http://bioenfapesp.org

FAPESP Bioenergy Research Program BIOEN: Science and Technology for Sustainable Bioenergy Production

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RIO+20
United Nations Conference
on Sustainable Development

"Many governments in the industrialized world are spending less in clean energy research now than they were a few years ago"
(Editorial, Nature June 6th, 2012)

"What is missing are solutions that are cheap, scalable and politically viable"

Planet

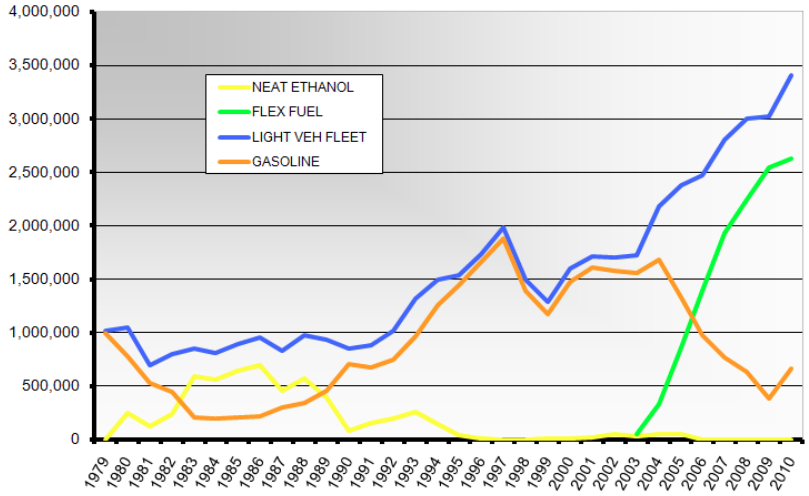
People **Profit**

Call for serious investment in renewable energy research
Increased international cooperation
Interdisciplinary and transdisciplinary approach to problems

Energy vs. Biodiversity Protection vs. Environmental Resources

Brazil as an example of a renewable energy matrix and the bioethanol program

The brazilian energy matrix is 47% renewable
Bioethanol represents 20% of Brazil's fuel matrix



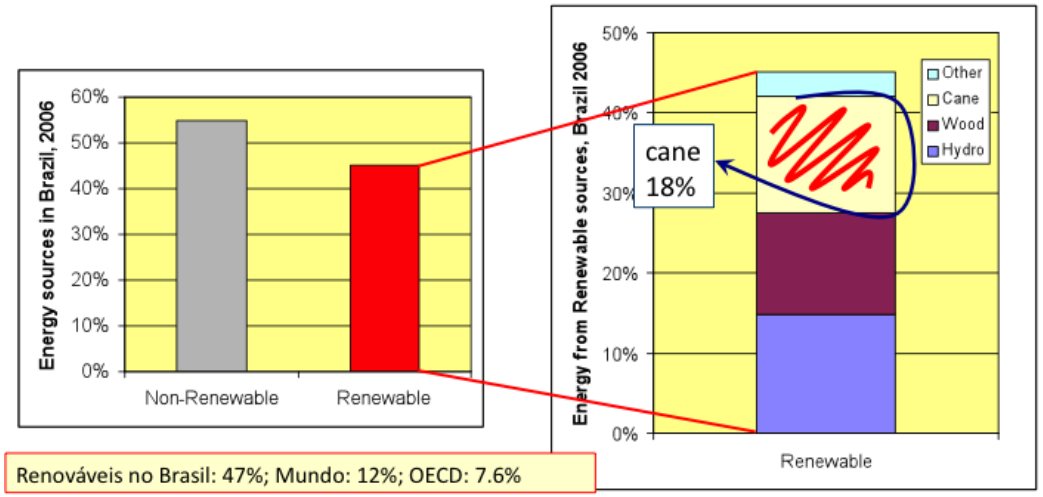
15 million flex-fuel vehicles

Total brazilian bioethanol production for 2012/13 is projected at 23.9 billion L

Total sugarcane production is estimated to be 571,47 million tons

Co-generation (burning of the bagasse in boilers) contributes to 4.7% of our electricity

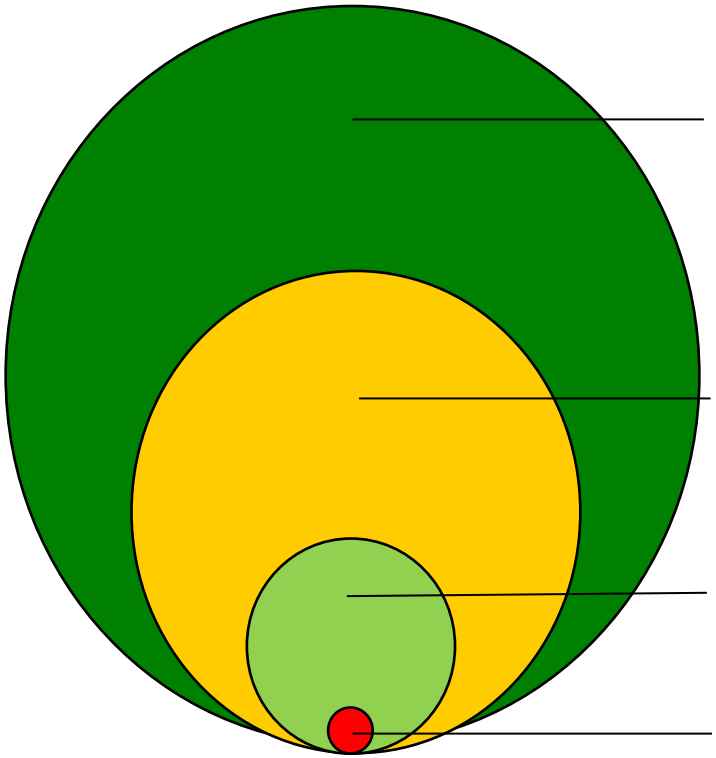
9 million ha sugarcane
405 mills



UnicaData, 2012

Sugarcane for ethanol uses 2% of agricultural area

We have 60 million ha that could be used for expansion



Total country area (851 Mha, 100%)

Rural properties area (355 Mha, 42%)

