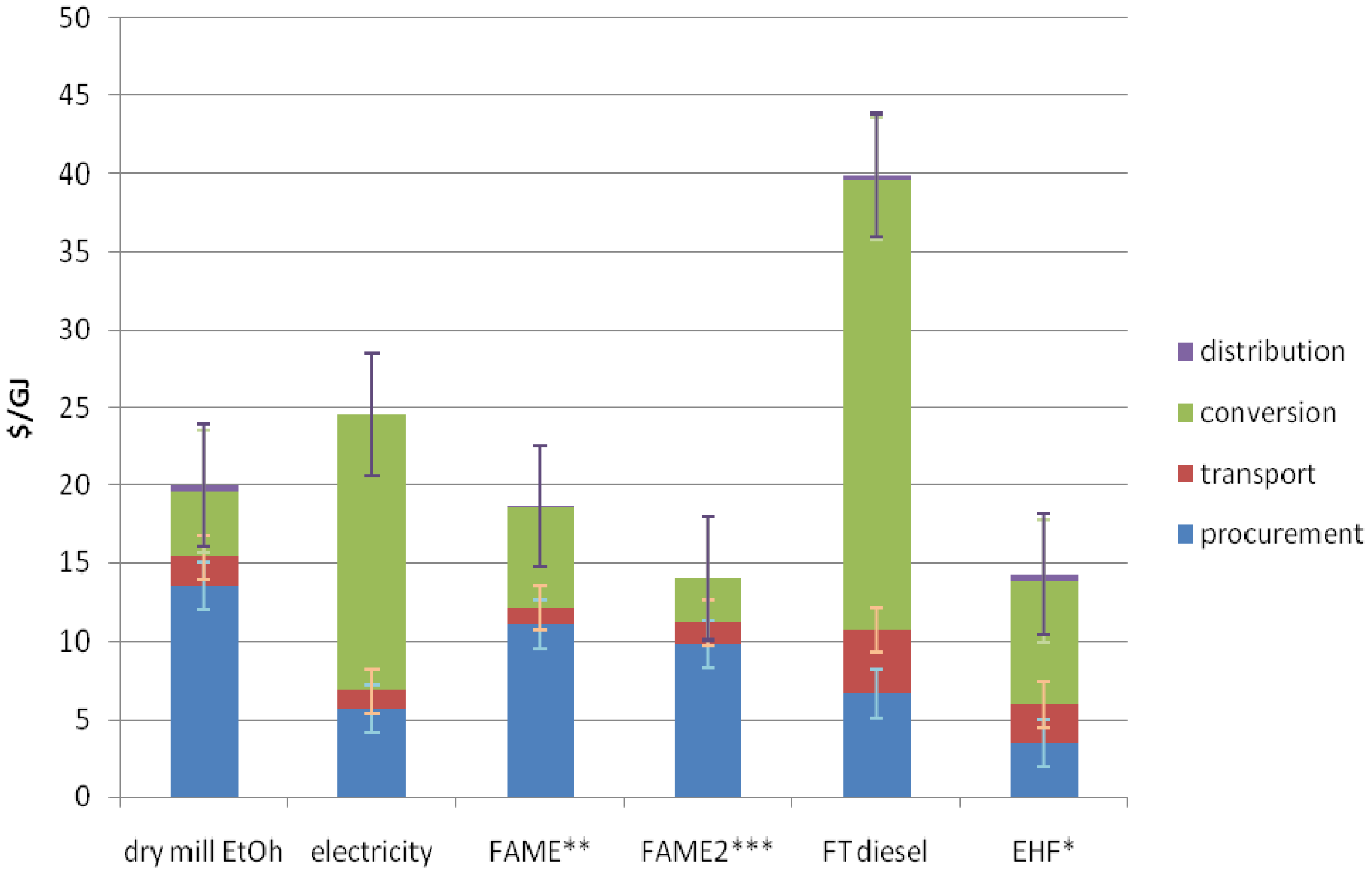
- < $1.50/gge
  - Biopower provides market for 14% of biomass
- $1.50-2.50/gge
  - Rapid increase in utilization due to most procurement costs set at $25-35/dry ton
  - Corn ethanol enters at $2.50/gge
- > $5.00/gge
  - FT diesel from low quality mixed MSW



