Strategic Research on Biomass Energy in California

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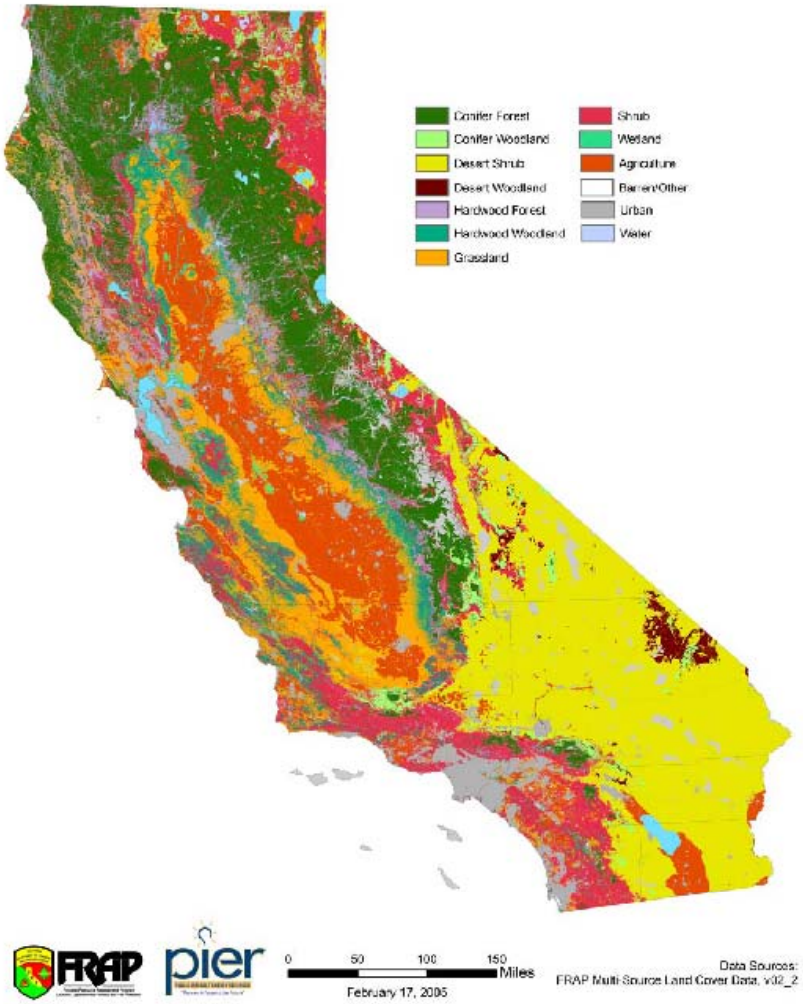
- Statewide Biomass Coordinating Group
- Biomass Facilities Reporting System
- Biomass Resource Assessments
- Technology assessments
- Planning Functions/Policy
  - Needs Assessment
  - Roadmap for biomass development
- Public Education/Forums
- Coordination with State Bioenergy Interagency Working Group



California Biomass PIER Collaborative: Task List

3.1 CBC technical support (management, staffing, other)

- 3.1.3 Targeted support (consulting) for CEC--- X
- 3.1.4 Database management---X
- 3.1.5 Biomass resource inventory---X

3.2 Research tasks

- 3.2.1B Road map implementation plan
  - 3.2.1.1 Energy crops and residue assessment---X
  - 3.2.1.2 Food residue assessment---X
  - 3.2.1.3 Sustainability standards_---(X)
  - 3.2.1.4 Barriers to market development (X)
  - 3.2.1.5 GIS based modeling---(X)
  - 3.2.1.6 Re-powering biomass to electricity_Feb 2012
  - 3.2.1.7 Biomass (forestry) Management Zones_X

3.5 Education and Outreach

- 3.5.1 Forums (6, 7, 8)---X
- 3.5.5 Website---X

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California Biomass Collaborative Biomass Facilities Database: Summary Table

	Power MW	Biogas MMscf/day	Fuel MGY	Operating Facilities
Biomass, solid fuel (net production)	594.6			29
Landfill gas (LFG, gross)	270.8			66
Landfill gas (LFG, gross)		20.66		10
Landfill gas (LFG, gross)			4	1
Wastewater Treatment Facilities (gross)	91.5			57
Wastewater Treatment Facilities (gross)		7.74		2
Biofuels, ethanol			179	3
Biofuels, biodiesel			62	13
Food residue and manure digesters	5			13
Totals	961.9	28.4	245	194