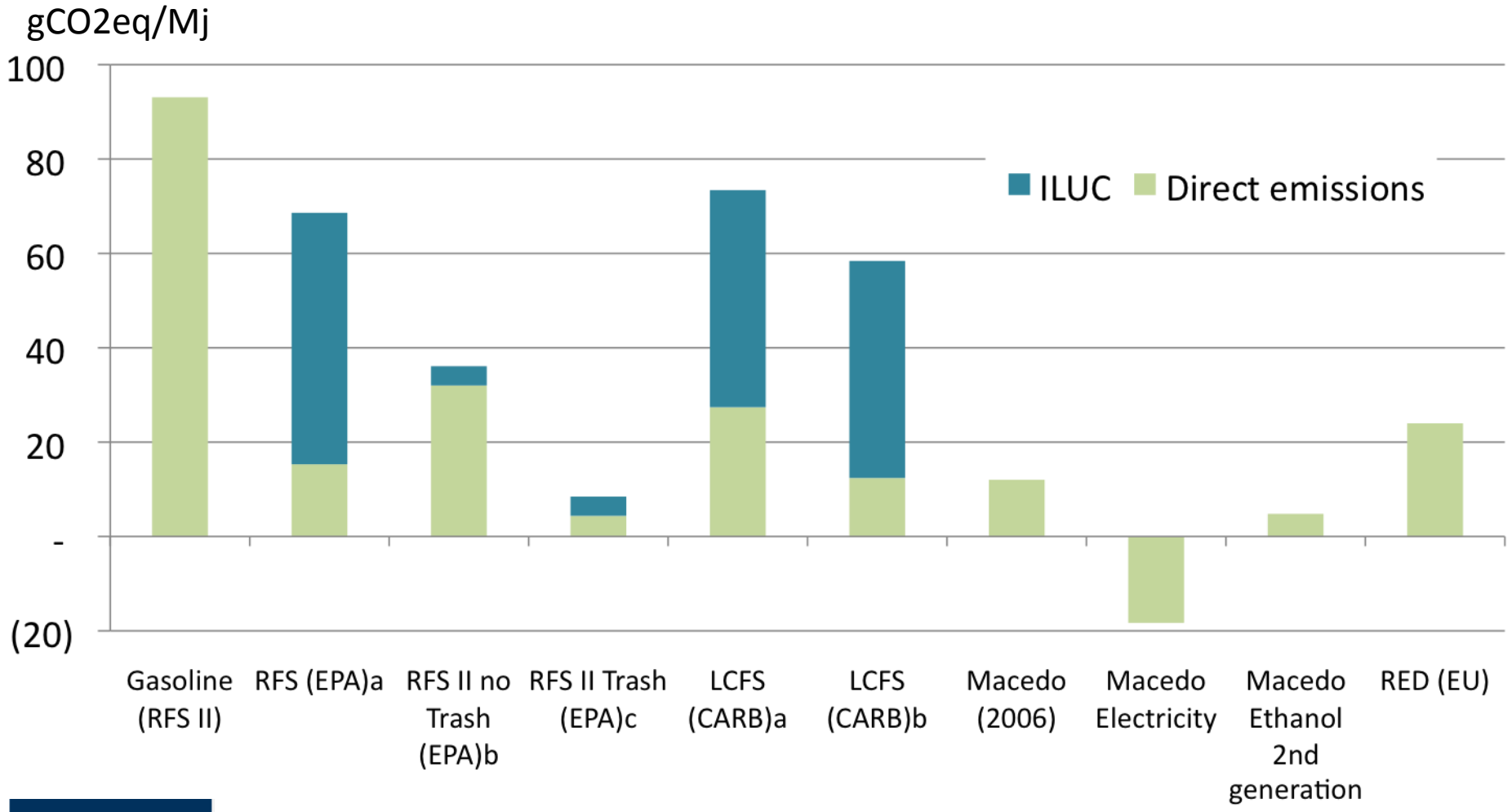
Area used for agriculture (76.7 Mha, 9%)

Area used for sugarcane for ethanol (4 Mha, 0.5%)

Pasture 200 Mha
Soya 22 Mha

Source: Horta Nogueira e Seabra (2008)

80% reduction of GHG emissions using sugarcane ethanol



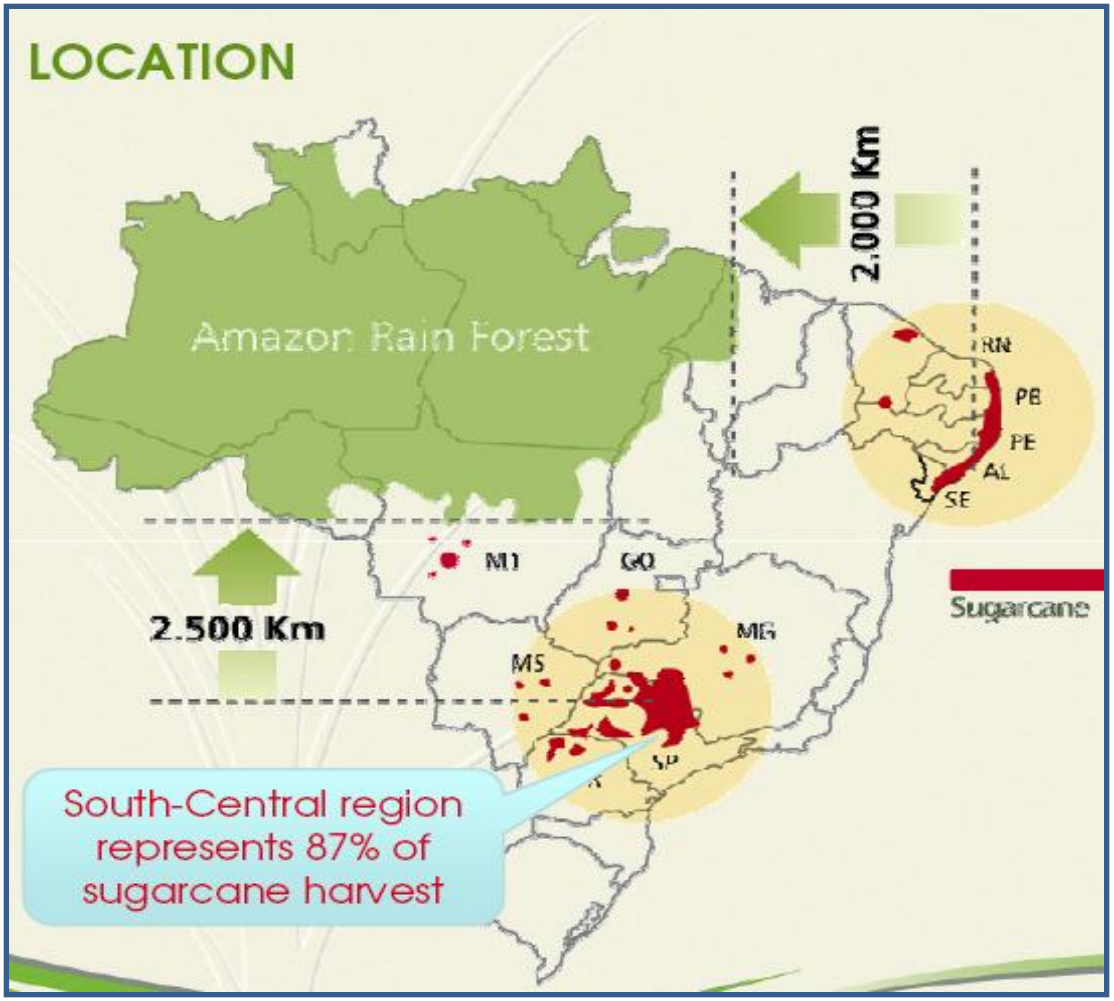
ICONE
Instituto de Estudos do Comércio e Negociações Internacionais

