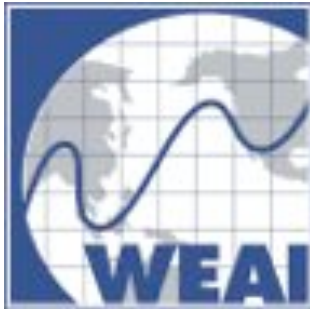


# US Importation of Brazilian Ethanol:

## Methods Sensitive to Economic and Ecological Issues

For the Assoc. of Environmental and Resource  
Economists session at the Western Economics  
Assoc. Int'l. Conference  
Vancouver, BC, Canada



Jason Barton  
Faculty of Land and Food Systems  
U. of British Columbia

Energy Biosciences Institute  
U. of Illinois



Energy  
Biosciences  
Institute



Faculty of Land and Food Systems  
Grounded in Science | Global in Scope

# Today's Agenda

- ◆ US Demand for Ethanol
- ◆ Background on Brazilian Ethanol
- ◆ Two Important Aspects of Cane Production
- ◆ Comments and Questions



Energy  
Biosciences  
Institute



Faculty of Land and Food Systems  
Grounded in Science | Global in Scope

# US Demand for Ethanol

The Energy Independence and Security Act of 2007 mandates

Year	ML Gasoline	ML Ethanol	% Ethanol
1996	452,246	4,163.9	0.92%
2006	524,535	18,378.1	3.50%
<b>2022 RFS</b>	<b>681,370</b> (projected)	<b>136,274.4</b>	<b>20.0%</b> (projected)

# US Demand for Ethanol

The Energy Independence and Security Act of 2007 mandates

Year	ML Gasoline	ML Ethanol	% Ethanol
1996	452,246	4,163.9	0.92%
2006	524,535	18,378.1	3.50%
<b>2022 RFS</b>	<b>681,370</b> (projected)	<b>136,274.4</b>	<b>20.0%</b> (projected)

✦ 60% of these must come from “advanced biofuels.”

# US Demand for Ethanol

The Energy Independence and Security Act of 2007 mandates

Year	ML Gasoline	ML Ethanol	% Ethanol
1996	452,246	4,163.9	0.92%
2006	524,535	18,378.1	3.50%
<b>2022 RFS</b>	<b>681,370</b> (projected)	<b>136,274.4</b>	<b>20.0%</b> (projected)

- ♦ 60% of these must come from “advanced biofuels.”
  - ♦ By some estimates (Macedo et al., 2008) Brazilian cane accomplishes this.

# US Demand for Ethanol

The Energy Independence and Security Act of 2007 mandates

Year	ML Gasoline	ML Ethanol	% Ethanol
1996	452,246	4,163.9	0.92%
2006	524,535	18,378.1	3.50%
<b>2022 RFS</b>	<b>681,370</b> (projected)	<b>136,274.4</b>	<b>20.0%</b> (projected)

✦ 60% of these must come from “advanced biofuels.”

✦ By some estimates (Macedo et al., 2008)

Brazilian cane accomplishes this.

✦ So should we switch the emphasis to cane instead of corn?

## Table 1. Land Productivity

<b>Production</b>	<b>units</b>	<b>2006</b>	<b>2022*</b>
<b>SP Sugarcane</b>	tn ha <sup>-1</sup>	81	95
	L tn <sup>-1</sup>	86.3	92.5
	L ha <sup>-1</sup>	6990.3	8768.5
	Gal ac <sup>-1</sup>	747.33	937.43
<b>US Corn</b>	L ha <sup>-1</sup>	3729.81	4662.26
	Gal ac <sup>-1</sup>	398.75	498.44

\*These projections are very difficult to determine but are well supported in the literature as moderate possibilities.

## Table 1. Land Productivity

<b>Production</b>	<b>units</b>	<b>2006</b>	<b>2022*</b>
<b>SP Sugarcane</b>	tn ha <sup>-1</sup>	81	95
	L tn <sup>-1</sup>	86.3	92.5
	L ha <sup>-1</sup>	6990.3	8768.5
	Gal ac <sup>-1</sup>	747.33	937.43
<b>US Corn</b>	L ha <sup>-1</sup>	3729.81	4662.26
	Gal ac <sup>-1</sup>	398.75	498.44

\*These projections are very difficult to determine but are well supported in the literature as moderate possibilities.



