Final Program

Quantifying and managing land use effects of bioenergy

19-21 September 2011, Campinas, Brazil

Jointly organized by:

IEA Bioenergy

Task 38: Greenhouse Gas Balances of Biomass and Bioenergy Systems

Task 40: Sustainable International Bioenergy Trade - Securing Supply and Demand

Task 43: Biomass Feedstocks for Energy Markets

Hosted and sponsored by:

CTBE Brazilian Bioethanol Science and Technology Laboratory

Workshop Rationale and Aim

In the past decades, the production of biomass for energy in agriculture and forestry has increased in many parts of the world. For years to come, further increase in land use for bioenergy will be needed to meet the renewable energy ambitions of many countries, and to reduce fossil fuel use and associated GHG emissions. As many industrialized countries have a limited biomass production potential compared to their prospective demand, it is expected that substantial international bioenergy trade will develop in the coming decades where regions such as Latin America and sub-Saharan Africa will produce feedstocks for both domestic consumption and for export.

Increasing the production and energetic use of biomass has many direct and indirect effects, including land-use related GHG emissions, impacts on biodiversity, and other environmental and social effects. However, while much of the recent years' debate has concerned negative effects, it is important to note that bioenergy expansion can also lead to positive environmental and socio-economic outcomes.

This workshop aims to bring together current state-of-the-art research concerned with assessing land use effects of bioenergy, mitigating negative impacts, and promoting beneficial outcomes.

Contact Information

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Workshop Co-Ordination

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Workshop setup and field trips

The workshop will be held at the premises of the Brazilian Bioethanol Science and Technology Laboratory (Laboratório Nacional de Ciência e Tecnologia do Bioetanol - CTBE), located at Brazilian Center of Research in Energy and Materials in Campinas, Sao Paulo, Brazil. For more information, see http://www.bioetanol.org.br/english/index.php. The city of Campinas can be reached from Sao Paulo Guarulhos International Airport in approximately 1 - 1.5 hours by bus or car.

The workshop features two full days (19-20 September) of presentations, including an evening poster session on Monday, and a full day (21 September) technical field trip. Two field trip options will be provided: one field trip will visit a sugarcane plantation and mill (planning to see the green cane harvesting and other agricultural operations in the morning and the distillery and power generation facilities in the afternoon); the second will visit a Eucalyptus plantation and the associated processing plant.

Lunch will be provided at the workshop on both days. On Monday evening, finger food will be provided during the poster session, and on Tuesday evening, we offer a workshop dinner. In case you will take other meals at the hotel: The prices vary according to the menu choice, but are typically around R$ 35- 40 for each meal.

REGISTRATION FOR THE CONFERENCE WILL REMAIN OPEN UNTIL SEPTEMBER 15TH, 2011

Registration and payment should be made through the following website: http://www.bioetanol.org.br/hotsite/workshop8

Accommodation

We kindly ask the participants to make their room reservations through the following travel agency, mentioning that you are joining this workshop:

Flytour American Express Business Travel, **contact: João Marcelo Rossini**
joao.cpq@flytour.com.br, Tel.: 55 19 3343.4634 / Fax: 55 19 3343.4617

You can choose between two hotels (prices were only guaranteed till mid-August and may be subject to change):

COMFORT SUITES:
http://www.atlanticahotels.com.br/atlantica/hoteis/estrutura.asp?Numfuncionalidade=292&NumHotel=24
Single Rate Standard **Apartment**: R$ 185.00[1] + 5% tax with breakfast included
Double Rate Standard **Apartment**: R$ 217.00 + 5% tax with breakfast included
Single Rate Deluxe **Apartment**: R$ 220.00 + 5% tax with breakfast included
Double Rate Deluxe Apartment: R$ 252.00 + 5% tax with breakfast included

SOL INN Barão Geraldo:
http://www.hotelariabrasil.com.br/solinnbaraogeraldo/
Single Rate Executive Apartment: R$ 194.00 + 5% tax with breakfast included
Double Rate Executive Apartment: R$ 226.00 + 5% tax with breakfast included
Single Rate Superior Apartment: R$ 223.00 + 5% tax with breakfast included
Double Rate Superior Apartment: R$ 258.00 + 5% tax with breakfast included

[1] The present currency exchange rate is Euro 1.00 = BR$ 2.32. 1 US$ = 1.62 BR$ (variations are usually small).

Getting to Campinas

Most international participants will arrive in São Paulo at the Guarulhos International Airport (GRU), which offers excellent airline connections for the whole world, at a distance of less than 60 minutes from the inner city. The Airports of São Paulo-Congonhas (CGH) and Campinas-Viracopos (VCP) are also convenient choices depending on flight availability.

Infraero Guarulhos: 55 11 2445 2945 (Central Information of the Airport)

How to change money at the airport

You have 2 possibilities:

A) Use an electronic cash machine: there are many at the airport (Santander, Bradesco, Itaú....)

B) Use a Money Exchange office

- Action Cambio – from 05 to 00h
  Passengers Terminal 1 – Wing B – phone: 55 11 2445 4458
- American Express – Foreign Exchange – from 05 to 00h
  Passengers Terminal 1 – Wing A – phones: 55 11 2445 3351 2445 3835
- Confidence Cambio – 24hrs
  Passengers Terminal 2 – Wing C – phone; 55 11 2445 3762
- Safra Bank – 24hrs
  Passengers Terminal 1 – Wing B
  Passengers Terminal 2 – Wing C – phones: 55 11 2445 3701 – 55 11 2445 2321

How to take the bus to Campinas

CAPRIOLI BUS (11) 2445-3506 | (11) 2445-3869.
As soon as arriving at the Airport in São Paulo (Aeroporto de Cumbica Guarulhos), you should go to Terminal 2, Wing C. There are 2 terminals, 1 and 2, both of them at walking distance (150m).

At the exit, on your right, at 50m, you will see buses with sign “CAPRIOLI”. Before going to the buses, you should go on the left to buy your ticket: you first have car rental offices, then “ONIBUS” ticket offices and finally “CAPRIOLI” ticket office. The price of the bus ticket is **R$ 37.00 = USD 22.00 (they accept USD or EUR)**.

It takes 1h30 min from SP Airport to Campinas (~120 km). Below you can find the timetable of the bus from Guarulhos airport to Campinas:

00:30 06:45 08:00 09:00 10:30 AM / / 12:00 1:00 2:00 5:30 6:45 8:00 9:30 11:00 PM

Arriving in Campinas downtown at the Caprioli Bus Terminal “Largo do Pará”, take a taxi to Barão Geraldo (the District of Campinas where CTBE and the hotels are located ; the trip should cost around R$ 30, and must be paid in Brazilian currency.

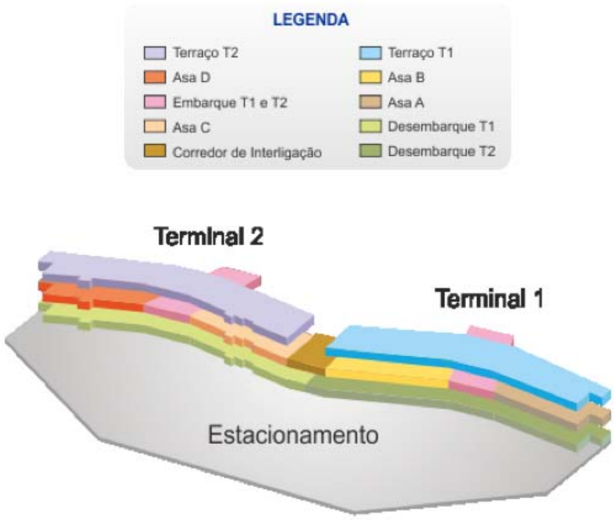
Getting to CTBE

The CTBE is located at: Rua Giuseppe Máximo Scolfaro, 10.000 - Polo de Alta Tecnologia - Campinas – SP, close to the UNICAMP campus, north of the city of Campinas.

Buses will be bringing workshop participants from the above hotels to CTBE in the morning, and back in the evening. A general route description on how to reach CTBE is available at:

http://www.bioetanol.org.br/english/interna/index.php?chave=visitors

CAPRIOLI – Terminal 2 ASA C (Wing C)



Estacionamento = Parking Lot

Miscellaneous

Visa Requirements
Passport-holders from countries in West Europe as well as from South America will not need a visa to enter Brazil. For some nationalities the visa has to be applied before arrival at the Brazilian Embassy or Consulate. Useful information is also available at:
http://www.braziltour.com/dicaturista/dicasPassaporte.html

Insurance
Registration fees do not include insurance of any kind. It is strongly recommended that at the time you register for the workshop and book your travel you consider an insurance policy of your choice to protect your interests in relation to cancellations, medical expenses, loss or damage to personal property. The conference organizers cannot take any responsibility for participants failing to arrange their own insurance.

Program Outline CTBE, Brazilian Center of Research in Energy and Materials, Campinas, Sao Paulo	
Monday 19 September 2011	
8:00	Registration Opens The timetable of the transportation between the hotels and the workshop venue will be sent by email to the registered participants.
9:00-9:10	Official Opening – Arnaldo Walter, University of Campinas - Manoel Regis Lima Verde Leal, Brazilian Bioethanol Science and Technology Laboratory
9:10-10:30	**Session 1: Plenary**
10:30-11:00	Coffee Break
11:00-13:00	**Session 1: Plenary (continued)**
13:00-14:00	Lunch
14:00 -15:20	**Session 2: Quantifying land use effects of bioenergy** **Concurrent sessions of contributed papers** ****Each presentation in Sessions 2 and 3 will be 20 minutes, including 2-3 minutes for questions/discussion** Session 2a: **Conceptual approaches**: Methodology, modeling approaches, estimation techniques Session 2b: **Practical application**: Case study results, demonstration of methods
15:20-15:40	Coffee Break
15:40-17:30	**Concurrent sessions of contributed papers (continuation)**

18:00	**Poster session**: Drinks and finger-foods served
Tuesday 20 September 2011	
8:30-10:30	**Session 3 Concurrent sessions of contributed papers** **Session 3a: Quantifying land use effects of bioenergy - continued** **Session 3b: Managing land use effects of bioenergy –** **Conceptual responses**: Policy mechanisms, certification concepts, models for managing trade-offs.
10:30-11:00	Coffee Break
11:00:13:00	**Session 3: Concurrent sessions contributed papers** **Session 3a: Quantifying land use effects of bioenergy - continued** **Session 3b: Managing land use effects of bioenergy -** **Practical application:** examples of policies, standards, certification schemes; assessment of their application; tools for integrated land use planning.
13:00 -14:00	Lunch
14:00-16:40	**Session 4: Plenary**
16:40-17:10	**Workshop summary**
17:10-17:30	**Closing**
19:00	**Conference Dinner** Details on the location and logistics will be sent by email to registered participants and announced during the workshop.

<table>
<tr><th colspan="2">Wednesday 21 September 2011</th></tr>
<tr><td>7:00-17:00</td><td>Field trips
Both trips will depart at 7 AM, and return at approximately 5:00 PM .
Participants will be picked up from SOL INN Barão Geraldo and Comfort suites Hotels. Final details will be announced during the workshop. Breakfast is served from 6 AM at the Comfort suites, and 6:30 AM at the SOL INN.

1. Visit to the Cresciumal Sugar/Ethanol Mill
Location: Leme, São Paulo
Mill data for the 2011/2012 season
• Total milled cane: 1.7 million tonnes (50% harvested unburnt)
• Sugar production: 140,000 tonnes
• Ethanol production: 44 million liters
• Total electricity production: 95 GWh (56.5 kWh/tc)
• Surplus electricity sold to the grid: 70.5 GWH (42 kWh/tc)
Energy sector: 200 t/h bagasse fired boiler, steam @ 66 bar/ 520 ºC, turbine generators of 15 and 21 MW
Visit Program:
• Morning: cane field operations
• Lunch will be at the company restaurant
• Afternoon: sugar/ethanol factory
Note that it will not possible to enter the ethanol distillery area due to safety reasons, but all other areas will be visited (cane preparation and juice extraction, juice treatment and concentration, sugar factory, energy sector).

2. Visit to the International Paper Eucalyptus Plantations
Location: Mogi Guaçu, São Paulo
The International Paper eucalyptus plantation is certified by CERFLOR (Brazilian Forest Certification Program). The factory at that site produces bleached eucalyptus kraft cellulose.
Visit Program:
• Morning: seedlings and research areas
• Lunch will be at the company restaurant
• Afternoon: planting and harvesting operations</td></tr>
<tr><td>±17 :00</td><td>Return to Campinas</td></tr>
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Technical Program Detail

WORKSHOP TECHNICAL SESSIONS – DAY 1 ***Monday Sept. 19, 2011***

8:00 **Registration opens**

9:00 **Opening of the Workshop**

Welcome and Introduction

Arnaldo Walter, University of Campinas

Manoel Regis Lima Verde Leal, Brazilian Bioethanol Science and Technology Laboratory

9:10-13:00 **Session 1 Plenary 1**

Chaired by Arnaldo Walter, Task 40

Invited speakers presenting the perspectives of key government, industry and NGO bodies on the significance of land use effects of bioenergy, and approaches being taken to manage impacts and promote bioenergy systems that avoid/mitigate negative effects.