Mandates around the world: demand of 227 billion Liters of EtOH by 2022

Southwest: dry winter

Marginal land, pastureland, and poor soils

- Drought resistance
- Crop breeding to new environments
- Revise nutritional needs and managing of fertilizers
- Recycle nutrients of crop and industry residues
- Land Use Change Models



FAPESP Bioenergy Research Program BIOEN

Fundamental knowledge and new technologies for a bio-based society

- Academic Basic and Applied Research (US$ 30 million)
  59 grants, 300 brazilian researchers, collaborators from 15 countries
  – Regular, Theme and Young Investigator Awards
  Open to foreign scientists who want to come to Brazil

- State of São Paulo Bioenergy Research Center (US$ 90 million)

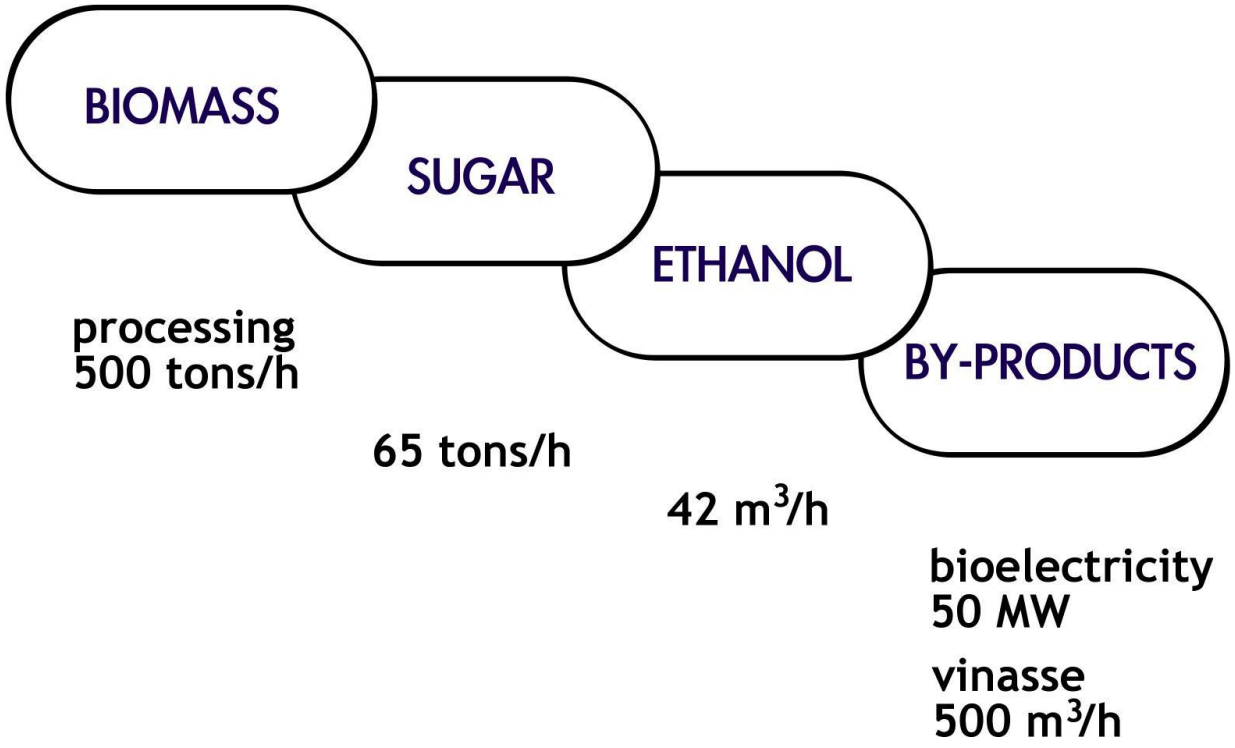
- International partnerships
  United States, United Kingdom and The Netherlands
  (Oak Ridge National Laboratories, UKRC, BBSRC, BE-Basic)

- Innovation Technology, Joint industry-university research (5 years) (US$ 83 million)

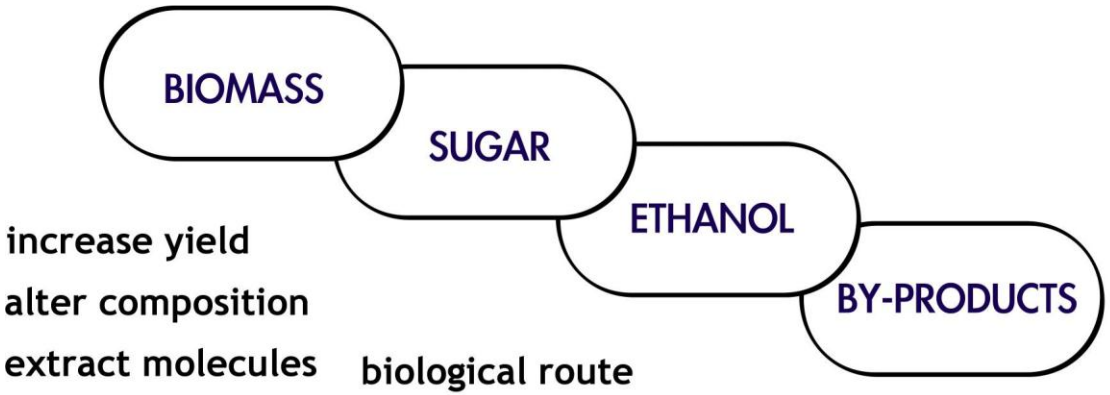
Company	Subject	Value by industry
Oxiteno	Lignocellulosic materials	US$ 3,000,000
Braskem	Alcohol-chemistry	US$ 25,000,000
Dedini	Processes	US$ 50,000,000
ETH	Agricultural practices	US$ 5,000,000
Microsoft	Computational development	US$ 500,000

Australia
Austria
Belgium
China
Denmark
Finland
France
Germany
Guatemala
Italy
Portugal
Spain
The Netherlands
United Kingdom
United States

Sugarcane Agro-industry



Research to expand the industrial model



increase yield
alter composition
extract molecules
transform

biological route
ethanol
butanol
lactic acid

chemical route
biokerosene
green ethane
bulk chemicals
engines

bioelectricity
bagasse
straw
CO_2
cellulosic ethanol
algae biodiesel
syngas
biogas
vinasse