# How should the US meet its RFS?

Cellulosic ethanol is not yet feasible, so what are our current options?

## Cane vs. Corn



# How should the US meet its RFS?

Cellulosic ethanol is not yet feasible, so what are our current options?

## Cane vs. Corn

- ♦ Sugarcane is much more efficient in terms of land and energy



# How should the US meet its RFS?

Cellulosic ethanol is not yet feasible, so what are our current options?

## Cane vs. Corn

- ✦ Sugarcane is much more efficient in terms of land and energy
- ✦ Sugarcane avoids much of the food vs. fuel debate



# How should the US meet its RFS?

Cellulosic ethanol is not yet feasible, so what are our current options?

## Cane vs. Corn

- ✦ Sugarcane is much more efficient in terms of land and energy
- ✦ Sugarcane avoids much of the food vs. fuel debate
- ✦ BUT, increasing demand for both food and fuel indicate this is likely only a temporary measure!



# Brazilian Ethanol



# Brazilian Ethanol

- ◆ PROALCOOL was instituted in the 1970's in response to oil and currency crises.
- ◆ Brazil is 2nd largest ethanol producer, largest exporter
- ◆ Sao Paulo accounts for over 60% of Brazilian cane
- ◆ Growth in cane production is increasing:
  - ◆ 1990: 263 Mt
  - ◆ 2008: 490 Mt
  - ◆ 2012: 728 Mt



# Possible US Importation from Brazil

- ♦ Existing tariff of \$0.54 per gallon blocks significant ethanol importation.
- ♦ But many government officials (on both sides of the aisle) favor reducing or abolishing the tariff.
- ♦ How much more importation is possible?
  - ♦ What would be the economic, ecological, and social impacts, and the interactions between them?



# First Example: Cane Burning

- ✦ Traditional harvesting was done by hand
- ✦ Creates jobs
  - ✦ Though not very good jobs
  - ✦ Job quality is improving due to increased enforcement of labor laws
- ✦ Manual harvest requires fields to be burned before harvest
  - ✦ Resulting air pollution risks human health







# Cane Burning (cont'd)

## Cane Burning (cont'd)

- ✦ Burning to be banned by 2031

## Cane Burning (cont'd)

- ✦ Burning to be banned by 2031

## Cane Burning (cont'd)

- ✦ Burning to be banned by 2031
  - ✦ Prior bans have been ineffective

## Cane Burning (cont'd)

- ✦ Burning to be banned by 2031
  - ✦ Prior bans have been ineffective

## Cane Burning (cont'd)

- ✦ Burning to be banned by 2031
  - ✦ Prior bans have been ineffective
  - ✦ Costs of labor rising due to improved enforcement

## Cane Burning (cont'd)

- ✦ Burning to be banned by 2031
  - ✦ Prior bans have been ineffective
  - ✦ Costs of labor rising due to improved enforcement



## Cane Burning (cont'd)

- ✦ Burning to be banned by 2031
  - ✦ Prior bans have been ineffective
  - ✦ Costs of labor rising due to improved enforcement
  - ✦ Costs of mechanization falling (stronger currency, increased domestic production of tractors, etc.)

## Cane Burning (cont'd)

- ✦ Burning to be banned by 2031
  - ✦ Prior bans have been ineffective
  - ✦ Costs of labor rising due to improved enforcement
  - ✦ Costs of mechanization falling (stronger currency, increased domestic production of tractors, etc.)

## Cane Burning (cont'd)

- ✦ Burning to be banned by 2031
  - ✦ Prior bans have been ineffective
  - ✦ Costs of labor rising due to improved enforcement
  - ✦ Costs of mechanization falling (stronger currency, increased domestic production of tractors, etc.)
  - ✦ Results: Producers are moving to mechanized harvesting

## Cane Burning (cont'd)

- ♦ Burning to be banned by 2031
  - ♦ Prior bans have been ineffective
  - ♦ Costs of labor rising due to improved enforcement
  - ♦ Costs of mechanization falling (stronger currency, increased domestic production of tractors, etc.)
  - ♦ Results: Producers are moving to mechanized harvesting
    - ♦ One tractor = 80 jobs (79 lost)