There were 88 WWTF and 13 food residue processors using methane for process heat.

http://biomass.ucdavis.edu/tools/

Welcome to the 8th Annual California Biomass Collaborative Forum

http://biomass.ucdavis.edu/events/

The 8th Forum focused on:

1. The use of forest biomass and the issue of carbon neutrality.
2. The role and use of urban residual wastes for power and alternative fuel production.
3. Potential for energy and bio-product production from California's food processing industry.

Previous forums covered the Biomass Action Plan, urban derived residuals, sustainability and certification, net benefit analysis from biomass energy, and the use and regulation of biofuels.

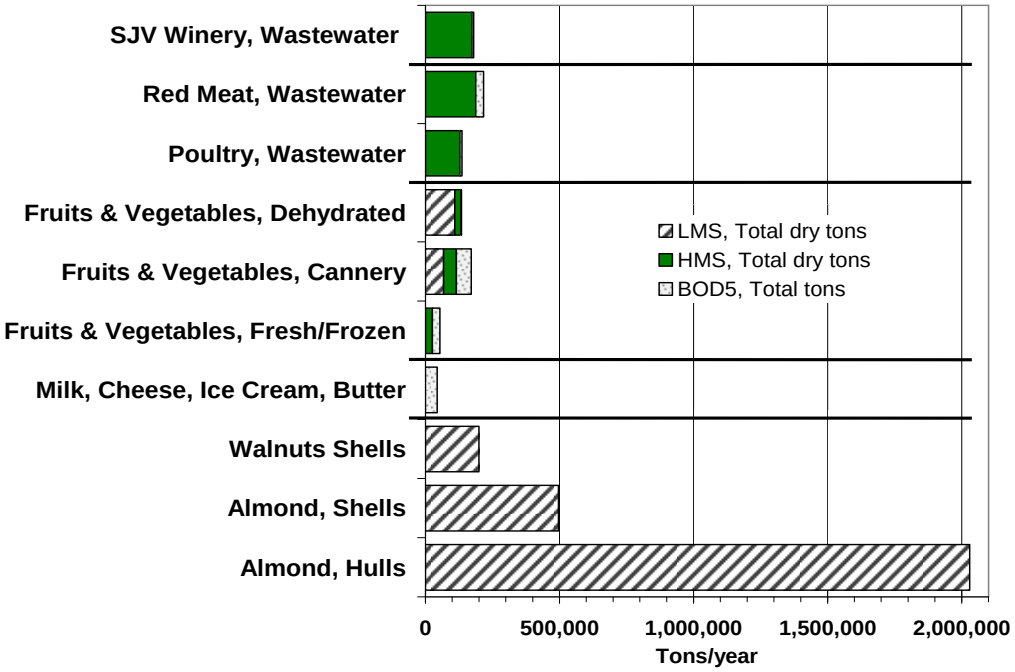
California Food Processing Industry Residue Assessment

Amon et al., 2011

SUMMARY: Supplements the Biomass Resource Inventory. The goal was to compile a county-level inventory of food processing industry residues and to estimate the amount of energy that these resources could generate

The food industry sectors surveyed were;

