Biofuel resources mapping for energy planning

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The Land Use Mapping Program (LUMP) can be used to inventory crop residues

Interest in the use of agricultural residues as a source of energy has increased dramatically in the past decade. Technological innovation, induced in part by the rising costs of imported petroleum, has fostered the development of numerous biomass energy conversion programs and processes. Producing over 10 million tons of collectable crop residue annually, California's agricultural sector is a significant potential resource base for alternative energy production.

Bioconversion technologies include direct combustion, gasification, fuel alcohol production, and biogas generation, all of which transform crop residues into usable energy. These technologies may become more widely used in the near future in specific geographical locations that allow their economical and efficient operation. Biofuel development to any significant level will probably have several environmental effects, particularly changes in land use. For planning purposes, an important step in studying different biofuel technologies is to inventory and evaluate the resource base under consideration. The most effective site location of biofuel conversion plants is close to the source of crop residues. This article describes a computer-based mapping program that can be used for biofuel planning and illustrates the approach with an application to the Sacramento Valley.

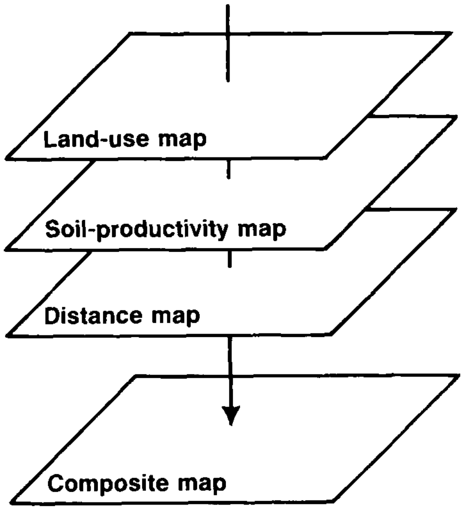
Biofuel resources mapping

The Land Use Mapping Program (LUMP) has been developed and refined in the Division of Environmental Studies at the University of California, Davis, for work on a variety of land use

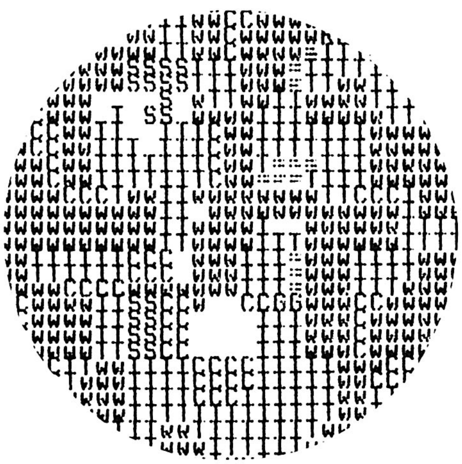
Crop residue for Storie classes I to IV for inner, middle, and outer sectors*

Crops	Stories classes I and II			Storie classes III and IV		
	Inner (0-8 mi)	Middle (8-16 mi)	Outer (16-24 mi)	Inner (0-8 mi)	Middle (8-16 mi)	Outer (16-24 mi)
	tons	*tons*	*tons*	*tons*	*tons*	*tons*
Corn	32,778	28,992	3,268	18,891	64,009	32,099
Barley (dryland)	0	1,336	602	1,616	9,291	4,219
Wheat (dryland)	82	2,650	3,312	314	6,972	4,505
Rice	3,685	3,595	666	47,444	101,686	9,543
Grain sorghum	785	187	187	226	4,222	7,584
Tomato	21,513	16,604	1,347	5,269	10,580	5,189
Sugarbeet	5,133	9,401	2,566	7,325	19,047	12,398
Barley (irrigated)	542	212	0	37	187	580
Wheat (irrigated)	57,755	48,259	11,230	18,777	39,208	34,074
Total, each sector	122,273	111,236	23,178	99,899	255,202	110,191
Total, by Storie class		256,687			465,292	
Total, inner sector (0-8 mi)				222,172		
Total, inner + middle sector (0-16 mi)					588,610	
Total, all sectors						721,979

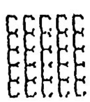
Note: Tonnage figures are field dry weight
* Distances on a radius from Woodland.