# Cane Burning (cont'd)

- ♦ Burning to be banned by 2031
  - ♦ Prior bans have been ineffective
  - ♦ Costs of labor rising due to improved enforcement
  - ♦ Costs of mechanization falling (stronger currency, increased domestic production of tractors, etc.)
  - ♦ Results: Producers are moving to mechanized harvesting
    - ♦ One tractor = 80 jobs (79 lost)
    - ♦ Air quality improves

## Cane Burning (cont'd)

- ✦ Burning to be banned by 2031
- ✦ Prior bans have been ineffective



sed

# Cane Burning (cont'd)

- ✦ Burning to be banned by 2031
- ✦ Prior bans have been ineffective



So economics can be a powerful driver, but externalities must be considered.

## A second example: Legal Reserves and Areas of Permanent Preservation

(the focus of my work)



Energy  
Biosciences  
Institute



Faculty of Land and Food Systems  
Grounded in Science | Global in Scope



# My Research:

A cost-benefit analysis of Legal Reserves and Areas of Permanent Preservation (APP's)

## Legal Reserves:

- ◆ Mandated 20% of each agricultural parcel
- ◆ Harvest of wood, fruit, etc., permitted

## APP's:

- ◆ Mandated along waterways and other sensitive areas
- ◆ No agricultural activity is permitted
- ◆ Approx. 5-10% of agricultural land

# Legal Reserves and APP's (cont'd)



## Legal Reserves and APP's (cont'd)

- ◆ Less than half of the mandated areas have actually been established



## Legal Reserves and APP's (cont'd)

- ◆ Less than half of the mandated areas have actually been established
  - ◆ Enforcement is difficult



## Legal Reserves and APP's (cont'd)

- ◆ Less than half of the mandated areas have actually been established
  - ◆ Enforcement is difficult
    - ◆ But the burning example provides a potential solution



## Legal Reserves and APP's (cont'd)

- ◆ Less than half of the mandated areas have actually been established
  - ◆ Enforcement is difficult
    - ◆ But the burning example provides a potential solution
      - ◆ Cost-Benefit analysis of RL's and APP's



**Iracemápolis, São Paulo**

**Municipal Reservoir**

**Cane removed in 1986, replaced with forest**

# **Iracemápolis, São Paulo**

## **Municipal Reservoir**

**Cane removed in 1986, replaced with forest**





# Iracemápolis, São Paulo

## Municipal Reservoir

Cane removed in 1986, replaced with forest

♦ What would be the increase in price per gallon of ethanol for sugarcane producers to be in compliance with the law?



# **Iracemápolis, São Paulo**

## **Municipal Reservoir**

**Cane removed in 1986, replaced with forest**

✦ **What would be the increase in price per gallon of ethanol for sugarcane producers to be in compliance with the law?**

✦ **US could lower tariff to motivate compliance**



# **Iracemápolis, São Paulo**

## **Municipal Reservoir**

**Cane removed in 1986, replaced with forest**

- ✦ **What would be the increase in price per gallon of ethanol for sugarcane producers to be in compliance with the law?**
  - ✦ **US could lower tariff to motivate compliance**
  - ✦ **Monitoring performed by usinas (refineries)**



# **Iracemápolis, São Paulo**

## **Municipal Reservoir**

**Cane removed in 1986, replaced with forest**

- ✦ **What would be the increase in price per gallon of ethanol for sugarcane producers to be in compliance with the law?**
  - ✦ **US could lower tariff to motivate compliance**
  - ✦ **Monitoring performed by usinas (refineries)**
- ✦ **What would be the ecological benefits, and is it possible to perform economic valuation of these?**

# **Iracemápolis, São Paulo**

## **Municipal Reservoir**

**Cane removed in 1986, replaced with forest**

- ✦ **What would be the increase in price per gallon of ethanol for sugarcane producers to be in compliance with the law?**
  - ✦ **US could lower tariff to motivate compliance**
  - ✦ **Monitoring performed by usinas (refineries)**
- ✦ **What would be the ecological benefits, and is it possible to perform economic valuation of these?**
- ✦ **What would be the benefits in terms of job creation (diversification of ag. activities)?**