Introduction by André Faaij, Utrecht University, Task 40 and Göran Berndes, Chalmers University, Task 43

- **Neil Bird, Joanneum Research, Task 38**, Bioenergy, sustainability and trade-offs: Can we avoid deforestation while promoting bioenergy? Results of a CIFOR project
- **Robert H. Beach, RTI International:** Economic and environmental impacts of U.S. bioenergy policies
- **Govinda R. Timilsina, World Bank**: Biofuels, land-use change and climate change mitigation: Some insights from global CGE model simulations
- **David Laborde, IFPRI:** Assessing the land use change consequences of European Biofuel Policies
- **Holger Matthey, FAO:** Global agriculture to 2020: drivers and issues
- **André Nassar, ICONE:** Land use models and iLUC under a Brazilian perspective

14:00-17:30 Parallel Session 2a Quantifying land use effects of bioenergy – Conceptual approaches: Methodology, modeling approaches, estimation techniques

Chaired by: Neil Bird, Joanneum Research, Task 38

- **Cheney Shreve et al., Winrock International:** Developing a framework for monitoring biofuel sustainability: Integrating remote sensing and geospatial analysis to quantify impacts of biofuel expansion
- **André Nassar et al., Institute for international trade negotiations:** The development and use of methodologies to measure direct and indirect land use effects of sugarcane bioethanol
- **Francesco Cherubini et al., Norwegian University of Science and Technology (NTNU):** What is the contribution to Global Warming of time-distributed biogenic CO2 fluxes ?
- **Rodrigo Augusto Freitas de Alvarenga et al., Ghent University, Belgium:** Accounting land as natural resource for energetic and exergetic LCA - a new method
- **Annette Cowie, National Centre for Rural Greenhouse Gas Research, University of New England:** Can biochar reduce the pressure on land used for bioenergy?
- **Serina Ahlgren et al., Lund University:** Combining economic modelling and life cycle assessment – is it possible from a scientific method point of view?
- **Robert Beach et al., RTI International**: Oil price shocks and the U.S. bioenergy market: Assessing demand and land use impacts
- **Keith Kline et al, Oak Ridge National Lab:** 'Top Ten' steps to improve the quantification of land-use change effects of bioenergy systems

14:00-17:30 Parallel Session 2b Quantifying land use effects of bioenergy – Practical application: Case study results, demonstration of methods

Chaired by: André Faaij, Utrecht University

- **Gerd Sparovek et al., University of Sao Paulo, Dept. of Soil science:** The revision of the Brazilian forest act: increased deforestation or a historic step towards balancing agricultural development and nature conservation
- **Elisa Dunkelberg, Institut für ökologische Wirtschaftsforschung (IÖW):** Sugarcane Ethanol production in Malawi: A 'real word' case study on indirect effects
- CANCELLED: **Rob Bailis et al, Yale School of Forestry and Environmental Studies:** Carbon impacts of direct land use change in semiarid woodlands converted to biofuel plantation in India and Brazil
- **Nicole Kalas et al., Imperial College London: c**LCA of European biodiesel – estimation of key drivers for iLUC and identification of mitigation option
- **Lorie Hamelin et al., Univ. of Southern Denmark:** Modeling environmental consequences of direct LUC from energy crops in a self-sustained and fully renewable energy system in Denmark: Effect of crop types, soil, climate, residues management, initial carbon level and turn over time
- **Anders Hammer Strømman, et al, Norwegian University of Science and Technology (NTNU):** Radiative forcing impacts of boreal forest biofuels: A dynamic study for Norway in light of Albedo
- **Pål Börjesson et al., Lund University:** The climate benefit of Swedish ethanol – present and prospective performance
- **Maggie R. Stevens, Oak Ridge National Lab:** Decomposition analysis of empirical data to recognize potential land-use Effects of bioenergy

18:00 Poster Session

(see separate list of poster authors and titles)
Drinks and finger foods served

WORKSHOP TECHNICAL SESSIONS – DAY 2 ***Tuesday Sept. 20, 2011***

8:30-13:00 Session 3a Quantifying land use effects of bioenergy –continuation

Chaired by: Gustaf Egnell, Task 43

- **Michael O'Hare, University of California:** Policymaking for refractory uncertainty
- **Leif Gustavsson et al., Linnaeus University:** Time-dependent climate benefits of using forest residues to substitute fossil fuels
- **Kim Pingoud et al., VTT Technical Research Centre of Finland:** GWP factors and warming payback times as climate indicators of forest biomass use cycles
- **Richard Hess et al., Idaho National Laboratory:** The importance of pre-conversion technologies for coupling sustainable bioenergy land use to biomass trade
- **Hector M. Nuñez et al., University of Illinois Urbana-Champaign:** A prospective analysis of Brazil and U.S. biofuel policies: Impacts on land use, greenhouse gas emissions, and social welfare
- **Klaus Peter Zulka et al., Environment Agency Austria:** Approaches to quantify the biodiversity effects of biofuel production
- **Oscar Englund et al., Chalmers University:** Biodiversity considerations in certified biomass production
- **Érica Geraldes Castanheira et al., University of Coimbra**: GHG life-cycle assessment of soybean-based biodiesel: assessing the implications of alternative land use change scenarios
- **Barbara Kishchuk, et al., Canadian Forest Service, Natural Resources Canada**: Nutrient and carbon trajectories, LUC, and the sustainability of short rotation woody crop production for bioenergy in Canada
- **Saori Miyake, School of Geography, Planning and Environmental Management, Univ. of Queensland:** Framework for evaluating the environmental consequences of bioenergy-driven land-use changes at local and regional scales

8:30-10:30 **Session 3b Managing land use effects of bioenergy**

Conceptual responses: Policy mechanisms, certification concepts, models for managing trade-offs

Chaired by: Göran Berndes, Chalmers University

- **Keith Kline, Oak Ridge National Lab**: Moving forward: bioenergy policies to improve land-use and address social concerns
- **Julie Witcover et al., Institute for Transportation Studies, UC Davis**: Market-mediated land use change and biofuel policy towards an evaluation of mitigation options
- **Kenneth Hermele , Human Ecology Department, Lund University:** Sustainable agro-fuels, land use change, and certification schemes
- **Bruno Perosa et al., The University of Illinois**: The three pillars to operationalizing biofuels sustainability - standards in agricultural and forest landscapes
- **Birka Wicke et al., Utrecht University**: Improved modeling and mitigation of land use change related to bioenergy production

11:00-13:00 **Session 3b Managing land use effects of bioenergy**

Practical applications: examples of policies, standards, certification schemes, assessment of their application, tools for integrated land use planning

Chaired by: Martin Junginger, Utrecht University

- **Jasper van de Staaij, Ecofys Netherlands BV**: Developing and field testing a certification module for low indirect impact biofuels
- **Virginia Dale et al., Oak Ridge National Lab**: Indicators to support environmental sustainability of bioenergy
- **Eduardo Barretto de Figueiredo et al., FCAV/UNESP Depto Ciências Exatas:** Mitigation assessment of greenhouse gas due to the conversion of sugarcane areas from burned to green harvest, considering reduced tillage and the crop-rotation

14:00-16:40 **Session 4 Plenary 2**

Chaired by Annette Cowie, University of New England

Synthesis presentations by the IEA Bioenergy Task Leaders summarizing issues addressed in Sessions 2 and 3, panel discussion: Can we ensure sustainability through certification? Panel members from government, industry and NGOs, including the following speakers:

- **Victoria Junquera**, **Roundtable on Sustainable Biofuels**: Addressing indirect impacts of biofuel production in sustainability standards
- **Alison Goss Eng, US DOE**: Data, analysis, and field studies to evaluate and minimize land use change impacts of large-scale bioenergy production
- **Evelyne Thiffault, Natural Resources Canada:** Establishing ecologically sustainable forest biomass supply chains - a case study in the boreal forests in Canada
- **Fabio Marin, EMBRAPA:** Acroecological Zoning for Biofuels
- **Gerd Sparovek, University of Sao Paulo**
- **Eduardo Leão de Souza, UNICA**
- **Keith Kline, Oak Ridge National Lab**

16:40-17:10 **Summary and Closing**

17:30 **Workshop Dinner**

Posters

- João Luis Nunes Carvalho, Delta CO2: Quantification of soil carbon stock changes due to the expansion of sugarcane areas in Brazil
- Gustaf Egnell, SLU, Dept. Of Forest Ecology and Management: Realistic expectations on biomass potential in conventional forestry and agriculture - Swedish experiences
- Yaw Sasu-Boakye, Chalmers University of Technology: Greenhouse gas emissions and land use change from the substitution of Brazilian soybean with locally produced protein feedstuff in Scandinavian dairy and pig production.
- **CANCELLED:** Nicolae Scarlat, Joint Research Centre, EC: Impact of national renewable energy plans (NREAPs) in terms of European land use
- Emma Jonson, Chalmers University of Technology: Estimating indirect land use changes of biofuels given increased organic farming in Europe
- Andrea Restrepo Ramirez, University of Brasilia: Potential effects of Brazilian biodiesel and palm oil program on socioeconomic insertion of family farming
- Georgia Ribeiro Silveira de Sant'Ana, Federal University of Goias: Impacts of sugar cane cultivation on physical-chemical, biochemical and microbiological properties of yellow and red oxisols under different management in the microregion of Quirinopolis, GO, Brazil
- Hans Langeveld, Wageningen University: Using multipliers to assess ecological and economic interlinkages between bioenergy and other cropping systems in North America
- Saori Miyake, School of Geography, Planning and Environmental Management, Univ. of Queensland: Land-use pressures resulting from bioenergy crop expansion
- Cindy Silva Moreira et al., Delta CO2: Estimating soil carbon stock changes due to the expansion of sugarcane production in Brazil
- Clifford Louime et al., Florida A&M University: Evaluating the risk of biological invasions from the biofuel feedstock
- Érica Geraldes Castanheira, University of Coimbra: Environmental life cycle assessment palm oil biodiesel in Colombia addressing alternative land use change and practices
- Marcelo Valadares Galdos, CTBE, Quantification of soil carbon stock changes due to recent expansion of sugarcane areas in Brazil

Plenary Speaker Abstracts

In alphabetical order by last name of first author.

Plenary speaker **Beach**

Economic and Environmental Impacts of U.S. Bioenergy Policies

Sara Bushey Ohrel[1] and Robert H. Beach[2]

[1] Climate Change Division, U.S. Environmental Protection Agency. 1200 Pennsylvania Avenue, NW (6207-J), Washington, DC 20460, USA; Telephone: 1-202-343-9712; email: ohrel.sara@epa.gov
[2] Environmental, Technology, and Energy Economics Program, RTI International

Objective: Bioenergy production has been expanding rapidly in many regions of the world, due primarily to increasing concerns related to climate change and energy security. However, because commercially viable bioenergy is produced primarily from agricultural feedstocks, higher production volumes increase pressure on land resources. In the U.S., bioenergy expansion has been driven primarily by mandated increases in liquid biofuels for transportation. There is also ongoing interest in policies promoting renewable electricity production and greenhouse gas (GHG) mitigation that would place further demands on land. In this study, we examine ongoing policy developments in the U.S. and explore the interactions between demand for agricultural and forest land for GHG mitigation, transportation biofuels feedstocks, and bioelectricity feedstocks and the implications for land use change and GHG emissions.

Approach: We apply the recently updated Forest and Agriculture Sector Optimization Model with GHGs (FASOMGHG) to explore the implications of alternative bioenergy policies for renewable energy production mix, land use, trade, and net GHG emissions. FASOMGHG is a forward-looking dynamic model of the forest and agriculture sectors that simulates the allocation of land over time to competing activities in both the forest and agricultural sectors and the associated impacts on commodity markets. In addition, the model simulates environmental impacts resulting from changing land allocation and production practices, including detailed accounting for changes in net GHG emissions.

Scientific Innovation and Relevance: Competition for land is expected to continue growing in the future as mandated biofuels volumes increase along with rising demand for food, feed, and fiber both domestically and internationally. Thus, large-scale bioenergy production has important implications for the forest and agriculture sectors, land use, trade, and net GHG emissions. However, there has been little work examining the net effects of jointly implementing policies requiring the use of transportation biofuels and bioelectricity while simultaneously promoting GHG mitigation.

Results: We find substantial interactions between alternative bioenergy and forest and agricultural GHG mitigation policies, with potentially large impacts on commodity markets, land use, and net GHG emissions.
Conclusions: There are important economic and environmental impacts associated with bioenergy production that should be further explored to enhance our understanding of the potential implications and to inform policy design that mitigates any negative effects.

Data, analysis, and field studies to evaluate and minimize land use change impacts of large-scale bioenergy production

Alison Goss Eng

Co-authors: Budhendra Bhaduri, Virginia Dale, Keith Kline, Gbadebo Oladosu, Oak Ridge National Laboratory
Richard Hess, David Muth, Idaho National Laboratory, Michael Wang, Argonne National Laboratory

Objective: Evaluating the direct and indirect impacts of large-scale bioenergy production land use change requires high quality data, modeling, and field studies. The Department of Energy works to address these needs through supporting research and analysis of the links between land use change and bioenergy production.

Approach: DOE's Biomass Program sustainability portfolio includes research and analysis to identify areas of high importance for biodiversity and ecosystems, to develop and improve modeling of LUC, to evaluate the impact of policy alternatives on LUC, and field studies to site and manage bioenergy crops to minimize LUC. Our work on land use change focuses in four areas:

- Defining sustainability and its metrics
- Evaluation of assumptions and definitions used in current analysis of land-use effects of bioenergy
- Determination of key drivers of land-use change
- Identification of factors not in current analysis of indirect effects

Scientific innovation and relevance: These results inform policy discussions and the Biomass Program's entire portfolio of research, development, and deployment to build a sustainable bioenergy industry. In the U.S., both the state of California and the Environmental Protection Agency have proposed regulations that use rough attempts at incorporating indirect land use change effects in the life cycle analysis used to set biofuel and low-carbon energy mandates. In Europe, the European Commission is moving forward with studies on incorporating indirect land use change effects in their low carbon energy regulations. The success of these efforts depends on an accurate and verifiable method to predict how much, if any, indirect land-use change occurs in response to a multitude of different policy scenarios.

Results: DOE-EERE is funding research across the national labs and universities to collect and analyze data that can be used to inform sound regulation in regards to the indirect impacts of biofuels production. This work will validate our existing life cycle analysis models as well as inform the development of new analytical tools.
We are working with Argonne National Laboratory, Oak Ridge National Laboratory, and Purdue University to better quantify the direct and indirect land use change emission impacts of biofuels. This work is showing that the indirect land use change impacts due to biofuels are significantly less than those that were published in the earlier literature. In 2009, DOE sponsored a Land-Use Change and Bioenergy workshop in Vonore, Tennessee which developed a roadmap for future research in this area. Over 50 experts from around the world working on land-use change (LUC) issues gathered to review the state of the science, identify opportunities for collaboration, and prioritize future steps for research needed to address key issues in the area of LUC.

Conclusions: Managing land resources sustainably requires investigating the links between bioenergy production and land-use change, both domestically and internationally. In addition to direct land-use changes from increased bioenergy production, converting non-fuel agricultural land into bioenergy production may indirectly cause other land to be converted. Studies continue to shed light on the complex and important issue of whether biofuel production threatens prime farmland, reduces habitat, or increases GHG emissions through direct and indirect land conversion. The Biomass Program takes an active role in understanding these links. In conjunction with the National Labs, the Program coordinates with the environmental and scientific communities to assess the model assumptions, available and needed global data sets, and research needs. The Program is committed to using the best available findings to inform decisions and investments that protect domestic and international land resources.

The Role of Sustainability Certification in Mitigating Negative Indirect Impacts of Biofuel Production

Victoria Junquera
Roundtable on Sustainable Biofuels,BAC 004; Station 5, CH-1015 Lausanne, Switzerland;
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As a voluntary multi-stakeholder standard for sustainable bioenergy production, the RSB faces a set of challenges in addressing indirect impacts of biofuel production. The RSB Standard can only affect the boundary of the biofuel operations and is thus limited in the scope of its applicability. Furthermore, reaching consensus on the subject of indirect impacts of biofuels can be a challenge in an organization where the views and interests of many and diverse biofuel stakeholders (farmers, producers, NGOs, fuel users, etc.) are represented. Nevertheless, the RSB is moving forward in addressing this subject. The RSB Indirect Impacts Expert Group is active and has discussed a number of white papers issued by the Secretariat. In addition the RSB continues to act as a platform for collaboration and dissemination of information; among other activities it collaborates on the development of the Bioenergy Wiki ILUC Portal.

In its in-person meeting in June 2010, the RSB Steering Board determined that risk of indirect impacts, including, but not limited to, food security and indirect land use change (ILUC), is a very important issue and it urged the RSB Secretariat to explore options for the mitigation of indirect impacts risks by, among other things, developing tools that can differentiate 'low risk' biofuels and incentivize their use and production. The RSB Secretariat, in collaboration with other organizations, its own members, and experts, is assessing how indirect impacts can best be addressed in the RSB. The results of this work are applicable not only to the RSB but to sustainability certification schemes in general.

