Getting biofuels right: Agricultural biofuels in California & sustainability

Stephen Kaffka

UC DAVIS PLANT SCIENCES

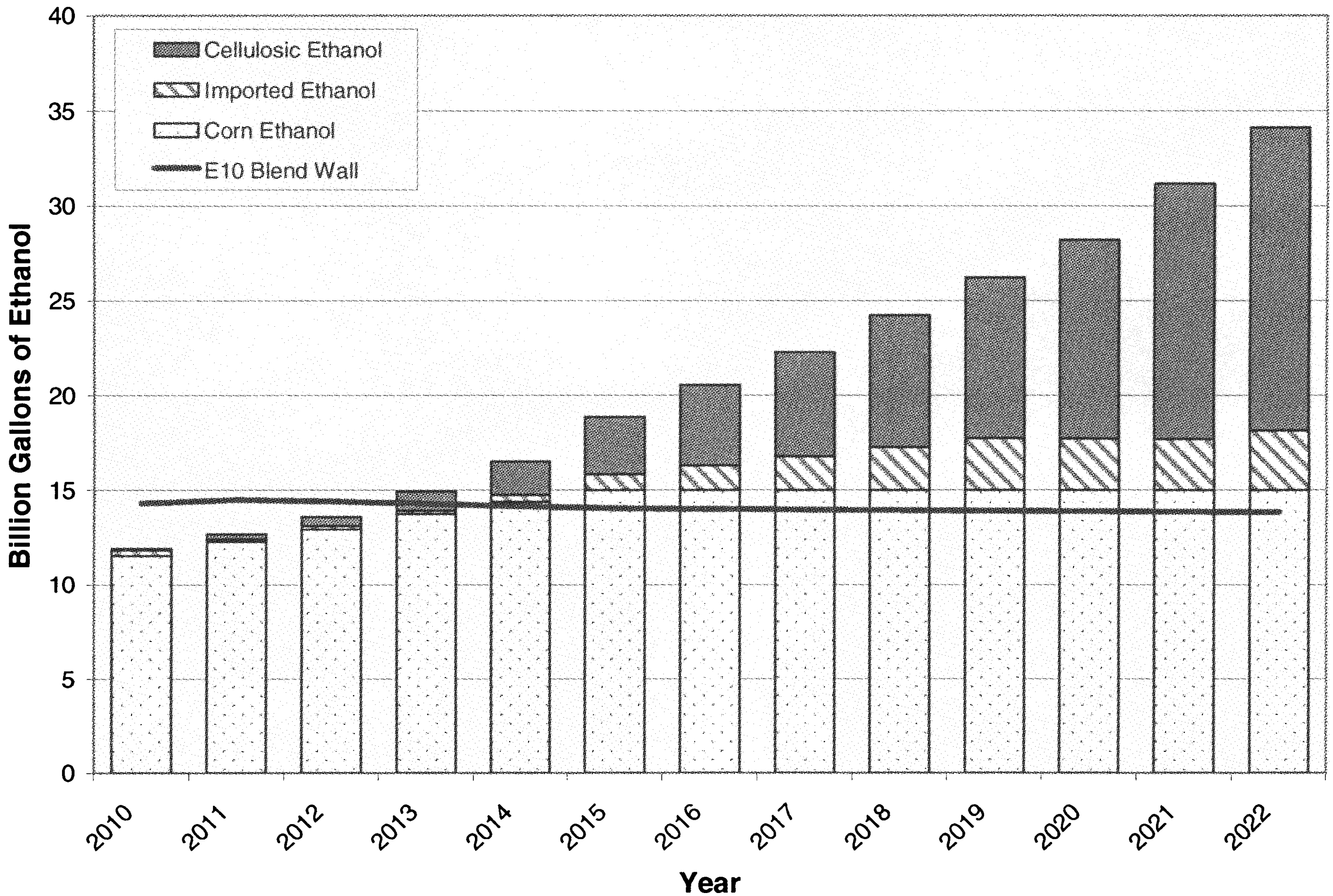
CALIFORNIA biomass COLLABORATIVE

CA Energy Commission

September 14, 2009

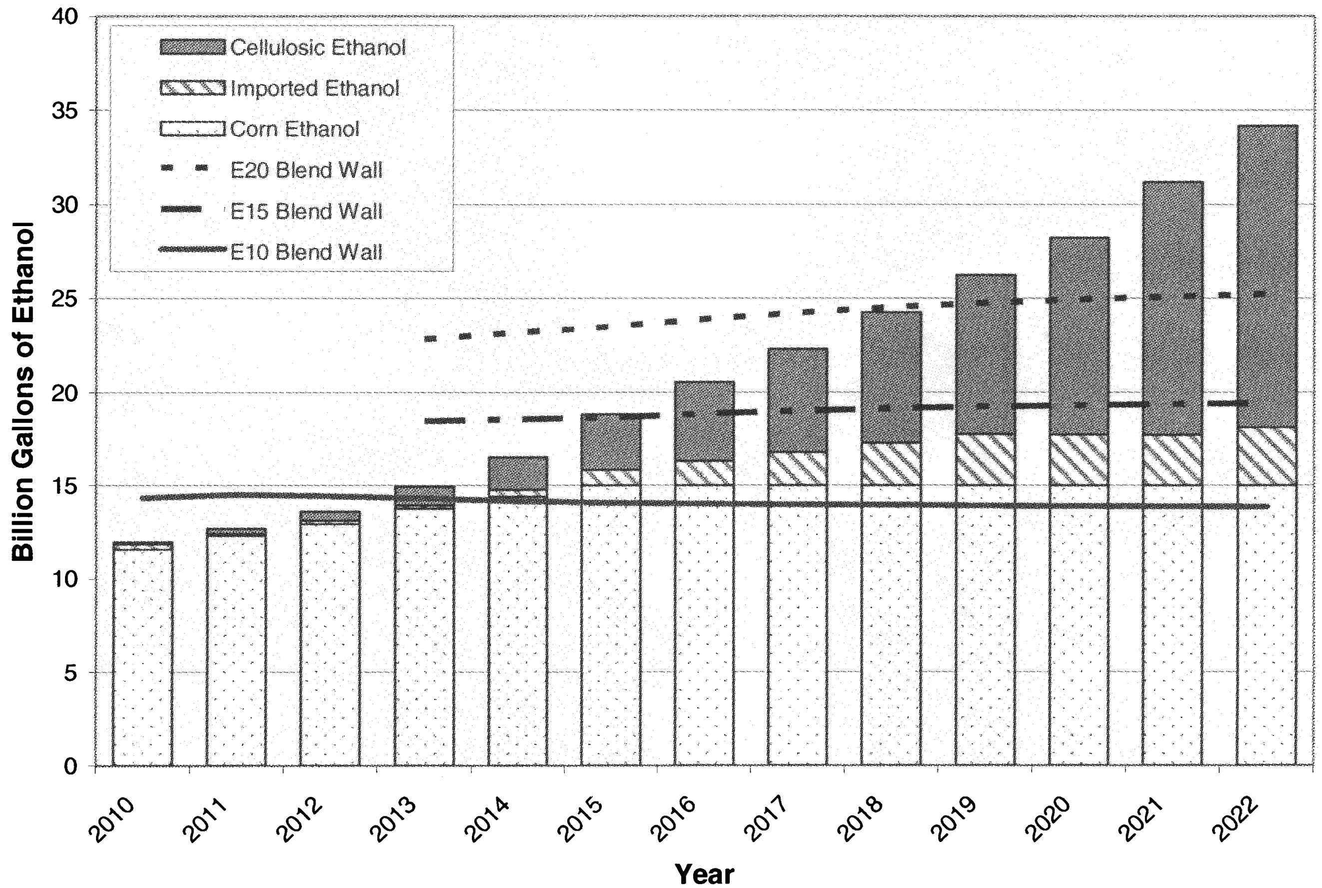
1. Where do things stand?
2. Where will alternative fuels come from in CA?
3. Can biofuels be produced sustainably in CA?
4. How can integrated assessment help?

Figure V.D.2-1
Max E10 Ethanol Consumption Compared to RFS2 Requirements[212]