- *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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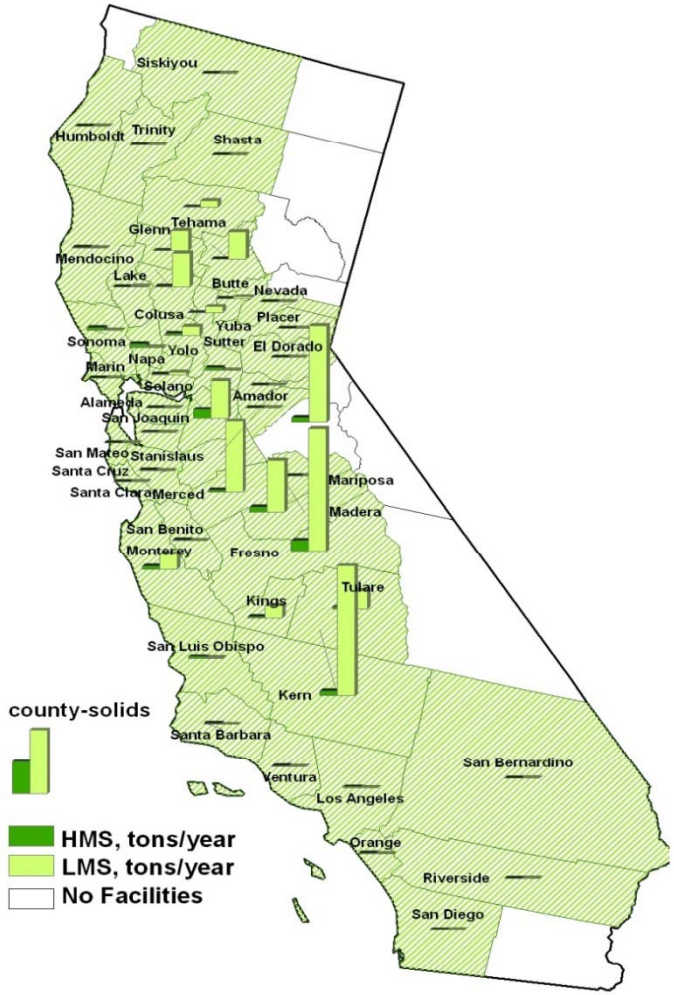
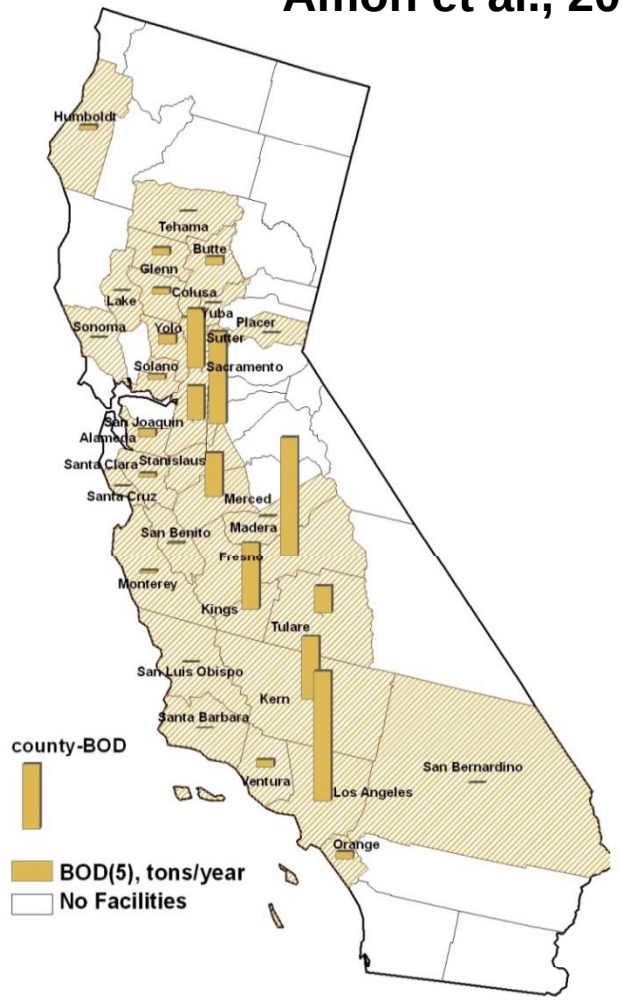
California Food Processing Industry Residue Assessment

Amon et al., 2011





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Summary of Bioenergy Potential from Food Processing Residuals

Food Processing Sector	BOD5 Biogas Power (MW)	BOD5 Biogas CHP (MMBtu)	Solids Biogas Power (MW)	Solids Biogas CHP (MMBtu)	Low MoistureSolids Power (MW)	Low MoistureSolids CHP (MMBtu)	Potential Residue Availability
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