Feedstock consumption



Supply chain costs



*Enzymatic Hydrolysis and Fermentation
**Fatty Acid Methyl Esterification (virgin fatty acids)
***Fatty Acid Methyl Esterification (waste grease)

Model conclusions—Feedstock

- **Depending on market scenario, total economic biomass resource in the state varies between about 18 and 25 million dry tons per year at biofuel prices from $2.20 to $4.00 per gallon of gasoline equivalent. Further model investigations are needed to assess conditions and incentives under which greater resource use may be justified while maintaining a sustainable supply.**
- **Much further research is needed to understand the spatial distribution, sustainability, and cost of natural forest stand biomass.**
- **Analysis of the dynamics of natural forest stand carbon dynamics vis a vis increasing wildfire frequency and severity and forest biomass harvesting may greatly affect the availability and carbon benefit of forest-based bioenergy**

Model conclusions—Land use

- **Land use policies will have a significant impact on the availability feedstock.**
- **Land use policies should enable the expansion of energy crop production on marginal lands, but must be based on substantive sustainability standards or research findings.**
- **Model capability exists to assess policy alternatives, such as exploring the possibility of meeting GHG reduction targets under the federal RFS through sustainable energy crop substitution on lands currently producing corn and other high-input crops at low relative yields.**

Model conclusions—Transport

- **A more detailed analysis is needed of the capacity of existing transportation infrastructure to meet demands of the biofuel supply chain.**
- **A spatially explicit analysis should be conducted of the potential for new transportation infrastructure to improve supply chain economics for biofuels production.**

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Economic and agro-ecological assessment of agricultural biofuel production in California

- Farming conditions and farm size vary across California by region and within regions. Large scale, average calculations may obscure the actual potential for bioenergy crop production across this diverse agro-ecological and economic landscape.
- Based on funding from the California Energy Commission to the California Biomass Collaborative, linear programming models have been (are being) created that represent specific farming conditions and crop responses in the northern and southern Sacramento Valley, the Delta region, various dry farmed conditions in the coastal mountains, the intermountain region, the western San Joaquin Valley, and Imperial Valley.
- These models identify optimal crop rotations in each region subject to regionally-parameterized constraints including soil quality, cropping season length, water availability and quality, locally appropriate yields and other specific farming constraints.
- They can be used for multiple analyses. (Bren School, STEPS/CARB)

Macro-regions modeled

Detailed assessment of dedicated feed stock biomass availability from crops and crop residues in diverse regions of California.

S. Kaffka, F. Yi

Economic and ecological assessment of agricultural biofuel production in California

- The most likely purpose grown crops to be produced on California farms for biofuels are small grains (wheat, barley), corn, sorghum, millet, sugar cane, oilseed crops (safflower, canola, camelina), and perennial grass crops (Bermuda grass, Jose tall wheat grass on salt-affected lands; orchardgrass, and perhaps *Miscanthus* species and switchgrass).
- Policy-related issues like constraints on runoff pollution, trace element management, CO2 accumulation in soils, N2O evolution and global warming potential (GWP) will also be incorporated as the modeling effort progresses. Greenhouse gas contributions from farming systems may be assessed separately using crop and soil simulation models like DAYCENT.

