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The Brazilian Biofuel Experience: Lessons for the Future

DOE/EIA Workshop

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www.Advancedbiofuelsusa.org

2010-2011 Drought
Effects on Brazilian Fuel Market

- Fuel market bifurcated.
- Petroleum products have maximum price established by law. (Gasoline @ $3.20/gallon).
- Ethanol prices not controlled.

2010-2011 Drought Effects

- Ethanol prices rose to $6.57/gallon.
- Gasoline sales rose. 1.5 million barrels/day of refined fuels, gasoline and diesel imported at a loss (purchased above controlled $3.20 price).
- Minimum ethanol content of gasoline dropped to 18%.
- 17.9 million gallons of ethanol imported from the US (2010).
- Brazil moving toward regulation of ethanol market.

Future of Biofuels in Brazil

- *Expansion of Ethanol Production?*
- *Production of Advanced Biofuels?*
- *Improved Vehicle Fleet Efficiency?*

What Are The Deployment Issues to be Considered ?

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Brazilian Ethanol & Sugar Cane Production Current and Future

- Sugar Cane: 8 million hectares (1 hectare=2.47 acres).
- While ethanol production grew at 18%/year from 2006 to 2009; uses approximately 1.5% of total agricultural land.
- Large increase in Brazilian ethanol production could occur.
- Current Federal agricultural land use plans allows up to 62 million hectares for sugar cane.
- Federal plans envisioned that additional sugarcane acreage would come primarily from pastureland (74%), with only a small amount (.5%) from natural lands.

- *Is this increase in sugarcane cultivation realistic?*

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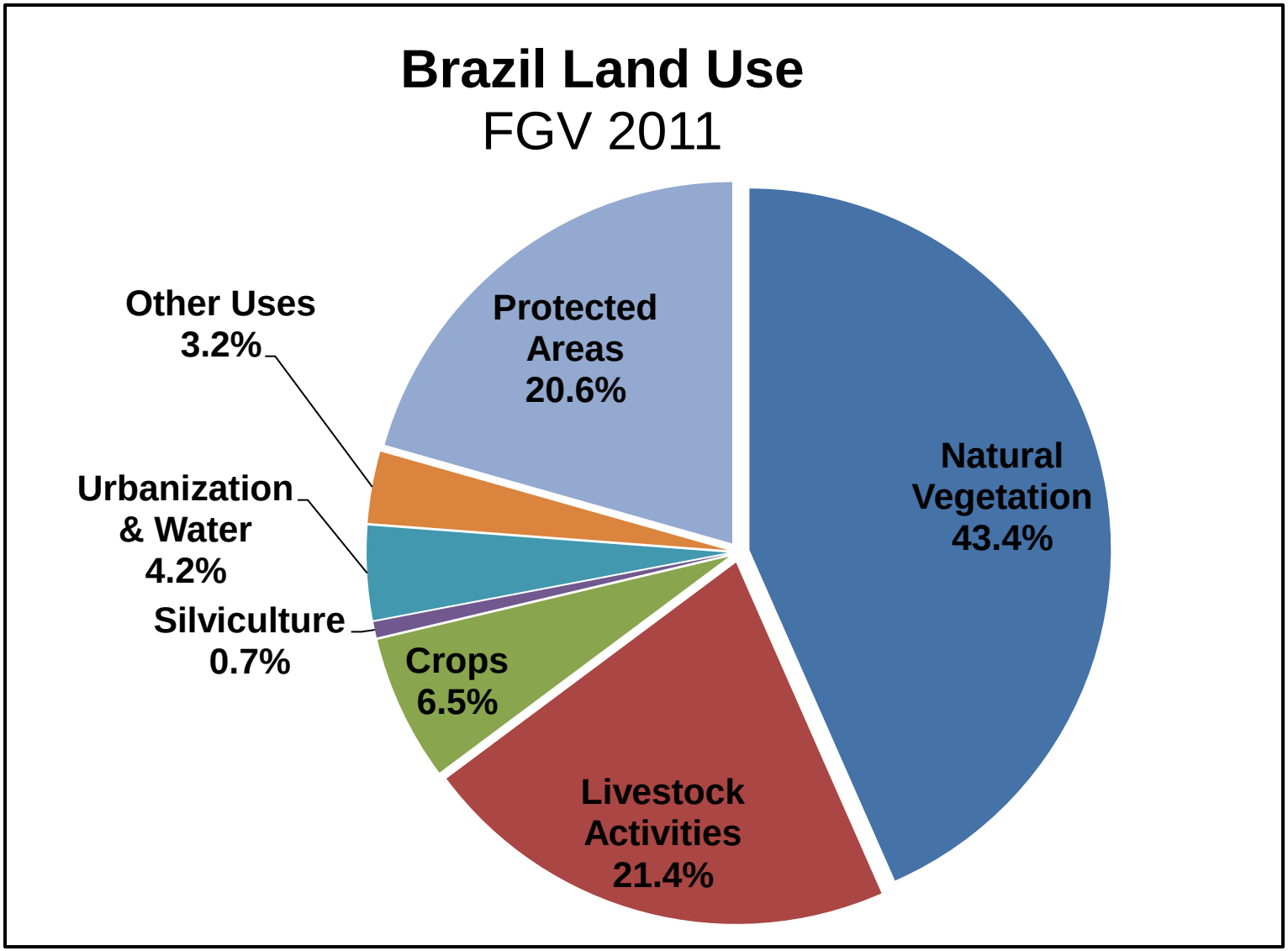
Issue #1: Land Use