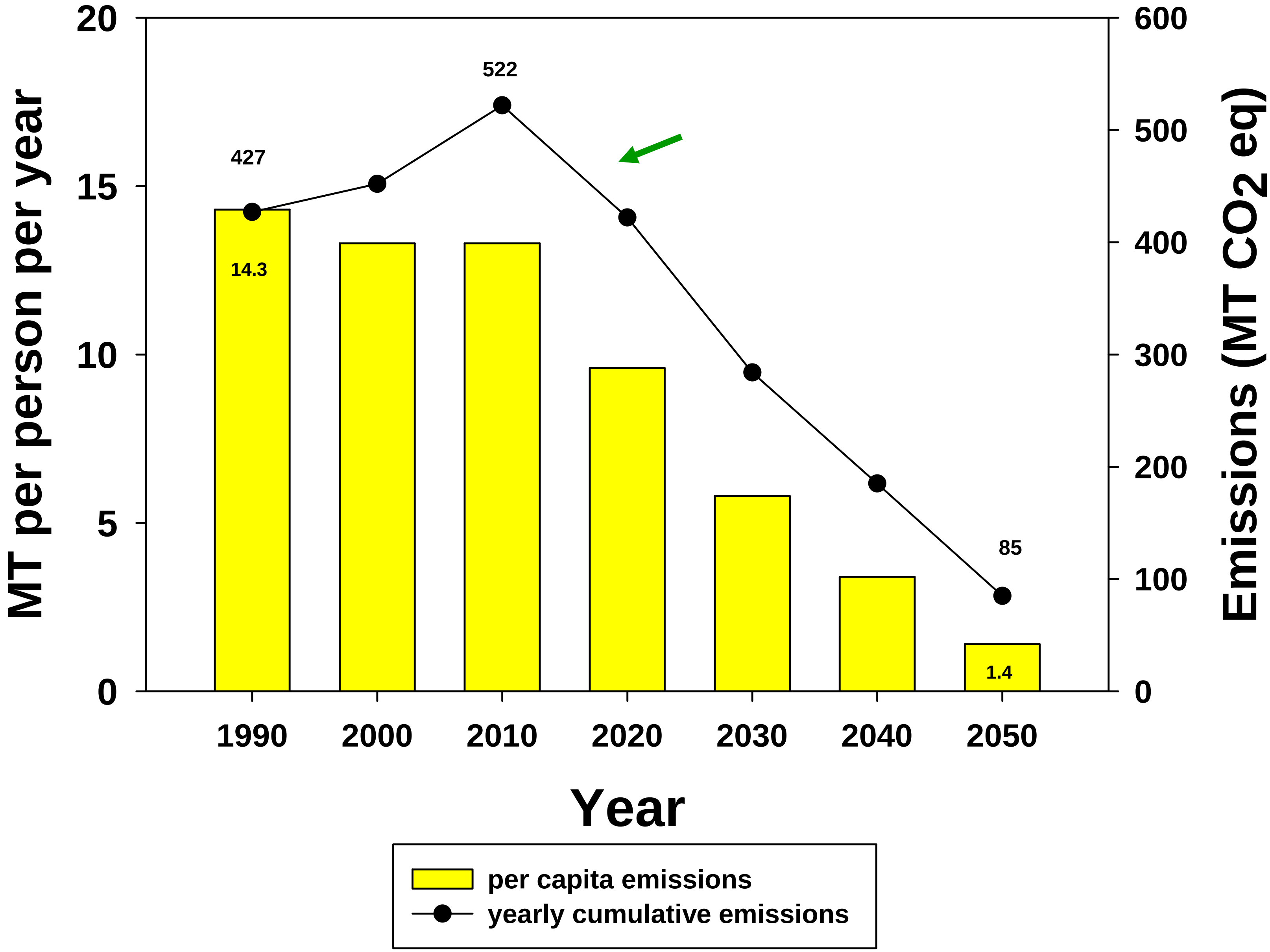
US EPA-2009

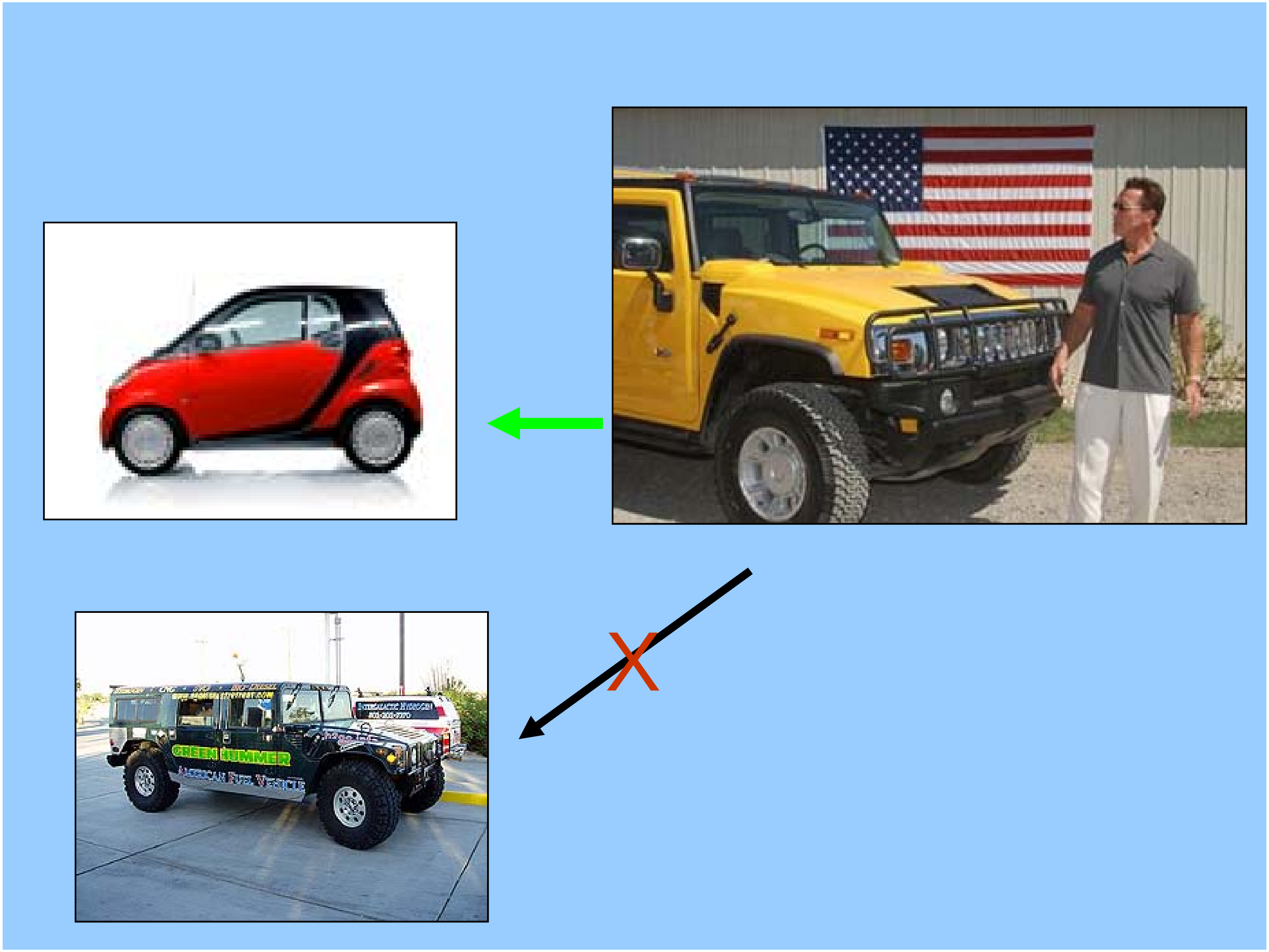
Figure V.D.3-1
Max E15/E20 Ethanol Consumption Compared to RFS2 Requirements



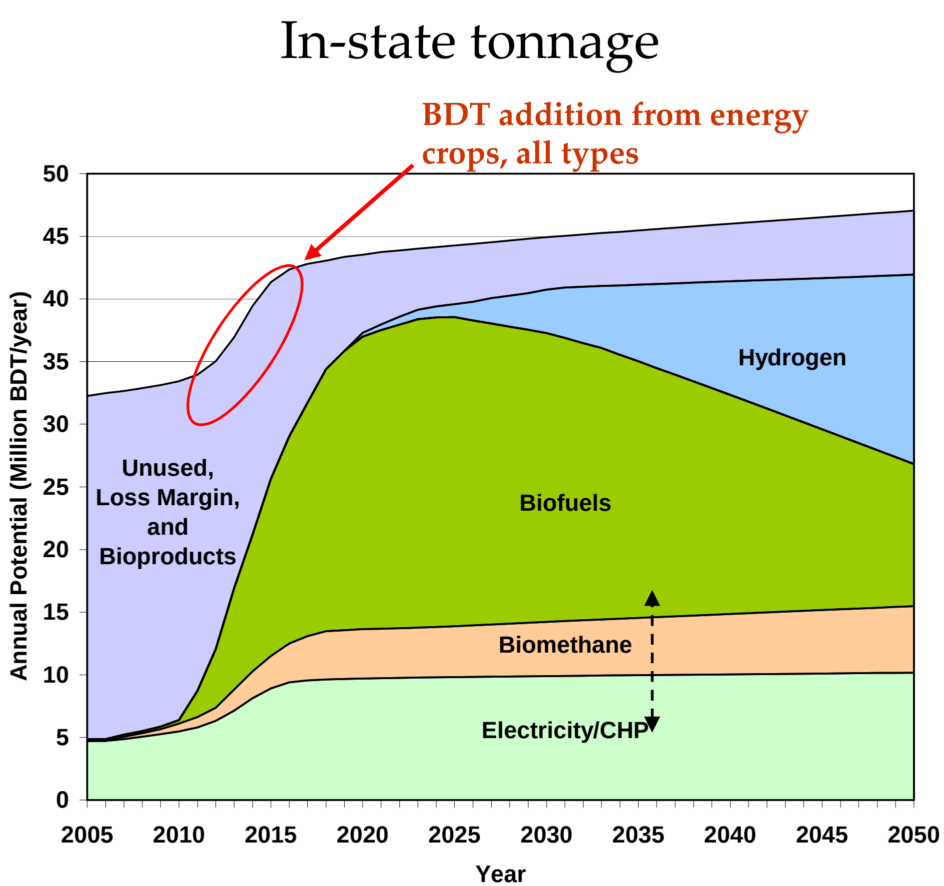
Signing AB 32: The Global Warming Solutions Act

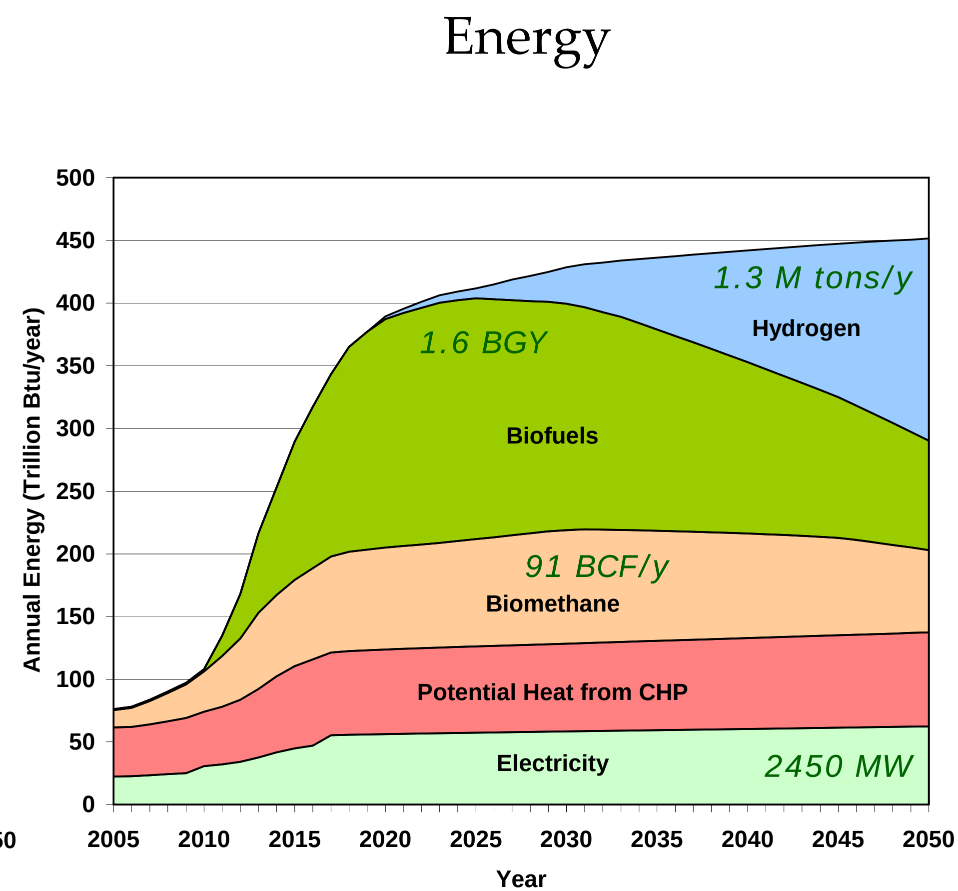
Fig . 6: Emission Trajectory Towards 2050




GREEN HUMMER
AMERICAN FUEL VEHICLE

One development scenario for California biomass (1.5 billion dry tons utilized through 2050)



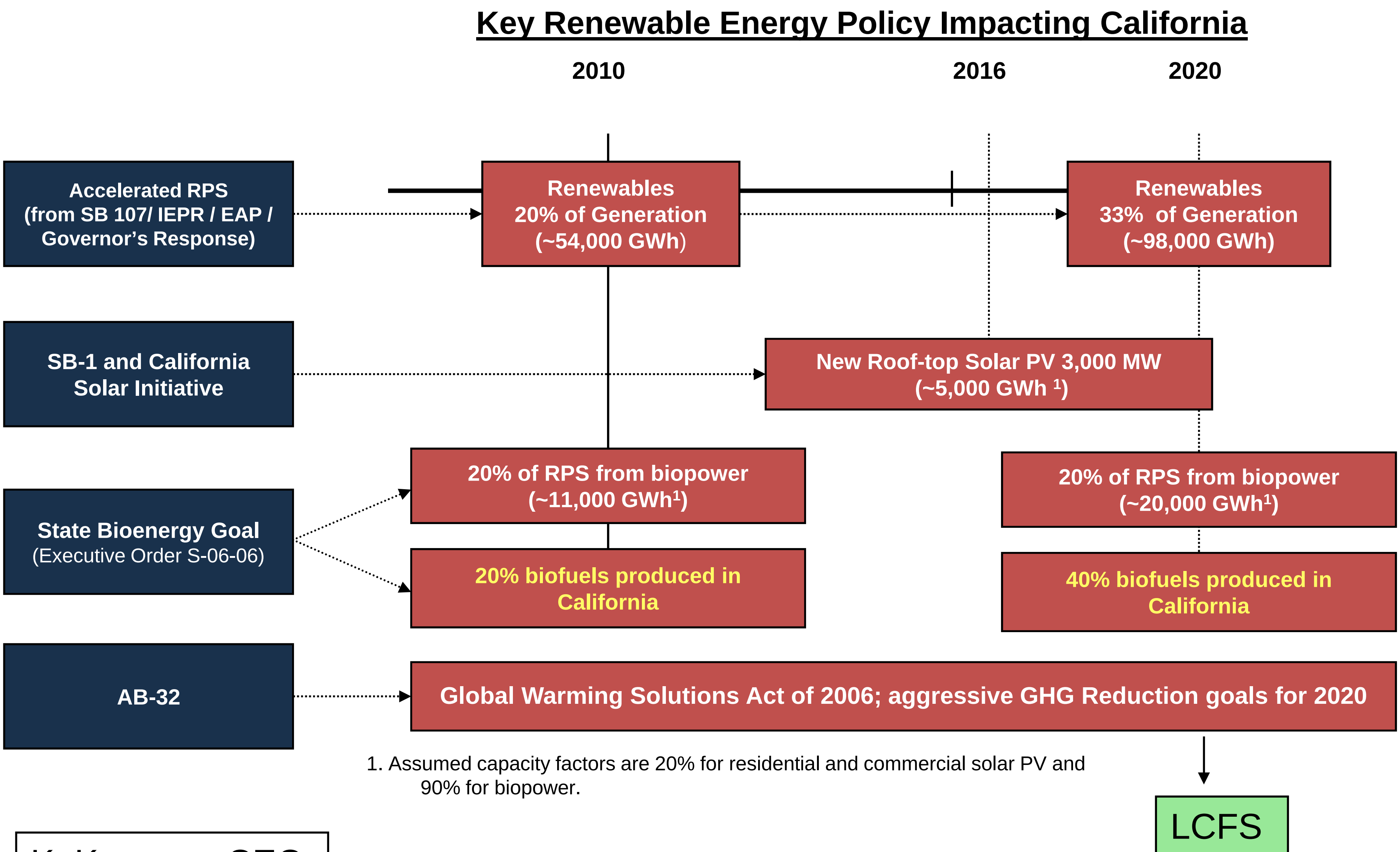


About 5 of the 32 million BDT are currently utilized.
Assumes 10 million BDT from dedicated energy crops ultimately available; ramping up from 2012 to 2018.

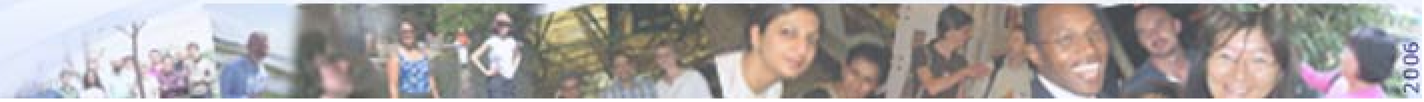
Potential technical recovery, not including economic costs

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

Policy Context



K. Koyama, CEC



GTAP (**Global Trade Analysis Project**) is a global network of researchers … who conduct quantitative analysis of international economic policy issues, especially trade policy. They … produce a consistent global economic database, covering many sectors and all parts of the world. The database describes bilateral trade patterns, production, consumption and intermediate use of commodities and services. There are … databases for such things as **greenhouse gas emissions** and **land use**.