The RSB Secretariat and project partners WWF International, Ecofys, WWF Indonesia, WWF Mozambique, Wageningen University, the University of São Paulo and others have developed a certification system for low-indirect impacts biofuels (CIIB), which focuses on preventing the displacement of existing provisioning services such as food, feed and fiber. The CIIB identifies four categories of biofuels or biofuel feedstocks that can be certified as having low negative indirect impacts —namely feedstock produced on unused land, the use of waste as feedstock, feedstock produced from increased yields, and the integration of agricultural and bioenergy systems— and provides clear and simplified guidance on qualifying parameters.

The RSB Secretariat is also exploring the option of developing simplified ILUC factors for biofuel feedstock produced on arable land.

In addition, the RSB has started collaborating with other NGOs and researchers on a project that is aimed at exploring the possibility of developing a methodology or framework for a "land use productivity fund", whereby organizations could contribute to a monetary fund that is aimed at improving food/feed productivity in countries with untapped potentials and economic barriers to the development of such potentials.

There are several options for addressing indirect impacts in a standard such as the RSB Standard. For example, the CIIB module could be incorporated into the Standard, e.g., as a voluntary module that leads to an additional "low negative indirect impacts" claim by the certified operator. The CIIB module could also be used as a basis to define "good practices" of biofuel production that lower the risk of negative indirect impacts; the result would be process-based criteria that could be added to the existing RSB Standard, e.g., under an additional Principle on Indirect Impacts and/or within the RSB Standard for Risk Management. In addition, ILUC factors can be used in the Principle on GHG Emissions and added to the GHG balance of the biofuel, which under the RSB Standard must meet minimum GHG emission reductions. Finally, a "land use productivity" fund to which operators can contribute (see above) could be set up in collaboration between standards and other organizations. These options, or a combination thereof, can be integrated in a voluntary certification scheme. This paper discusses the advantages and disadvantages of each option, how it may drive and impact change in bioenergy production, and how it may affect overall sustainability.

Assessing the Land Use Change Consequences of European Biofuel Policies

David Labordé

On 23 April 2009, the European Union adopted the Renewable Energy Directive (RED) which included a 10 target for the use of renewable energy in road transport fuels by 2020 and established the environmental sustainability criteria that biofuels consumed in the EU have to comply with. Among them, only direct land use changes has been restricted. The revised Fuel Quality Directive (FQD), adopted at the same time as the RED, includes identical sustainability criteria. Moreover, the Parliament and Council asked the Commission to examine the question of indirect land use change (ILUC), including possible measures to avoid this, and report back on this issue by the end of 2010.

The Commission launched four studies in 2009 to examine ILUC issues, including a first general equilibrium modeling study that aimed to analyse the impact of the EU biofuels mandate, and possible changes in EU biofuels trade policies, on global agricultural production and the environmental performance of the EU biofuel policy as concretised in the RED. That report was published in March 2010[2] (Al-Riffai, Dimaranan and Laborde, "Global Trade and Environmental Impact Study of the EU Biofuels Mandate"). It showed that indirect land use changes were a valid concern, but that the degree of uncertainty regarding their magnitude was large.

Since then, this study has been widely cited and commented on in discussions with stakeholders and civil society on EU biofuels policy. Numerous suggestions for improvements in the study were received. Research on biofuels modeling also continued and made progress since then. In order to feed this new information and insights into the Commission's impact assessment on the land use change effects of biofuels, and into the report to the Parliament and Council, the European Commission requested IFPRI to carry out the present updated study.

This new study contains several important changes compared to the previous report. It uses an updated version of the global computable general equilibrium model (CGE), MIRAGE-Biof, as well as a revised scenario describing the EU mandate based on the National Renewable Energy Action Plans of the 27 member states. In addition, a stronger focus has been placed on specific feedstock Land Use Change (LUC) computation and the uncertainties surrounding these values. Systematic sensitivity analysis is used to measure the potential range of LUC. In the absence of empirical evidence on the impact of the direct land use change criteria in the RED this report revolves around total LUC, comprising both direct and indirect changes, instead of the narrower concept of indirect LUC only.

We will present the key findings of this study as well as potential policy recommendations

[2] http://ec.europa.eu/trade/analysis/chief-economist/

Global Agriculture to 2020: drivers and issues

Holger Matthey

The 2011-2020 OECD-FAO Agricultural Outlook is cautiously optimistic that commodity prices will fall from their 2010-11 levels, as markets respond to these higher prices and the opportunities for increased profitability that they afford. Restoring market balances may take some time. Until stocks can be rebuilt, risks of further upside price volatility remain high.

There are signs that production costs are rising and productivity growth is slowing. Energy related costs have risen significantly, as have feed costs. Resource pressures, in particular those related to water and land, are also increasing. land available for agricultural in many traditional supply areas is increasingly constrained and production must expand into less developed areas and into marginal lands with lower fertility and higher risk of adverse weather events.

The use of agricultural output as feedstock for biofuels will continue its robust growth, largely driven by biofuel mandates and support policies. By 2020, an estimated 13% of global coarse grain production, 15% of vegetable oil production and 30% of sugar cane production will be used for biofuel production. Higher oil prices would induce yet further growth in use of biofuel feedstocks, and at sufficiently high oil prices, biofuel production in many countries becomes viable even in the absence of policy support.

New drivers are also emerging, in particular the stronger link to energy markets which play an important role in transmitting volatility to agriculture through both production costs and competing demand from the biofuels sector. Future commodity prices may well be higher than projected in the event that energy prices should strengthen further than assumed in this Outlook.

Since 2005, the Organization of Economic Cooperation and Development (OECD) and the Food and Agriculture Organization of the United Nations (FAO) jointly produce an annual 10-year projection for national and global agricultural markets, called the OECD-FAO Agricultural Outlook. The Outlook provides baseline projections for production, consumption, imports, exports, stocks and prices of the main temperate agricultural commodities, tropical oil crops and biofuels. The OECD-FAO Secretariats use a partial equilibrium simulation model (Aglink-Cosimo) to produce a baseline scenario for global and national agricultural markets. The Aglink-Cosimo model is driven by elasticities, technical parameters and policy variables. It provides projections of agricultural markets based on a set of macroeconomic projections, technical assumptions and agricultural policies. All major agricultural sectors, including the biofuel sector, are connected within the model so that all of the main characteristics of the crops and livestock sectors influence the final equilibrium. The Aglink-Cosimo model and Outlook projections are reviewed by OECD member countries as well as FAO experts and international collaborators to reach a consensus view among the major stakeholders. The model serves also as a scenario simulation tool to analyse challenges and opportunities in global and domestic agricultural markets.

Land use models and iLUC under a Brazilian perspective

Andre M. Nassar

ICONE – Institute for International Trade Negotiations

The complexity of agricultural expansion and its land use impacts challenge modelers and the scientific community. Two main topics must be under consideration regarding GHG emissions due to land use change: (1) the limitations of existing methodologies and (2) how to isolate the effect of biofuels.

Land use models are being improved throughout time as data becomes available and new methodologies are developed. However, they are still far from perfection. The possibility to isolate the biofuel responsibility on the conversion of natural vegetation is also very limited. The presentation will discuss the adherence of the main methodologies currently used by policymakers to take decisions, especially for the Brazilian case. Models will be compared with empirical evidences with the objective of identifying the most appropriate route to address LUC and iLUC decisions. The possibility to isolate biofuels indirect effects rather than thinking the agricultural sector as a whole is also addressed.

Plenary speaker

Timilsina

Biofuels, Land-Use Change and Climate Change Mitigation: Some Insights from Global CGE Model Simulations

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The potential impact on land-use changes of large-scale expansion of biofuels has taken much attention from policy makers, academia and other stakeholders as it is directly related to food vs. fuel debate and also biofuels' role on climate change mitigation. Existing literature does not provide converging views on these issues. Using a global computable general equilibrium model that explicitly represents land-use changes, this study attempts to shed some light on these issues. The study shows that if biofuel mandates and targets currently announced by more than 40 countries around the world are implemented by 2020 using crop feedstocks, it would cause significant land re-allocation with notable decreases in forest and pasture lands in some countries. The study also finds that lands, currently used for non-biofuel feedstock crops, such as rice, vegetable and fruits would be diverted towards biofuel feedstock crops, such as sugar cane, corn and oil seeds. If both forests and pasture lands are used to meet the new land demands for biofuel expansion, this would cause a net increase of greenhouse gas (GHG) emissions for more than two decades after meeting these mandates and targets. This is because the cumulative GHG emissions released through land-use change would exceed the reduction of emissions due to replacement of gasoline and diesel until then. However, if the use of forest lands is avoided by channeling only pasture lands released through intensification of livestock production, the biofuels mandates and targets would cause reduction of GHG emissions starting from 2021, a year after the assumed full implementation of the mandates and targets.

Establishing ecologically sustainable forest biomass supply chains:

A case study in the boreal forest of Canada

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Changing forest management practices towards more intensive forest biomass use raises issues of sustainability. Although they recognize the crucial importance of increasing the share of renewable energy and replacing fossil fuels, some communities, notably in Canada, have high concerns about preserving of the integrity of forest ecosystems. They demand that ecological services derived from forests be taken into account when designing biomass supply chains, and insist that those services should not be traded off in favor of bioenergy production. Different examples from all around the world show that the success (or lack thereof) of forest energy implementation and development depends largely on community support and 'buy-in'.

A case study was carried out in the Lac-St-Jean region, in the boreal forest of Quebec (Canada), to (1) identify the ecological and local concerns of stakeholders relative to forest biomass supply obtained from residues of final cuttings in that region, and to (2) assess the impacts of applying constraints to residue removal, in order to meet those concerns, on the availability, procurement costs and CO_2 balance of biomass. Site suitability to residue removal was mapped, which allowed the spatial identification of unsuitable sites for which soil, biodiversity and other local concerns exist. As a result, 26% of the territory was deemed unsuitable for residue removal, which represents 29% of the total potential volume of residues available during the next 10 years. However, because of operational constraints associated with residue removal technology, only 55% of the total potential volume of a suitable site can be recovered for bioenergy production. When adding ecological constraints, the ecologically+technically available volume of residues represents 39% of the total potential of the territory.

Applying ecological constraints by excluding sensitive sites raises the cost of biomass supply (in $CAN per oven-dry metric ton) on the territory by increasing the transport distance for the procurement of a given mass of residues to the processing plant. This increase ranged from 1 to 4% when moderate constraints were applied, and went up to 15% with very strict constraints; this effectively represents the opportunity cost of applying high standards for the protection of ecological services when designing forest biomass supply chains. However, other factors can have a similar or higher impact on procurement costs; for example, competition among processing plants for access to the resource caused an increase in the cost of residues of up to 19%. Also, despite longer transport distances, there was no significant increase in CO_2 emissions related to ecological constraints: the share of CO_2 emissions relative to the carbon delivered at the plant was below 4%, even with strict ecological constraints.

This information will feed community- and regional-level discussions and sustainability assessments on the deployment of forest biomass use in the Canadian boreal forest so that it may take into account the ecological and social aspects along with the economic aspects of sustainability.

Contributed Presentations Abstracts
Oral and Poster

In alphabetical order by last name of first / presenting author.

Combining economic modelling and life cycle assessment – is it possible from a scientific method point of view?

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Introduction

Indirect land use change (iLUC) connected to biofuel production has during the last years been on the political agenda. One suggested way to handle the issue is by adding an iLUCfactor to the existing greenhouse gas (GHG) calculations, this is for example considered to be implemented within EU´s biofuel sustainability criteria framework. For this purpose, economic models are used to quantify iLUC-factors. However, not many studies have analysed how the results from economic models can be coupled with life cycle assessments (LCA) used for calculating the GHG-balance of biofuels including both direct land use changes (dLUC) and iLUC. The purpose of this work is to investigate the principles for how economic modelling can be integrated with LCA. The aim is also to show how different methods for the coupling calculations can influence the resulting iLUC-factors of a biofuel.

Approach

LCA is usually dived in two types – attributional and consequential. While attributional LCA (aLCA) generally is used for accounting emissions of existing production systems, consequential LCA (cLCA) is used for accounting future changes in production systems. Therefore, the calculation method and type of input data also differs between the two types. For example, in aLCA average data is often used, in cLCA marginal data are accounted. In aLCA, allocation is often done to divide environmental impact between products and byproducts, whereas in cLCA system expansion is used. We will examine how these two types of LCA can handle iLUC. Some simple calculation examples are also done to highlight this. Further, the output from the economic models is often expressed as changes in hectares or tons of raw material and can be recalculated to changes in GHG emissions in different ways, this is also highlighted in the calculation examples. The uncertainty connected to economic modelling of iLUC has been much debated, this is however not further discussed in this work. We here only analyse how results from economic models (as uncertain as they may be) can, or can not be integrated with LCA.

Results and conclusions

If economic models and LCA is to be combined, there are some principal matters to consider:

- The assessment tools have different resolution; while LCA mostly is used to calculate the emissions from a specific production system, economic models study changes on a global level and then divide it over single products
- In principle, it is not possible to include iLUC in aLCA since it assesses the GHGbalance of existing systems and does not include future (marginal) changes
- Many economic models use average data in the modelling which makes it difficult to use the results in cLCA that has the purpose to reflect the marginal change
- Since economic models can not distinguish between dLUC and iLUC there is a risk for double counting and thereby overestimating changes in GHG emissions In the calculation examples, the same basic assumptions were used. Depending on type of LCA and how the calculations were done the resulting iLUC-factor was 2, 6, 69 or 134 g CO2-ekv/MJ biofuel (see further in the explanatory pages).

Oral presentation **Bailis**

CANCELLED: Carbon impacts of direct land use change in semiarid woodlands converted to biofuel plantations in India and Brazil

Rob Bailis and Heather McCarthy

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Unfortunately, Rob Bailis will not be able to participate. If you have any questions tregarding his abstract, please contact him by email or phone.

Objective: To quantify land use changes occurring as a result of the introduction of jatropha plantations in semi-arid woodlands

Approach: Quantitative analysis of change in aboveground biomass and soil in sites undergoing transition from woodland to jatropha plantation.

Innovation and relevance: As a novel crop, aboveground biomass in Jatropha has not been established. In addition, dLUC assessments typically rely on IPCC default values, which vary by a factor of 10 in semiarid woodlands. In addition, changes in soil conditions are highly uncertain, particularly when shifting from a natural woodland to a perennial plantation. This analysis quantified AG biomass in pruned and unpruned Jatropha plantations, estimated carbon stocks in woodlands based on direct measurements of trees and herbaceous matter, and measured changes in soil carbon.