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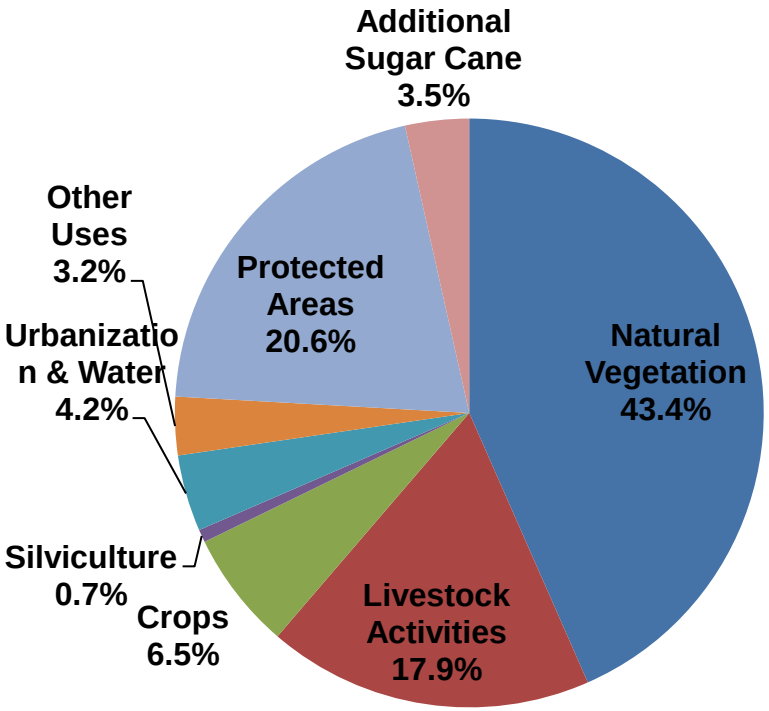

Additional Sugar Cane: No Natural Vegetation Land Needed

- 54 million sugar cane hectares in livestock grazing land
- Grazing land decreased by 16%
- No additional grazing land needed through livestock grazing improvements