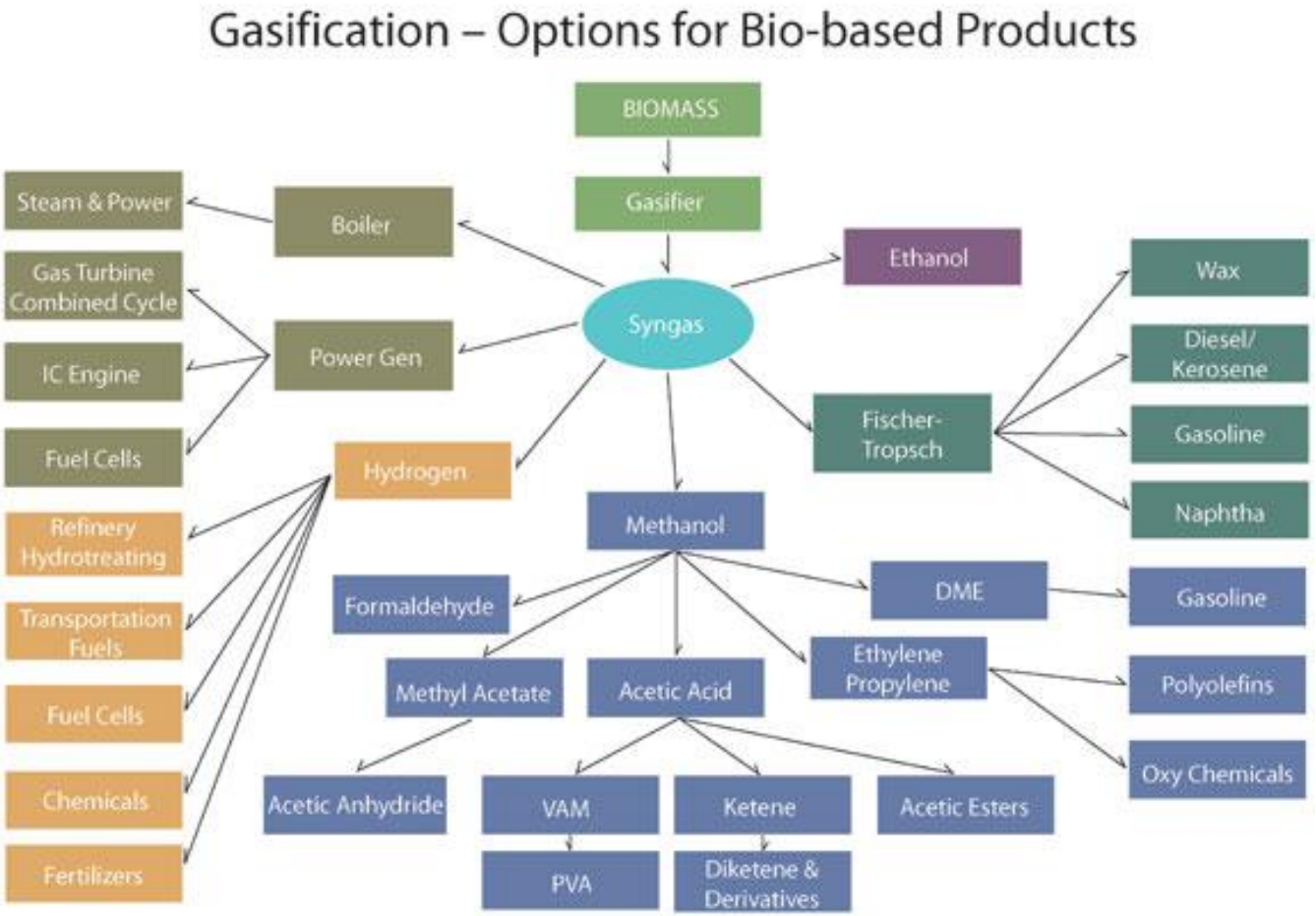
Biomass Gasification

Some advantages

- Almost any biomass can be used to produce Syngas with small adaptations required

- From Syngas many products can be otained (some need improvement)

- Use of Syngas as source of some products is consolidated using coal



Energy Crops and Green Technologies: a new Green Revolution

Development of biorefinery systems

- Zero-carbon emission biorefinery
- Complete substitution of petro-chemicals with bio-based chemicals
- Low water footprint, low polution, low emissions
- Alcohol chemistry, sugar chemistry, oil chemistry to diversify the biomass industry with co-products

New technologies for biomass processing, fuel production, engines

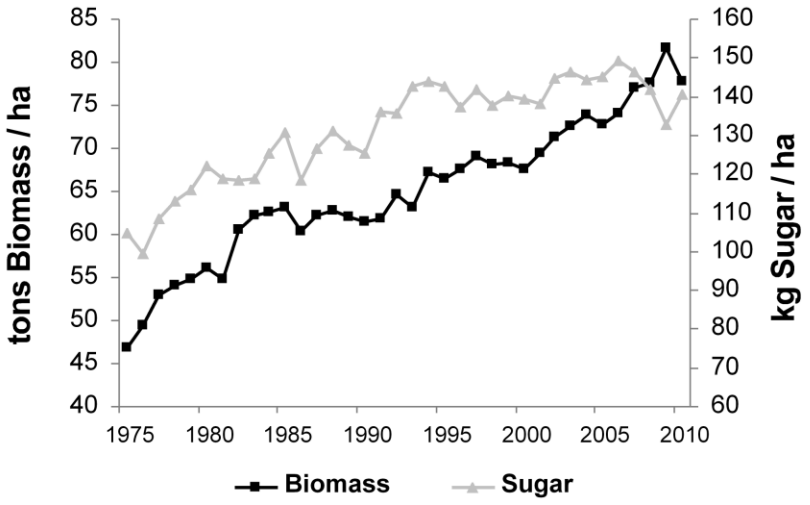
- Low cost of energy production from biomass
- Significantly positive energy balance
- Significant GHG reduction
- Low polution

Designing crops for energy production

- High yield and fast growth crop
- Able to produce under short growing seasons
- Tolerant to periodic drought and low temperatures
- Low nutrient inputs requirements
- Relatively small energy inputs for growth and harvest
- Ability to grow in sub-prime agricultural lands

Sugarcane: the highest tonnage crop

Type of yield	Cane yield ($t\ ha^{-1}\ yr^{-1}$)	Biomass*	
		($t\ ha^{-1}\ yr^{-1}$)	($g\ m^{-2}\ d^{-1}$)
Commercial Average	84	39	10.7
Commercial maximum	148	69	18.8
Experimental maximum	212	98	27.0
Theoretical maximum	381	177	48.5



Theoretical maximum: 380 tons/ha
Current average: 75 tons/ha

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Available online at www.sciencedirect.com
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Current Opinion in Biotechnology
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Sugarcane improvement: how far can we go?