Results and conclusions: The jatropha plantations store 8–10 tons of carbon per hectare (tCha□1) in AG biomass and litter when managed with regular pruning in both India and Brazil. Unpruned trees, only examined in Brazil, store less biomass (and carbon), accumulating just 3 tCha□1 in AG pools. The two woodlands that were replaced with jatropha show substantial differences in carbon pools: prosopis contains ~11 tCha□1 in AG stocks of carbon, which was very close to the jatropha stand which replaced it. In contrast, caatinga stores ~35 tCha□1 in AG biomass. Moreover, no change in SOC was detected in land that was converted from Prosopis to jatropha. As a result, there is no detectable change in AG carbon stocks at the sites in South India where jatropha replaced prosopis woodlands. In contrast, large losses of AG carbon were detected in Central Brazil where jatropha replaced native caatinga woodlands. These losses represent a carbon debt that would take 10–20 years to repay. The data reveal a greater complexity than the use of default values can accommodate. We suggest that a system of long□term monitoring is needed to better understand these dynamics, particularly in perennial systems that receive less attention in existing literature than biofuel production using annual crops.

Oral presentation **Barretto**

Mitigation assessment of greenhouse gas due to the conversion of sugarcane areas from burned to green harvest, considering reduced tillage and the crop-rotation

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There is a growing need to develop GHG (greenhouse gas) mitigation techniques for all productive sectors in order to meet emission reduction targets. Changes in several agricultural management practices have indicated to reduce GHG emissions, however the challenge of agricultural sector is to reduce net emissions increasing production to meet the growing demand for food, fiber and biofuel. The present study focuses on changes of GHG balance once sugarcane areas are converted from burned (BH) to green harvest (GH, mechanized harvest), including the adoption of one year crop rotation with sunn-hemp (Crotalária Juncea L.), during sugarcane replanting season. The annual emission balance takes into account the major agricultural sources of GHG in one hectare of BH and GH, considering both agricultural and mobile sources. Our dataset is based on the mean practices conducted in the sugarcane areas of southern Brazil, according to the mean annual use of supplies (per hectare per year). The sources of GHG emission considered were associated with the following agricultural practices: a) sugarcane residue burning; b) N2O direct and indirect emissions from N synthetic fertilizer applied on soil, including the emissions from the manufacture and distribution, organic composts such as vinasse and filtercake application and sugarcane residues left on soils after green harvest; c) lime application and d) emission that results from fossil fuel use. Crop residues left on soil surface and potential soil carbon sequestration were also considered in GH plot, according to IPCC, (2006), Chapter 5, Cropland. The results are presented in terms of CO2 equivalent, computing CO2, CH4 and N2O, and indicate that residues burning are responsible for the higher emissions in BH while N synthetic fertilizer and diesel use resulted in higher emission on GH system with total amounts of 3,143 and 2,832 kg CO2eq ha-1 y-1 for BH and GH, respectively. Considering a mean annual soil carbon sequestration rate (154 kg C ha-1 y-1) due to the long term crop residues input associated to the conversion from BH to GH, emissions balance in GH decreased to 2,267 kg CO2eq ha-1 y-1. A second step occurs once reduced tillage is adopted during the replanting season in GH plot, with a total emission balance reduced to 1,355 kg CO2eq ha-1 y-1, comparing to BH. According to the present scope and methodology applied, the conversion of sugarcane from BH to GH with adoption of crop rotation with sunn-hemp in addition with reduced tillage during sugarcane renovation season would result in a new GHG balance decreased to 1,236 kg ha-1 y-1. Hence, the conversion of sugarcane crop systems from burned to mechanized harvest associated to the adoption of reduced tillage could save 1,788 kg CO2eq ha-1 y-1 from GH comparing to BH, moreover the introduction of N fixing crop rotation techniques could avoid a rate of 1,907 kg CO2eq ha-1 y-1 (compared to BH), being strategic to GHG mitigation of sugar and ethanol production, in southern Brazil.

Oil Price Shocks and the U.S. Bioenergy Market: Assessing Demand and Land Use Impacts

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Objective: One rationale for the rapid expansion of bioenergy production in recent years has been to improve energy security and reduce reliance on fossil fuels. However, transportation accounts for a sizable share of the cost of delivered bioenergy feedstocks. Thus, while higher oil prices tend to make biofuels for transportation more competitive, they also raise the delivered costs of feedstocks for both biofuels and bioelectricity. In this study, we examine the effects of oil price shocks on demand for different types of bioenergy and implications for land use change and net GHG emissions.

Approach: We apply the recently updated Forest and Agriculture Sector Optimization Model with GHGs (FASOMGHG) to explore the implications of alternative global oil price scenarios for bioenergy use, land use, trade, and net GHG emissions. FASOMGHG is a forward-looking dynamic model of the forest and agriculture sectors that simulates the allocation of land over time to competing activities in both the forest and agricultural sectors and the associated impacts on commodity markets. In addition, the model simulates environmental impacts resulting from changing land allocation and production practices, including detailed accounting for changes in net GHG emissions. To further explore international trade impacts and interactions between sectors, we also apply the Applied Dynamic Analysis of the Global Economy (ADAGE) CGE model.

Scientific Innovation and Relevance: Bioenergy will potentially play an important role in helping to meet future energy demand. However, bioenergy production itself is currently dependent on fossil fuels in production and transportation of feedstocks, to a degree that differs across feedstocks. Thus, higher oil prices will alter the relative competitive position between alternative feedstocks and between use in transportation (where biofuels compete directly with petroleum products) and electricity generation.
Results: We find substantial interactions between the oil and bioenergy markets, with potentially large impacts on the distribution of feedstock use between transportation biofuels and bioelectricity production, land use, and net GHG emissions.

Conclusions: Changing oil prices have major implications for bioenergy demand, with very different net impacts between transportation biofuels and bioelectricity. Exploration of the linkages between oil and bioenergy markets provides valuable insights that aid our understanding of the potential effects of changing oil markets on the competing demands for bioenergy feedstocks and can help inform the development of appropriate policies.

Oral presentation **Börjesson**

The climate benefit of Swedish ethanol – present and prospective performance

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Objective
This paper present an assessment of the climate benefit of current and future Swedish bioethanol production from a life cycle perspective, when also potential direct and indirect land use changes (dLUC and iLUC) are considered. Current ethanol production is based on wheat, whereas the use of lignocellulosic feedstock (e.g. straw, short rotation forestry, forest residues etc) is estimated to increase in the future. The choice of feedstock and it's implication on LUC and corresponding greenhouse gas (GHG) emissions is in particular focus.

Approach
The GHG assessment is based on adapted data from existing LCA's of Swedish ethanol production systems and additional studies of dLUC and iLUC relevant for Swedish conditions. Scientific innovation and relevance This paper has a broad multidisciplinary systems perspective which combine an assessment of critical issues, such as (i) current and future technical design of ethanol systems, (ii) category of feedstock, (iii) dLUC, (iv) iLUC, and (v) treatment of co-products.

Results and conclusions
• Current Swedish ethanol production based on wheat leads to around 70% GHG reduction compared with petrol when also the GHG benefit of DDGS as protein feed replacing soy meal is included
• dLUC is estimated to a maximum of 25% of current feedstock cultivation located on previous grassland, whereas no iLUC is assumed (from a physical resource perspective) due to the current excess of unused farmland
• A future expansion of wheat-based ethanol may lead to increased dLUC reducing the GHG benifit to around 50% or above, when excess grassland is converted, or iLUC which may give similar GHG performance, thus dLUC and iLUC should not be double counted in this scenario
• Future improvements in the technical production systems (e.g. biogas-based nitrogen fertilizer production with catalytic nitrous oxide cleaning) could, to a significant extent, counteract the increased negative dLUC
• A changed utilisation of DDGS from protein feed (e.g. due to a saturated protein feed market) to biogas production will give a minor change in GHG performance
• Future straw-based ethanol production leads to a GHG reduction of about 80%, when also dLUC is included
• Future willow-based ethanol may lead to a GHG reduction of 65 to 85% depending on systems design and previous land use, which may result in no dLUC or iLUC, or a positive dLUC and negative iLUC
• Ethanol based on fast growing deciduous trees (e.g. poplar, hybrid aspen) cultivated on unused marginal land may lead to a GHG reduction which could exceed 100%, due to a positive dLUC (and no iLUC)
• Future ethanol based on logging residues from spruce forests having long rotation periods (60-100 years) leads to a long-term GHG reduction of around 90%, whereas the short-term reduction (10 to 20 years) may be significantly lower due to negative dLUC
• Thus, short-term GHG emissions from dLUC are not sufficient reason to exclude logging residue-based ethanol, and a future global GHG emissions cap that regulates both fossil and biospheric carbon emissions should be flexible where countries may use a certain share of their allowed GHG emission space in relation to GHG targets for developing long-term sustainable bioenergy systems.

Poster presentation ***Castanheira***

Environmental life-cycle assessment of palm oil biodiesel in Colombia addressing alternative land use change and practices

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Palm oil is a major feedstock accounting for 34% of the world's vegetable oil production, but its increased use as a source for biodiesel has been a focus of discussion due to several environmental problems. Life Cycle Assessment (LCA) has been applied to characterize the environmental impacts of palm oil biodiesel (palm methyl ester, PME), mainly for South-East Asia. However, the majority of LCA studies have focused on energy and carbon balances and only a few LCA studies have addressed a wider set of environmental impacts or the impacts of land use change (LUC).

The main aim of this paper is to present a LCA of biodiesel from palm oil produced in Colombia. A comprehensive evaluation of the implications of seven alternative LUC scenarios and five fertilization types, namely ammonium sulphate (#AS), ammonium nitrate (#AN), calcium ammonium nitrate (#CAN), urea (#U) and poultry manure (#Poultry) has been performed. A life-cycle inventory and modeling of PME has been implemented, including the following stages: LUC, plantation and oil extraction in Colombia as well as palm oil transportation to Europe where biodiesel production (transesterification) and use takes places.

Life-cycle impact assessment (LCIA) results in terms of global warming potential (GWP), acidification (AP), eutrophication (EP), ozone layer depletion and photochemical oxidation are presented for the various LUC scenarios and types of fertilization. Normalized environmental impacts are also presented allowing the comparison between LCIA categories and process contribution. Detailed findings concerning each stage of the PME chain are also discussed.

The results show the importance of LUC and type of fertilization on the environmental performance of PME. The GWP results presented show that LUC is a critical issue. Large variations in GWP have been calculated between the various LUC scenarios. Considerable reductions in GHG emissions can be achieved by converting savannahs into palm oil plantations; however, when forests are converted, significant GHG emissions occur. Regarding the alternative types of fertilization, contradictory results have been obtained for the various categories. Fertilization type influences GWP (but considerable less than LUC), with the highest GWP calculated for calcium ammonium nitrate (#CAN) and the lowest for poultry manure. However, #CAN fertilization presents the lowest impacts for the other categories and poultry manure the highest impacts in terms of AP e EP. This research shows that to assure the sustainability of PME, savannahs should be preferably converted into palm plantation, using ammonium nitrate as fertilizer.

GHG life-cycle assessment of soybean-based biodiesel: assessing the implications of alternative land use change scenarios

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The increase in soybean production is being stimulated by the growing demand for animal feed and biodiesel. However, soybean production is creating environmental concerns that have not been fully assessed. Soybean production is highly dependent on non-renewable resources, such as fossil fuels, fertilizers and pesticides, which together with land use change (LUC), associated with the expansion of soybean agriculture, results in important greenhouse gas (GHG) emissions. Several life-cycle (LC) studies have been performed for soya. However, just a few studies have addressed alternative cultivation systems and even a smaller number have accounted for LUC.

The main goal of this paper is to investigate the LC GHG balance of biodiesel produced in Portugal, based on soybeans cultivated in Latin-America, assessing the implications of alternative LUC scenarios, cultivation systems and multifunctionality approaches. A LC model has been developed, addressing direct LUC, plantation, transport, soya oil extraction and biodiesel production in Portugal (based on real data from industry). A comprehensive evaluation of 35 scenarios, resulting from a combination of alternative previous land use types (conversion of tropical forest, forest plantation, perennial crops plantations, savannahs and grasslands) and different cultivation systems (tillage, reduced-tillage and no-tillage) have been performed to analyze the impact on the GHG balance. Concerning the production of soybean-based biodiesel in Portugal, there is one important co-product (soybean meal) and various allocation approaches as well as the substitution method have been adopted to assess the influence on the biodiesel GHG performance.

The results show the importance of LUC but significant differences in the GHG balance have been observed for the alternative scenarios assessed. In particular, the highest GHG emissions have been calculated when tropical rainforest is converted into soybean plantation (16,5 kg CO_2eq/kg soybean), while the lowest is for severely degraded grasslands in Warm temperate (dry) regions (0,1 kg CO_2eq/kg). A sensitivity analysis to N_2O emission calculation has been performed based on the IPCC Guidelines Tier 1 (default and uncertainty range) showing a high-level uncertainty, which dominates the GHG emissions from cultivation. Concerning soil management practices, it can be also observed that all the tillage systems have higher GHG emissions than the no-(reduced-) tillage corresponding systems.

The previous land use is a critical issue to assure the sustainability of soybean production and degraded grassland should be preferably used for cultivation. In addition, it is very important to reduce the uncertainty in N_2O emission calculation and further studies should be performed using transparent agricultural inventories to improve conclusions concerning alternative cultivation systems. Concerning the multifunctionality, it is shown that the method selected to deal with co-products has a high influence on biodiesel GHG performance.

What is the contribution to Global Warming of time-distributed biogenic CO_2 fluxes?

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The inclusion of time-distributed carbon dioxide (CO2) fluxes in LCA reveals shortcomings when the analysis is constrained by specific time boundaries established by policy makers or needed for particular impact category indicators. One typical example is the accounting for biogenic CO2 emissions (from oxidation of biomass products or land use change) and removals (from sequestration of CO2 in growing trees or soil) and their inclusion in LCA with sound unit-based indicators. Carbon dioxide (CO2) emissions from biomass combustion are traditionally assumed climate neutral if the bioenergy system is carbon flux neutral, i.e. the CO2 released from biofuel combustion approximately equals the amount of CO2 sequestered in biomass. In LCA studies, this convention results in a space and time approximation of CO2 emissions and removals, which are typically summed up without regard for where or when they occur. For the particular case of GHGs, the space approximation is appropriate because they are global pollutants, but the time approximation can potentially be inaccurate, because the impact caused by an instantaneous single pulse emission is different from the release of the same pulse at a different year or at a small rate over a certain number of years.

In this work, we elaborate on this issue using relatively simple mathematical methods which provide accurate predictions of the carbon flow dynamics. Probability distribution functions are used to include in LCA the dynamic profiles of CO2 emissions and removals associated with biomass management for bioenergy. Following an approach based on Impulse Response Functions (IRF), the CO2 atmospheric profiles are calculated and then the respective changes in radiative forcing, used to quantify the climate impacts, are estimated.

Results show the importance of using emission and removal functions rather than single pulses or linear amortization procedures, which generally overestimate the climate impact of CO2 emissions, especially in presence of short time horizons and for relatively wide time-distributed emissions.

This method is a first step towards the overcoming of the inadequacy of accounting for time-distributed CO2 fluxes from bioenergy and appears highly suitable to be routinely applied in LCA case studies, accounting of emissions from harvested wood products and in processing data by emission inventory experts within the Kyoto protocol and its successor.