# **Iracemápolis, São Paulo**

## **Municipal Reservoir**

**Cane removed in 1986, replaced with forest**

- ✦ **What would be the increase in price per gallon of ethanol for sugarcane producers to be in compliance with the law?**
  - ✦ **US could lower tariff to motivate compliance**
  - ✦ **Monitoring performed by usinas (refineries)**
- ✦ **What would be the ecological benefits, and is it possible to perform economic valuation of these?**
- ✦ **What would be the benefits in terms of job creation (diversification of ag. activities)?**
- ✦ **What are the barriers to implementation?**

# **Iracemápolis, São Paulo**

## **Municipal Reservoir**

**Cane removed in 1986, replaced with forest**

- ✦ **What would be the increase in price per gallon of ethanol for sugarcane producers to be in compliance with the law?**
  - ✦ **US could lower tariff to motivate compliance**
  - ✦ **Monitoring performed by usinas (refineries)**
- ✦ **What would be the ecological benefits, and is it possible to perform economic valuation of these?**
- ✦ **What would be the benefits in terms of job creation (diversification of ag. activities)?**
- ✦ **What are the barriers to implementation?**
  - ✦ **Established through interviews of stakeholders**

# **Iracemápolis, São Paulo**

## **Municipal Reservoir**

**Cane removed in 1986, replaced with forest**

- ✦ **What would be the increase in price per gallon of ethanol for sugarcane producers to be in compliance with the law?**
  - ✦ **US could lower tariff to motivate compliance**
  - ✦ **Monitoring performed by usinas (refineries)**
- ✦ **What would be the ecological benefits, and is it possible to perform economic valuation of these?**
- ✦ **What would be the benefits in terms of job creation (diversification of ag. activities)?**
- ✦ **What are the barriers to implementation?**
  - ✦ **Established through interviews of stakeholders**
  - ✦ **Laborers, land owners, gov't officials, etc.**



Comments or questions?

*Thank You!*

Year	Brasil			São Paulo		
	Production (th tons)	Area Harvested (th ha)	Yield (tn ha <sup>-1</sup> )	Production (th tons)	Area Harvested (th ha)	Yield (tn ha <sup>-1</sup> )
1990	262,674	4,273	61.5			
1991	260,888	4,211	62.0	136,200	1,852	73.5
1992	271,475	4,203	64.6	145,500	1,890	77.0
1993	244,531	3,864	63.3	148,647	1,896	78.4
1994	292,102	4,345	67.2	174,100	2,173	80.1
1995	303,699	4,559	66.6	174,960	2,259	77.5
1996	317,106	4,750	66.8	192,320	2,493	77.1
1997	331,613	4,814	68.9	194,025	2,446	79.3
1998	345,255	4,986	69.2	199,783	2,565	77.9
1999	333,848	4,899	68.1	197,144	2,555	77.2
2000	326,121	4,805	67.9	189,040	2,485	76.1
2001	344,293	4,958	69.4	198,932	2,567	77.5
2002	364,389	5,100	71.4	212,707	2,661	79.9
2003	396,012	5,371	73.7	227,981	2,818	80.9
2004	415,206	5,632	73.7	239,528	2,952	81.1
2005 <sup>1</sup>	455,272	6,172	73.8	266,071	3,285	81.0