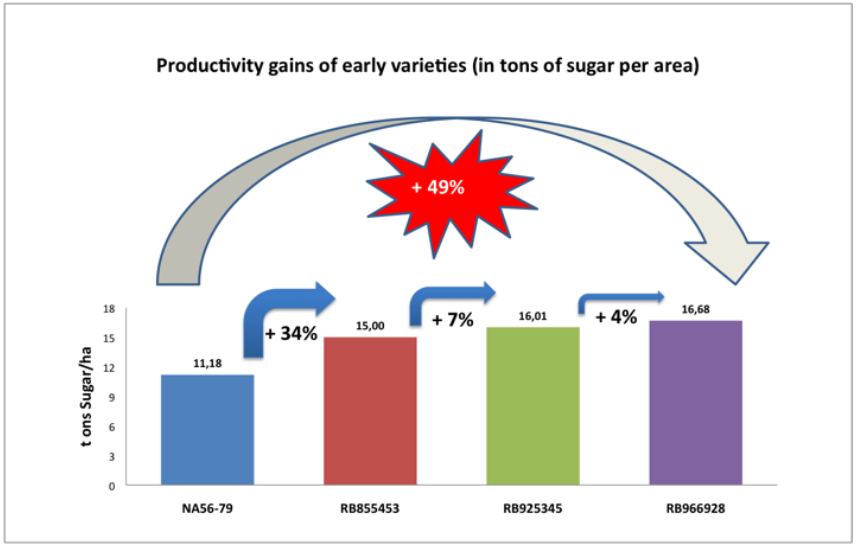
Maximiller Dal-Bianco[1], Monalisa Sampaio Carneiro[2], Carlos Takeshi Hotta[1], Roberto Giacomini Chapola[2], Hermann Paulo Hoffmann[2], Antonio Augusto Franco Garcia[3] and Glaucia Mendes Souza[1]

Plant Biotechnology Journal
Plant Biotechnology Journal (2010) 8, pp. 1–14
doi: 10.1111/j.1467-7652.2009.00491.x

Review article

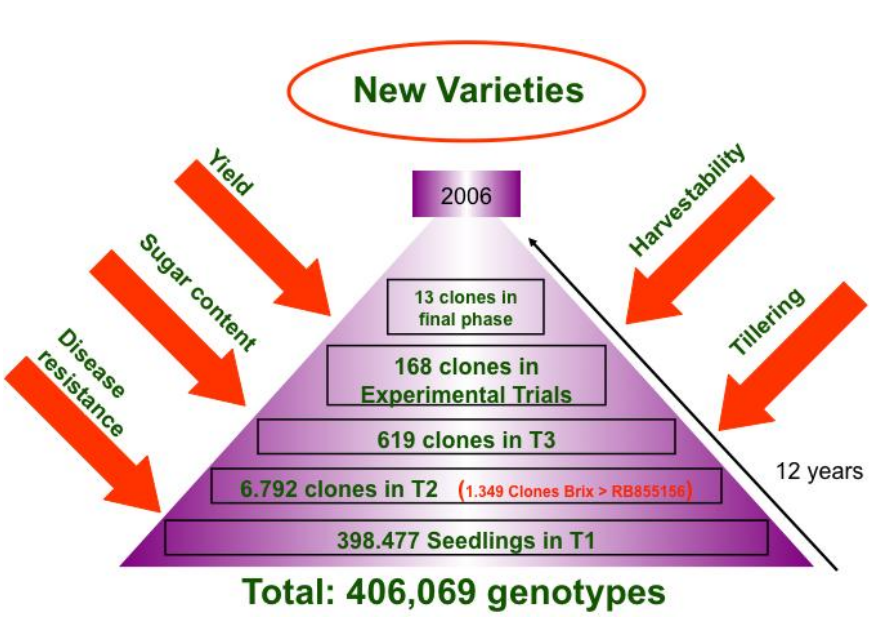
Sugarcane for bioenergy production: an assessment of yield and regulation of sucrose content

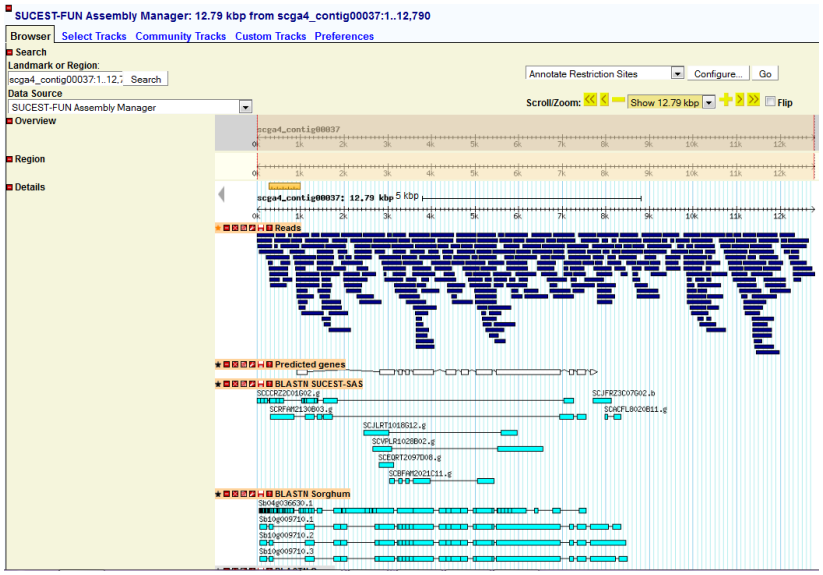
Alessandro J. Waclawovsky[1,†,‡], Paloma M. Sato[1,‡], Carolina G. Lembke[1], Paul H. Moore[2] and Glaucia M. Souza[1,*]



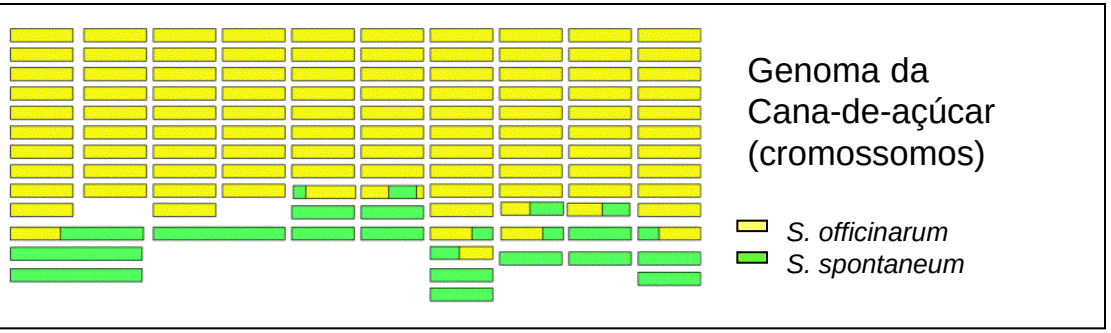
Glaucia Mendes Souza, USP; Monalisa Carneiro, Hermann Hoffmann, UFSCAR