The network maintains a global computable general equilibrium (CGE) model, which uses the GTAP database. Besides the core model, there are many variants (including one focused on agricultural analysis), each focusing on a different issue in economic policy analysis.

GTAP is used by CARB to estimate indirect land use effects (carbon costs) of crop-based biofuel production for the LCFS.

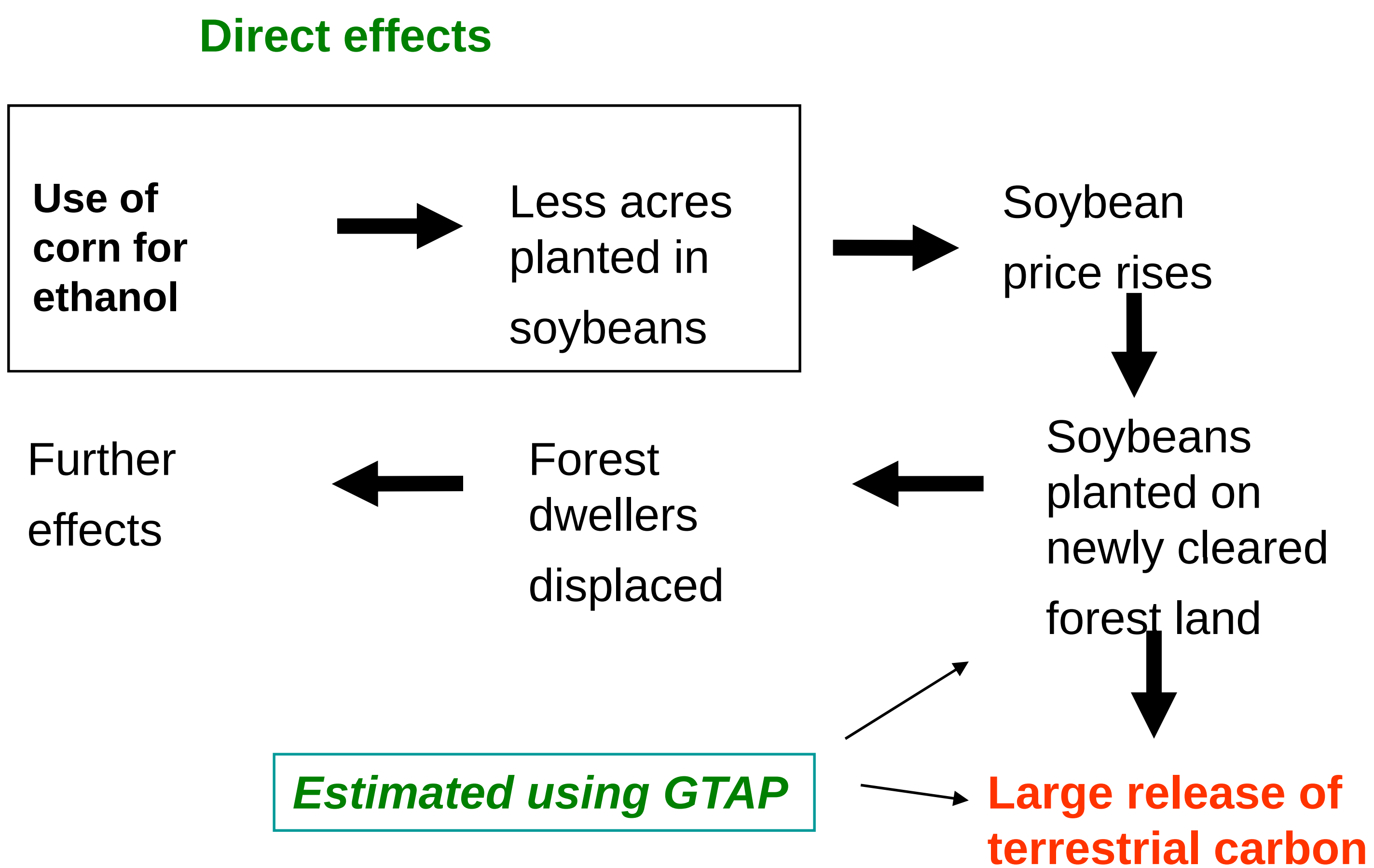
CGE models (like GTAP) model the reactions of the economy at one point in time. Results … are interpreted as showing the reaction of the economy in some future period to one or a few external shocks or policy changes. (Like crop withdrawal from food and feed markets for biofuels). This assumes the future behaves like the past, adjustment is instantaneous, and there is limited technological change occurring.

The results show the difference … between two alternative future states (with and without the policy shock). (e.g., how much new land was brought into production).

Causality is assigned in the model.

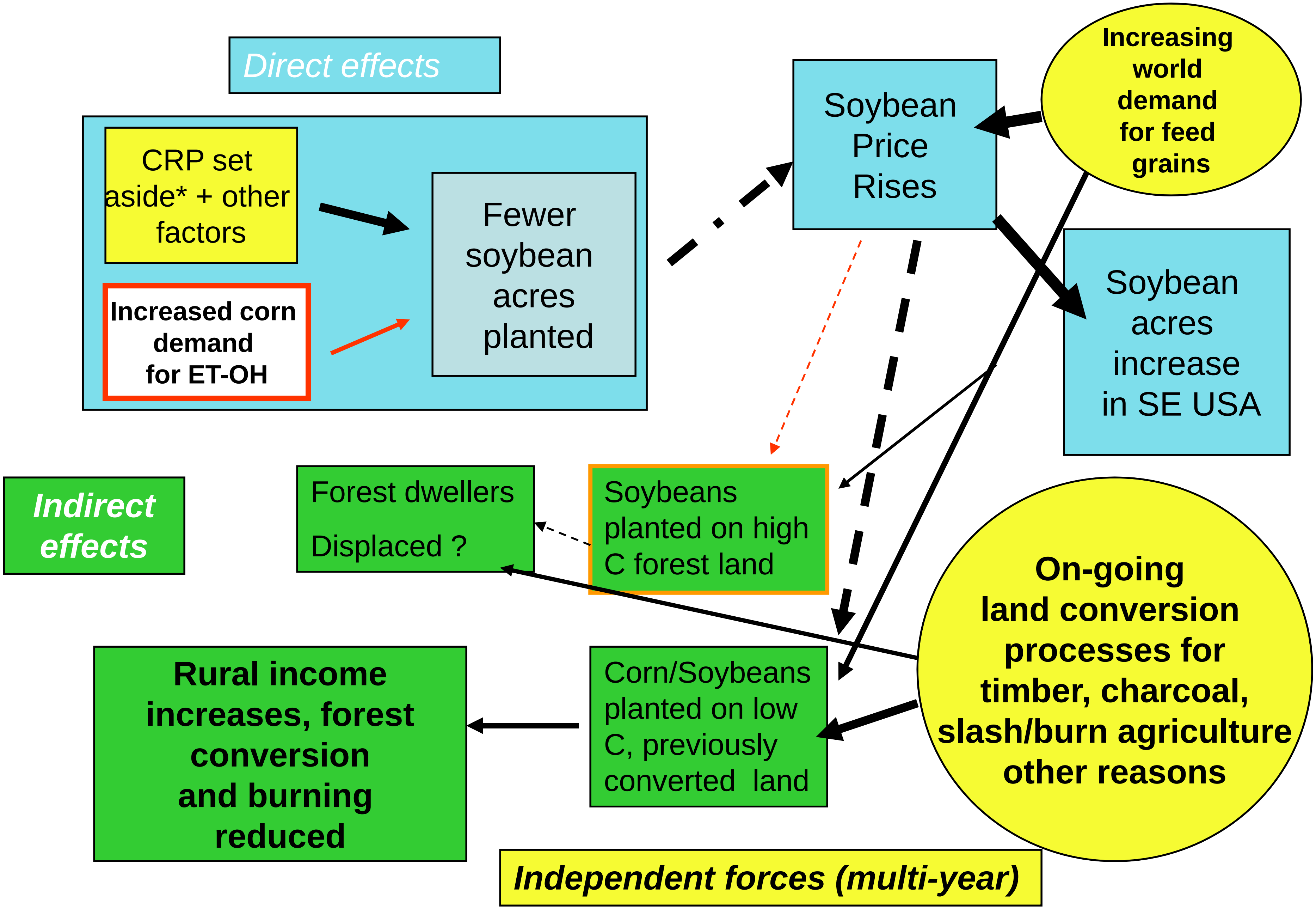
Market Mediated Effects:

- **Market-mediated or Indirect Land Use Change (iLUC):**

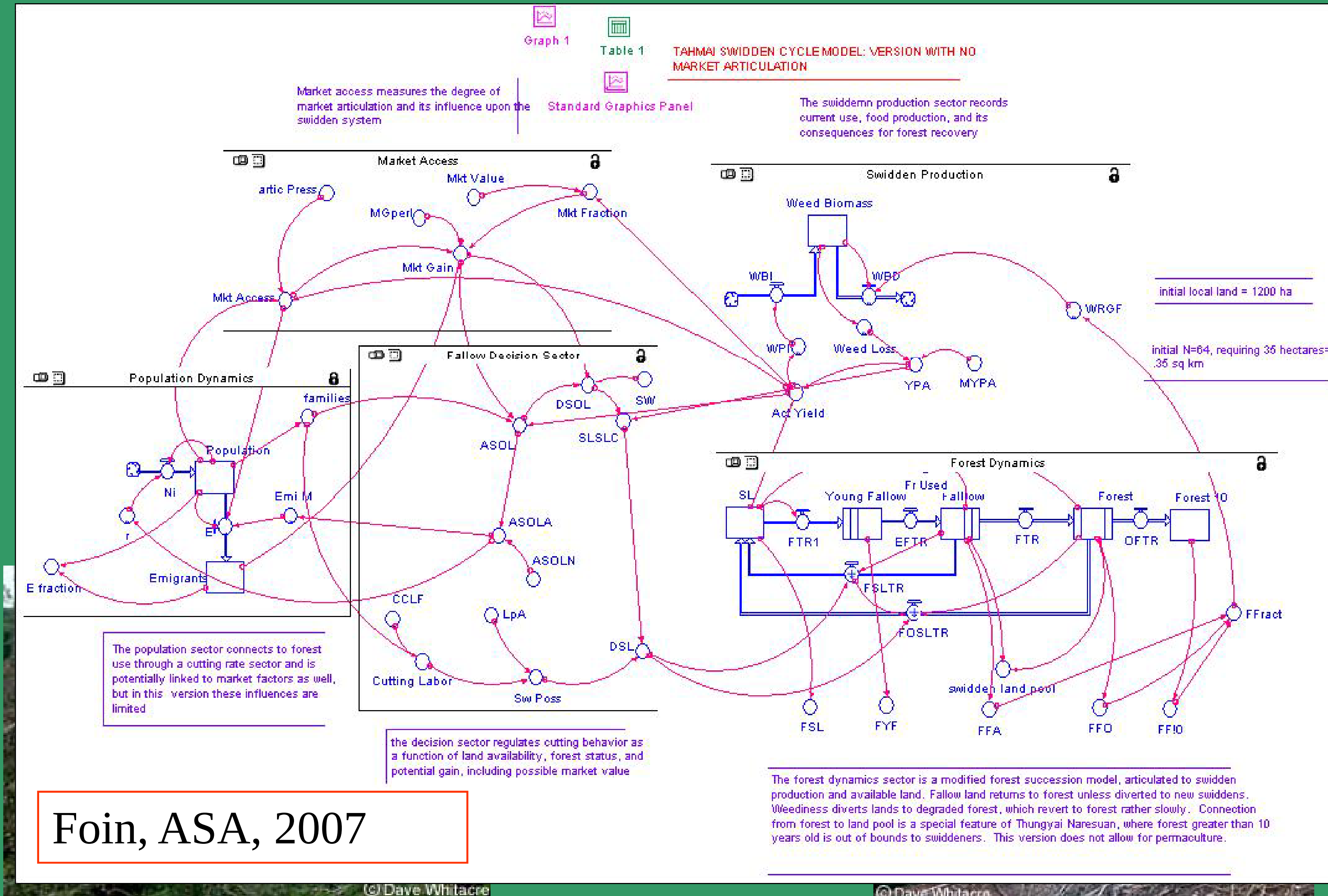


Modified from Spatari, 2008

Market Mediated Effects of Corn Ethanol Use on Indirect Land Use Change



Site-specific analysis of LUC, NE Thailand



Foin, ASA, 2007

Land that is not included in GTAP databases may play an important role in bio-energy production in the tropics and sub-tropics and in affecting the global terrestrial C balance.