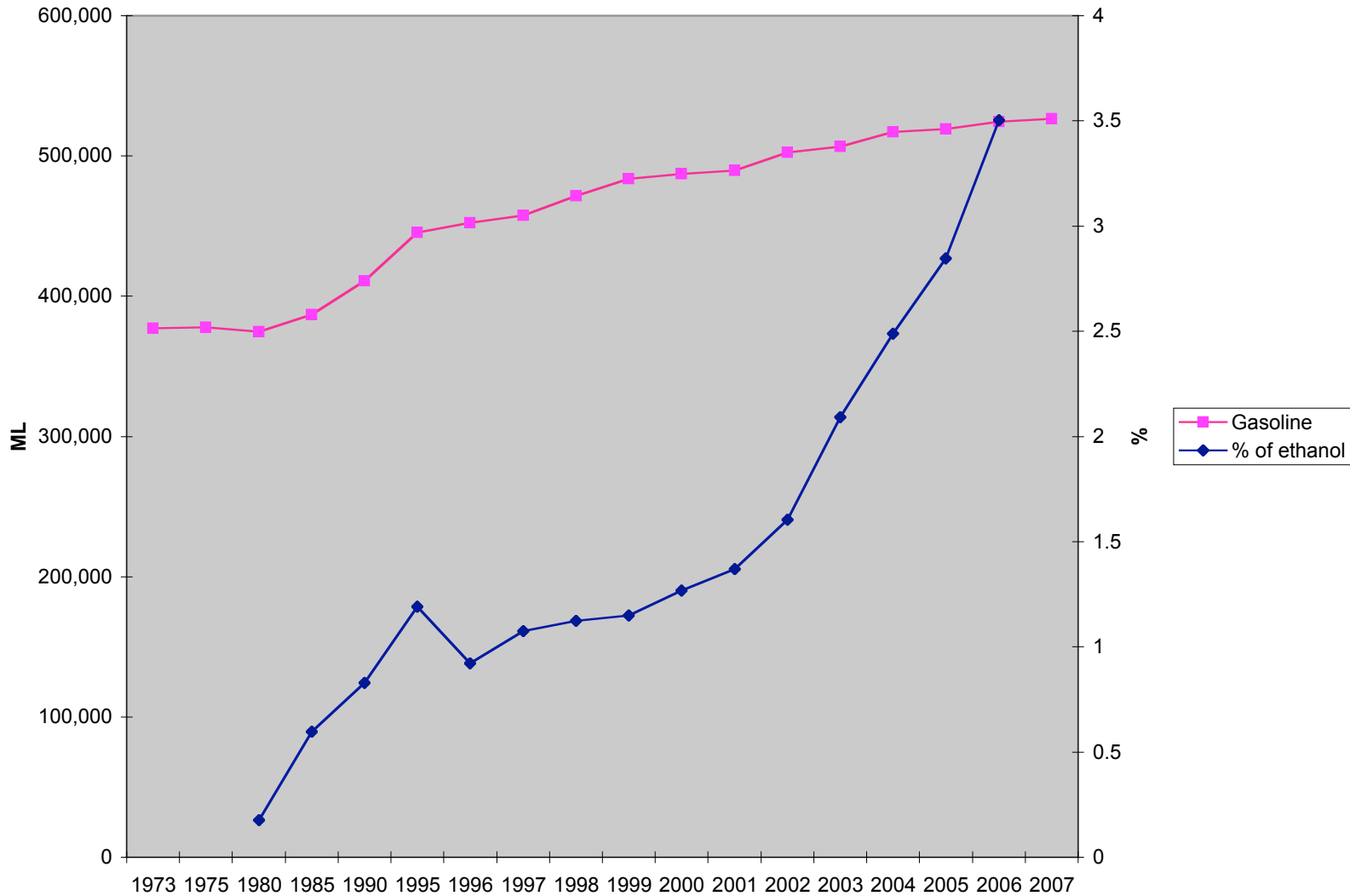
Source: Brazilian Ministry of Agriculture, available at <http://www.agricultura.gov.br>

# Thruithiness

- ◆ Ethanol is starving the poor.
  - ◆ The Amazon Rainforest will be cut down to grow sugarcane.
    - ◆ We don't need to import ethanol because we can make ethanol from cellulose and even algae.
      - ◆ More cane production will create jobs in Brazil for people who need them.



# Figure I. Historical US Gasoline and Ethanol Consumption



## Land Use Scenarios (40% RFS)

<b>Feedstock</b>	<b>units</b>	<b>2006</b>	<b>2022</b>	<b>40% of 2022</b>
Sugarcane	Th. ac.	6,496.48	38,402.70	15,361.08
	% BR ag land	0.75	4.45	1.78
	% BR crop land	3.43	20.26	8.11
	% SP ag land	14.31	84.60	33.84
	% SP crop land	35.27	208.48	83.39
Corn	Th. ac.	12,175.51	72,225.46	28,890.18
	% US ag land	1.30	7.70	3.08
	% US crop land	4.02	23.86	9.54