Breeding and Genomics: the challenging sugarcane genome



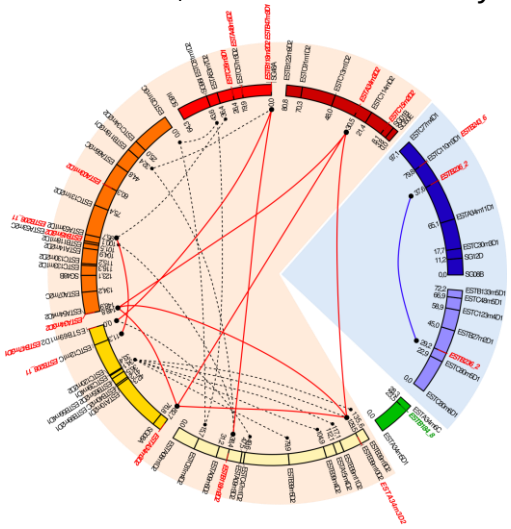


Glaucia Souza, Carlos Hotta, Marie-Anne Van Sluys, USP



Genoma da Cana-de-açúcar (cromossomos)

- *S. officinarum*
- *S. spontaneum*



OPEN ACCESS Freely available online — PLoS one

Efficient Exact Maximum a Posteriori Computation for Bayesian SNP Genotyping in Polyploids

Oliver Serang[1,2]*, Marcelo Mollinari[3], Antonio Augusto Franco Garcia[3]

1 Department of Neurobiology, Harvard Medical School, Boston, Massachusetts, United States of America, 2 Department of Pathology, Children's Hospital Boston, Boston, Massachusetts, United States of America, 3 Department of Genetics, University of São Paulo/ESALQ, Piracicaba, São Paulo, Brazil

Augusto Garcia, USP; Anete Pereira, UNICAMP

Giant Genome (n ≅ 750-930 Mpb), Polyploid (2n = 70-120 cromossomos), ~10 Gb

Fuel production and more: a zero-carbon emission biorefinery

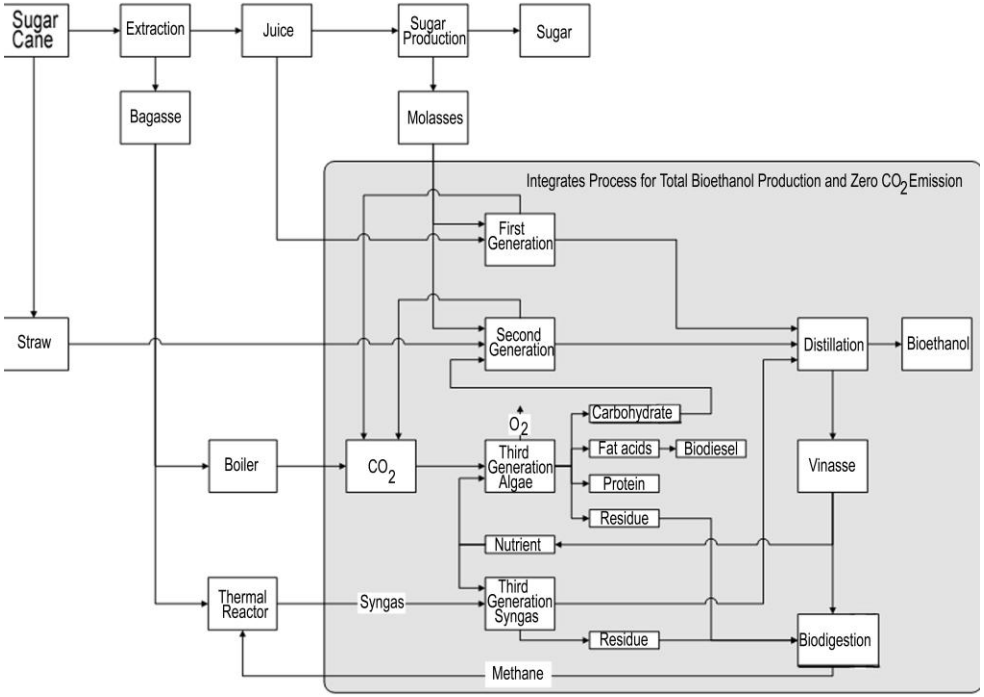
It is possible to have bagasse surplus to produce electricity and ethanol

Integrated bioethanol, biogas and electricity production (double energy output)

Zero carbon emission biorefinery system (consorted bioethanol-biodiesel-biokerosene production)

Bio-based chemicals using a synthetic biology approach (production of lactic acid isomers from sucrose, $$$, 190,000 added value)

Products from ethanol via acetaldehyde and ethylene route (Green Ethane Process to 98.9% purity)



Rubens Maciel, UNICAMP

Cantarella, H., Buckeridge, M. S., Van Sluys, M. A., Souza, A. P., Garcia, A. A. F., Nishiyama-Jr, M. Y., Maciel-Filho, R., Brito Cruz, C. H. and Souza, G. M. (2012). Sugarcane: the most efficient crop for biofuel production. **Handbook of Bioenergy Crop Plants.** Taylor & Francis Group, Boca Rotan, Florida, USA. Editors: Chittaranjan Kole, Chandrashekhar P. Joshi and David R. Shonnard. ISBN: 978-1-4398-1684-4.

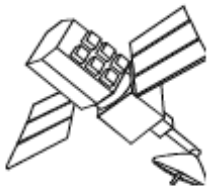
SUSTAINABILITY AND IMPACTS

Ethanol as a global strategic fuel

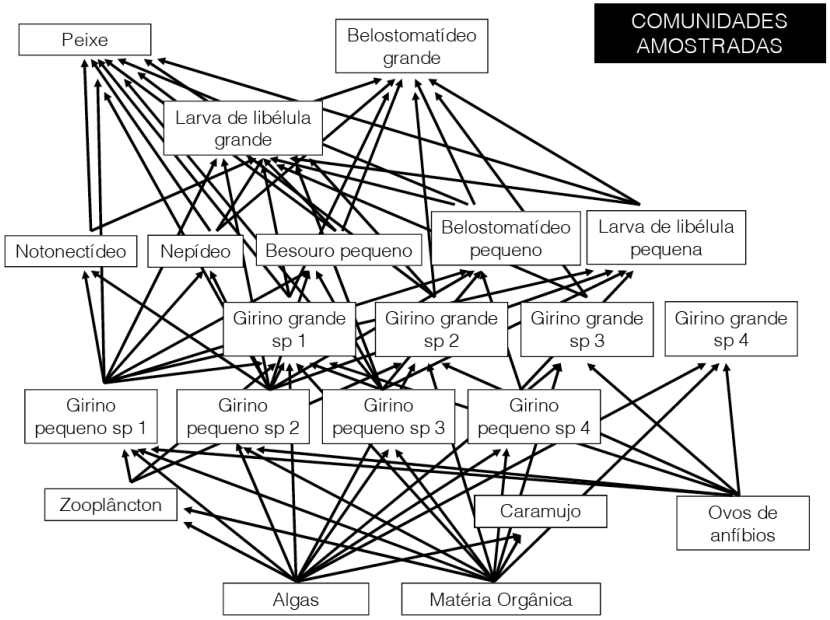
Land use changes
GHG emissions
Biomass and soil carbon stocks
Water use
Biodiversity
Regional income generation
Job creation and migration
Integrating tools