Additional Sugar Cane: Natural Vegetation Land Needed

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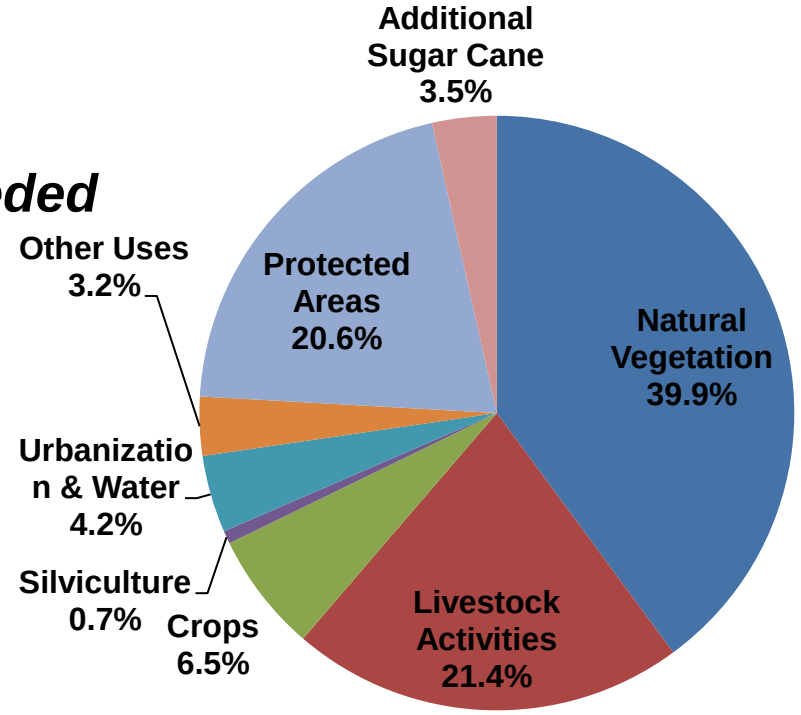

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Issue #2: Water

"The reaction of the pollution chain transformed the burning and destruction of the Amazon forests into a problem in the South and Southwest of Brazil. The scientific experiments that took place in the last years by the LBA [Large Scale Biosphere-Atmosphere Experiment in the Amazon, under the scientific coordination of INPA] revealed that a reduction of rains in the South and Southwest regions is intimately linked to the existing environmental in the northern region of the country." (Ottoboni, 2004)

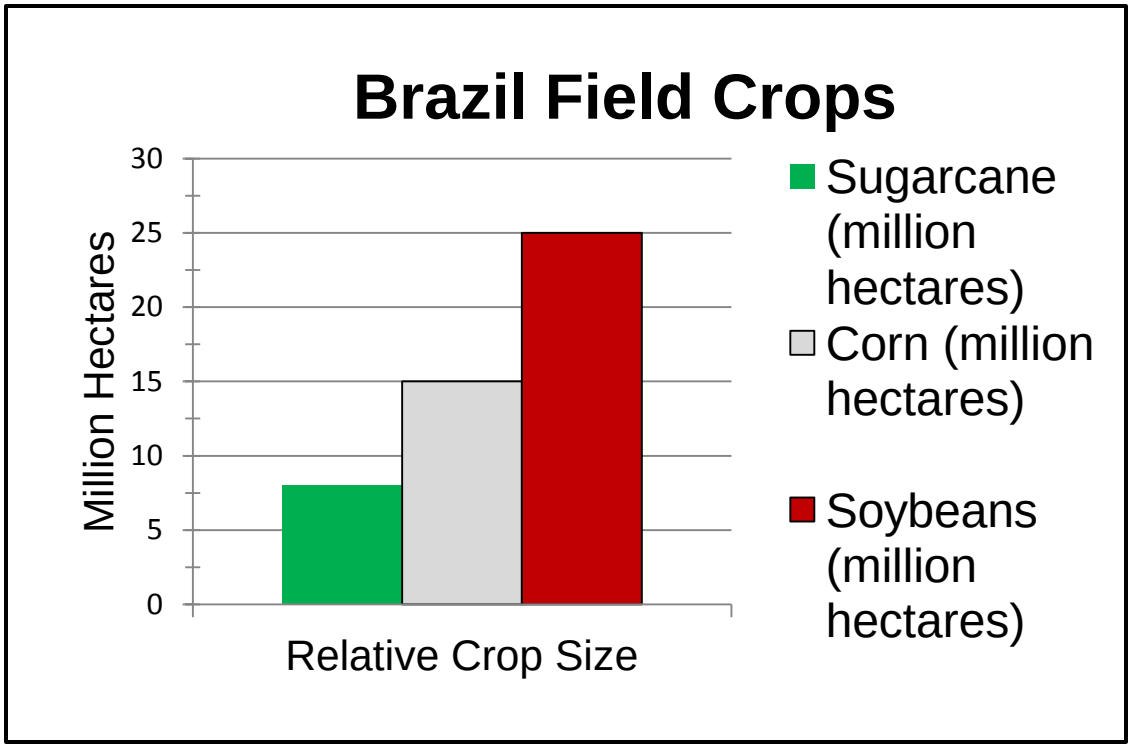
- **2010-2011 Droughts: Pernambuco State (northeastern Brazil) ethanol production fell by 18% and electrical production fell 32%.**
- **2010-2011: One-off or indication for the future?**