**Energy  
Biosciences  
Institute**



**Faculty of Land and Food Systems**  
Grounded in Science | Global in Scope

# Permanent Preservation Areas (APP's)



**Energy  
Biosciences  
Institute**



**Faculty of Land and Food Systems**  
Grounded in Science | Global in Scope

# Permanent Preservation Areas (APP's)

- ◆ These exist along rivers and other waterways (5-10% of ag. land)



**Energy  
Biosciences  
Institute**



**Faculty of Land and Food Systems**  
Grounded in Science | Global in Scope



# Permanent Preservation Areas (APP's)

- ◆ These exist along rivers and other waterways (5-10% of ag. land)
  - ◆ No agricultural activity is allowed



Energy  
Biosciences  
Institute



Faculty of Land and Food Systems  
Grounded in Science | Global in Scope

# Permanent Preservation Areas (APP's)

- ◆ These exist along rivers and other waterways (5-10% of ag. land)
  - ◆ No agricultural activity is allowed
    - ◆ They have been deemed essential to preserving the health of water and soil



Energy  
Biosciences  
Institute



Faculty of Land and Food Systems  
Grounded in Science | Global in Scope

# Permanent Preservation Areas (APP's)

- ◆ These exist along rivers and other waterways (5-10% of ag. land)
  - ◆ No agricultural activity is allowed
    - ◆ They have been deemed essential to preserving the health of water and soil

## Legal Reserves:



Energy  
Biosciences  
Institute



Faculty of Land and Food Systems  
Grounded in Science | Global in Scope

# Permanent Preservation Areas (APP's)

- ◆ These exist along rivers and other waterways (5-10% of ag. land)
  - ◆ No agricultural activity is allowed
    - ◆ They have been deemed essential to preserving the health of water and soil

## Legal Reserves:

- ◆ 20% of each plot of agricultural land must be set aside for forests



Energy  
Biosciences  
Institute



Faculty of Land and Food Systems  
Grounded in Science | Global in Scope

# Permanent Preservation Areas (APP's)

- ◆ These exist along rivers and other waterways (5-10% of ag. land)
  - ◆ No agricultural activity is allowed
    - ◆ They have been deemed essential to preserving the health of water and soil

## Legal Reserves:

- ◆ 20% of each plot of agricultural land must be set aside for forests
  - ◆ These are meant to preserve biodiversity, water and soil quality



Energy  
Biosciences  
Institute



Faculty of Land and Food Systems  
Grounded in Science | Global in Scope

# Permanent Preservation Areas (APP's)

- ◆ These exist along rivers and other waterways (5-10% of ag. land)
  - ◆ No agricultural activity is allowed
    - ◆ They have been deemed essential to preserving the health of water and soil

## Legal Reserves:

- ◆ 20% of each plot of agricultural land must be set aside for forests
  - ◆ These are meant to preserve biodiversity, water and soil quality
    - ◆ Fruit trees and wood collection are allowed, creating income opportunities, but not for several years



Energy  
Biosciences  
Institute



Faculty of Land and Food Systems  
Grounded in Science | Global in Scope

# The bottom lines:

- Brazilian ethanol demand will not stay flat
- The US is not the only country that will import
- How expanded production happens will make all the difference in terms of sustainability
  - Economic
  - Ecological
  - Social
- We (in the North) consume too much energy!







Is this a solution?

Is this a solution?

One more thought...

Is this a solution?