Horizontal studies to consolidate sugarcane ethanol as the leading technology path to ethanol and derivatives production

Monitoring water quality and aquatic communities

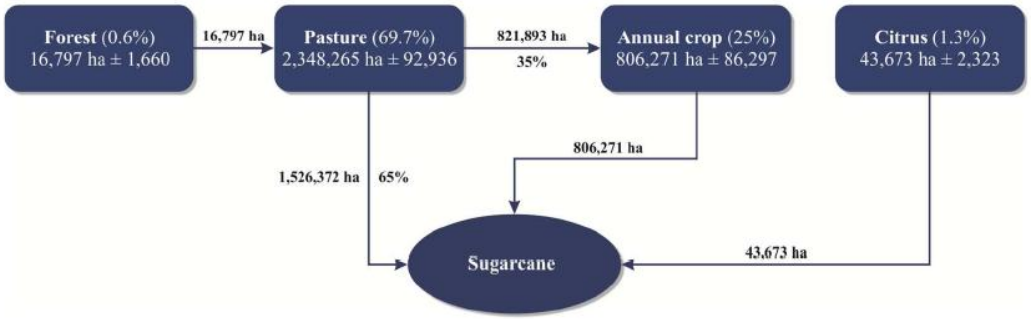


Satelite monitoring of water quality
Capacity to antecipate changes in euthrofization



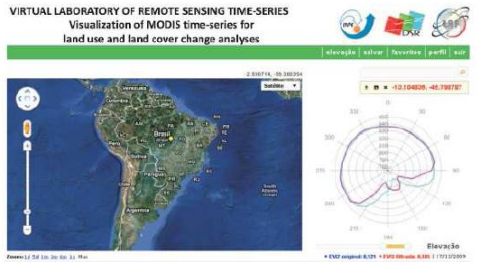
Bernardo Ruddorf, INPE; Luis Schiesari, USP

LUC and ILUC: expansion and GHG emissions



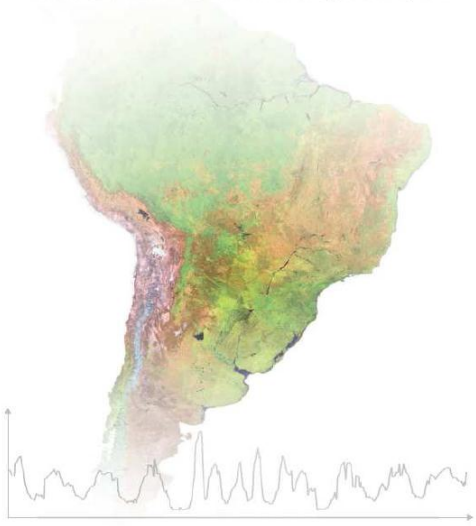
Virtual Laboratory of
Remote Sensing Time-Series

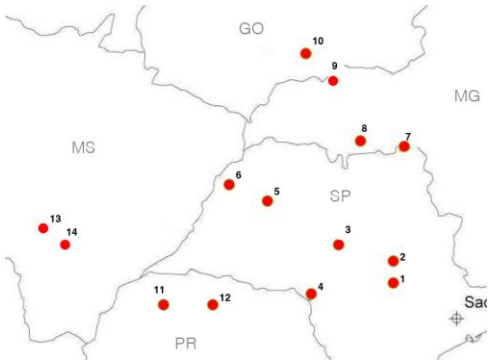
www.dsr.inpe.br/laf/series



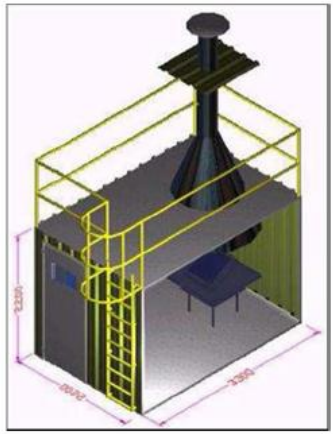
Av. dos Astronautas, 1.758, prédio SERE-II, Jd. Granja - ZIP: 12227-010.
São José dos Campos - SP, Brazil Voice: +55 (12) 3208-6465 e-mail: laf@dsr.inpe.br

Visualization of MODIS
time-series for
land use and land cover change analyses





Soil carbon stocks
N_2O emissions



Emission monitor

Remote sensing series feeding an Economic Model for Food vs. Fuel vs. Land vs. Biodiversity

Bernardo Ruddorf, INPE; Carlos Cerri, USP; Andre Nassar, ICONE

International bioenergy market, certification and policy implications

Competitive and sustainable production of bioenergy in
South America
Central America
Africa

0.43 GHa @ 10kL/Ha.yr

→**Potential 4,300 GL**

2050: Available land for biofuels (Doornbosch and Steenblik, 2007)

New-comers insertion does not depend only on the agricultural and economical aptitudes but on their political institutions, and most important on their capacity to implement public policies for the development of biofuels. Internal public policy legitimacy is a condition necessary for competitiveness.

Public regulatory systems orient the private certification systems. NGOs can intervene with public regulation to assure broad sustainability criteria for biofuels production.

Certification systems that will prevail (e.g. Bonsucro) are those that present lower cost of verification, biomass specific, make use of ongoing public regulation, reduced costs of compliance and verification and are legitimated by social-economic interests (NGOs).

Paulo Furquim de Azevedo, Bruno Perosa; FGV

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Available online at www.sciencedirect.com

ScienceDirect

Current Opinion in Biotechnology

Sugarcane improvement: how far can we go?