WATER FLOW IN THE MAIN BRAZILIAN RIVER BASINS SOURCE: Margulis & Dubeux (2010)							
			A2-BR SCENARIO				
	1961-1990		2011-2040		2041-2070		2071-2100
Tocantins	13,264		9,945		9,091		6,434
Amazon	131,047		123,238		111,609		91,930
Paraguay	2,368		2,145		2,169		3,470
Oriental Atlantic NE	779		133		83		2
Atlantic East	1,492		423		375		88
Paraná	11,453		10,764		9,649		12,669
Parnaiba	763		261		150		75
Sao Francisco	2,850		1,223		1,227		1,504
Atl antic South	4,174		4,659		4,496		4,599
Uruguay	4,121		4,435		4,511		4,342
Southeast Atlantic	3,179		3,174		2,674		3,036
Occidental Atlantic NE	2,683		1,915		1,670		1,250
Total	178,173		162,315		147,704		129,399
(%) Reduction			**8.9%**		**17.1%**		**27.4%**

Fundação GetUlio Vargas (FGV) Center for Sustainability Studies; ***Public Policy Proposals by the Business Sector for a Low Carbon Economy in Brazil: Energy, Transportation, and Agriculture***, 2011

Issue #3 :Competing Brazilian Agricultural Goals

- Sugar cane acreage distant third behind corn and soybeans.
- Between 2000 and 2008, agribusiness exports increased from 4.1% to 7% of global total. Ranked 3rd in 2010. (FAO, 2010)
- In 2011, Brazil's soy exports to China increased 7 percent, now leads US as China's leading soy provider.



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Sugar Costs For Biofuels: Compared to Oil and Soybean Prices

	$/Barrel of Oil		Input Cost/Gallon of Fuel @ 42 gallons/Barrel of Oil
Crude Oil (DOE Target Price)	$ 90.00		$ 2.14

Sugar Cost = Input Oil Cost per Gallon/Sugar Required per Gallon

Biofuel Production Systems	Lbs of Sugar for 1 Gallon Biofuel		Cost of Sugar/Gallon BioFuel		***Maximum Price*** 1 Pound of Biofuel Sugar
Cellulosic Ethanol	15.6		$ 2.14		$ 0.14/lb
Heterotrophic Algae	17.5		$ 2.14		$ 0.12/lb
Aqueous Reforming	21.2		$ 2.14		$ 0.10/lb
Soybean Price/lb (July 2012 Price)	@$15.50 Bushel				$ 0.26/lb

Brazil Transportation Fuels
A Bagasse/Advanced Biofuel Future?

- 40-45% of fuel produced is sugar cane ethanol.
- 48% of total fuel use is for diesel powered vehicles.
- No significant renewable diesel production. Several US advanced biofuel technologies being tested.
- Much diesel fuel has to be imported because of a lack of refining capacity (additional scheduled by Petrobras for 2013) and crude oil supply (deep-sea oil exploitation delayed by lack of investments post 2008).
- Sugar cane bagasse, corn stover, soy bean hulls could be feedstock.
- If available at < $.14-$.12/lb.