Amon et al., 2011

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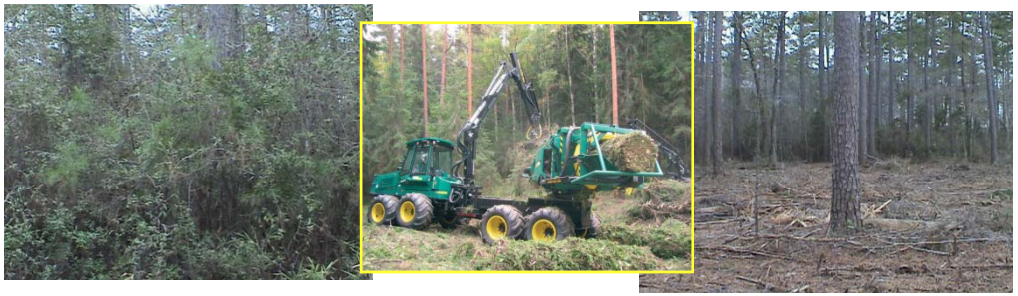
Biomass Management Zones

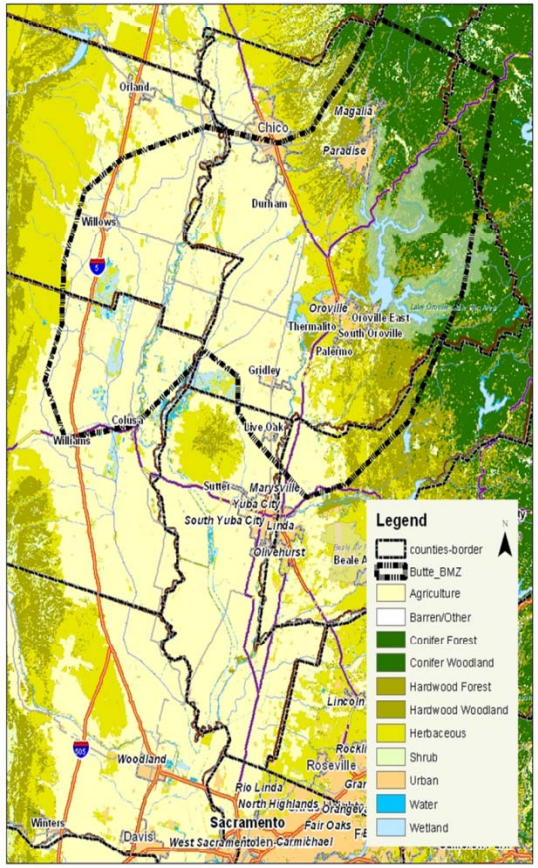
'sustainably managed woodsheds and other biomass production regions' that will support the sustainable management of urban interface woodlands and forested lands to reduce fuel loading and the potential of uncontrolled wildfire, utilize biomass and residues from forest management/products to produce bio-energy and bio-products and to stimulate local economic activity and long-term stability.

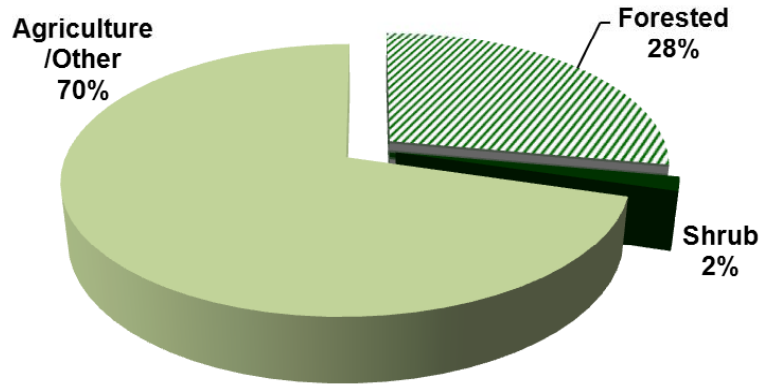


Warming and Earlier Spring Increases Western U.S. Forest Wildfire Activity

A. L.Westerling,1,2* H. G. Hidalgo,1 D. R. Cayan, 1,3 T. W. Swetnam4 1Scripps Institution of Oceanography, La Jolla, CA 92093, USA. 2University of California, Merced, CA 95344, USA. 3US Geological Survey, La Jolla, CA 92093, USA. 4Laboratory of Tree-Ring Research, University of Arizona, Tucson, AZ 85721,USA. Science Express, July, 2006