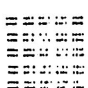


The biomass inventory map consists of three basic maps (shown at right reduced to 14 percent of actual size): land use soils, and distance. They are sandwiched together, as in this schematic drawing, and the variables are calculated

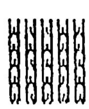


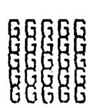
A section of the land-use map at actual size, showing the area south of Woodland.

Corn, irrigated 

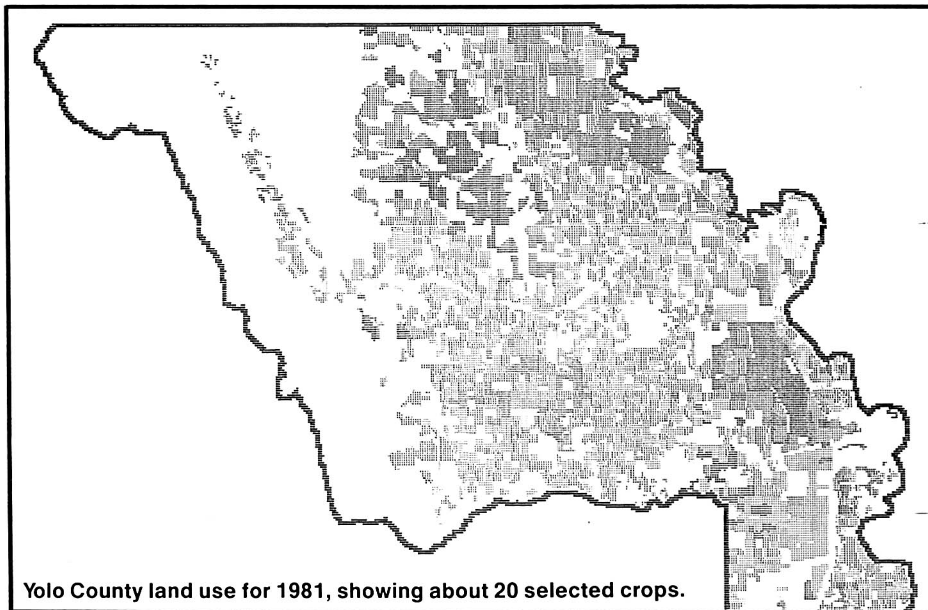
Grain, irrigated, double-cropped with corn 