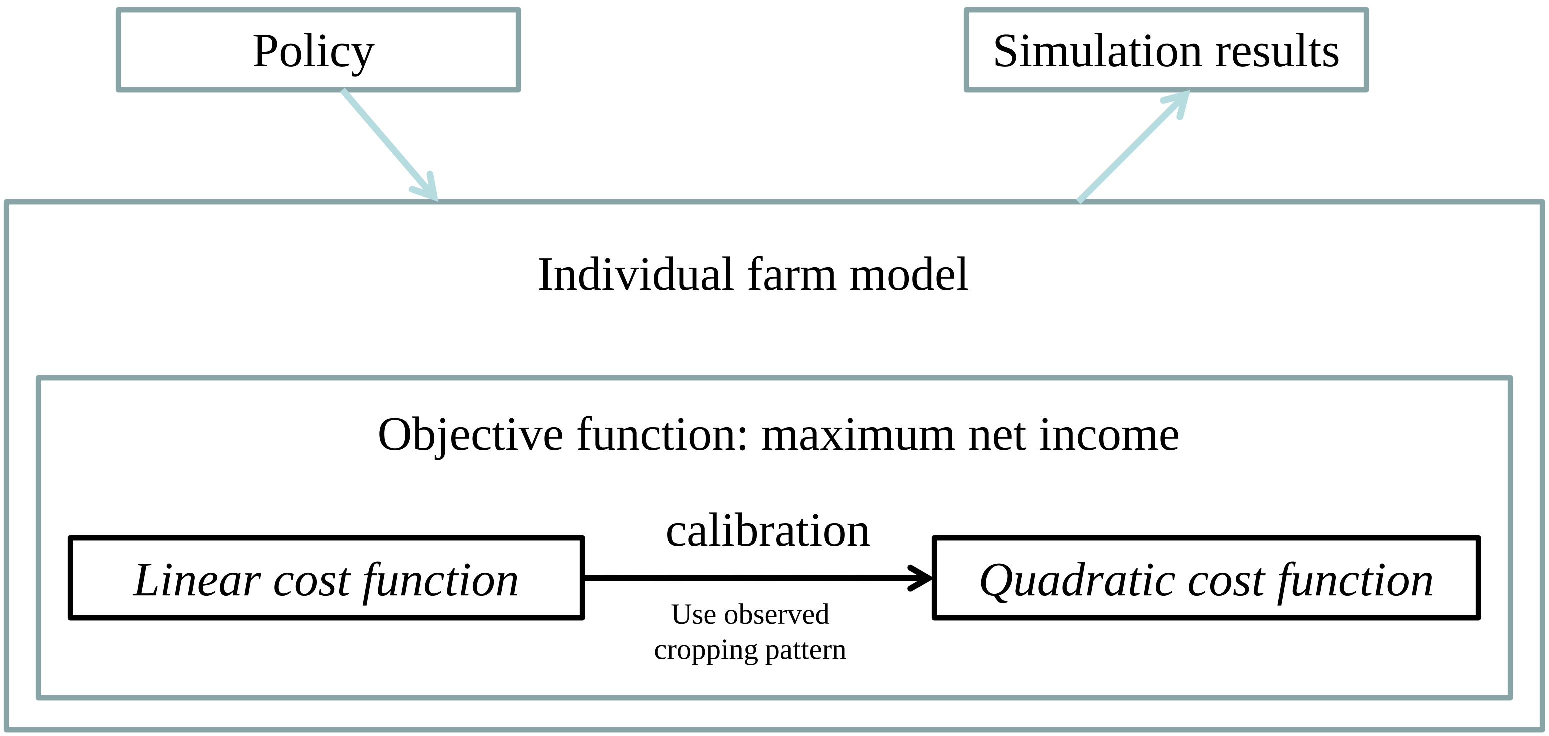
Sample farmers' production cost comparison (San Joaquin Valley)

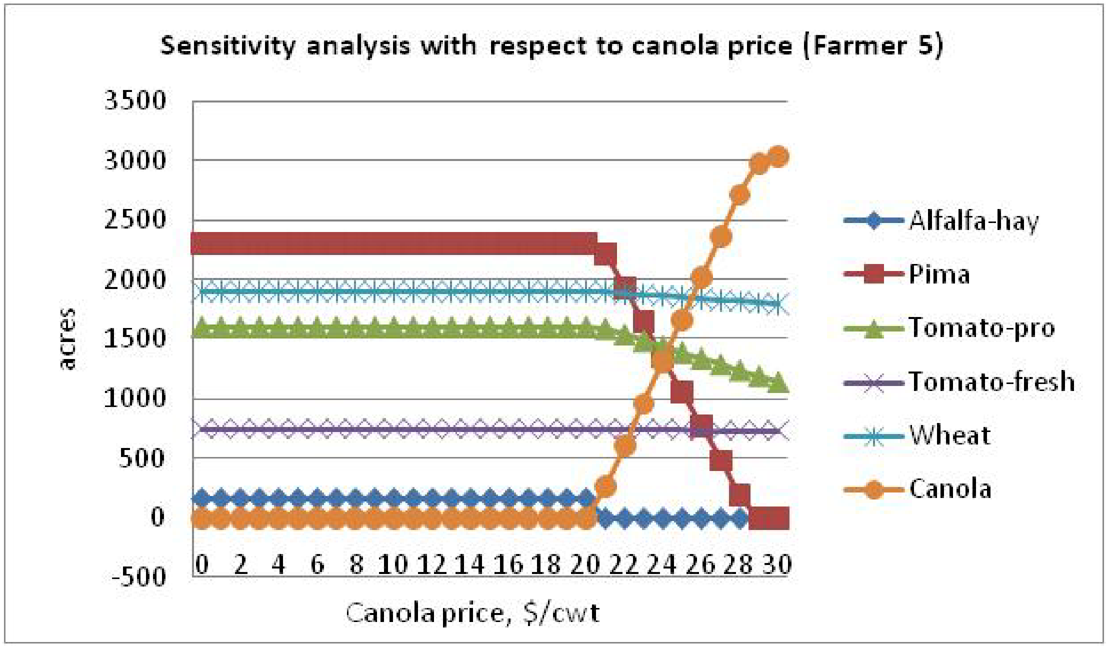
	Merced	Fresno				Kern	UC cost & return study data
	Farmer 2	Farmer 3	Farmer 4	Farmer 5	Farmer 6	Farmer 7	
1.Alfalfa (hay)	1400		1282 (0.34)	1324 (0.57)	754 (0.04)	965 (0.18)	804 (SJV, 2008)
2. Alfalfa (seed)			1677 (0.15)				--
3. Corn (silage)	425				770 (0.04)		972 (SJV, 2008)
4. Corn (grain)			759 (0.41)				1002 (SJV, 2008)
5. Cotton (30-inch row)	1250						736 (SJV, 2003)
6. Cotton (Transgenic)					754 (0.05)		671 (SJV, 2003)
7 Cotton (Pima		1990		1280 (0.35)		740 (0.14)	791 (SJV, 2003)
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)