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Brazil Electrical Sector
Competing Bagasse User

- Annual use projected to grow at 6%/year.
- Approximately 90% of electricity is from hydroelectric installations.
- Approximately 10% is imported annually from Paraguay.
- Additional projects under construction in adjacent countries.
- 5% of electricity is from biomass combustion (primarily sugar cane bagasse).
- Bagasse boilers and processing equipment being upgraded to increase electrical production.
- Additional bagasse produced from new sugar cane and other crops planned to be used for electrical production.

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Will Value of Ethanol in Fuel Be Utilized?

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Fuel

journal homepage: www.elsevier.com/locate/fuel

High octane number ethanol–gasoline blends: Quantifying the potential benefits in the United States

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ABSTRACT

Ethanol provides a significant contribution to road transportation fuel in the US, Brazil, and elsewhere. Renewable fuels regulations in the US and EU imply that ethanol use will continue to increase in the near future. The high octane rating of ethanol could be used in a mid-level ethanol blend to increase the minimum octane number (Research Octane Number, RON) of regular-grade gasoline. Higher RON would enable greater thermal efficiency in future engines through higher compression ratio (CR) and/or more aggressive turbocharging and downsizing, and in current engines on the road today through more aggressive spark timing under some driving conditions. Such an approach would differ from the current practice of blending ethanol into a gasoline blendstock formulated with lower octane rating such that the net octane rating of the resulting final blend is unchanged from historical levels.

Developing scenarios of future ethanol availability, we estimate that large increases (4–7 points) in the RON of US gasoline are possible by blending in an additional 10–20%v ethanol above the 10% already present. Keeping the blendstock RON at 88 (which provides E10 with ~92.5 RON), we estimate RON would be increased to 94.3 for E15 to as much as 98.6 for E30. Even further RON increases may be achievable assuming changes to the blendstock RON and/or hydrocarbon composition. For example, an increase in blendstock RON from 88 to 92 would increase the RON of E10 from 92.5 to 95.6, and would provide higher RON with additional ethanol content (e.g., RON of 97.1 for E15 to 100.6 for E30). Potential CR increases are estimated for the different estimates of future octane number, including the effect of increased evaporative cooling from ethanol in direct injection engines. For the ethanol and blendstock RON scenarios considered, CR increases were estimated to be on the order of 1–3 CR-units for port fuel injection engines as well as for direct injection engines in which the greater evaporative cooling of ethanol can be fully utilized. Impacts to the fuel refining and blending sector and transition considerations are discussed. While additional work is needed to quantify and optimize the costs and benefits for both the automotive and refining sectors and for consumers, it appears that substantial societal benefits may be associated with capitalizing on the inherent high octane rating of ethanol in future higher octane number ethanol–gasoline blends.

Brazilian IndyCar Driver Anna Beatriz IndyCar uses E-85 for octane and cooling

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Will Vehicle Fleet Change to Optimize Ethanol?

- Current “Flex-Fuel Vehicles” (FFVs) are only ***Compliant*** with ethanol mixtures. No mileage benefits.
- Essentially tuned for gasoline with alcohol tolerant components.
- ***Optimized*** FFVs would use on-board computers, DFI, and turbocharging to optimize ethanol for efficiency and mileage. Are 2nd Gen Ecoboost /Ecotec based.
- Current non-turbo technology can produce equivalent ethanol fuel economy at E-30.
- US adoption because of 54 mpg fuel mileage standards.
- Brazil would need similar standards.

Brazilian IndyCar Driver
Anna Beatriz
IndyCar uses E-85 for octane and cooling

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Future of Biofuels and Economies in Brazil and US Choices

Low-Tech Food Based Biofuels?

- US: Corn-to-Ethanol
- Brazil: Sugar Cane to Ethanol

Economy Based on Resource Exports?

- Extracted energy exports
- Commodity crop exports

Investment Choices?

- Extracted energy industries
- Commodity farming

High-Tech Biofuels?

- Total Biomass non-food feedstocks
- Jetfuels, diesel, optimized ethanol

Economy Based on Value-Added Exports?

- Energy conversion system exports
- Biomass genetic technology exports

Investment Choices?

- Basic science
- Biofuel technology
- Sustainable agriculture

MANY THANKS

Bob Kozak