Oroville Region Biomass Management Zone





Woody Biomass Availability and Potential Power Production Summary

Biomass Fuel Type	Economical Availability (BDT/Y)		MW	MW
	Low range	High range	Low	High
Timber Harvest Residuals	32,000	32,000	6	6
Orchard	279,000	279,000	52.1	52.1
Urban Wood	40,000	40,000	7.5	7.5
Subtotal of Established Biomass	***351,000***	***351,000***	***65.6***	***65.6***
Fuels Reduction*	90,000	90,000	18.8	18.8
Sawmill Residuals**	11,700	109,000	2.1	20.3
Total Biomass and Power	**452,700**	**550,000**	**86.5**	**104.7**

** Assumes scenario of treatment on lands 0-45% slopes with SMZ's ~ 4900 acre/year (30 year treatment) in the Wildland-Urban Interface and ~ 2580 acres/year (50 year treatment) outside the Wildland-Urban Interface*

Estimated benefits from anaerobic digestion of rice straw.

		Feedstock BDT	Power Capacity, MW	Heat Value MMBTU	CH4 Avoided Mg CH4
1, Rice straw AD unit	Power production	50,000	1.9		55,000
140 tons/day	Heat production	50,000		177,000	53,000
All BMZ rice straw	Power production	223,000	8.5		245,000
4.5 AD units	Heat production	223,000		788,000	236,000

Repowering Solid Fuel Biomass Electricity Generation, J. Birdsall and B. Jenkins

A techno-economic analysis of repowering solid fuel bio-energy facilities is currently underway. The fleet of solid fuel facilities in CA is aging (most recent built in 1992). Repowering scenarios include: improved boilers, switching to integrated gasifier combined cycle systems (e.g., gas turbine & steam cycle, or fuel cell & steam cycle).

Improvements in efficiency and emissions performance are possible. A better understanding of costs and benefits from advanced generation technologies is the expected outcome.

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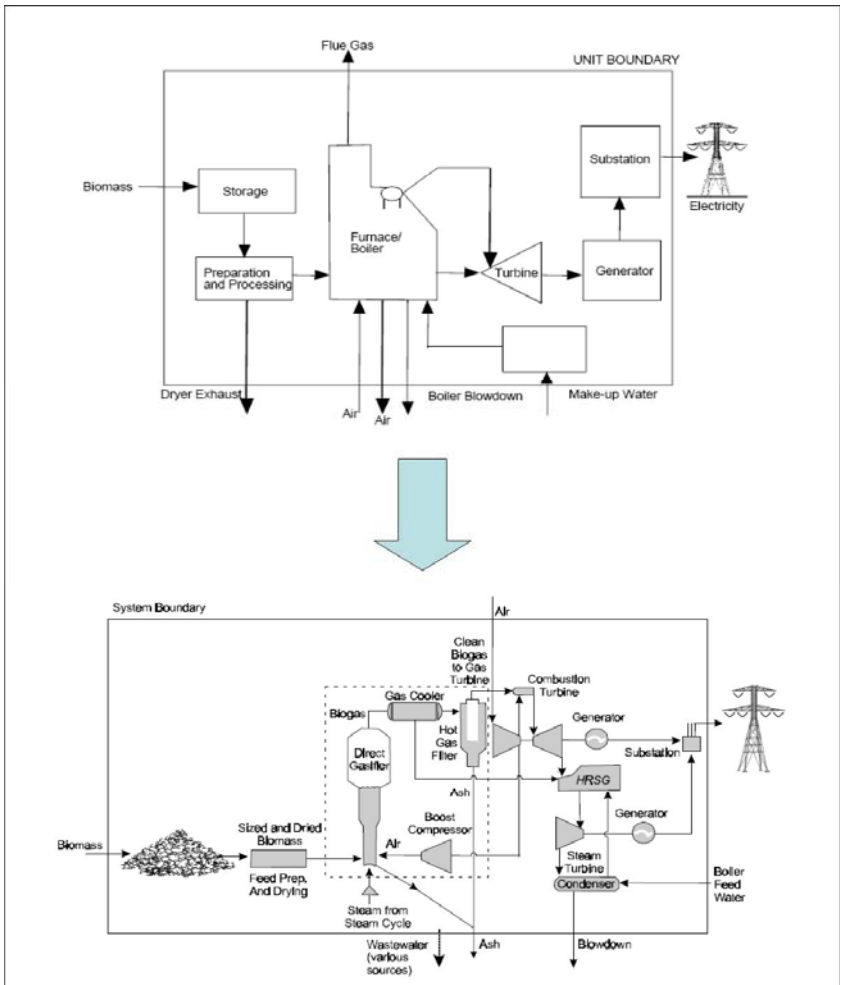