Can biochar reduce the pressure on land used for bioenergy?

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Purpose: Expansion and intensification of biomass production, to contribute to the growing demand for renewable energy, will put pressure on land resources, threatening to deplete soil carbon and nutrient stocks, and ultimately reduce land productivity. Use of biochar as a soil amendment is an option for maintaining soil health in biomass production systems: biochar has been shown to enhance soil physical properties including water holding capacity, improve nutrient retention, and promote beneficial microbial activity. Biochar is manufactured through slow pyrolysis, which also produces renewable energy in the form of combustible syngas. The introduction of integrated biomass production – pyrolysis systems would allow simultaneous production of renewable energy and biochar, with the latter used to maintain productivity of the site where biomass is harvested. Due to its polycyclic aromatic structure biochar is resistant to chemical and microbial decomposition, having turnover time of hundreds to thousands of years. Biochar offers further climate change mitigation benefits through reduction in N_2O emissions from soil. Thus, the pyrolysis of biomass to produce biochar can offer multiple benefits in terms of mitigation of GHG emissions: delayed CO_2, decreased N_2O, production of syngas to replace fossil fuels for heat or electricity; reduced fuel needs for cultivation or irrigation; reduced manufacture of GHG-intensive nitrogen fertiliser. Additionally, if the feedstock is a biomass material that would otherwise have released methane or N_2O, for example in landfill or manure management, production of biochar can avoid these emissions. However, the concept is not without tradeoffs: use of biomass for biochar reduces the energy product output, and thus the potential to use biomass to offset fossil fuel emissions from provision of electricity and heat. This project quantifies the mitigation value of biochar projects, in comparison with alternative uses of the biomass.

Approach: To calculate the mitigation benefits of biochar a life-cycle approach must be taken, acknowledging emissions associated with biomass procurement, production of biochar, and its application. Furthermore, the issue of time should also be considered. Bioenergy is commonly considered to be “carbon neutral”, meaning that the carbon cycle is considered to be in equilibrium, so uptake and release of carbon is not included in greenhouse gas calculations. The “carbon neutral” convention ignores the fact that a pulse of CO_2 is released during the pyrolysis process. This increase in atmospheric CO_2 relative to the reference system leads to additional warming that should be recognised in quantifying the climate change impacts of biochar systems. Conventional LCA methods do not take timing of emissions and removals into account. This paper applies new approaches to include time in the assessment of the climate change impacts of biochar systems, and presents results for a range of biochar systems utilising small and large scale production facilities, with and without renewable energy co-products.

Application: These methods may be applied in emissions trading schemes to calculate offset credits for biochar systems, and may be used to guide investment towards the most beneficial uses of biomass. Mitigation value for bioenergy can exceed that for biochar in some situations.

Conclusion: Biochar could play a significant role in sustainable biomass production systems. The best use of biomass should be considered for any situation, and will be dependent on feedstock properties, reference energy source, energy demand, land use demands, and soil constraints.

Oral presentation **Dale**

Indicators to support environmental sustainability of bioenergy

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Purpose: Indicators that can be used to assess the condition of the environment and to monitor trends over time are needed to characterize conditions under which uses of resources are sustainable.

Relevance: Environmental sustainability can be defined as the capacity of an activity to continue while maintaining options for future generations and considering the environmental systems that support the activity. While much work has focused on the development of environmental indicators, only recently has attention focused on developing indicators for sustainable bioenergy systems. Effective indicators will help in the quantification of benefits and costs of bioenergy options and resource uses. We identify 19 measurable indicators for soil quality, water quality and quantity, greenhouse gases, biodiversity, air quality, and productivity, building on existing knowledge and on national and international programs that are seeking ways to assess sustainable bioenergy. Together, this suite of indicators is hypothesized to reflect major environmental effects of diverse feedstocks, management practices, and post production processes.

Conclusions: The importance of each indicator is identified. Future research relating to this indicator suite is discussed, including field testing, target establishment, and application to particular bioenergy systems. Coupled with such efforts, we envision that this indicator suite can serve as a basis for the practical evaluation of environmental sustainability in a variety of bioenergy systems.

Sugarcane Ethanol Production in Malawi: A Real-World Case Study on Indirect Effects

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Sugarcane ethanol is considered to be one of the most efficient first-generation biofuels in terms of greenhouse gas (GHG) emissions. The GHG balance, however, worsens significantly if emissions induced by indirect land use changes (ILUC) are taken into account. This study investigates sugarcane ethanol production in the Republic of Malawi, in Sub-Sahara Africa (SSA); the main research objectives were to identify and quantify direct and indirect effects on GHG emissions as well as to identify measures to avoid ILUC. Our estimations with regard to ILUC take into account further expansion plans for sugarcane crop production. During a research trip to Malawi we collected data and information by means of interviews and documentary analysis. Until recently, very few studies have used real-world case studies to quantify ILUC. The major approach has been to make use of economic models, which are largely based on theoretical assumptions. This empirical paper contributes to closing this gap. Although the results of the Malawian case study are only valid for a specific region, some of the findings may be transferable to other regions in SSA.

In Malawi, sugarcane ethanol is produced at two locations. In Dwangwa, in the Central region, an ethanol plant has been operating since 1982. A second plant, in Nchalo, in the Southern region, has been producing ethanol since 2004. Altogether, sugarcane covers an area of 23,000 ha. The Malawian government promotes ethanol production with a mandated blending rate that increased in February 2011 from 10% to 20%—further regional expansion in crop production is thus to be anticipated.

Two main indirect GHG emission effects of sugarcane cultivation have been identified. The first is that further expansion of crop plantations can lead to ILUC; however, the results are dependent on the specific conditions. Already planned expansions are part of a large-scale government-led irrigation effort, the Shire Valley Irrigation Project (SVIP). This new irrigation project will serve a 40,000 ha region in Nchalo using the water resources of the Shire River. Of this area, 9,000 ha are targeted for sugarcane cultivation. The ILUC resulting from the expanded sugarcane production depend on whether food crops will be cultivated within the SVIP along with sugarcane and whether the investment in irrigation will increase yields enough to sufficiently compensate the displacement of former food crop production. The project planners assume that corn yields will increase by a factor of 15 compared to rain-fed cultivation. Malawian scientists, however, assume lower yield increases. To estimate ILUC effects we designed three scenarios: High Yield, Low Yield and NOSVIP (no implementation of the SVIP). The results demonstrate that ILUC will presumably not occur with implementation of the SVIP if roughly half of the area is dedicated to food crop cultivation. If the SVIP is not implemented, emissions of roughly 100 g CO2 MJ-1 ethanol are anticipated due to ILUC.

The second indirect GHG emission effect arises due to the interplay of increasing prosperity and energy demand. In 2008 more than 88% of Malawi's total energy consumption was supplied by biomass, mainly fuel wood and charcoal. The experiences of the district administrations show that sugarcane cultivation is linked with a higher economic activity in the sugarcane regions; current knowledge further suggests that higher incomes reduce the propensity for fuel wood collection from forest reserves. At the same time, however, charcoal usage is likely to increase as a consequence of growing purchasing power. Switching from fuel wood to charcoal would probably only displace deforestation to regions located nearby. In the long-term, there are also potential linkages between increasing prosperity and electrification. In Nchalo, for example, several villages were electrified with the help of premiums earned from fair trade sugar cultivation. Whether electrification will lead to a positive effect regarding GHG emissions depends very much on the energy source used most widely for electricity production. Further research should focus on analyzing the potential interactions between biofuels production and energy supply and demand in developing countries.

Our results indicate that ILUC can be avoided, at least in part, if expansions in crop production are linked to compensatory measures. One possible measure in SSA is the implementation of irrigation projects that also serve the agricultural needs of the small farmers living in the immediately surrounding region; such an approach can lead to substantial increases in food crop yields.

Project Information

The project *Fair Fuels*? addresses the question of whether biofuels can be produced and used in a socio-ecologically compatible manner and looks at the socio-ecological impacts that derive from present production and promotion. Since biofuels are produced regionally but the products and raw materials are traded internationally and subsidy policy is influenced by national and international agreements, a socio-ecological multi-level analysis of the production, use, subsidization, and transformation potential of biofuels will be conducted.

The project is divided into case studies in three different world regions as well as three supra-regional cross-section components and a results integration component. In addition to the regional case studies, which include Germany, Brazil, and two Sub-Saharan African countries (Malawi and Tanzania), specific issues, such as the role of international politics, the evaluation of ecological aspects, and possible policy instruments for dealing with socio-ecological conflicts (e.g., certification systems), will also be addressed.

One goal of the regional case studies is to calculate the GHG balance of relevant biofuels in these countries. Indirect land use changes (ILUC) has been one of the main research topics during the past four years; therefore, we want to gain information on relevant indirect effects which occur in specific countries. Such knowledge, partly qualitative and partly quantitative in nature, may help to improve assumptions used in economic as well as deterministic modeling. It can likewise support the development of measures to avoid ILUC.

The project team consists of junior scientists and researchers, all of whom are pursuing further academic qualification (doctorate, postdoctorate). The project, initiated and led by the Institute for Ecological Economy Research (IÖW), is sponsored within the framework of the socio-ecological research program of the Federal Ministry of Education and Research.

For further information: www.fair-fuels.de/en/

Poster presentation **Egnell**

Realistic Expectations on Biomass Potential in Conventional Forestry and Agriculture – Swedish Experiences

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Abstract applicable for an oral presentation at session 1a or 1d at the joint workshop "Quantifying and managing land use effects of bioenergy" in Campinas, Brazil, 19-21 September 2011.

This abstract is based on an IEA task 43 report intended for stakeholders interested in, or dependent on, accurate and realistic estimates of both short-and long-term feedstock supply from forestry and agriculture excluding imports. The objectives is to show factors that will reduce the amount of physically available biomass in forestry and agriculture reaching the market and factors that will reduce the theoretically available biomass in the near future if an expanded area of the agricultural land is used for feedstock production. Examples are given from Sweden – a country within the European Union characterized by large areas of slow growing boreal and temperate forest with long rotation periods, a limited agricultural land area and a large number of smallholders owing relatively small lots of forests and agricultural land.

A typical feature of the boreal and temperate forest with long rotation periods is that it takes time to increase its annual growth. Thus, the short--term feedstock supply from these forests is restricted to the growing stock. In Sweden the biomass market for energy has increased steadily since the late 1970s and residues from the forest industry is fully used. To meet the growing demand logging residues, i.e. branches and tops, are already on the market. The other major "logging residue" following harvest of round wood is the stumps. Here the physically available amount of biomass in stumps is estimated based on data from the Swedish National Forest Inventory. Due to techno economical and environmental constraints the market potential was estimated to be considerably less and not larger than 10-20 % of the physically available potential.

The advantage with agricultural---based biomass production systems is that they can deliver additional feedstock to the market in the short---term. Typically estimates of the potential in agriculture are based on available harvest residues like straw together with assumptions about establishment of bioenergy crops on excess agricultural land, e.g. set aside land. The harvest residue potential is typically restricted by alternative use, techno-economical constraints and the need for organic material to maintain the preferred soil structure. The biomass potential from new establishment of biomass crops is typically based on assumptions about crop, mean productivity, and how much of the set aside land that will be used. Here we give an example for Salix-establishment in Sweden where the market potential, due to a number of constraints, is considerably smaller than the estimated physical potential. The amount of agriculture land used for Salix cultivation has been constant during the past 15 years, equivalent to 0.5% of the total agriculture land, whereas previous potential studies often anticipate large---scale implementation of Salix plantations covering 10 to 20% of the agriculture land.

Biodiversity considerations in certified biomass production

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One important aspect of sustainability in biomass production concerns biodiversity, which is central in ecology and natural resource management. Biodiversity has both intrinsic value and instrumental value to humans and is important for ecosystem stability and provision of the numerous ecosystem services that are essential for human survival. Studies indicate that human activities have increased the species extinction rate, primarily through (i) habitat destruction, degradation and fragmentation; (ii) invasive species; (iii) pollution, including human induced changes in climate; and (iv) over-exploitation of essential resources, including overhunting. Bioenergy expansion may influence most of the causes of increased species extinction rate.

The aim of this study is to assess the biodiversity considerations in certification standards for sustainable biomass production. In total, 23 standards for forest management, agricultural management and production of bioenergy crops, were included in the assessment. Aharmonization ofdifferent definitions of biodiversity was madebased on considering principles of conservation biology, in order to identify aspects of biomass production of relevance for biodiversity. Based on the identified aspects, a referencestandard was constructed andall included standards were compared with this reference standard as a way to establishhow the different standards showed similarities and differences regarding how biodiversity was considered. Restrictions on specific ecosystems conversion were also assessed for all standards.

The results showed a noticeable variation in how the certification standards consider aspects of relevance for biodiversity. There was both a variation among similar standards and between different types of standards. In general, the bioenergy crop standards had the strictestrules and restrictions in relation to biodiversity followed by the forest management standards. The agricultural management standards hadmore laxrules and restrictions. It is proposed that biodiversity conservation in production of sustainable biomass can be improved by further developments of the certification standards.

Accounting land as natural resource for energetic and exergetic LCA: A new method

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Life Cycle Assessment (LCA) is an environmental assessment methodology that considers the life cycle perspective of products (goods and services). It is divided in four steps, and in the Life Cycle Impact Assessment (LCIA) stage is where the potential environmental impacts are raised [1, 2]. Some other assessment methodologies can be considered as LCIA methods when the life cycle approach is considered. For energetic and exergetic analysis, three resource-based LCIA methods are found in literature: Cumulative Energy Demand (CED) [3], Cumulative Exergy Demand (CExD) [4], and Cumulative Exergy Extraction from the Natural Environment (CEENE) [5]. These methods are well structured for evaluation of fossil fuels, but for biofuels there is still room for some advances regarding the biotic resources, which in the one way are accounted by the energy or exergy content in biomass (in CED and CExD, respectively), while in other way the land area where the biomass is grown is accounted (CEENE). There is no consensus in which is the best approach, but the methods are flexible, and the researcher can decide what to account (the energy/exergy of the biomass or the land for growing). When this happens, special attention has to be given because only one way should be chosen; otherwise double-counting may occur. The way of accounting for land in the CEENE method (by solar radiation) can also be found in other energetic and exergetic analysis [6], but might be considered misleading, since the fraction of solar radiation used for photosynthesis is influenced by several factors, including water availability, soil quality, temperature, etc. The objective of this paper is to introduce a way of accounting for land through its potential Net Primary Production (NPP). NPP is the amount of biomass production of a certain area and it represents how much energy is available to transfer from plants to other trophic levels in the ecosystem [7, 8]. It is an output indicator influenced by several factors [9] and it is in accordance with ecosystem thermodynamics theory [10, 11]. The potential NPP is an estimation of the possible natural biotic production that would occur in a certain area if there was no land use or land use change. A regionalized database over the World is available [8]. Therefore, regarding the challenge of considering regional aspects in LCA [12], to account for land occupation through potential NPP might give better results since other site-dependent factors would be considered. In NPP data, the unit usually considered is mass of carbon (gC/m2a) or dry matter (kgDM/m2a), but since the aforementioned resource-based LCIA methods produce single score results (in energy or exergy), the units of NPP have to be transformed. This obstacle may be overlapped through the creation of generic energy/exergy conversion factors for biomass, which may be regionalized in biome level. This new approach was applied in a sugarcane case study from Brazil and the results were confronted with the three original LCIA methods. The analysis was considered until the farm gate ("cradle-to-gate"), and we used data from ecoinvent database. CED and CExD presented a slight increase on the total value (around 1%), while CEENE had a decrease of 42%. The Potential NPP appears to be a good indicator for as natural resource, having advantage of availability of a regionalized database. It is important to point that the potential NPP mentioned here is the "natural" NPP, considering that no land use change would have occurred; not a potential NPP "produced" by men through forestry or agricultural practices. Keywords: Land, NPP, LCA, Resource.