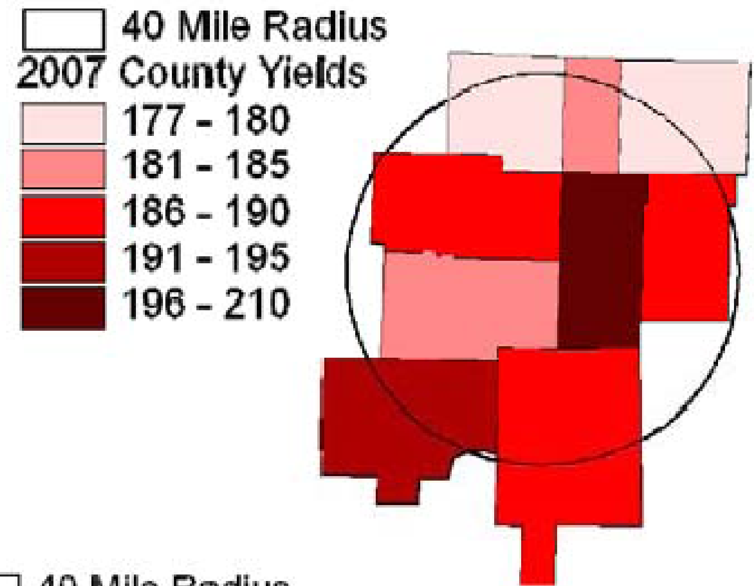
“While 38 million ha of primary rainforest are being cut down every year, there is an estimated 2.1 billion acres of potential replacement forest growing in the tropics.”

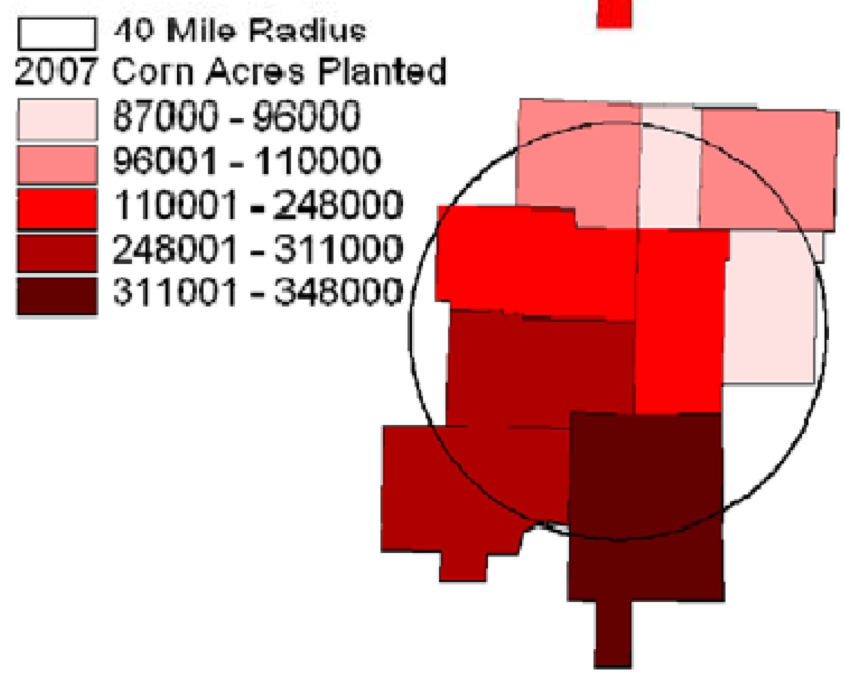
FAO (2005)/ State of the World’s Forests Report

Cited by E. Rosenthal, NYT, 1-3-09

Counties in the 40-mile Radius and USDA NASS Data

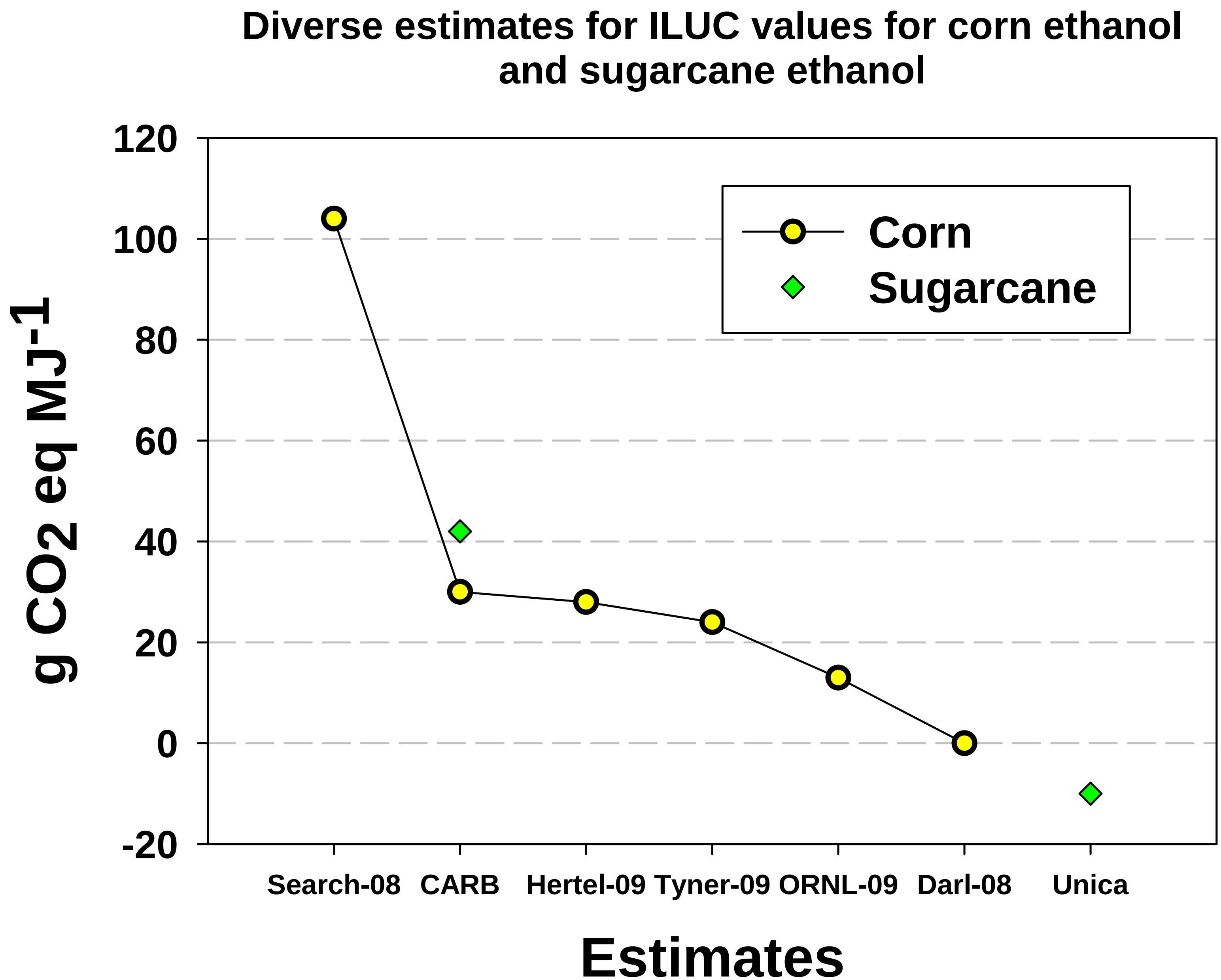
Mueller et al., 2008, studied the effect on land conversion within the “corn-draw” area of a new ethanol plant in IL. They found that the new needs for grain for Et-OH were met via increases in yield, related to price response and favorable weather, and a small amount of land conversion from grasslands/woodlands (~4,000 ac) out of a total of 1,487,000 crop acres used (0.28%).





Oak Ridge National Lab GTAP-based Simulations: Oladosu and Kline, (2009)

- Export/production data show little or no indirect impact from corn grain use for ethanol
- Trade and export fluctuations are similar to previous periods prior to ethanol development
- Currently, nearly 9 bgal/yr ethanol in US = 2/3 of EISA requirement
- There is less US cropland planted in 2009 than in 2001 (-1%)
- All this means that there is little evidence to suggest that ethanol has forced crops out of production in ways needed to drive the "indirect" effects modeled.


Diverse estimates for ILUC values for corn ethanol
and sugarcane ethanol
120
100
80
60
40
20
0
-20
g CO2 eq MJ-1
Corn
Sugarcane
Search-08
CARB
Hertel-09
Tyner-09
ORNL-09
Darl-08
Unica
Estimates

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CALIFORNIA biomass COLLABORATIVE

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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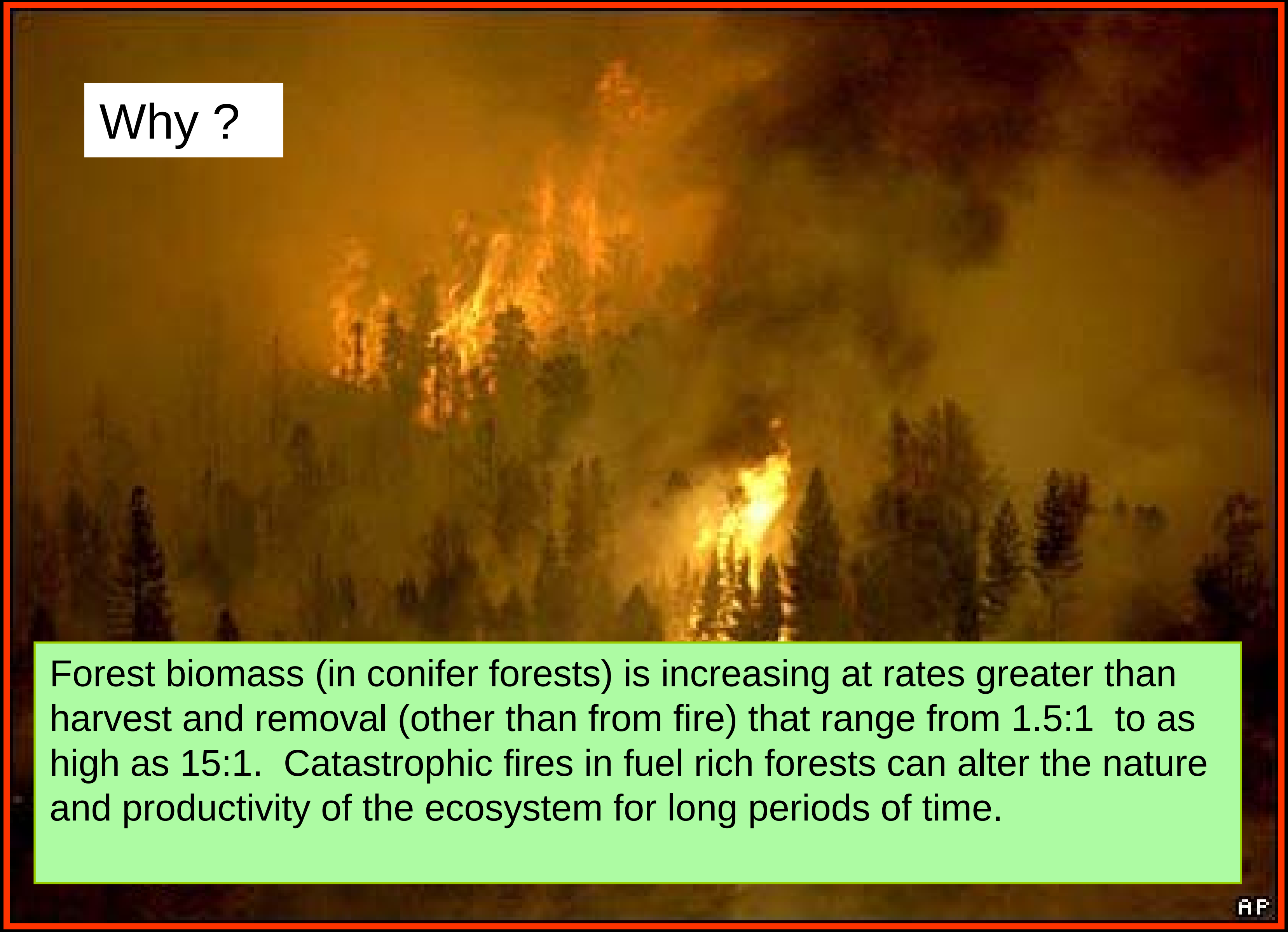


Why ?

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.

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.

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

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***

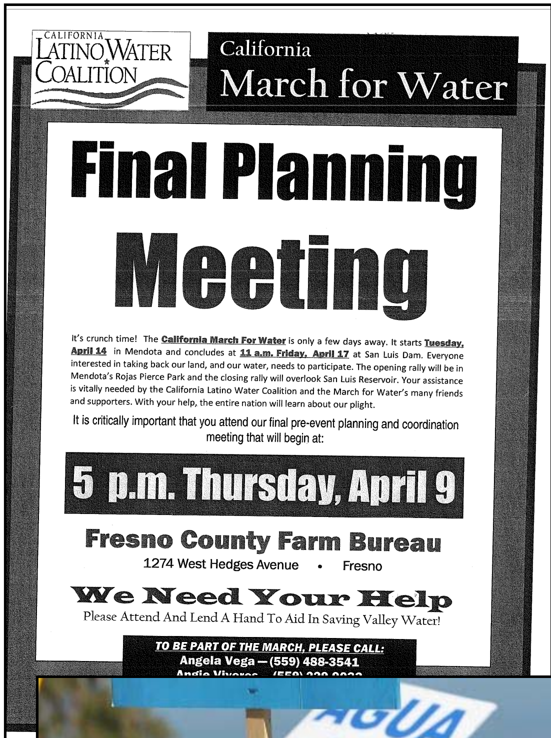
*1.5 M acres of dedicated cellulosic energy crops could add 400 to 900 Mgge to potential.