Source: US Department of Energy, Office of Utility Technologies, Energy Efficiency and Renewable Energy. Renewable Energy Technology Characterizations. December 1997

IGCC: Integrated Gasification Combined Cycle

Modeling Agricultural Feedstocks for Biofuels in California

Steve Kaffka, Mark Jenner

Department of Plant Sciences &

California Biomass Collaborative

Estimating Biofuel Carbon Intensity

- **All biomass is local**: Can general or average values in LCA models accurately estimate the direct GHG emissions from biofuel production?
- **Technology is dynamic**: the newest is not well characterized in the literature, and integrated biorefineries present unique challenges.
- At least in California, where farmers have many crop choices, can the trade effects of biofuel feedstock production (ILUC) be estimated using CGE and PE models?
- Short answer: No.

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CBC Optimization Model

Production function

$$Max \prod_{X_{e,g,i,j}} \sum_{g} \sum_{j} \left[\begin{array}{l} \sum_{i} \left(P_{g,i,j} \times \left(\beta_{g,i,j} - \omega_{g,i,j} X_{g,i,j} \right) - C_{g,i,j} \right) X_{g,i,j} \\ + \sum_{e} \left(P_{e,g,j} Y_{e,g,j} - C_{e,g,j} \right) X_{e,g,j} \end{array} \right] \begin{array}{l} \} \text{ PMP function} \\ \} \text{ Energy crop function} \end{array}$$

Subject to: $\sum_{\bar{A}^{i}} \sum_{e} X_{g,i,e,j} \leq \overline{A_{g,j}}$ *j= {acres, ac-ft of water}*

$P_{e,g,i,j}$ = farm price of crop *i*, and energy crop *e*, in region *g*, and resource, *j*.
$C_{e,g,i,j}$ = farm cost of crop *i*, and energy crop *e*, in region *g*, and resource, *j*.
$Y_{e,g,i,j}$ = yield of crop, *i*, and energy crop *e*, in region, *g*, and resource, *j*.
$X_{e,g,i,j}$ = level of hectares *r* applied to energy crop e, in region *g* for crop *i*.
$\bar{A}_{g,j}$ = constrained hectares of crop *j* in region *g*.
$\beta_{g,i,j}$ = intercept of the quadratic (marginal) curve of crop, *i*, in region, *g*, resource, *j*.
$\omega_{g,i,j}$ = slope of quadratic (marginal) curve of crop, *i*, in region, *g*, and resource, *j*.