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Plant Biotechnology Journal (2010) 8, pp. 1–14 doi: 10.1111/j.1467-7652.2009.00491.x

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Zanca et al. BMC Plant Biology 2010, 10:260
http://www.biomedcentral.com/1471-2229/10/260

BMC Plant Biology

RESEARCH ARTICLE Open Access

Identification and expression analysis of microRNAs and targets in the biofuel crop sugarcane

Almir S Zanca[1†], Renato Vicentini[1†], Fausto A Ortiz-Morea[2], Luiz EV Del Bem[1], Marcio J da Silva[1], Michel Vincentz[1,3], Fabio TS Nogueira[2,4*]

Expression Profile of Signal Transduction Components in a Sugarcane Population Segregating for Sugar Content

Journal	Tropical Plant Biology
Publisher	Springer New York
ISSN	1935-9756 (Print) 1935-9764 (Online)
Issue	Volume 2, Number 2 / June, 2009
DOI	10.1007/s12042-009-9031-8
Pages	98-109
Subject Collection	Biomedical and Life Sciences
SpringerLink Date	Wednesday, July 15, 2009

PDF (394.7 KB) HTML Supplemental Material

Juliana de Maria Felix[2, 5], Flávia Stal Papini-Terzi[3], Flávia Riso Rocha[3], Ricardo Zorzetto Nicoliello Vêncio[3], Renato Vicentini[1, 2], Milton Yutaka Nishiyama Jr[3], Eugênio César Ulian[4], Gláucia Mendes Souza[3] and Marcelo Menossi[2]

Tropical Plant Biol.
DOI 10.1007/s12042-010-9050-5

The Biotechnology Roadmap for Sugarcane Improvement

Carlos T. Hotta · Carolina G. Lembke · Douglas S. Domingues · Edgar A. Ochoa · Guilherme M. Q. Cruz · Danila M. Melotto-Passarin · Thiago G. Marconi · Melissa O. Santos · Marcelo Mollinari · Gabriel R. A. Margarido · Augusto César Crivellari · Wanderley D. dos Santos · Amanda P. de Souza · Andrea A. Hoshino · Helaine Carrer · Anete P. Souza · Antônio A. F. Garcia · Marcos S. Buckeridge · Marcelo Menossi · Marie-Anne Van Sluys · Glaucia M. Souza

BMC Genomics

BioMed Central

Research article Open Access

Sugarcane genes associated with sucrose content

Flávia S Papini-Terzi[1], Flávia R Rocha[1], Ricardo ZN Vêncio[2], Juliana M Felix[3,5], Diana S Branco[3], Alessandro J Waclawovsky[1], Luiz EV Del Bem[3], Carolina G Lembke[1], Maximiller DL Costa[1], Milton Y Nishiyama Jr[1], Renato Vicentini[4,5], Michel GA Vincentz[3,4], Eugênio C Ulian[5,6], Marcelo Menossi[4] and Glaucia M Souza*[1]

Characterization of new polymorphic functional markers for sugarcane

Authors: Oliveira, K. M.; Pinto, L. R.; Marconi, T. G.; Mollinari, M.; Ulian, E. C.; Chabregas, S. M.; Falco, M. C.; Burnquist, W.; Garcia, A. A.F.; Souza, A. P.

Source: Genome, Volume 52, Number 2, 1 February 2009 , pp. 191-209(19)

Marconi et al. BMC Research Notes 2011, 4:264
http://www.biomedcentral.com/1756-0500/4/264

BMC Research Notes

SHORT REPORT Open Access

Functional markers for gene mapping and genetic diversity studies in sugarcane

Thiago G Marconi[1], Estela A Costa[1], Hercília RCAN Miranda[1], Melina C Mancini[1], Cláudio B Cardoso-Silva[1], Karine M Oliveira[1,5], Luciana R Pinto[2], Marcelo Mollinari[3], Antônio AF Garcia[3] and Anete P Souza[1,4*]

Bioresource Technology 102 (2011) 7887–7895

Contents lists available at ScienceDirect

Bioresource Technology

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

Production of bioethanol, methane and heat from sugarcane bagasse in a biorefinery concept

S.C. Rabelo [a,b,*], H. Carrere [b], R. Maciel Filho [a], A.C. Costa [a]

J Ind Microbiol Biotechnol
DOI 10.1007/s10295-010-0867-6

ORIGINAL PAPER

Simulation of integrated first and second generation bioethanol production from sugarcane: comparison between different biomass pretreatment methods

Marina O. S. Dias · Marcelo Pereira da Cunha · Rubens Maciel Filho · Antonio Bonomi · Charles D. F. Jesus · Carlos E. V. Rossell

Appl Biochem Biotechnol (2010) 161:227–237
DOI 10.1007/s12010-009-8828-0

Production of Lactic Acid from Sucrose: Strain Selection, Fermentation, and Kinetic Modeling

Betânia H. Lunelli · Rafael R. Andrade · Daniel I. P. Atala · Maria Regina Wolf Maciel · Francisco Maugeri Filho · Rubens Maciel Filho

ARTICLE

BIOTECHNOLOGY AND BIOENGINEERING

Bioproduction of Butanol in Bioreactors: New Insights From Simultaneous In Situ Butanol Recovery to Eliminate Product Toxicity

Adriano Pinto Mariano,[1,2] Nasib Qureshi,[3] Rubens Maciel Filho,[2] Thaddeus Chukwuemeka Ezeji[1]

BIOEN FAPESP

Sustainability **2012**, *4*, 574-585; doi:10.3390/su4040574

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ISSN 2071-1050
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Article

Remote Sensing Time Series to Evaluate Direct Land Use Change of Recent Expanded Sugarcane Crop in Brazil

Marcos Adami *, Bernardo Friedrich Theodor Rudorff, Ramon Morais Freitas, Daniel Alves Aguiar, Luciana Miura Sugawara and Marcio Pupin Mello

Remote Sensing Division (DSR), National Institute for Space Research (INPE), Av. dos Astronautas 1758, São José dos Campos, São Paulo 12227-010, Brazil; E-Mails: bernardo@dsr.inpe.br (B.F.T.R.); ramon@dsr.inpe.br (R.M.F.); daniel@dsr.inpe.br (D.A.A.); lmiura@dsr.inpe.br (L.M.S.); mello@ieee.org (M.P.M.)

Biofuels and land-use changes: searching for the top model

Andre M. Nassar, Leila Harfuch, Luciane C. Bachion and Marcelo R. Moreira

Institute for International Trade Negotiations (ICONE), 740 General Furtado do Nascimento, suite 81, Sao Paulo 05465-070, Brazil

model. Interface Focus 1, 224–232. (doi:10.1098/rsfs.2010.0043)
http://rsfs.royalsocietypublishing.org/content/early/2011/02/04/rsfs.2010.0043.full.html#related-u

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Archive > Volume 474 > Issue 7352 > Outlook > Article

NATURE | OUTLOOK

Perspective: Lessons from Brazil

Marcia Moraes

Nature **474**, S25 (23 June 2011) | doi:10.1038/474S025a
Published online 22 June 2011

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