These are not estimates of economically recoverable or sustainable biomass.

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.,



CALIFORNIA LATINO WATER COALITION

California March for Water

Final Planning Meeting

It's crunch time! The **California March For Water** is only a few days away. It starts **Tuesday, April 14** in Mendota and concludes at **11 a.m. Friday, April 17** at San Luis Dam. Everyone interested in taking back our land, and our water, needs to participate. The opening rally will be in Mendota's Rojas Pierce Park and the closing rally will overlook San Luis Reservoir. Your assistance is vitally needed by the California Latino Water Coalition and the March for Water's many friends and supporters. With your help, the entire nation will learn about our plight.

It is critically important that you attend our final pre-event planning and coordination meeting that will begin at:

5 p.m. Thursday, April 9

Fresno County Farm Bureau
1274 West Hedges Avenue • Fresno

We Need Your Help
Please Attend And Lend A Hand To Aid In Saving Valley Water!

TO BE PART OF THE MARCH, PLEASE CALL:
Angela Vega — (559) 488-3541

Plumas town to lose 150 jobs as mill shuts

By Jane Braxton Little
Bee correspondent

Published: Wednesday, Mar. 4, 2009 - 12:00 am | Page 5B

QUINCY – Sierra Pacific Industries is closing its small-log mill in Quincy, eliminating about 150 jobs in this Plumas County town.

The broad-scale, net effect of diverse current public policies is to drastically reduce access and availability of biomass. The cost of establishing a new resource-based business in CA is high and may be getting higher.

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California biomass collaborative

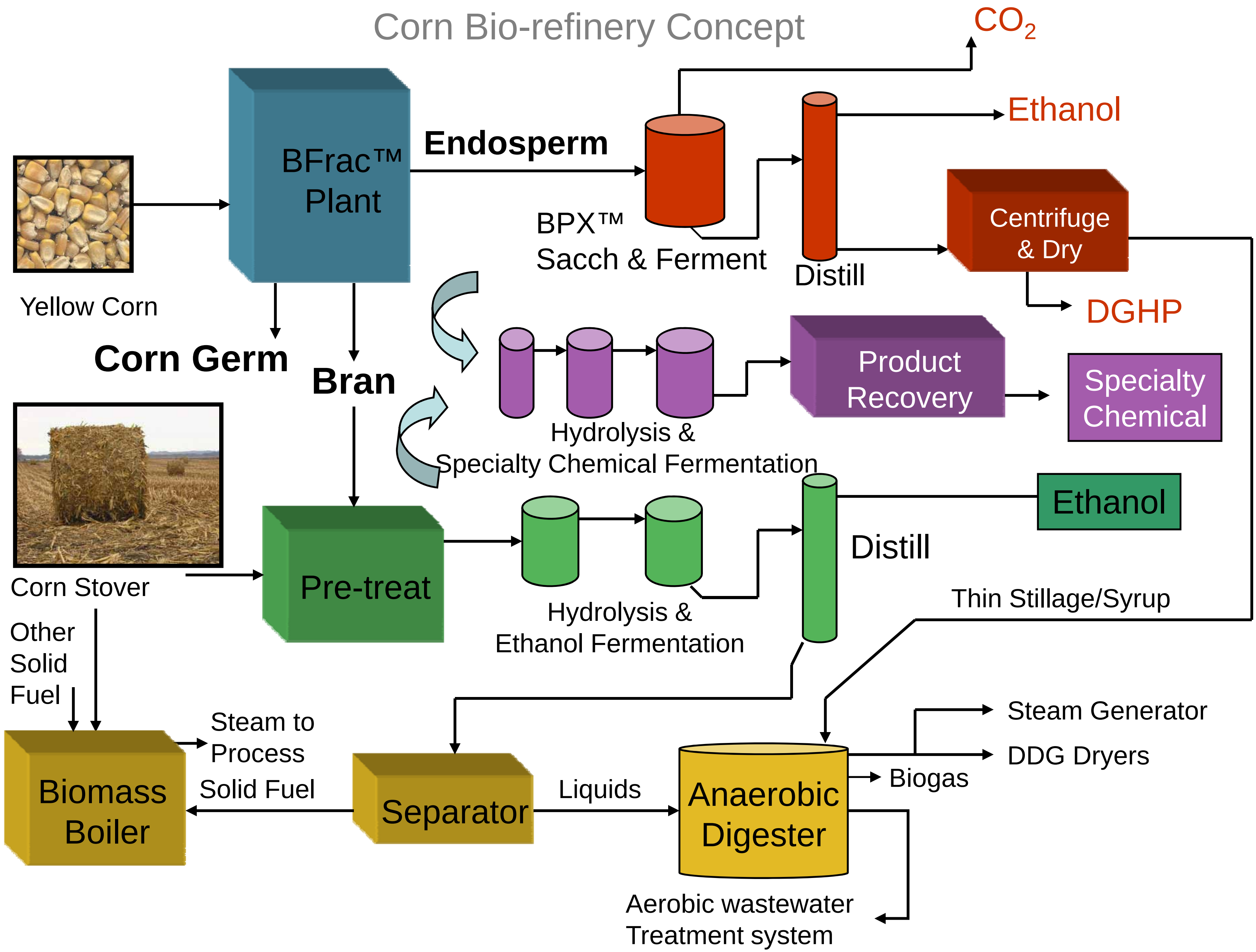
Sudzucker factory: Zeitz, Germany

Powered by lignite plus biomass

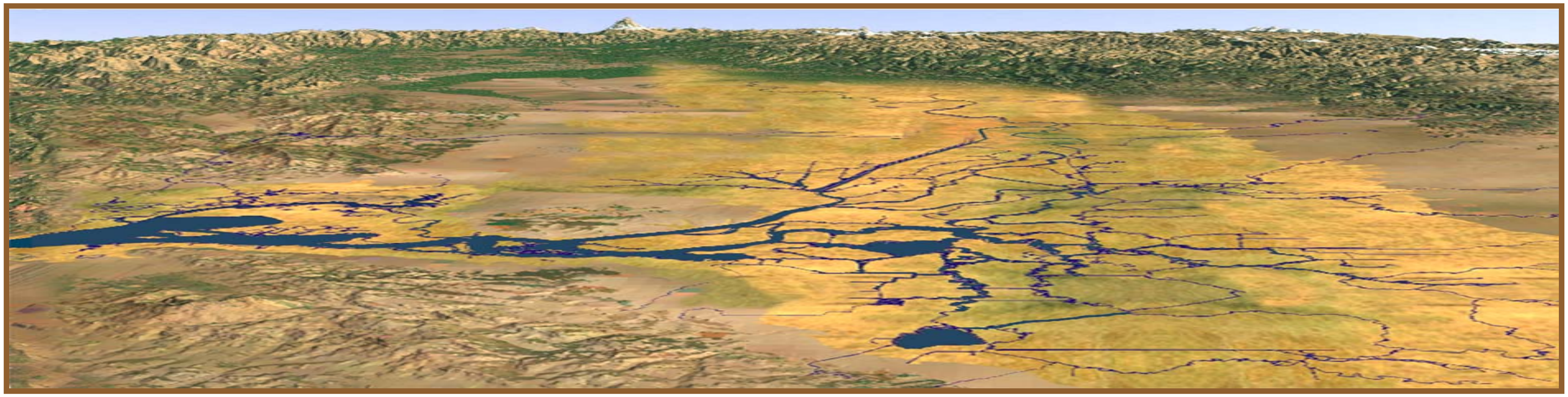
Feedstocks: sugarbeets, small grains, maize grain

Products: ethanol (350 M L/yr), biogas, electricity, animal feeds, nutrients

Pending: chemical feed stocks

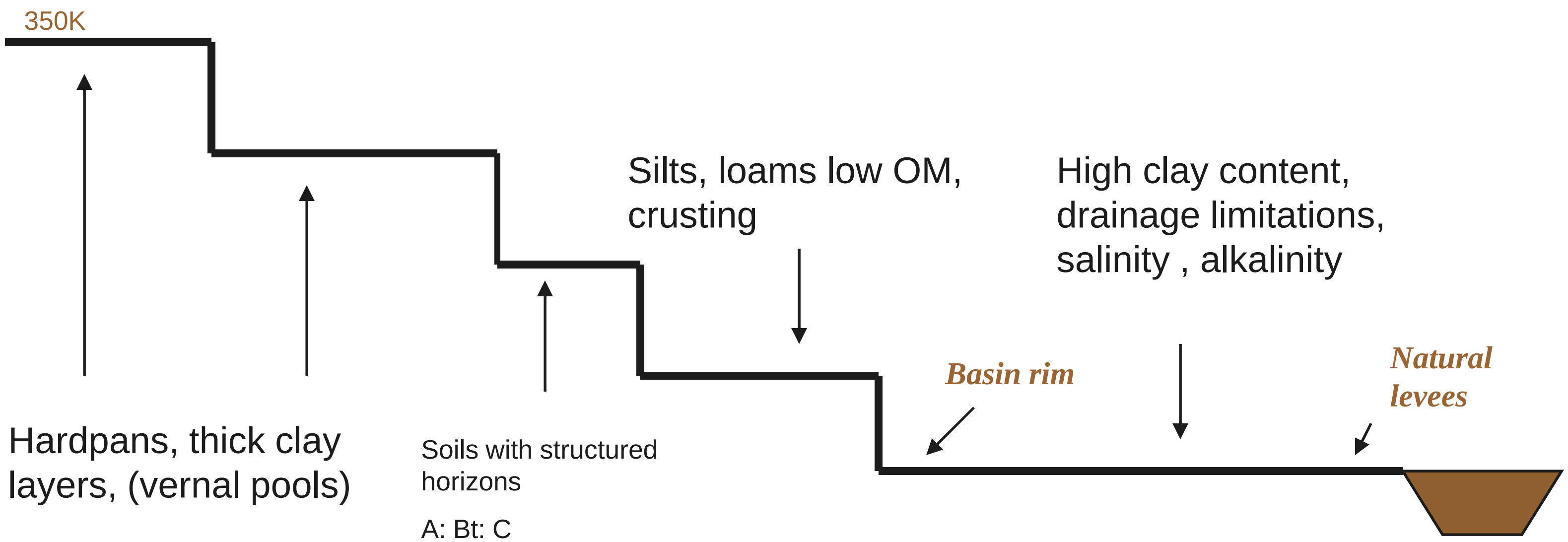


Corn Bio-refinery Concept
CO_2
Ethanol
Yellow Corn
BFrac™ Plant
Endosperm
BPX™ Sacch & Ferment
Distill
Centrifuge & Dry
DGHP
Corn Germ
Bran
Product Recovery
Specialty Chemical
Hydrolysis & Specialty Chemical Fermentation
Ethanol
Corn Stover
Pre-treat
Distill
Hydrolysis & Ethanol Fermentation
Thin Stillage/Syrup
Other Solid Fuel
Steam to Process
Solid Fuel
Biomass Boiler
Separator
Liquids
Anaerobic Digester
Biogas
Steam Generator
DDG Dryers
Aerobic wastewater Treatment system



Soil age: ->

oldest 100K 30-80K 10K youngest



Oak-savanna/rangelands

rangeland/pasture, some perennials

perennials, annuals

mostly annuals

Soil use →

Why use economic optimization models to study biofuel production?

- To better estimate the actual potential for biofuel crop production and crop residue use in CA.
- To estimate yield and cost goals needed to introduce new biofuel crops into CA farming systems through the estimation of dual values or “shadow costs.”

What is linear programming?

LP/PMP models predict the most profitable combination of crops for a farm subject to a series of constraints.

These constraints include water supply, land, soil quality, and other limitations specific to individual farms or for specific locations in the state.

They generate an optimum economic solution and identify the limitations for crop choices that are left out of the model (dual variables or shadow prices).