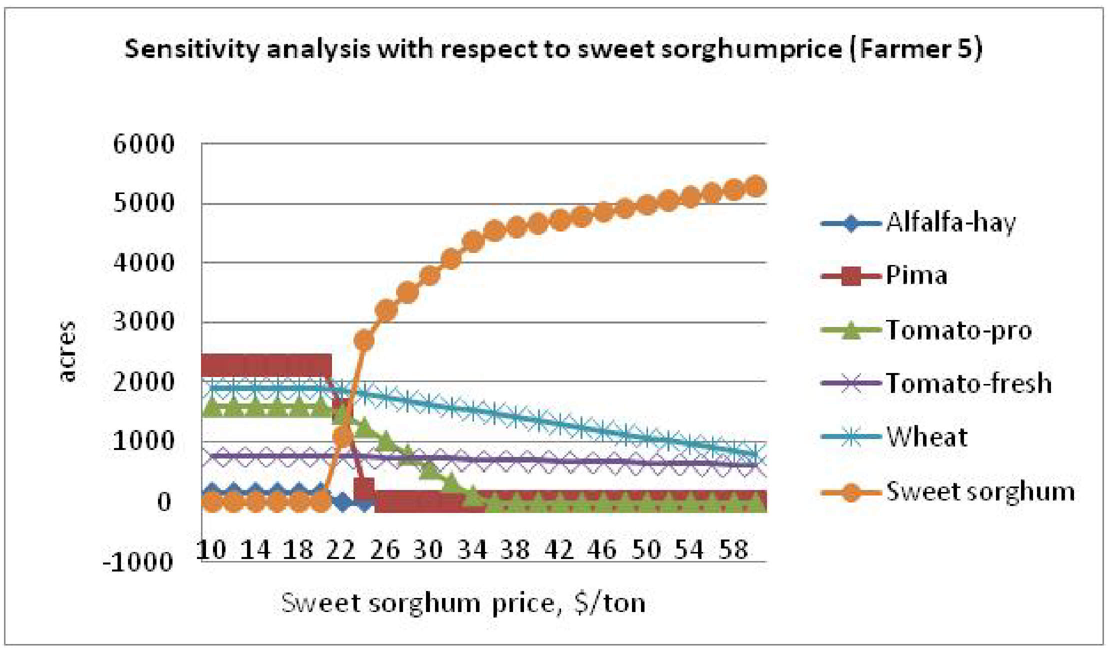
Notes:(1) SCV-Sacramento Valley; SJV-San Joaquin Valley; IV-Imperial Valley; IM-Intermountain area;