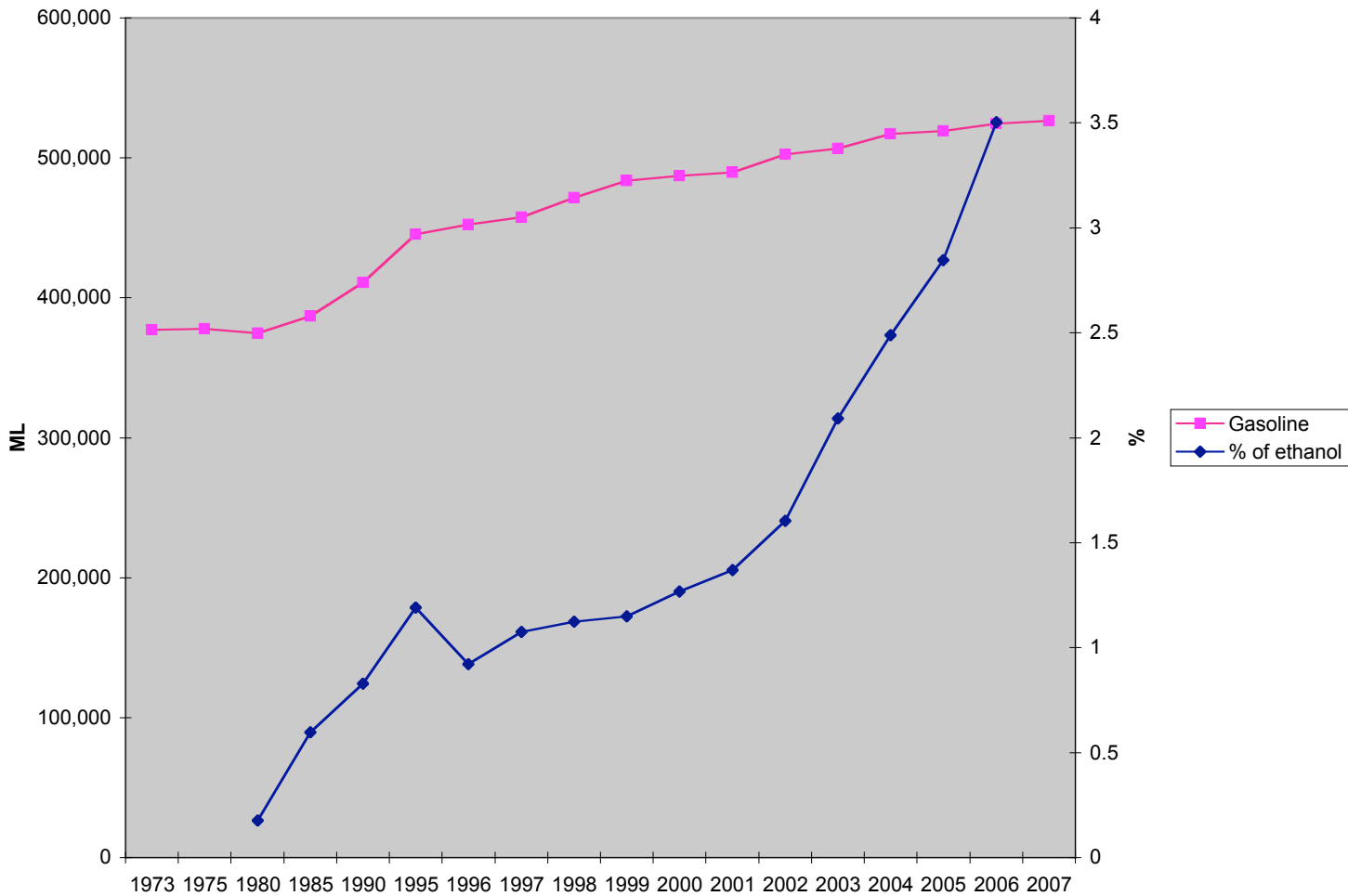
One more thought...

Figure 1. Historical US Gasoline and Ethanol Consumption

# Is this a solution?

One more thought...