Example LP Matrix

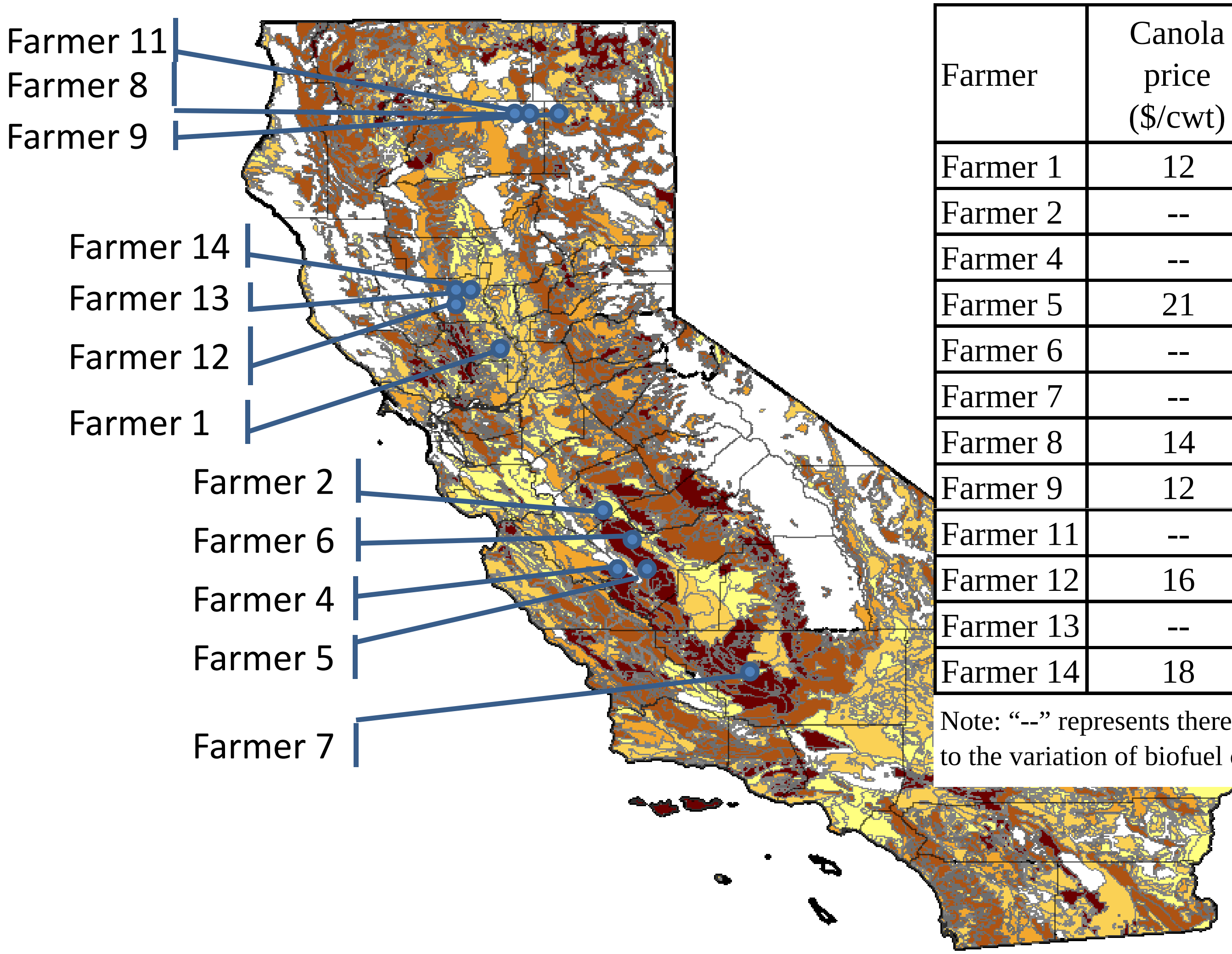
$$Max \qquad \text{Profit} = [P_{alfalfa} \times Acreage_{alfalfa} \times Yield_{alfalfa} - Cost_{alfalfa}] + [P_{tomato} \times Acreage_{tomato} \times Yield_{tomato} - Cost_{tomato}] + \cdots$$

s.t.

	alfalfa	corn	tomato	$\cdots$	wheat		
Land	1	1	1	$\cdots$	1	$\leq$	Amount of Land
Water	α_1	α_2	α_3	$\cdots$	α_I	$\leq$	Amount of Water

Where, α_i represents the water demand for each crop *i* per acre.

- Trigger prices for the surveyed 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

Irrigated agriculture in the San Joaquin Valley

The irrigation of semi-arid/arid landscapes cannot be done without loss of salts to groundwater.

Biofuels and salinity management in the WSJV

Without conjunctive use of surface water (deliveries) integrated with GW pumping, the consequences of continuing irrigation in the WSJV are clear and largely not reversible. The area of saline high water tables will increase and the quality of GW will decline.

The duration of a conjunctive use strategy could be extended through land retirement, improved irrigation management, and reuse of drainage water for irrigation of salt tolerant crops.

Wichelns and Oster (2006). Ag Water Management. Pg 120-121

Retired farmland in former Broadview Irrigation District

USBR cost estimates for in-valley DW management in the WSJV*
(drainage service to 300,000 ac of land)

Project item	In-valley with land retirement	
	GW quality [Se> 50 ug/L]	**Impaired Drainage Retirement**
Evap. Ponds needed	yes	yes
RO facilities needed	yes	yes
Area retired (ac)	92,500	308,000
Vol of DW treated for Se	9,100 ac ft	4,000 ac ft
Investment costs (x 1,000)	$825,000**	$945,000**
Cost per ac	$2,180	$2,490
Annual tmt cost (x 1,000)	$21,230	$11,693
Cost per ac	$56	$31

*From Wichelns and Oster, 2006/**does not include on-farm drainage systems

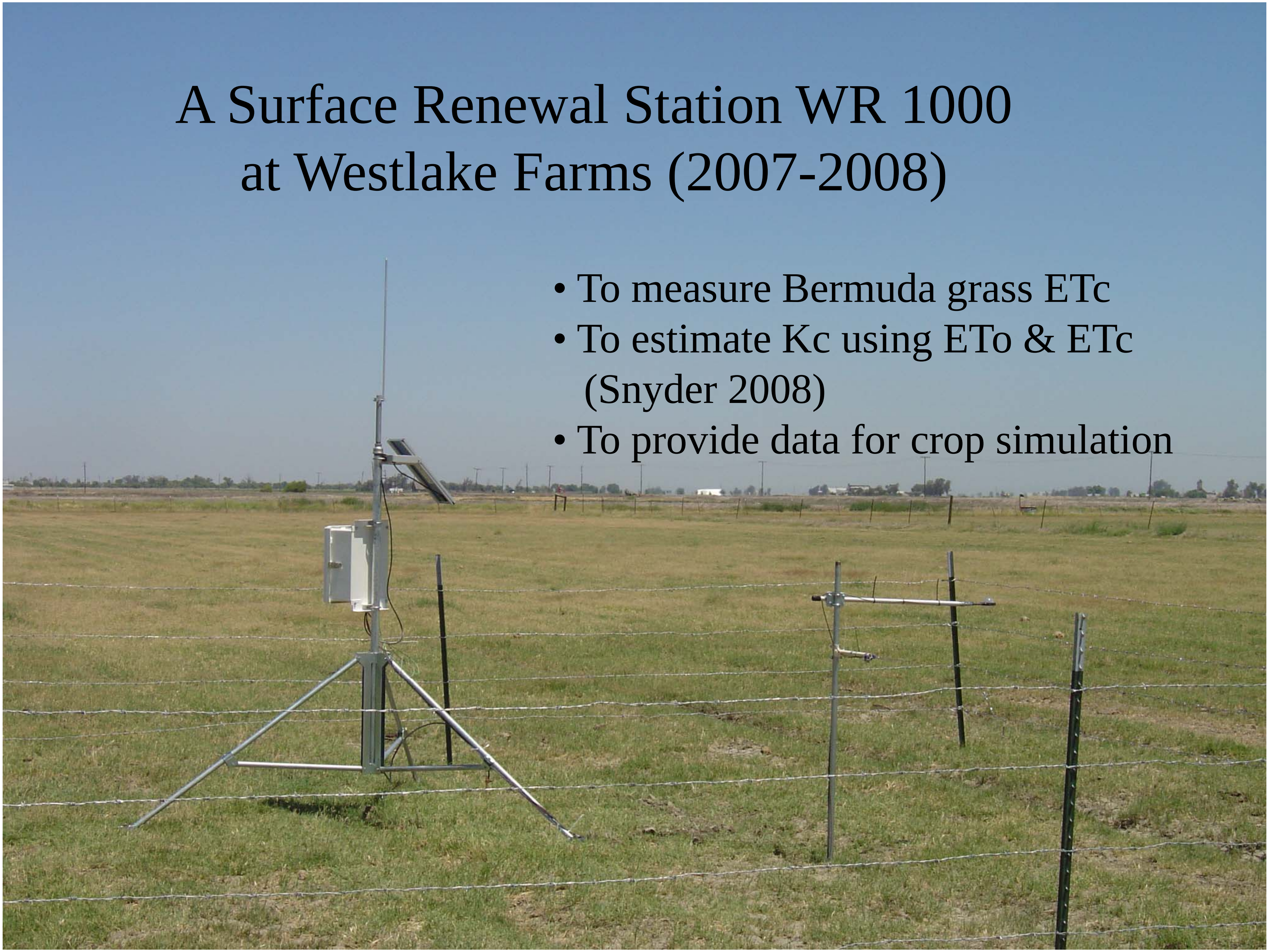
Biofuels and salinity management in the WSJV

The high cost of installing and operating the DW disposal options examined by USBR … motivate consideration of complex, on-farm DW management systems.

In addition, uncertainty regarding project cost overruns and exceedances of environmental standards might be smaller when farmers manage, reuse and dispose of DW within their farming operations.

Wichelns and Oster (2006). Ag Water Management. Pg 123

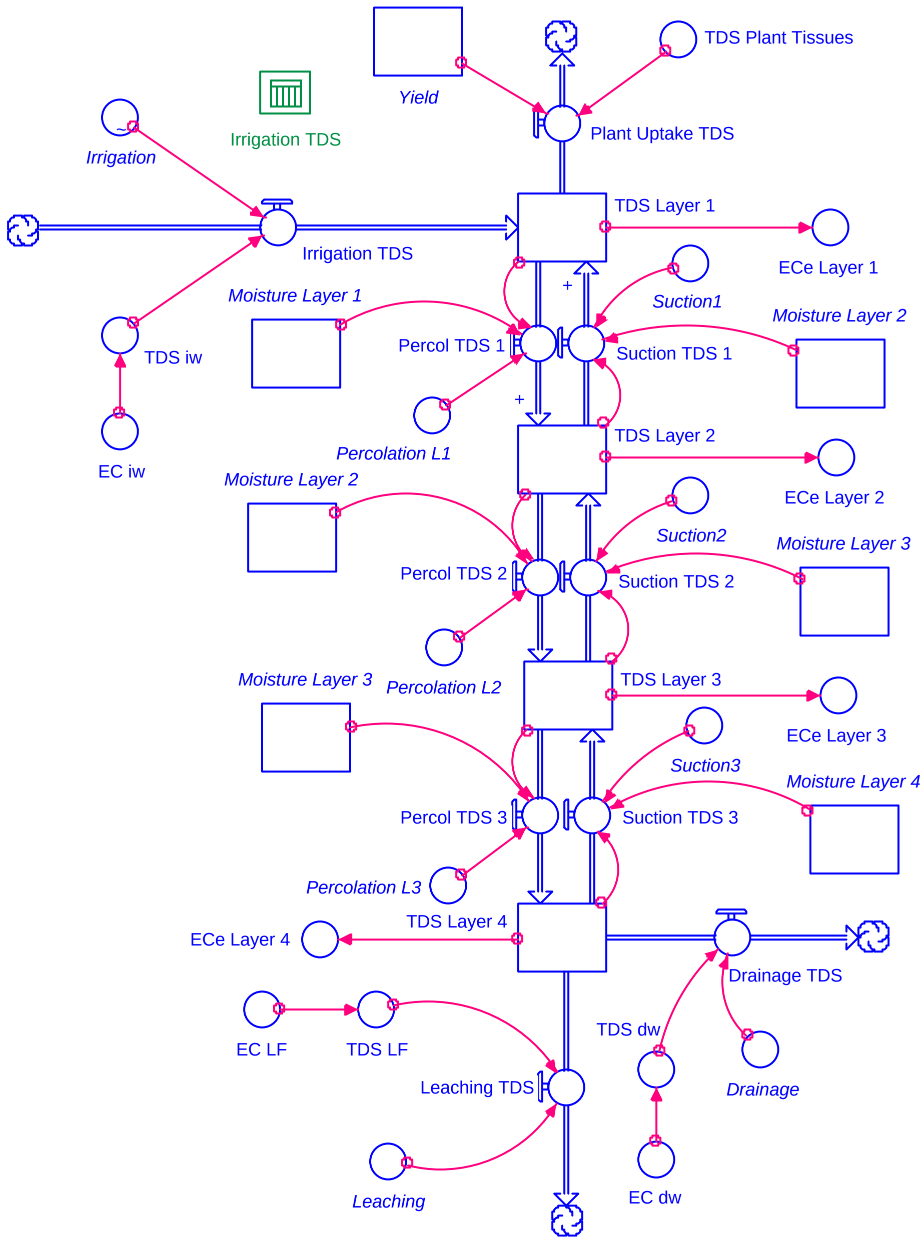
On a high SAR soil, using moderate EC_w irrigation water (2 to 12 dS m^{-1}), no infiltration and drainage problems have been observed where forages have been able to grow during the last ten years. Leaching and reclamation are occurring.