Quantification of soil carbon stock changes due to recent expansion of sugarcane areas in Brazil

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Due to the growing internal and external demand for bioethanol, there has been a significant increase in the production of sugarcane in Brazil over the last decade. In addition to an increase in productivity, this demand has been met by expanding the area under sugarcane into other land uses. Besides changes in biomass, this direct land use change (LUC) has the potential to cause losses or gains in soil carbon, an important global carbon pool. In order to evaluate the impacts of (LUC) on soil carbon, it is important to identify the previous land uses and management systems replaced by sugarcane, considering differences in climate and soil conditions. Although there are global default values for carbon stock changes with LUC, there are large uncertainties associated with them. By definition, they also fail to address country, regional or site-specific conditions. In order to assess in a spatially explicit manner the impact of sugarcane-driven direct LUC, we will i) map the main land uses replaced by sugarcane in a recent period of intense expansion (2000-2009); ii) identify the most relevant land use changes considering the area converted and the type of vegetation replaced; iii) select areas for sampling soil carbon in both the reference system and the adjacent sugarcane fields, using the chronosequence methodology; iv) calculate the soil carbon stock change factors of these land use changes. The quantification of land use change will be done by examining national statistics on land use at the municipal level, on a yearly basis over the 2000-2009 period. By examining how much land was converted to sugarcane, and where this conversion occurred, it will be possible to identify the main land uses replaced by the new sugarcane areas, such as pastures, annual crops, perennial crops and native vegetation. The method of chronosequence will be used to identify the temporal dynamics of soil carbon. In essence, a set of areas with similar topography, soil type and soil texture, with different land uses and periods of conversion is identified. A reference area is selected, which is usually a native vegetation site. Then, areas representing the main land uses with different times since conversion are sampled, providing an estimate of the temporal changes in soil carbon. Soil carbon stocks will be measured using sampling methodology compatible with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories – volume 4, as well as the ISO 10381-1:2002, ISO 10381-2:2002 and ISO 10381-4:2003 norms. Using the previous land use type, time since conversion, management systems, soil and climate data, we will be able to generate soil carbon stock change factors for the most relevant land use changes associated with recent sugarcane expansion in Brazil. Those factors will be useful in assessing and proposing improvements on the sustainability of sugarcane and sugarcane-derived products such as sugar, bioethanol, biopolymers and electricity.

Time-dependent climate benefits of using forest residues to substitute fossil fuels

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Objective
We seek to understand whether using forest residues as biofuel is an effective and efficient tool for climate change mitigation.

Approach
We analyze the climate impacts from the recovery, transport and combustion of both slash and stumps from forest harvest sites in Swedish forests, and compare these impacts to what would have occurred if the residues were left to decay in the forest and fossil fuels used instead. As indicators of climate change mitigation efficiency, we calculate the cumulative radiative forcing (CRF) reduction per hectare of forest and the CRF reduction per unit of dry matter of biomass. We vary key parameters including the fossil fuel that is replaced, the forest productivity, decomposition rates for different biomass types, and fossil energy inputs for biomass recovery and transport. We also compare natural decay of biomass left in the forest to the common default assumption of instant oxidation, to determine the significance of that assumption.

Scientific innovation and relevance
Most analyses of the climate change mitigation effectiveness of biofuels have used a carbon balance approach, where all emissions and uptakes that occur during the study time horizon are summed up, regardless of when they occur. This approach, however, does not fully take into account the atmospheric dynamics of GHGs. The temporal pattern of carbon emissions and uptakes can affect the resulting radiative forcing, and hence the climate impact, depending on the time horizon under consideration. In this analysis we explicitly consider the time dynamics of biomass decomposition and atmospheric greenhouse gases over a 240-year time horizon.

Results
We find that CRF is significantly reduced when forest residues are used instead of fossil fuels. The type of fossil fuel replaced is important, with coal replacement giving the greatest CRF reduction. Replacing oil and fossil gas also gives long-term CRF reduction, although CRF is positive during the first 10-25 years when these fuels are replaced. Biomass productivity is also important, with more productive forests giving greater CRF reduction per hectare. The decay rate for biomass left in the forest is found to be less significant. Fossil energy inputs for biomass recovery and transport have very little impact on CRF reduction.

Conclusions
The use of forest residues from boreal forests to substitute fossil fuels appears to be an effective long-term means of reducing radiative forcing and the effects of climate disruption. A short-term increase in radiative forcing occurs if the residues replace oil or fossil gas, but not if they replace coal.

Modelling environmental consequences of direct land use changes from energy crops in a self-sustained and fully renewable energy system in Denmark: Effect of crop types, soil, climate, residues management, initial carbon level and turnover time

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The Danish government has set a target of achieving a 100 % renewable energy system in 2050. This study derives from a research program aiming at designing such a system, with the objective of being self-sustained and independent of imports, and it discusses the perspective of direct land use changes resulting from the use of agricultural biomass (energy crops and crops residues) as part of the design. Denmark is in fact one of the world's most intensively farmed countries, and as a result, has a relatively high amount of agricultural biomass residues like manure and straw available. Despite of this, a fully renewable energy strategy will require approximately 365 PJ of biomass, which is about 165 PJ more than what can be provided by residues alone. Conversion of agricultural land from food/feed crops to energy crops, if Denmark is to be independent of biomass imports, is therefore unavoidable. The goal of this study is to build a robust Danish-specific consequential life cycle dataset for assessing the consequences of direct land use changes caused by energy crops in Denmark. Indirect land use changes occurring as a result of food/feed displacement is beyond the scope of this study.

The system boundary includes all activities within the cultivation stage (from soil cultivation to harvest) and the reference flow used for each processes is 1 ha of land in a year. A considerable level of details has been included in the inventory, resulting in a total of 576 combinations, including 9 crops, 2 soil types (clay and sand), 2 climate types (wet and dry), 3 initial soil C level (high, average, low), 2 horizon time for soil C changes (20 years and 100 years), 2 residues management practices (removal and incorporation into soil) as well as 3 soil carbon turnover rate reductions for perennial crops in response to the absence of tillage (0, 25 %, 50 %). Selected energy crops include 5 annual (spring barley, spring barley combined with a catch crop, winter wheat, silage maize, sugar beet) and 4 perennial crops (*Miscanthus* harvested in spring, *Miscanthus* harvested in autumn, willow and ryegrass). Changes in soil C flows as well as nitrate leaching were modelled through dynamic empirical models built for Danish conditions (C-TOOL and N-LES_4, respectively). National data were used for calculating the partition of the dry matter between above and below ground biomass, while a mix of national data and internationally recognized methodologies (e.g. IPCC) were used for determining the outputs in terms of C flows (CO_2, soil sequestrated C), N flows (NH_3, N_2O, NO_3^-, N_2, NO_X) and other flows (P, Cu, Zn, NMVOC). Data for background processes (e.g. those related to energy systems and fertilizers) were obtained from the Ecoinvent 2007 v. 2.0 database. Sensitivity analyses were performed with different N fertilizers (urea instead of calcium ammonium nitrate) as well as with different calculation methodologies for N_2O.

A life cycle assessment was performed in order to test the database, with a temporal scope of 20 years. The LCA results obtained, as they are comparable to results from existing databases and from published studies, indicate that our database is reliable. These results highlight, among others, that perennial crops like miscanthus and willow should be favoured, if more land is to be dedicated to bioenergy production in Denmark. Based on our results, we also conclude that straw removal for energy production is, in a Danish context, only suitable for winter wheat, since it is the only annual crop not involving losses of soil organic carbon as a result of harvesting the straw.

This consequential LCA database is rather innovative for including such a high level of details, for including soil C changes and for including crops like willow and miscanthus for which, to authors' knowledge, no LCA database are yet available. Moreover, it is a valuable and essential input for assessing the environmental consequences of different bioenergy scenarios and conversion routes to be involved in a Danish 100 % renewable energy system.

Sustainable Agrofuels, Land Use Change, and Certification Schemes

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Objective. To assess whether international, regional and national certification schemes and mandatory blending requirements take sustainability criteria into consideration and to what extent such criteria are of ecological relevance for assessing the impact of direct and indirect land use change (LUC) caused by the production of agrofuel feedstocks.

Approach. "Sustainability" as an overarching objective of national and global policy suffers from an unclear definition of what sustainability actually means with a "weak" and a "strong" interpretation of sustainability competing to be seen as the "state-of-the- art"-definition. I use the strong perspective and test six certification schemes and mandatory blending regulations in order to see whether they among their criteria and benchmarks include the following three dimensions of sustainability in relation to LUC: landscape, biodiversity, and greenhouse gas (GHG) emissions. The comparison is qualitative.
The six schemes and regulations that are assessed are FAO/IFAD/UNCTAD/World Bank Principles for responsible agricultural investment, Roundtable of sustainable biofuels Principles and criteria, Fairtrade standards, IEA Good practice guidelines, EU mandatory blending regulations, and US mandatory bioenergy supply requirements.

Scientific innovation and relevance. The novelty with this approach is that I abandon any attempt to measure "weak sustainability" and replace it by three criteria that all are related to LUC: landscape, GHG emissions, and biodiversity.

Results. Of the six agrofuel schemes and regulations analyzed, only one includes criteria for all the three areas considered essential to capture the sustainability of LUC caused by a feedstock: the IEA Good practice guidelines. For the other certification schemes and blending regulations the result is mixed: FAO et al includes none of the three spheres, while the remaining schemes and regulations each fail on one, or several, of the criteria. The ecological relevance, then, here measured as the degree to which the three ecological dimensions are taken into consideration, varies greatly among the schemes and regulations analyzed. For one all three concerns are included, for one none of them is of concern; for the remainder, the outcome is mixed.

Conclusions. The scheme or regulation that a country or a region chooses to apply decides whether the ecological considerations of LUC will be part of the assessment or not. The production of agrofuel feedstocks would not have come about without a massive intervention of public policies (national and international), but the importance of studying the ecological impact of LUC owes more to the decisive work of and interventions by environmental NGOs and the academic and scientific community. Of the six schemes and regulations studied, one has the potential of forcing an assessment of agrofuel feedstocks LUC in terms of at least three ecological dimension; the other five benchmarks are less relevant in this respect, with the FAO et al surprisingly being the least relevant.

This is not to say that agrofuel feedstocks in reality match all the sustainability criteria; most problematic here is the criterion of biodiversity (for all but degraded lands).

A hypotheses to be tested is that all large-scale, monocultural, chemical intensive feedstocks – i.e. the overwhelming share of feedstocks that we have witnessed during the last decades – will encounter difficulties with their impact on biodiversity (unless they are grown on severely degraded lands). However, their impact on landscape and GHG emissions may still be acceptable.

Oral presentation **Hess**

The Importance of Pre-Conversion Technologies for Coupling Sustainable Bioenergy Land Use to Biomass Trade

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Large scale bioenergy development will shift current land use dynamics in the agricultural sector. The establishment of biofuel and biopower feedstock markets has great potential for encouraging more sustainable land use practices. Work has been done showing that strategically integrating food, feed, fiber, and fuel crops onto the landscape can create more sustainable and more productive agricultural systems. The challenge with implementing this integrated land use approach is that existing lignocellulosic biomass supply and trading systems cannot feasibly handle diverse crops produced in a highly distributed way across the landscape. Creating a robust biomass trading market that can couple diverse and distributed crops to energy producers requires establishing biomass commodity feedstocks which are stable, dense, and predictable in their material specifications. Advanced supply systems that include pre-conversion steps which convert raw biomass into a tradable commodity feedstock near the point of production are necessary to enable the sustainable bioenergy land use vision. The work presented here is exploring how pre-conversion technologies can be implemented in advanced feedstock supply system concepts to enable sustainable integrated land use. The feedstock supply systems investigated utilize distributed processing depots to perform the pre-conversion steps which can include thermal, chemical, and/or biological treatments. Biomass leaves these depots as a commodity feedstock that is stable, dense, and meets defined grades of material specification. The first step in assessing how these advanced supply system concepts perform is realistically coupling the supply system to the biomass production. This discussion will present comparative case studies for conventional and advanced pre-conversion based supply systems directly coupled to a projected biomass resource draw. The case studies will focus on how these systems perform in enabling sustainable integrated land use for bioenergy production.

Estimating indirect land use changes of biofuels given increased organic farming in Europe

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The EU has established a goal of increasing the use of renewable energy in the transport sector to 10% by 2020. Most of this share is expected to consist of biofuels. At the same time, the European Commission is working on increasing organic farming in Europe, for example by a number of initiatives to "develop the market for organic food and improving standards by increasing efficacy, transparency and consumer confidence".[3] The current market share of organic food and farming is around 2% in EU15.

A large number of studies have been made to quantify greenhouse gas emissions from indirect land-use change (ILUC) induced by the production of biofuels. However, so far there have been few estimates, if any, of what the ILUC emissions of biofuels would be assuming a future situation with a much larger share of organic farming compared with today. It might be that the ILUC emissions of biofuels in such a case would be larger. This seems not unreasonable to expect since organic farming, overall, has lower crop yields than conventional farming. Due to its lower yields, a substantially larger share of organic farming would lead to larger land areas being used for food, and higher land rents – in total, the prospect for biofuels might therefore be less favorable. In this on-going study, we will investigate to what extent an increasing fraction of organic farming in the EU will influence the global ILUC emissions of biofuels.

The estimates will be carried out using the Environment/Policy Integrated Climate model (EPIC) in conjunction with the Global Biomass Optimization Model (GLOBIOM). EPIC simulates the interaction of natural resources (soils, etc.) and crop management practices to estimate impacts on crop yields, profitability and nutrient/pesticide fate. GLOBIOM is an economic partial equilibrium model of the forest, agriculture, and biomass sectors with a bottom-up representation of agricultural and forestry management practices. A major methodological contribution in this study will be to create data sets representing organic farming in EPIC in the form of field operation schedules (e.g. crops and crop rotations with typical tillage operations etc.).