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

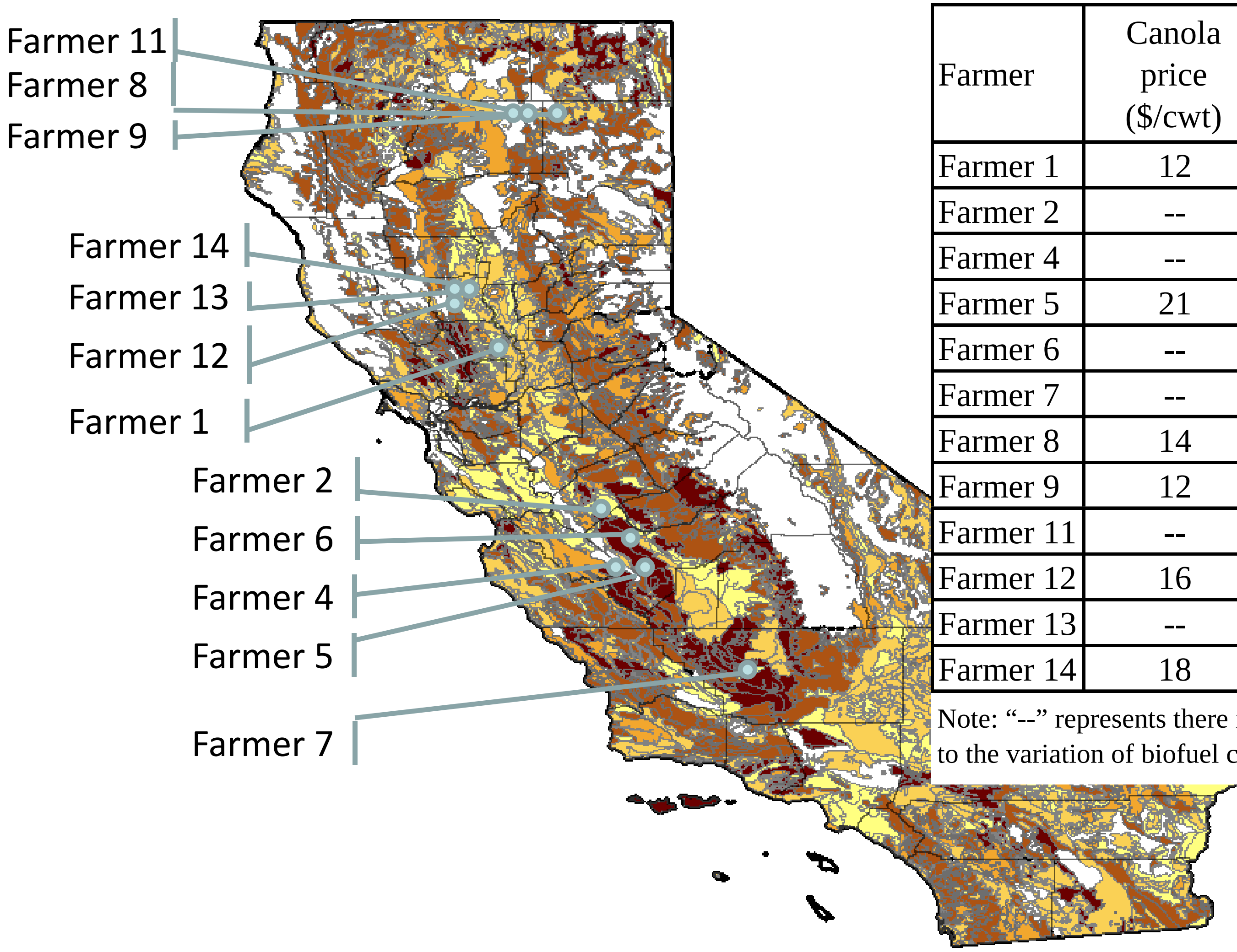
- Structure of calibrated individual farm model




Sensitivity analysis with respect to canola price (Farmer 5)
3500
3000
2500
2000
1500
1000
500
0
-500
acres
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Canola price, $/cwt
Alfalfa-hay
Pima
Tomato-pro
Tomato-fresh
Wheat
Canola


Sensitivity analysis with respect to sweet sorghumprice (Farmer 5)
6000
5000
4000
3000
2000
1000
0
-1000
acres
10 14 18 22 26 30 34 38 42 46 50 54 58
Sweet sorghum price, $/ton
Alfalfa-hay
Pima
Tomato-pro
Tomato-fresh
Wheat
Sweet sorghum