A Surface Renewal Station WR 1000
at Westlake Farms (2007-2008)
• To measure Bermuda grass ETc
• To estimate Kc using ETo & ETc (Snyder 2008)
• To provide data for crop simulation


Pre-grazing condition, summer

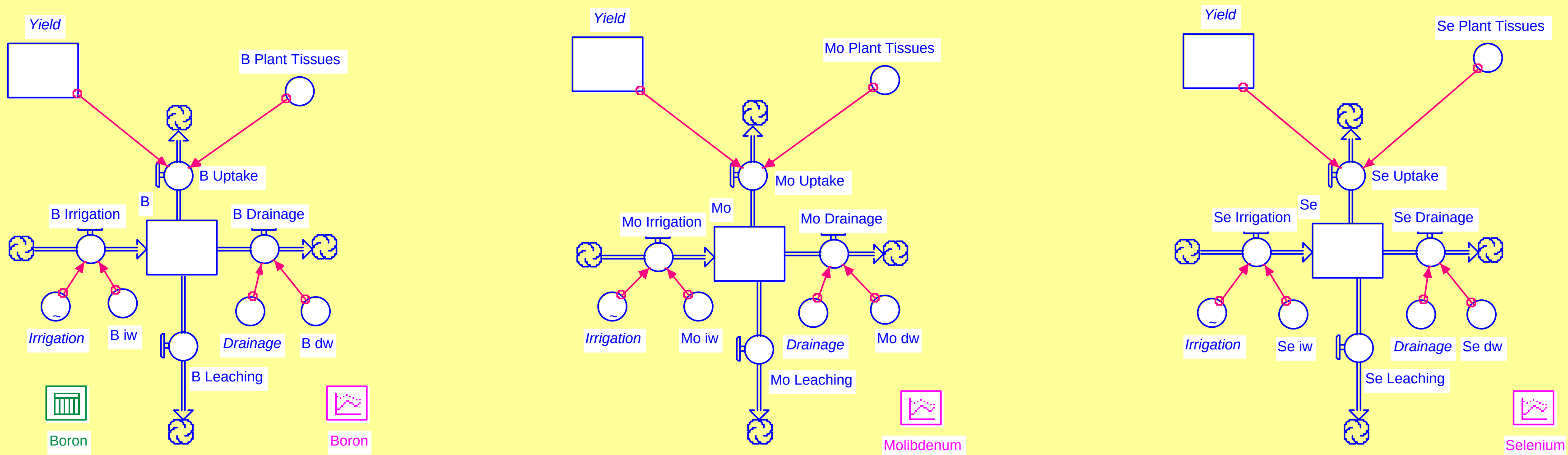
The Model:

Simplified subroutine for irrigation water & salt

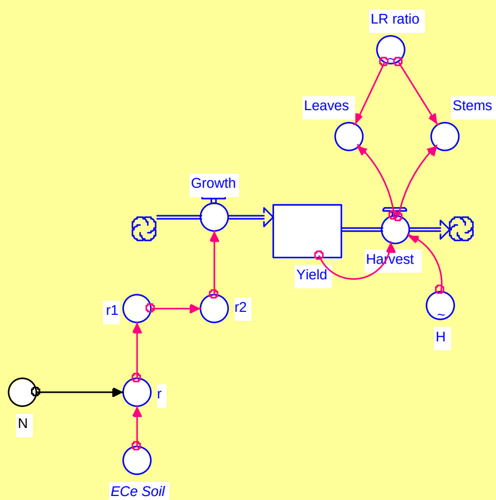


Written in Stella

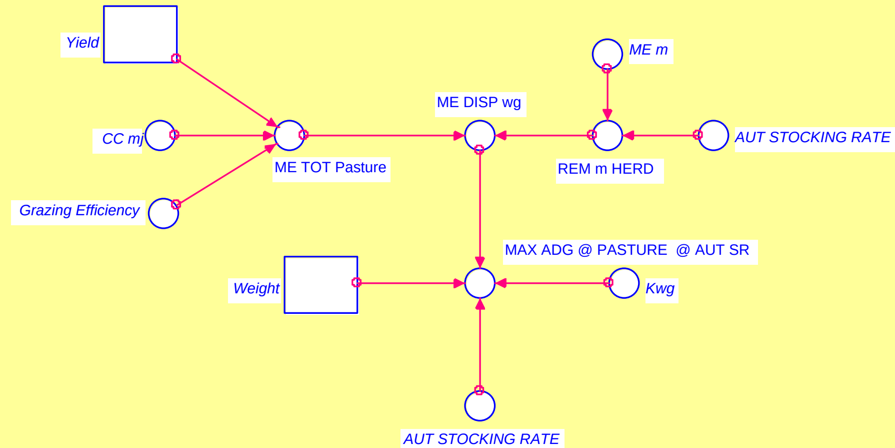
Subroutines for Trace Minerals



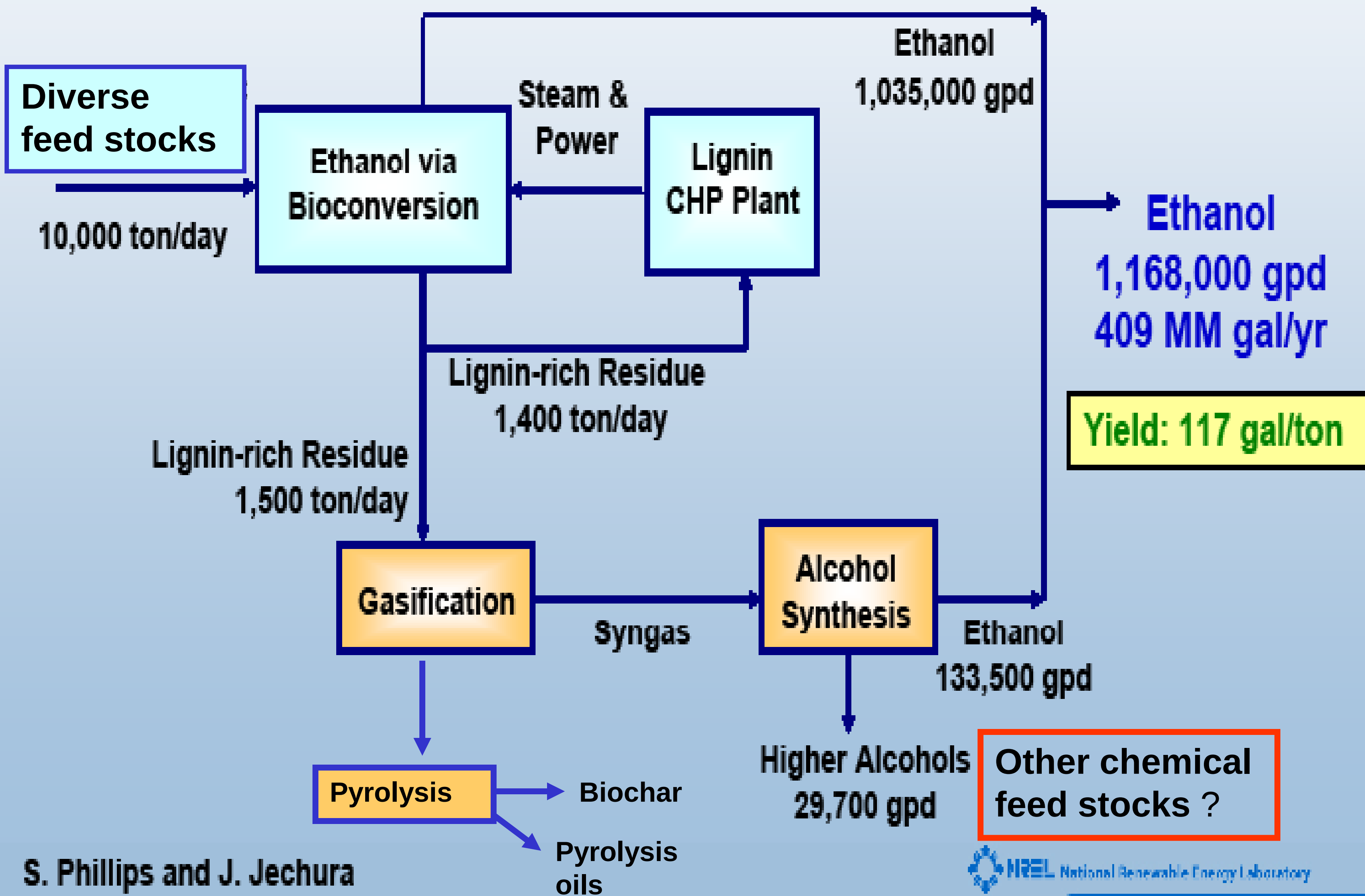
Subroutine Plant Yield



Subroutine Grazing Animals



Potential future ligno-cellulosic bio-refinery



S. Phillips and J. Jechura

NREL National Renewable Energy Laboratory

Potential ethanol production scenarios using Bermuda grass grown under saline conditions

Land Retirement alternative	TOTAL Biomass	Ethanol Potential[1]
ac	ton DM	gal
Current	54,198	5,148,853
100,000	50,414	4,789,330
200,000	38,743	3,680,566
300,000	24,980	2,373,066

NOTES

1: 95 gal/ton DM

Sources:

Williams, R.B. California Biomass and Biofuel Production Potential: Consultant Report. *In Review.*

Haap et al. 1991. Emissions of Selenium in the Combustion Products of Agroforestry Biomass. ASAE 91-4006.