Tomato, irrigated 

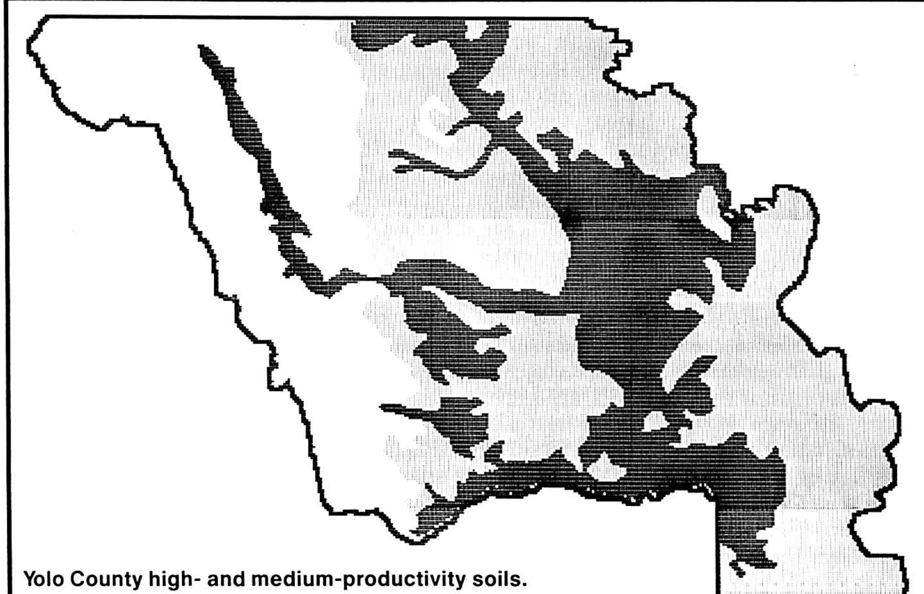
Wheat, irrigated 

Grains, unspecified, dryland, double-cropped 

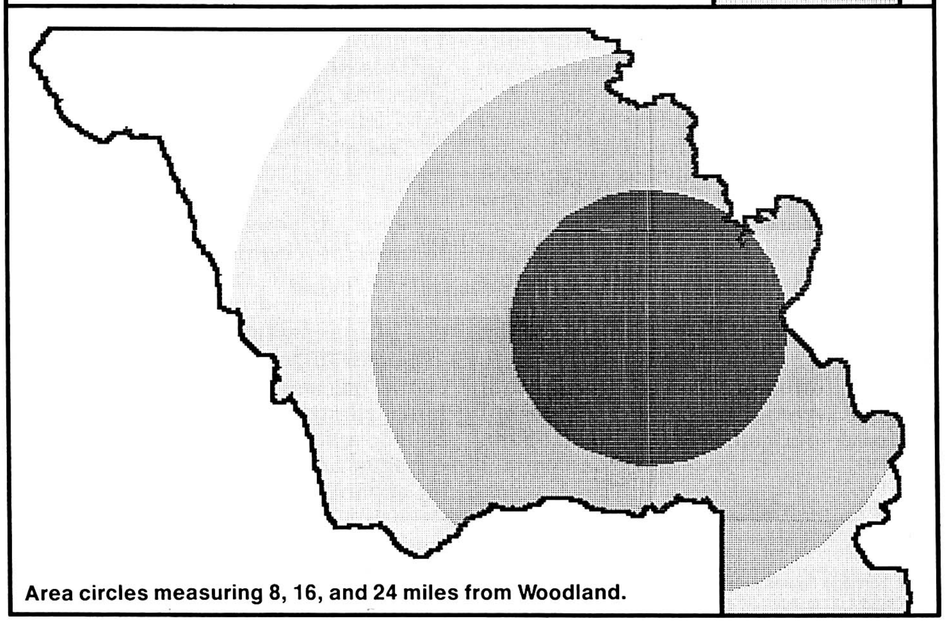
Examples of some of the symbols used in making the land-use map.



Yolo County land use for 1981, showing about 20 selected crops.



Yolo County high- and medium-productivity soils.



Area circles measuring 8, 16, and 24 miles from Woodland.

Calculation of crop residue tonnage for Storie classes I to IV in inner sector (0- to 8-mile) radius from Woodland)

	Storie classes I & II				Storie classes III & IV				
Crops	Acres	Yield/ac (tons)	Residue factor (ton res/ ton crop)	Residue total (tons)	Acres	Yield/ac (tons)	Residue factor (ton res/ ton crop)	Residue total (tons)	Residue total soil classes I-IV
Corn	5,995	4.5	1.215	32,778	4,417	3.52	1.215	18,891	51,669
Barley (dryland)	0	2.00	0.85	0	1,196	1.59	0.85	1,616	1,616
Wheat (dryland)	44	2.20	0.85	82	210	1.76	0.85	314	396
Rice	919	3.30	1.215	3,685	11,833	3.30	1.215	47,444	51,129
Grain sorghum	232	3.00	1.125	783	78	2.57	1.125	226	1,009
Tomato	18,387	25.0	0.0468	21,513	5,170	21.68	0.0468	5,246	26,759
Sugarbeet	2,037	28.0	0.09	5,133	3,244	25.09	0.468	7,325	12,458
Barley (irrigated)	255	2.50	0.85	542	22	1.99	0.85	37	579
Wheat (irrigated)	24,708	2.75	0.85	57,755	10,041	2.20	0.85	18,777	76,532