- Trigger prices for the sample farmers

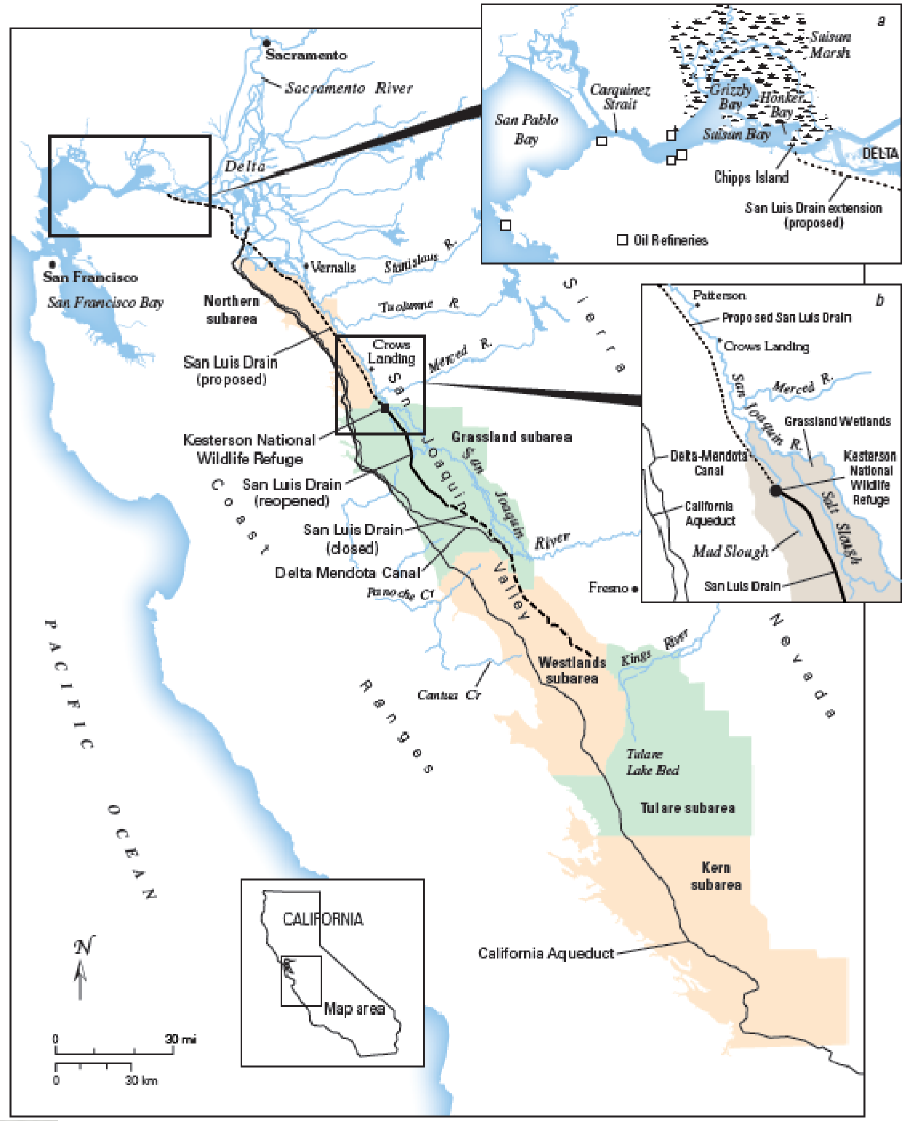


Farmer	Canola price ($/cwt)	Sweet sorghum price ($/ton)
Farmer 1	12	16
Farmer 2	--	30
Farmer 4	--	28
Farmer 5	21	22
Farmer 6	--	28
Farmer 7	--	44
Farmer 8	14	18
Farmer 9	12	18
Farmer 11	--	32
Farmer 12	16	20
Farmer 13	--	30
Farmer 14	18	20