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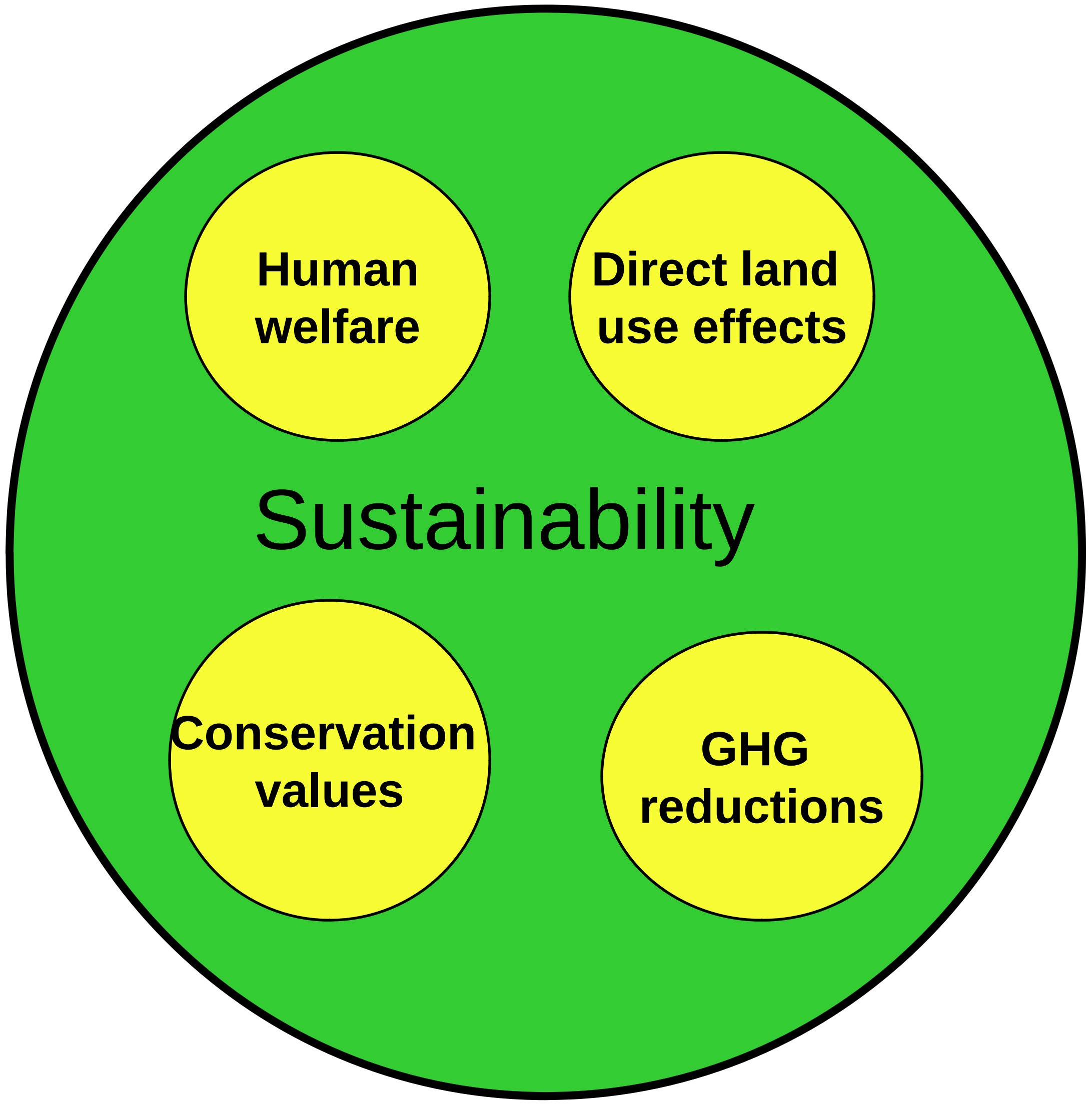
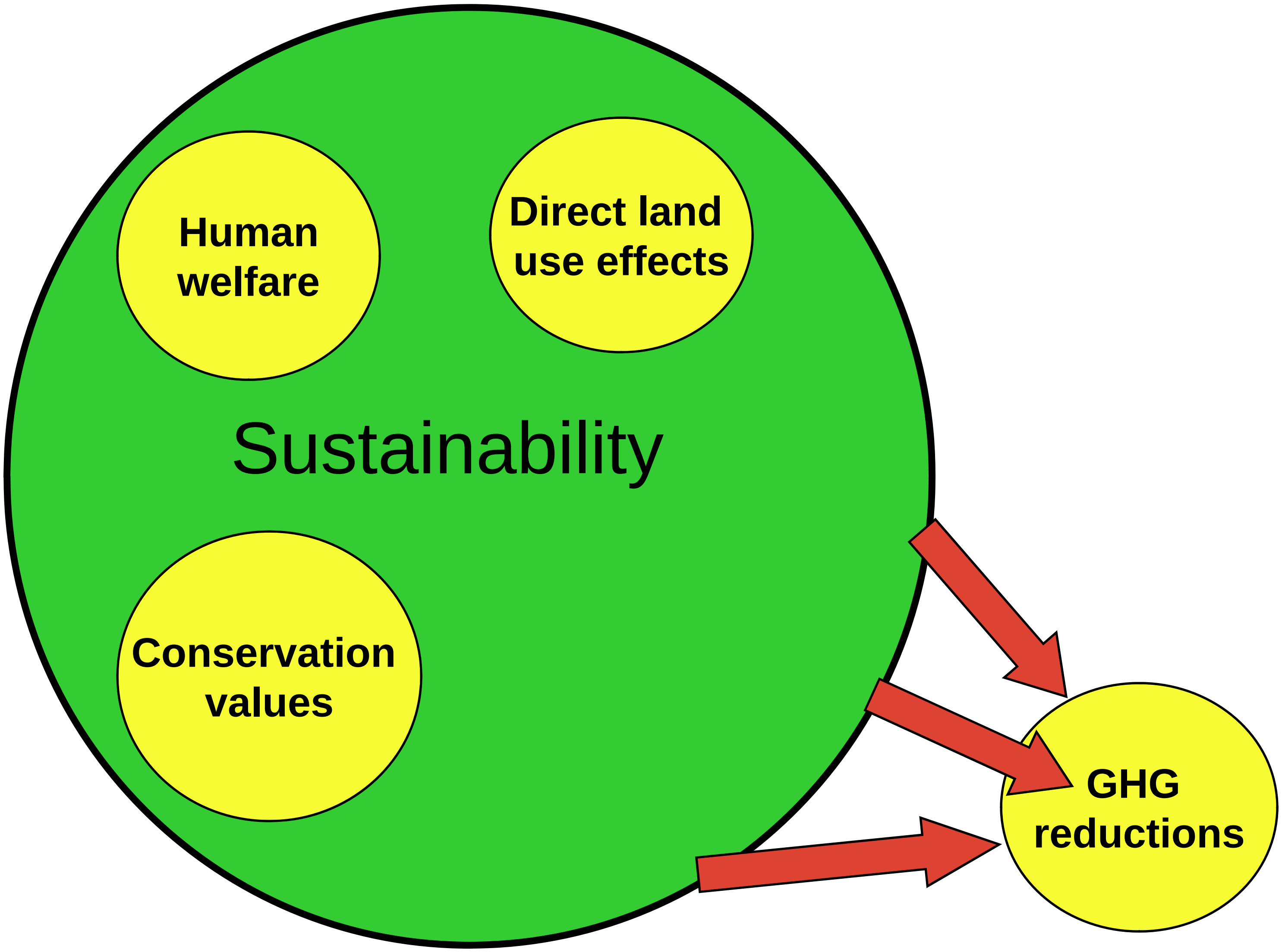

Human
welfare
Direct land
use effects
Sustainability
Conservation
values
GHG
reductions


Human welfare
Direct land use effects
Sustainability
Conservation values
GHG reductions

Multiple reasons for biofuels- AB 32 and the LCFS are not just GHG policies

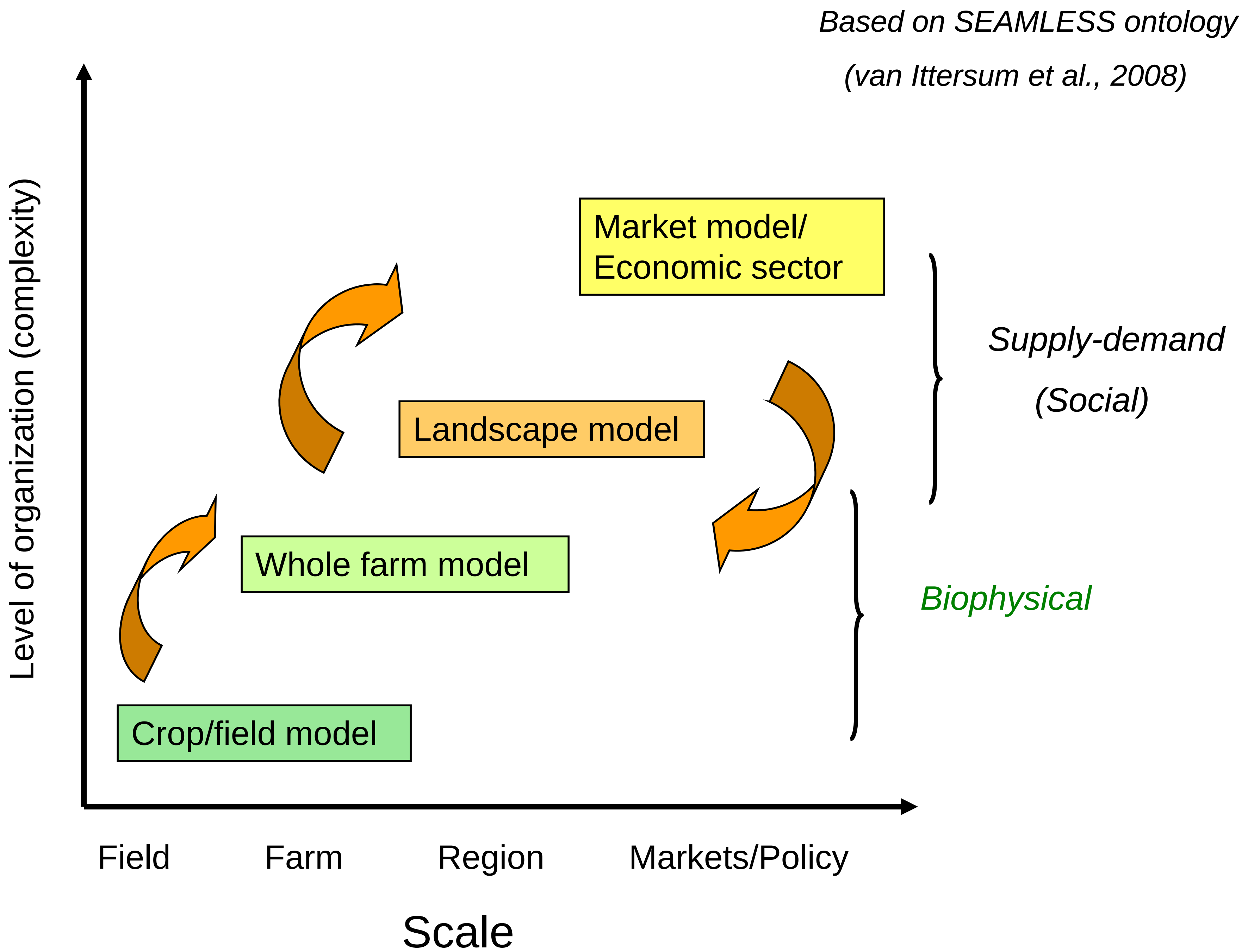
Alternative fuels from biomass will:

1. Diversify the supply of transportation fuels, provide more domestic sources and improve national security
2. Increase rural employment and wealth,
3. Reduce expensive crop surpluses
4. Distribute fuel refining
5. Benefit the environment by reducing petroleum use for transportation and GHG increases
6. Other benefits

(DOE, USDA, other sources-2004)

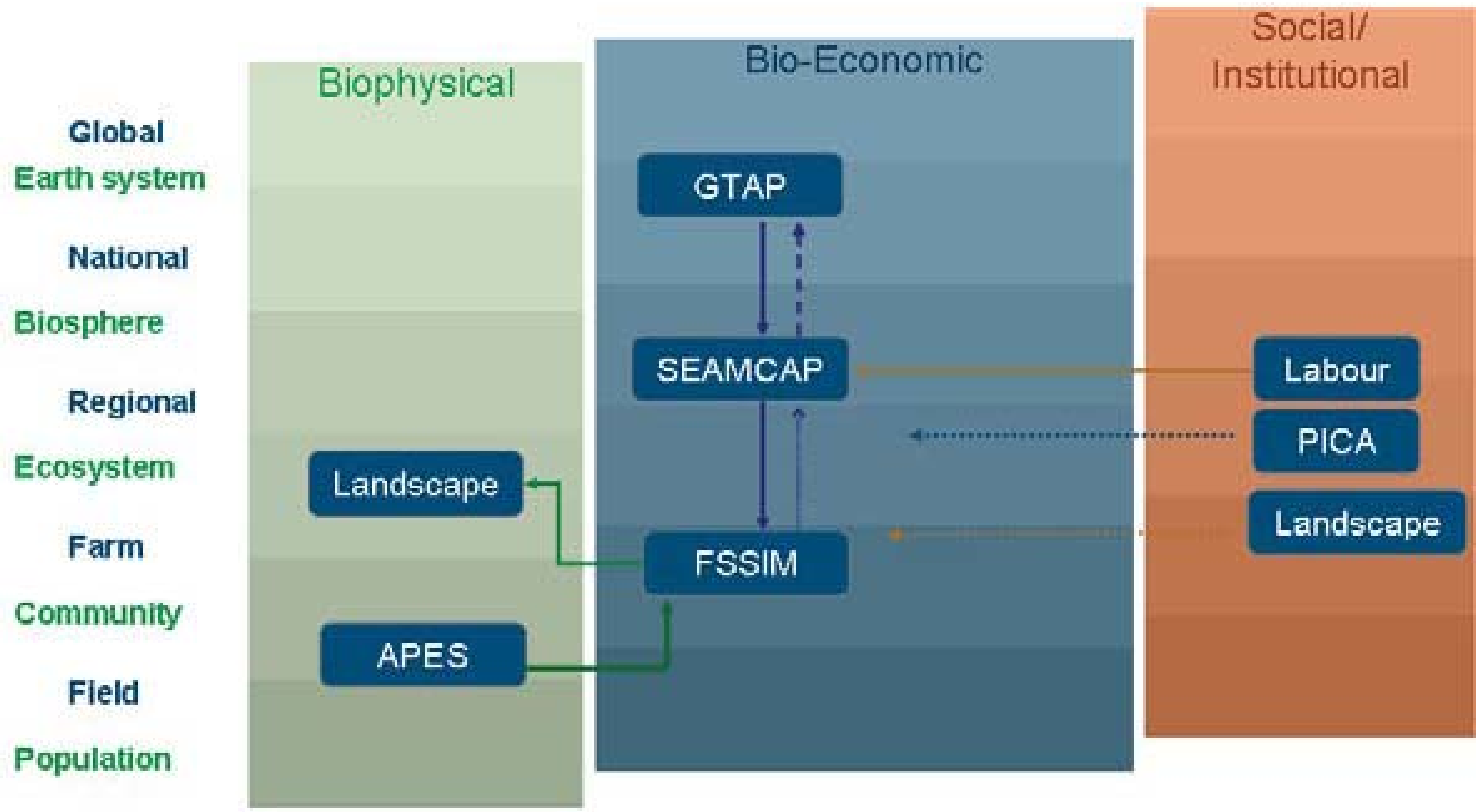
Integrative assessment

- Should be focused on the information needed for policy makers who must make complex evaluations of sustainability
- Must be multi-scale, predictive
- Should includes field, farm and landscape scale biophysical modeling
- Should includes farm, regional and sector scale economic analysis (social criteria)
- May include some measurement of social preferences
- Information from one level informs the next and must be portable across scales



Based on SEAMLESS ontology
(van Ittersum et al., 2008)
Level of organization (complexity)
Market model/
Economic sector
Landscape model
Whole farm model
Crop/field model
Supply-demand
(Social)
Biophysical
Field
Farm
Region
Markets/Policy
Scale

Quantitative and qualitative models used in SEAMLESS program (The Netherlands)



What do we mean by agricultural sustainability?

The debate over sustainability means discussing the implications of different choices when looking for compromise solutions between two pressures:

1. **Economic pressure driving further intensification (higher rates of throughputs per acre and per hour of labor)**
2. **Ecological limitations or pressure to reduce the rate of throughput because lower input systems may have less local environmental impact.**

M. Giampietro, 2004