Sources: Acres — from mapping process. Residue factors and amounts available — from J. Knutson and G. E. Miller, Jr., *Agricultural Residues (Biomass) in California — Factors Affecting Utilization*, Leaflet 21303, Division of Agricultural Sciences, University of California, Berkeley, 1982. Yield differences between high- and medium-productivity soils — from T. R. Hedges, *Water Supplies and Costs in Relation to Farm Resource Decisions and Profits on Sacramento Valley Farms*, Giannini Foundation Research Report No. 322, Division of Agricultural Sciences, University of California, Berkeley, 1977.
Note: Tonnage figures are field dry weight.

planning and policy evaluation problems. (Details of the LUMP system are given in reports available from the Division of Environmental Studies, University of California, Davis, CA 95616.) Essentially, LUMP enables a researcher to rapidly assemble different sets of resource information, analyze them either singly or in combination, and display the results as a map. Input data can be entered by keypunch, by hand digitizing, or from another computer. Output can be developed for various purposes as inventory maps, interpretive maps, combination maps, and evaluation maps.

In this study we confined the resource base to Yolo County, a highly productive agricultural region within the Sacramento Valley. We obtained land cover data from the California Department of Water Resources in the form of 7.5-minute quadrangles that illustrate 1981 land use patterns. Twenty-four crop combinations that produce residues were digitized by hand and entered into computer storage. LUMP output also tabulates the percentage and frequency of each crop's occurrence within the map and prints its respective acreage.

Since crops generally give better yields on soils of higher quality, we also digitized Storie Index data from 1972 U.S. Department of Agriculture soil survey information. Together, overlaying both sets of data tallied how much of each crop under study was grown on high-productivity soils (Storie Index Rating of I and II) and on medium-productivity soils (Storie Index Rating III and IV).

Plant siting

To illustrate the usefulness of LUMP for energy planning, we conducted the following analysis. First, we digitized concentric regions at increasing distances from a hypothetical biomass conversion plant in Woodland, the county seat. Within each region, we calculated the crop residues potentially available for biomass conversion (see tables).

To calculate each region's crop residues, we first tabulated the acreage of each crop for both high- and medium-productivity soils and multiplied the acreage by the average yield expected for that soil productivity class. Next, we calculated crop residue factors, which denote the tonnage of residue for each ton of a crop's yield (we excluded a percentage of residue likely to be lost during collection). Finally, we calculated net crop residues by multiplying crop tonnage for a given region by its corrected residue factor.

The calculated total tonnage of crop residues produced within a 24-mile radius of Woodland, given 1981 conditions, is nearly three-quarters of a million tons. Almost two-thirds of that is produced on soils with a Storie Index Rating of III or IV. On highly productive soils, irrigated wheat generates the greatest amount of residues; rice tonnage is very low. On medium-productivity soils, the situation is different. The largest volume of residue is generated by rice, followed by corn, irrigated wheat, and sugarbeet.

The most abundant crop residues within an 8-mile radius of Woodland come from irrigated wheat, corn, rice, and tomatoes, in descending order. Rice straw is considered a promising biofuel because its use would help to reduce the current practice of burning the stubble and would generate income. Within 16 miles of Woodland there are almost 150,000 tons of rice straw in lands primarily classified as medium-productivity soils. If 1 ton of rice residue is equivalent to 13.1 $\times$ 10^6 BTU (dry weight), there are almost 1.7 $\times$ 10^{12} BTU embodied in rice straw for that region.

Future work

Yolo County agricultural production includes other vegetable crops, orchard produce, and field crops omitted from this analysis. A comprehensive biofuel resource inventory could easily include these crops as well as the natural vegetation that grows on the marginal lands primarily in the western portion of the county.

To estimate how much energy is deliverable to Woodland, both the amounts of energy required to transport individual residues and enery lost in conversion processes should be subtracted from total crop residue energy. Residue collection and handling costs depend on the distance from the plant site. With computerized map analysis techniques, contours of crop residue profitability could be developed for residue shipment routes from any region within the county for any crop type. Energy production from biofuels may take many paths to development; computer mapping techniques make it possible to analyze different plant types and plant sites before large investment is made in a particular option.

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