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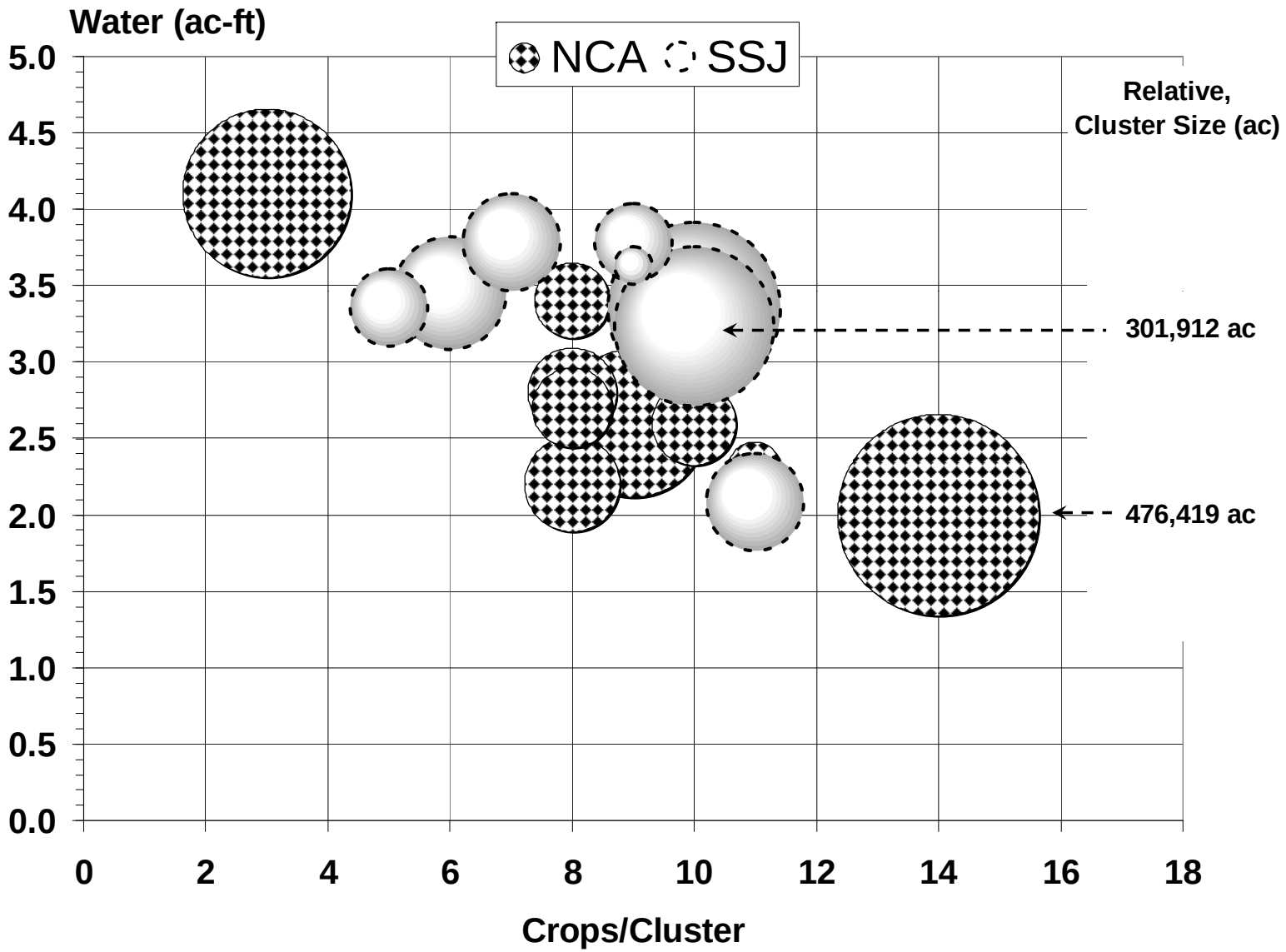
Example: Northern CA (C7)