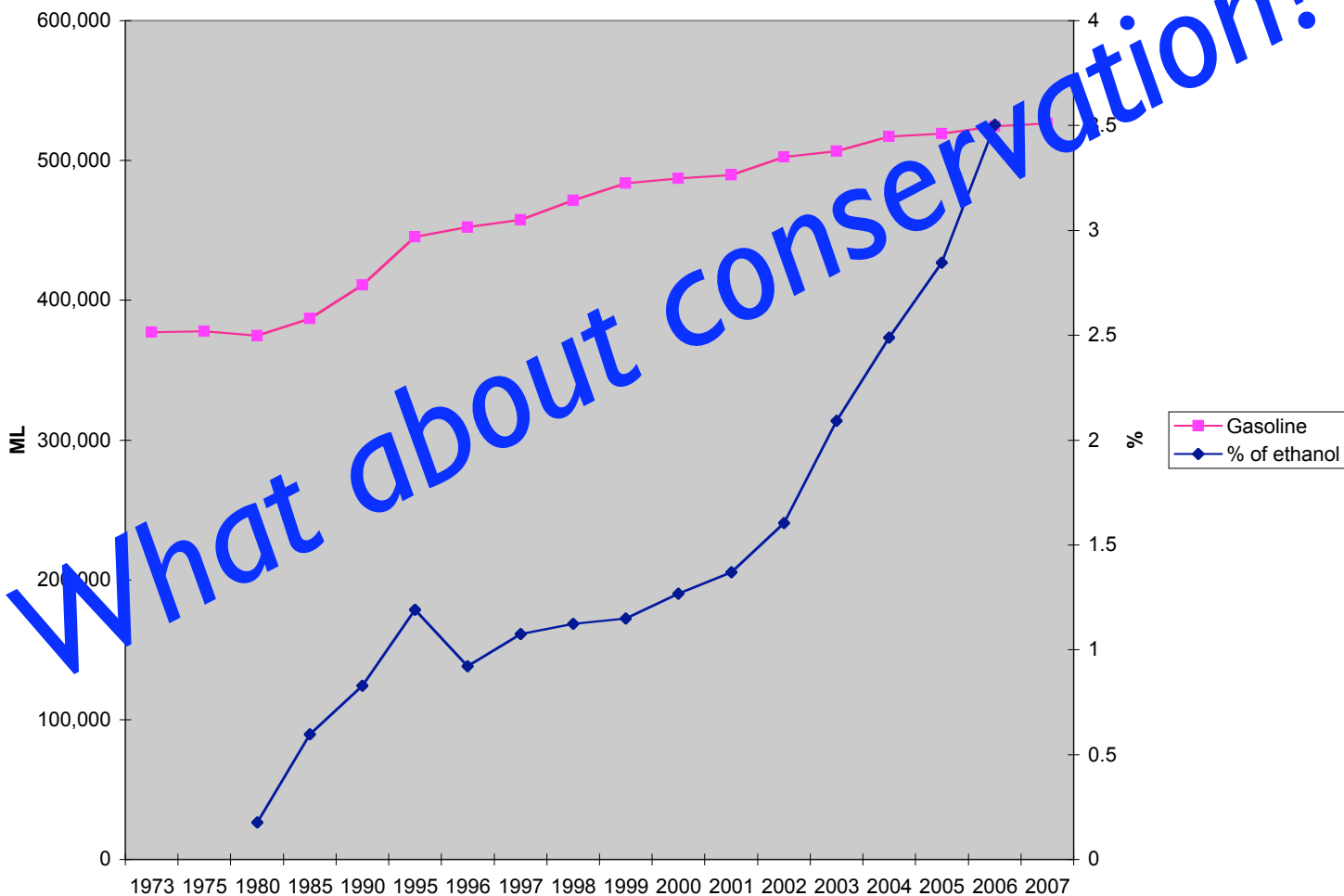
Figure 1. Historical US Gasoline and Ethanol Consumption



# Is this a solution?

One more thought...

Figure 1. Historical US Gasoline and Ethanol Consumption



# Queimas (Cane Burning)

## Environmental issues:

- ✦ Air Quality: Potential health problems for workers and others in sugarcane-producing communities (there are a lot of those in Sao Paulo)
- ✦ Cane “trash” that’s burned could be used for electricity/ethanol generation
- ✦ Burning is required for manual harvest

## Job creation/elimination:

- ✦ Worker wages have improved due to increased enforcement of labor laws
- ✦ This increases costs of labor

## Bottom line:

- ✦ Cane burning is to be eliminated by 2031
- ✦ (and thus, the jobs associated)



## Table 1. Land Productivity

<b>Production</b>	<b>units</b>	<b>2006</b>	<b>2022*</b>
<b>SP Sugarcane</b>	tn ha <sup>-1</sup>	81	95
	L tn <sup>-1</sup>	86.3	92.5
	L ha <sup>-1</sup>	6990.3	8768.5
	Gal ac <sup>-1</sup>	747.33	937.43
<b>US Corn</b>	L ha <sup>-1</sup>	3729.81	4662.26
	Gal ac <sup>-1</sup>	398.75	498.44

\*These projections are very difficult to determine but are well supported in the literature as moderate possibilities.