[3] Commission of the European communities. (2004). European Action Plan for Organic Food and Farming.

cLCA of European biodiesel – estimation of key drivers for iLUC and identification of mitigation option

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The model adapted and employed by Imperial College London, LCA^works provides a transparent assessment tool for the identification of key drivers of iLUC related GHG emissions of European biodiesel (RME) production. It represents a practical application the Consequential Life Cycle Assessment (cLCA) framework developed by E4tech[4] and allows users 1) to estimate iLUC impacts of a European biodiesel supply chain, 2) to assess the sensitivity of the results to key inputs, and 3) to identify possible iLUC mitigation option by targeting these key drivers.

EU RME production is used as a case study to highlight and discuss the impact of key assumptions on the resulting range of iLUC factors and overall GHG balance of this supply chain. The model outcomes are sensitive to substitution assumptions of soy for rape meal in animal feed and associated soy land use change estimates. The findings are further discussed in terms of the sustainability requirements of the RED and proposed iLUC policy.

[4] E4tech. A causal descriptive approach to modelling the GHG emissions associated with the indirect land use impacts of biofuels. Final report. A study for the UK Department for Transport. October 2010. Available at http://www.dft.gov.uk/pgr/roads/environment/research/biofuels

Oral presentation **Kishchuk**

Nutrient and carbon trajectories, land-use change, and the sustainability of short rotation woody crop production for bioenergy in Canada

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Biomass for bioenergy can provide options for the Canadian forest sector by diversifying product lines and enhancing competitiveness potential through production of green energy feedstock, as well as conventional forest products. The Canadian Forest Service and the Canadian Wood Fibre Centre-FP Innovations are currently obtaining information to support policy in the areas of clean and renewable sources of energy and other bioproducts, viable management regimes for productive lands in Canada, and ensuring economic, environmental, and social sustainability.

A national network of short rotation woody crop (SRWC) research sites has been established on productive agricultural lands across Canada to develop sustainable management systems for purpose-grown woody biomass crops. Specific objectives are: 1) identification and production of fast-growing, high-yield woody crop systems for energy production, 2) development of management practices that advance the sustainable production of those crops with minimal environmental impacts, and 3) supply chain analysis of feedstock to product value streams associated with these systems. The national network of sites allows comparison of SRWC alternatives across a range of climatic conditions and energy production opportunities in Canada. Management regimes on 64 sites in five provinces are: 1) High-yield afforestation (hybrid poplar): area-based, large-stem stands (1100 - 1600 stems/ha), minimum 20 ha installation, tree size 30 cm diameter and 20 m height over 12 - 20 year rotations, and 2) Concentrated production of small-stem woody biomass (hybrid poplar and willow): installations less than 1 ha, 15,000 – 20,000 stems/ha, and harvest cycles of 3-4 years with 5-7 generations for individual coppice systems.

Long-term sustainability research was initiated in 2009 and is focused on site suitability and soil quality indicators, carbon fluxes, management practices, and potential environmental impacts, while the productivity component addresses species and clonal suitability, biomass, yield, and fibre attributes. Preliminary soil nutrient and carbon results from several sites will be presented. Soil nutrient supply rate differed among sites at plantation establishment. Nutrient supply rate decreased at some sites within two years following establishment, while net ecosystem productivity values from the same and older sites showed steady increases. Net ecosystem productivity recovery rates differed with site quality. Establishment of nutrient and carbon trajectories from establishment through the harvest rotation of these intensively managed systems will allow us to quantify and document relationships among soil nutrient supply and biomass production on a range of sites, and to identify potential issues in sustainable production early in the rotation.

Oral presentation **Kline**

'Top Ten' steps to improve the quantification of land-use change effects of bioenergy systems

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Purpose: Describe key areas for improvement related to current science and modeling of land-use change effects of bioenergy. The goal is to identify steps needed to develop models capable of distinguishing the effect of a bioenergy policy from (or its interaction with) other factors that influence LUC, such as variations in weather, major disturbances such as droughts, floods, and fires and other diverse policy regimes and incentives that distort markets and drive land use behavior (trade, monetary, forestry, colonization, land tenure, extractive industries).

Approach: This presentation will briefly review recent literature and case studies in the context of the ten areas below, and offer some examples based on analysis of empirical data to underscore the sensitivity of current modeling results to these issues.

Relevance: While there is extensive use of modeling, there is a lack of documentation about the relative degrees of confidence and uncertainty involved in the underlying data and resulting projections.

Results: Areas that merit attention to improve future LUC modeling include:

1) Development of improved conceptual frameworks that include key variables and drivers of first time conversion;
2) Systematic collection of spatially explicit data on land cover, use and productivity over time to permit modeling and analysis at appropriate scales;
3) Consolidation and verification of spatially explicit data on stocks and flows of carbon - above and below ground – and particularly the changes that correspond to lands undergoing changes in use and management;
4) Parameterization of models to accurately represent policy effects (rather than assumed "shocks" in demand);
5) Documentation and representation of evolving interactions among multiple co-products and abilities for substation across markets;
6) Procedures to develop reasonable reference cases for land use in the absence of the bioenergy option;
7) Methods to classify, allocate and track the degree of confidence and uncertainty in the datasets used, and in model results after data are combined and processed;
8) Approaches to down-scale, up-scale and link models developed to represent changes at different scales.
9) Integration of climate forcing factors (effects of changing albedo, black carbon, latent heat) in different contexts and land use scenarios with effects of GHG emissions;
10) Clarification of choices and effects of spatial and temporal boundaries for analysis and the treatment of different emissions over time.

Conclusions: Despite advances, current modeled estimates of emissions from LUC associated with bioenergy remain speculative.

Moving forward: policies to improve land-use and address social concerns

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Purpose: The future of biofuels depends in part on society's perception of biofuels including their economic, social and environmental costs and benefits, ethical issues regarding food and fuel, and economic development opportunities. Legal, policy and regulatory issues arise concerning carbon neutrality, greenhouse gas emission monitoring, certification, and changes in biomass stocks. These are all inextricably linked to land use and land use change (LUC). Currently, effects are estimated based on modeling that relies on limited data and variable assumptions, yet the model outputs can determine whether biofuels are eligible under state, federal and regional renewable fuel mandates. These issues and the current perceptions of the sustainability of biofuels are reviewed and a path forward identified based on areas of growing consensus.

Efforts to address sustainability through regulations, standards and certification mechanisms are discussed with some focus on recent experiences working on Task Forces for the Council for Sustainable Biomass Production. The issues of costs, benefits and the transaction costs of striving for perfection versus practical issues of implementation are reviewed. The presentation concludes with some considerations about how to improve the communication of scientific results to decision makers and promote the development of regulatory frameworks that are effective, equitable and supportive of continual improvements toward more sustainable biomass energy production.

Using multipliers to assess ecological and economic interlinkages between bioenergy and other cropping systems in North America

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Objective
One of the most urgent problems of biofuel production in its present state is the fact that external effects of crop production activities (including indirect land use change, iLUC, and broader ecosystem impacts) do not play a role in bioenergy crop producers' decision making. Gan and Smith (2010) demonstrated how this problem can partly be solved, i.e. by internalising so-called externality effects in economic decision making. In their paper, they allow a comparison of loss of future income caused by tree residue removal with income that can be generated if the residues are used to produce bioenergy.

Bringing both elements (present income and future income loss) into consideration has major advantages. This approach prevents decision making focussing simply on short-run profits, and provides an instrument to valuate both direct economic activities as well as mitigation of ecologic risks (in this case, nutrient availability in forest soils and related crop production). Consequently, this approach goes beyond commonly applied instruments often used to evaluate the ecological consequences of bioenergy production chains. The objective of this project is to address deficiencies associated with analytical and risk assessment approaches that lack the ability to include external effects (e.g. iLUC, but also positive or negative social implications) and hence need refinement.

Theoretical Approach and Scientific Relevance
In our project, we propose to extend the approach of Gan and Smith. Specifically, a theoretical framework that accounts for both direct and indirect impacts of bioenergy crop/feedstock production will be developed. The concepts of ecological and economic multipliers will be framed. The approach and multiplier concepts will be applied to assessing the biofuels produced from forest residues and maize in the USA; preliminary results will be presented.

The complex ecological and economic interlinks in bioenergy production entail broader, yet effective assessments of its ecological and economic consequences. We attempt to develop an approach for incorporating direct and indirect impacts in bioenergy crop/feedstock production decision-making, and the concept of multipliers to measure the ecological and economic impacts of bioenergy with different system boundaries. Our approach and concept broaden and enrich existing approaches, and are applicable to various bioenergy crop/feedstock production systems.

References: Gan, J. and C.T. Smith. 2010. Integrating biomass and carbon values with soil productivity loss in determining forest residue removals. Biofuels 1(4): 539–546.

Poster presentation **Louime**

Evaluating The Risk Of Biological Invasions From the Biofuels Feedstock **K.** *pentacarpos*

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It is known that the introduction of any organism to a new ecosystem can create new challenges, such as new pests and disease pressures, unless extraordinary precautions are taken. Therefore, it has become a necessity to develop strategies that will ensure a sustainable transition of land to bioenergy production. This project focused on the development and evaluation of the salt tolerant potential bioenergy crop, Seashore Mallow (*Kosteletzkya pentacarpos*). *K. pentacarpos*, a perennial halophytic species native to the salt-marshes of the eastern United States is known to display tremendous potential as an alternative biofuel feedstock. As a facultative halophyte producing seeds with oil content between 18 and 24%, in par with soybean, *K. pentacarpos* can also be cultivated on land, removed from its natural habitat. The goal of this study was to evaluate the crop protection challenges presented by this halophytic species when cultivated on land as a biofuel feedstock. This study aimed at comparing the environmental impacts of monoculture of *K. pentacarpos* versus a multi-species mix of bioenergy crops. Specifically, we conducted faunistic/floristic surveys to document potential pests and assess their ecological relationships in single and mixed cropping, and determine their relations to crop yield. Preliminary data collected from our field trials, suggested that yield as high as 900kg/acre can be achieved. Besides these economic benefits, data generated here provided some insights on how the scale of production, soil types, and the concentration of biomass production would affect biodiversity and habitat value for different bioenergy feedstocks.

Framework for evaluating the environmental consequences of bioenergy-driven land-use changes at local and regional scales

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The environmental impacts of bioenergy crop production vary according to spatial scale, location and land-use change pathways. These consequences on natural resources (i.e. water, soil, biodiversity and landscapes) at local and regional scales have received little attention, due in part to the absence of a comprehensive evaluation framework for assessing land-use change impacts associated with bioenergy crop production (hereafter referred to 'bioenergy-driven land-use changes'). The aim of this research is to develop a spatially-oriented framework for evaluating and comparing the consequences of alternative land-use change scenarios for bioenergy crop production at the local and regional scales. We developed conceptual models using Casual Loop diagrams to identify key issues related to bioenergy-driven land-use change and to help understand the nature of the relationships among the factors. The evaluation framework was based on conceptual models, which incorporated indicators for key natural resource elements, such as water and biodiversity, and tools/models (e.g. catchment models and landscape-scale biodiversity analysis tools) to assess these indicators, which were partly or fully integrated into ArcGIS software. The output provided a mechanism for effectively communicating the multiple land-use change scenarios and their consequences with decision and policy makers.

Land-use pressures resulting from bioenergy crop expansion

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Current energy and climate change policies, particularly in the developed world, that have increased demand for bioenergy, in turn have driven both direct and indirect land-use changes and an array of associated environmental consequences. A comprehensive understanding of the land-use dynamics of bioenergy crop production is essential in the development of sustainable bioenergy and land-use policies. The aim of the research is to review and analyse the patterns and dynamics of land-use change associated with bioenergy crops (hereafter referred to as ‘bioenergy driven land-use change’). The review was global in its context and resulted in the identification of four focus countries/regions for further investigation. These included Brazil, Indonesia and Malaysia, the USA, and the European Union (EU). The research was primarily literature based and resulted in the identification of these focus countries/regions.

There are distinct differences in trends, characteristics and causes of bioenergy-driven land-use changes among countries/regions, particularly between the developed and developing worlds. Pathways of land-use change were developed for these focus countries/regions to help conceptualize the patterns and dynamics of land-use change and to deliver better predictive future scenarios. This review indicated that bioenergy-driven land-use change has impacted and will likely impact much more severely on ‘land- and resource-abundant’ developing regions, such as Brazil and Southeast Asian countries, where economic development policies have often prioritized crop expansion over sustainable land-use and conservation policies. This has resulted in high levels of deforestation with devastating consequences. The review also indicated that a promising new scenario for future bioenergy production is to allocate agricultural land not in or not suitable for food production to bioenergy crop production to minimize impacts (e.g. land under Conservation Reserve Program (CRP) in the USA and abandoned agricultural land/farmland). However, the use of such lands may be controversial because they can still have high conservation and biodiversity values. This scenario requires further evaluation to investigate more sustainable land-use change options for future bioenergy crop production.

Estimating soil carbon stock changes due to the expansion of sugarcane production in Brazil

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Delta CO2 is a science and technology consultancy specialized in GHG management including GHG emission projects, soil carbon sequestration assessments, direct land use change (LUC) assessments and life cycle assessments. The company is incubated at the Escola Superior de Agricultura "Luiz de Queiroz", the agricultural college of the University of São Paulo. Delta CO2 has performed land use change assessments involving the expansion of the sugarcane crop in Brazil, which has been driven by the increase in demand for bioethanol both in the internal and external markets. The focus of the LUC assessments has been on soil carbon stock changes, through the identification of the main land use changes in a specific region and period. In order to do that, the strategy that has been applied is the selection of chronosequences to study the temporal dynamics of soil carbon stocks. A chronosequence is a set of areas with similar topography, soil type and soil texture, with different land uses and periods of conversion. A reference area is selected, which is usually a native vegetation site. Then, areas representing the main land uses are sampled. Areas with the longest period under sugarcane will be given preference – soil carbon stock changes are usually not detectable in the short term (days and months), but in the time frame of years. Situations evaluated will be degraded pastures to sugarcane, managed pastures to sugarcane, and annual crops under different management systems, such as no-till, crop rotation. From each chronosequence, soil carbon stocks are measured using sampling methodology compatible with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories – volume 4, as well as the ISO 10381-1:2002 and ISO 10381-4:2003 norms. The stocks are calculated using data from soil bulk density, soil carbon content and sampled soil layer. Delta CO2 has the technical capability to analyze the necessary variables to calculate the mentioned soil carbon stocks and to discuss the factors influencing its changes.

The development and use of methodologies to measure direct and indirect land use effects of sugarcane bioethanol.

André Nassar, Marcelo Moreira, Leila Harfuch, Luciane C. Bachion, Laura Antoniazzi

INSTITUTE FOR INTERNATIONAL TRADE NEGOTIATIONS

Since the end of 2007 the Institute for International Trade Negotiations (ICONE) has been working on improving the methodologies used for measuring the impacts of the expansion of the agricultural sector on land use in Brazil. The main purpose of this research agenda is to quantify direct and indirect land use changes (LUC and iLUC) of agricultural□based biofuels in general and sugarcane ethanol in particular. In a partnership with the Center for Agricultural and Rural Development (CARD, Iowa State University), ICONE´s research team developed an economic model called Brazilian Land Use Model (BLUM) to simulate supply and demand of agricultural products produced in Brazil and its impacts on the demand for land. The improvements developed through this partnership were integrated to the FAPRI system of models for the measurement of iLUC of the Renewable Fuel Standard Program (RFS2).