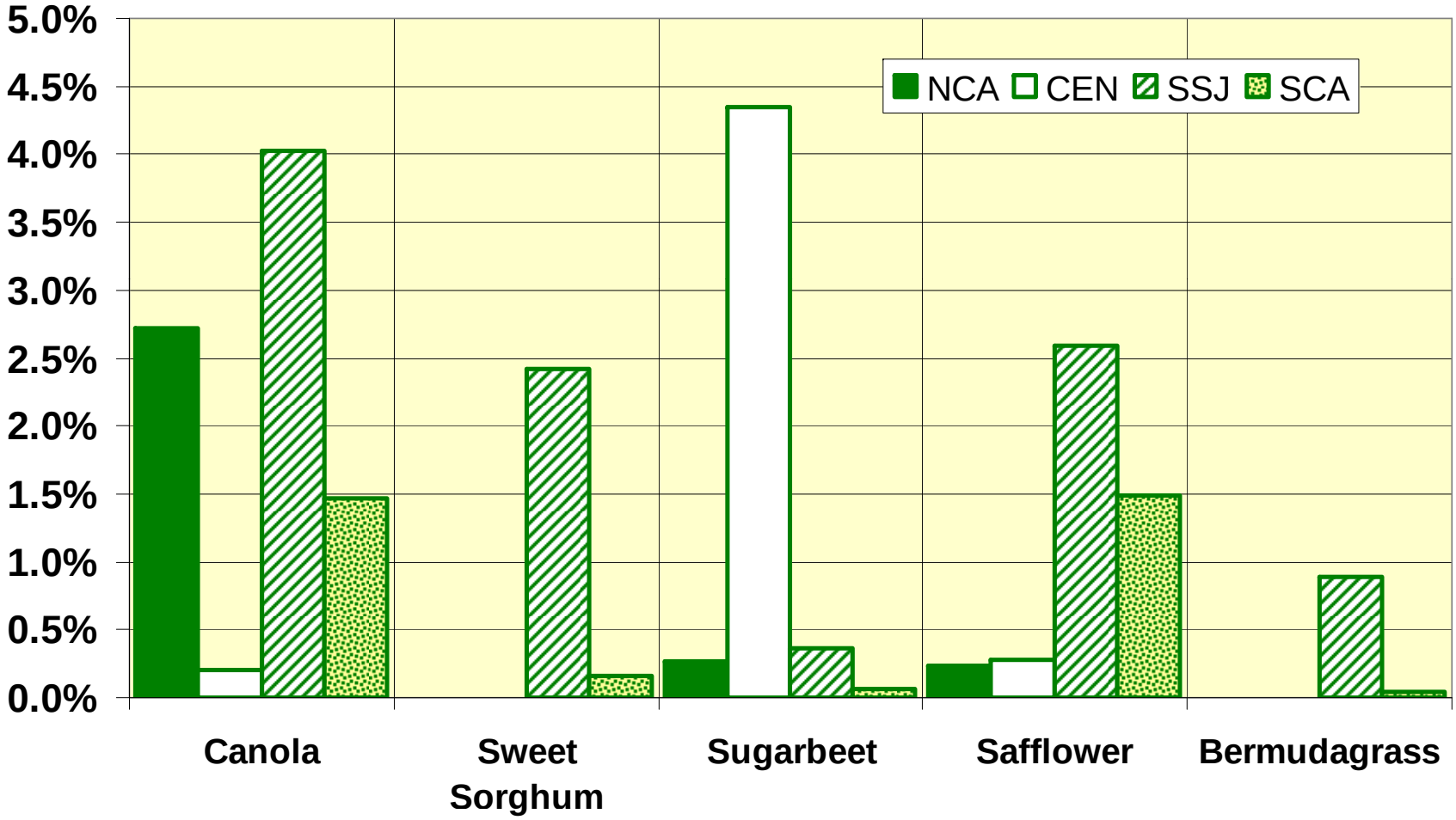
Crop	Score	Dist %	Dist %	
Rice	7.215	29.3%	|||||||||||||||||||||||||||||||	32.0%
Tomato	3.944	16.0%	|||||||||||||||||	17.5%
Wheat	3.285	**10.2%**	|||||||||||	11.2%
Beans	2.486	10.1%	|||||||||||	11.0%
Safflower	2.292	9.3%	|||||||||	10.2%
Melons	2.285	9.3%	|||||||||	10.1%
Corn	1.271	5.2%	|||||	5.6%
Alfalfa	0.542	2.2%	||	2.4%
Onion	0.424	1.7%	||	
Cotton	0.271	1.1%			
Carrots	0.236	1.0%			
Oats	0.132	0.5%			
Sorghum	0.125	0.5%			
Sugarbeet	0.063	0.3%			
Barley	0.028	0.1%			
Ryegrass	0.021	0.1%			
Broccoli	0.014	0.1%			
Sudangrass	0.014	0.1%			
Bermudagrass	0.000	0.0%			
Forage Grasses	0.000	0.0%			
Garlic	0.000	0.0%			
Lettuce	0.000	0.0%			
Potato	0.000	0.0%			
Rape	0.000	0.0%			
	24.646			100%

Green box shows a representative farm defined by **90%** of crops in Cluster 7

Regions Have Different Characteristics



Energy Crop Acreage Increases at $20/acre Profit Level



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Mendota Advanced Energy Beet Cooperative (an AB 118 funded project)

The City of Mendota to the West

The City of Mendota has a disadvantaged population and exceptionally high unemployment (> 40%).

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Other participation and projects

- Consult/ support CalRecycle
  - CT evaluation
  - Policy Analysis & Recommendations
  - Contribute to planning MSW AD conference (Spring '12)
- Partner on two proposals on biopower emissions analysis and impacts (CARB, CEC)
- US EPA biogas use technologies study

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