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

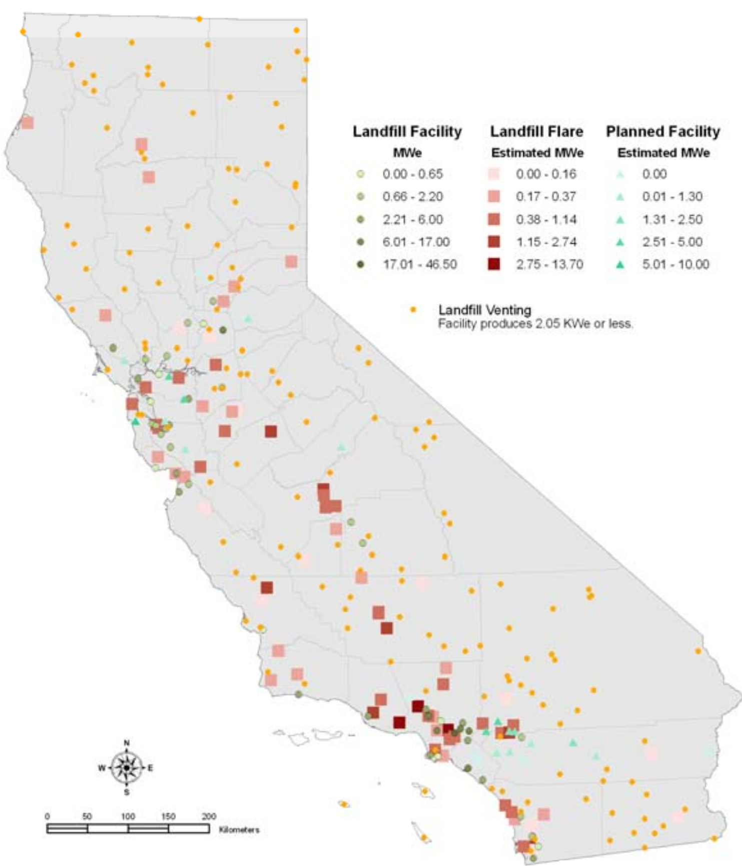
Bioenergy
phyto-rem

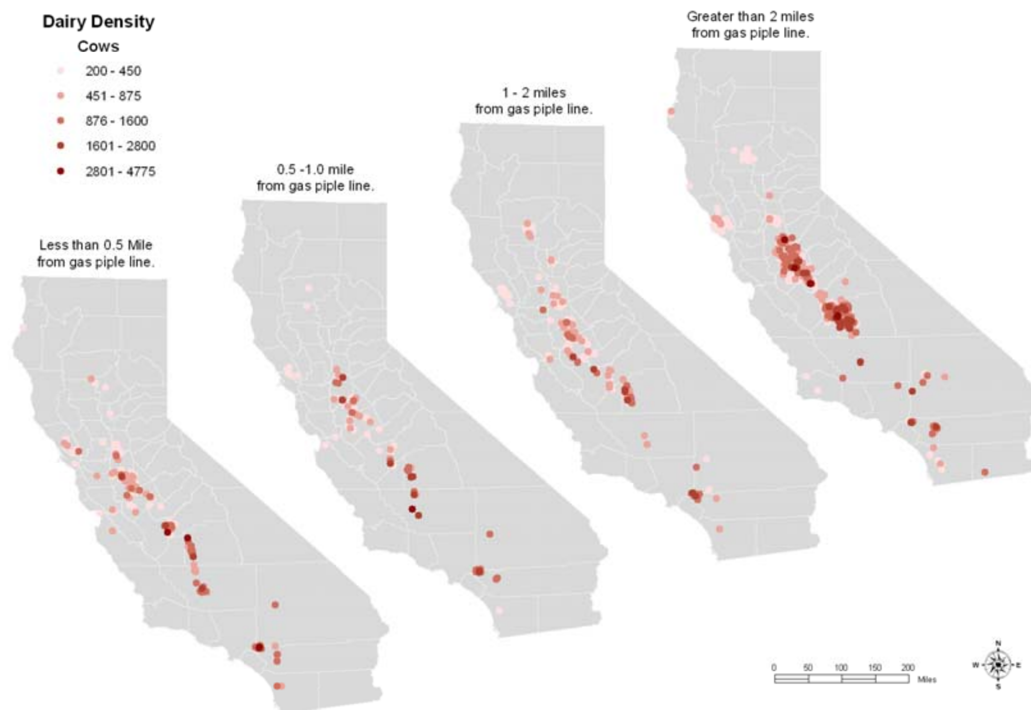
- Potential to use bioenergy crops to remediate drainage-impaired and salt-affected soils in California, especially on the west side of the San Joaquin Valley.
- Future model refinement



High selenium regions of San Joaquin Valley *(Presser and Luoma 2006)*

Landfill gas and digester gas not yet included in model

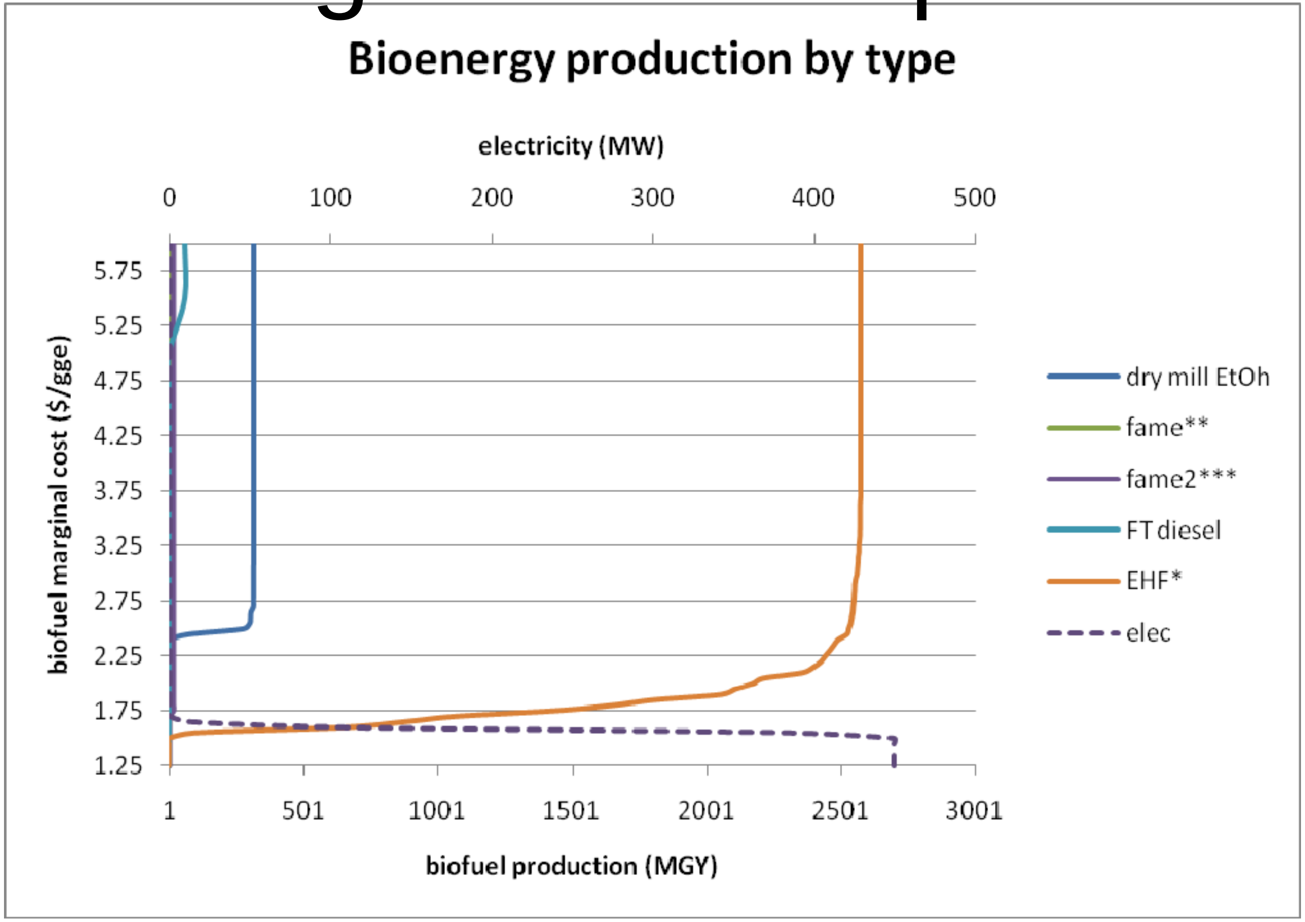




Dairy proximity to natural gas pipelines

Landfill gas facility locations

Electricity and biofuel production and marginal biofuel price



*Enzymatic Hydrolysis and Fermentation **Fatty Acid Methyl Esterification (virgin fatty acids) ***Fatty Acid Methyl Esterification (waste grease)

Constrained model for 20% of RPS (Bioenergy Action Plan-electricity)