Besides economic modeling, ICONE is also working with other methodologies to quantify land use changes as a consequence of the expansion of agricultural□based biofuels (Nassar et al., 2011a). The institute developed a deterministic methodology to estimate GHG land use emissions associated to the expansion of sugarcane (Nassar et al., 2010). Furthermore, the institute is currently working on improvements to insert GIS data as well as different technological pathways for biofuel production in economic land use models.

The objective of the presentation is to share the institute´s experience in quantifying iLUC impacts of biofuels production in Brazil. Strengths and weaknesses of both economic models and allocation methodologies will be presented, as well as the different results reached so far. The presentation will also focus on how GIS data and analysis can contribute to improve iLUC quantification in different methodologies.

A Prospective Analysis of Brazil and U.S. Biofuel Policies: Impacts on Land Use, Greenhouse Gas Emissions, and Social Welfare

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The complex biofuel policy climate in the U.S. and the blending standards in Brazil leave the public with unclear conclusions about the prospects for biofuels supply and trade; hence, several important questions are raised: If the U.S. removes the current trade policy restrictions can sugarcane ethanol imported from Brazil be a more economical alternative to corn-based and the advanced biofuels production in the U.S. to satisfy the Renewable Fuel Standard (RFS) blending requirements? If all subsidies and trade policies are removed what would be the economically optimum transportation fuel mix without biofuel mandates? How would the increased demand for sugarcane ethanol affect consumers and producers welfare, land uses in Brazil and the U.S., and aggregate Greenhouse Gas (GHG) emissions?

Brazil has a vast amount of agricultural land most of which is used for beef cattle production using an extensive grazing system. It has been argued that at a reasonable investment cost it is economically feasible to convert a substantial portion of the pasture lands into cropland and expand the current sugarcane plantation to meet the increased demand for ethanol including both the domestic and export demand. Removal of the U.S. trade policies would further intensify the conversion process. There is little previous research that considered the potential for transition (semi-intensification) in the livestock production practices in Brazil and impacts of this on the growth of the biofuel sector and agricultural land use.

In this paper, we develop a spatial, multi-market, multi-product partial equilibrium framework regionally disaggregated both for Brazil and the U.S. agricultural, livestock and biofuel sectors. The model integrates demands for food, feed, and fuel commodities, resource constraints in both countries, trade policy provisions, and the RFS targets. We use the model to analyze the impacts of trade policy distortions on the international biofuel economy, land use changes in both countries and the total GHG emissions. We focus particularly on the potential for livestock semi-intensification in Brazilian pasture grazing systems as a prospective pathway for releasing new lands and expanding sugarcane, corn, and soybean cultivation while simultaneously taking into account Brazil's role in the world beef market.

Regarding the bioenergy components, the main features of the model are: i) an explicit demand for distance driven by two vehicle types in each country, namely conventional and flex-fuel vehicles; ii) production and consumption of hydrous and anhydrous ethanol; iii) domestic and foreign supply functions for conventional transportation fuels; iv) biofuel policies, specifically blending mandates imposing the amounts of different types of biofuels (corn-based, advanced, and advanced non-starch) that must be blended with conventional liquid transportation fuels; v) export/import possibilities for tradable crops, semi-processed commodities, and biofuels. In specific, on the Brazil side: i) a reasonably fine spatial disaggregation (137 mesoregions) and detailed agricultural supply structure in each region for the production of sugarcane and eight temporal crops (soybeans, corn, wheat, sorghum, cassava, beans, cotton and rice) by use of inter-year and intra-year crop rotations (e.g. second corn after soybeans or beans, or corn-beans-beans, etc.); ii) in the livestock sector, three pasture land categories are distinguished, namely planted in good condition, planted degraded, and native pastures, and beef-cattle semi-intensification alternatives are considered in each region; iii) expansion of sugarcane on pasture lands is restricted to the Agro-Ecological Zoning for Sugarcane. On the U.S. side: i) the agricultural sector is regionally disaggregated into 48 states for the production of eleven crops including barley, corn, cotton, oats, peanut, rice, soybean, sorghum, sugar beets, sugarcane, and wheat, which can be produced by use of interyear crop rotations; ii) alternative cellulosic feedstocks including energy crops such as miscanthus and switchgrass, and crop residues including corn stover and wheat straw.

The model is calibrated to replicate the base year (2007) market conditions both for Brazil and the U.S. Then we proceed with the scenario analysis considering alternative biofuel trade policies between U.S. and Brazil for the year 2022. The model results show that under the current policy, cellulosic ethanol production would slightly exceed the advanced non-starch biofuel (ethanol) mandate, and ethanol imports from Brazil would fill the rest of the advanced biofuel category. The corn and sugarcane production in Brazil would increase significantly to fill the corn demand in the international market that was previously met by the U.S. and to fulfill the U.S. biofuel mandates; the new cropland areas would come from a corresponding reduction in the pasture area, although the beef supply would be maintained almost at its previous level due to the implementation of semi-intensive grazing practices. Under trade liberalization, i.e. no tariff on imported ethanol, Brazilian sugarcane ethanol would supply the entire 4-billion gallons advanced ethanol requirement. This would increase the Brazilian farmers' and blenders' welfare, but the total GHG emissions would remain almost unchanged. When all tariffs and producer subsidies are removed in the U.S., production of agricultural crops and biofuel feedstocks would be similar to those in the previous scenario. However, removing subsidies would make U.S. consumers better off. Finally, when the RFS is removed entirely, Brazilian ethanol exports to U.S. and U.S. cellulosic ethanol production would become zero, only some corn ethanol would be blended into gasoline consumed in the U.S. resulting in higher GHG emissions, particularly in the U.S., but Brazilian fuel consumers would gain welfare due to the lowered domestic ethanol price and food commodity prices.

Policymaking for Refractory Uncertainty

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Biofuels policies around the world have now generally recognized GHG discharges resulting from land use change (especially from forest to cultivation or pasture) induced through international food trading as a significant component of the "carbon intensity" of biofuels that compete with food for land. However, most of these policies depend in one way or another on an estimate of this effect, and the available estimates, even for the same biofuel from the same region vary widely. When an uncertainty analysis of the model prediction is performed, substantial likelihoods of very high values are indicated, even when the central estimators of this *global warming index* (GWI) are much lower.

Implementing most of these policies constitutes publication of an official value, or a finding that it is in a particular range: with our best knowledge characterized by an asymmetric probability distribution with non-trivial variance, what statistic of this distribution should be used? In principle, the implied policy is simple: choose the value that will minimize the expected cost of the program, a calculation that can be performed only with an assumption about the "cost of being wrong" and assumptions about how the fuel system will respond to possible published GWI values. Agencies have implicitly used the mode (the most likely value) but in such distributions, the mode, mean and median are not the same and usually, the mode does not minimize expected cost. Alternatively, heuristic methods like the application of a safety factor in engineering (which embodies recognition of an asymmetric cost of error function) might be invoked.

This paper will present the decision-theoretic basis for the step from a set of economic estimates of a fuel's GWI and the intrinsic uncertainty of this value, through the probable form of the cost of error function, to conceptually sound choice of a single operational GWI value or range when policy requires it. We will also discuss alternate policy frameworks within which refractory uncertainty in LUC estimates fit more comfortably and more consistently with existing policy in other contexts.

A Prospective Analysis of Brazil and U.S. Biofuel Policies - Impacts on land use, greenhouse gas emissions, and social welfare

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The complex biofuel policy climate in the U.S. and the blending standards in Brazil leave the public with unclear conclusions about the prospects for biofuels supply and trade; hence, several important questions are raised: If the U.S. removes the current trade policy restrictions can sugarcane ethanol imported from Brazil be a more economical alternative to corn-based and the advanced biofuels production in the U.S. to satisfy the Renewable Fuel Standard (RFS) blending requirements? If all subsidies and trade policies are removed what would be the economically optimum transportation fuel mix with and without biofuel mandates? How would the increased demand for sugarcane ethanol affect consumers and producers welfare, land uses in Brazil and the U.S., and aggregate Greenhouse Gas (GHG) emissions?

Brazil has a vast amount of agricultural land most of which is used for beef cattle production using an extensive grazing system. It has been argued that at a reasonable investment cost it is economically feasible to convert a substantial portion of the pasture lands into cropland and expand the current sugarcane plantation to meet the increased demand for fuel ethanol including both the domestic and export demand. Removal of the U.S. trade policies would further intensify the conversion process. There is little previous research that considered the potential for transition (intensification) in the livestock production practices in Brazil and impacts of this on the growth of the biofuel sector and agricultural land use.

In this paper, we develop a spatial, multi-market, multi-product partial equilibrium framework both for Brazil and the U.S. agricultural, livestock and biofuel sectors. The model integrates the demands for food, feed, and fuel commodities, resource constraints in both countries, trade policy provisions, and the RFS targets. We use the model to analyze the impacts of trade policy distortions on the international biofuel economy, land use changes in both countries and the total GHG emissions. We focus particularly on the potential for livestock intensification in Brazilian pasture grazing systems as a prospective pathway for releasing new lands and expanding sugarcane, corn, and soybean cultivation while simultaneously taking into account Brazil's role in the world beef market.

Both the US and Brazil supply response components of the model are regionally disaggregated, where regions differ in terms of their production costs, crop yields, and resource availabilities. Specifically, in the Brazil model we consider: i) 137 mesoregions and detailed agricultural supply structure in each region for the production of sugarcane and eight temporal crops (soybeans, corn, wheat, sorghum, cassava, beans, cotton and rice) by use of inter-year and intra-year crop rotations (e.g. second corn after soybeans or beans, or corn-beans-beans, etc.); ii) three pasture land categories, namely planted in good condition, planted degraded, and native pastures, and beef-cattle intensification alternatives in each region; iii) restricted expansion of sugarcane on pasture lands according to the Agro-Ecological Zoning for Sugarcane; iv) completion of the recently launched ethanol pipeline projects in Brazil. On the U.S. side we consider: i) 295 Crop Reporting Districts (CRD) for the production of eleven conventional crops (including barley, corn, cotton, oats, peanut, rice, soybean, sorghum, sugar beets, sugarcane, and wheat), which can be produced by use of inter-year crop rotations; ii) alternative cellulosic feedstocks including energy crops such as miscanthus and switchgrass, and crop residues including corn stover and wheat straw.

Regarding the bioenergy components, the main features of the model include: i) explicit demand functions for distance driven by pure ethanol (only in Brazil), conventional and flex-fuel vehicles; ii) domestic and foreign supply functions for conventional transportation fuels; iii) export/import possibilities for tradable crops, semi-processed commodities, and biofuels with the rest of the world; iv) China's increasing demand for both agricultural commodities and biofuels.

The model is calibrated to replicate the base year (2007) market conditions both for Brazil and the U.S. Then we proceed with the scenario analysis considering alternative biofuel trade policies between U.S. and Brazil for the year 2022.

The preliminary empirical results show that under both a business-as-usual scenario (i.e. no RFS, no subsidies, no trade barriers) and an 'only RFS mandates' scenario (without subsidies and tariffs), U.S. would substantially reduce the domestic ethanol production. Under the 'only RFS mandates' scenario, Brazil supplies a significant part of the U.S. ethanol demand. Implementing the RFS mandates and maintaining the current policy incentives for cellulosic ethanol production would decrease the aggregate welfare in both U.S. and Brazil. Under an 'only RFS madates' scenario, intensifying the current livestock systems, particularly in Mato Grosso, Mato Grosso do Sul, and some southern states, would release a significant amount of land for sugarcane production, mainly in Mato Grosso do Sul, Minas Gerais, and Goiás. This would allow and increased biofuel production potential in Brazil without deforestation and savannah conversion, which ultimately implies reduced GHG emissions.

The Three Pillars to Operationalizing Biofuels Sustainability Standards in Agricultural and Forest Landscapes

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How to balance land uses to sustainably feed, clothe and power a burgeoning population aspiring to western lifestyles will be one of, if not the most profound challenges to policymakers in the 21st century. And, climate change's unpredictable affects on natural systems will exacerbate already complex, uncertain and contentious land use decision-making. While biomass-based energy policies gained momentum throughout the 2000s as one way to reduce greenhouse gas (GHG) emissions, assumptions about biofuels' environmental and societal benefits are beginning to come under closer scrutiny. For example, if not grown on marginal or idle lands, biomass competes with food cropping for productive land, thereby posing a potential threat to food security. Higher commodity prices brought about by land scarcity may spur indirect land use changes in areas of high carbon stocks, which may increase net GHG emissions associated with biomass production. More recently, sustainability concerns have reached beyond GHG emissions to other negative environmental and social impacts associated with biomass production. In response, bioenergy laws have incorporated varying forms of sustainability considerations. Many private standards have emerged, however, to fill real and perceived gaps, or in some cases anticipate future regulatory requirements for increased sustainability. The authors present their conceptual framework for addressing one of the greatest challenges ahead for these standards – how to operationalize sustainability regimes to achieve the desired level of environmental and social protection. The authors start by briefly examining the drivers of sustainability requirements for biomass based energy in the US, EU and Brazil, including current bioenergy legislation, as well as the perception by interest groups that governments and markets have failed to protect the natural and human environment within fields and forests through enforcement of environmental, agricultural, and other laws. These drivers form the basis for various private and private-public standards that have developed at national and international levels, which the authors summarily review.

Agricultural biomass sustainability regimes represent a particularly groundbreaking paradigm shift within a traditional commodity landscape that historically has not been subject to certification to specialized sustainability metrics on a widespread basis. That is not to say that the forestry sector will be immune to similar reconfiguration, however, to the extent new demand, novel species, cultivation, and harvesting techniques, and the emergence of a carbon regulated economy raise unique sustainability questions. With these new landscape paradigms in mind, the authors' propose the lens through which private (e.g, firms, non-governmental organizations) and public actors must successfully navigate three pillars of operationalization to ultimately achieve the sustainability goals contained in any sustainability standard. The authors' innovative approach integrates for the first time in scholarship the concepts of:

(1) development of substantive, field-based measurements and tools; (2) building standards organizations on good governance principles; and, (3) harmonization of standards to facilitate international trade. The authors conclude that each pillar in and of itself presents great challenges at all governance levels in transitioning from aspirational to operational standards.

CANCELLED: Impact of National Renewable Energy Action Plans (NREAPs) in terms of pressure on European land use.

The general picture and the case of Italy

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Unfortunately, Nicolae Scarlat and Jean-François Dallemand will not be able to participate. If you have any questions regarding their abstract, please contact them by email (Jean-Francois.DALLEMAND@ec.europa.eu).

According to the EU Renewable Energy Directive (RED) 2009/28/EC on the promotion of renewable energy sources, the EU Member States should increase the use of renewable energy to 20% of final energy consumption and 10% in the transport sector by 2020. The National Renewable Energy Action Plans (NREAPs) prepared in 2009 by the 27 European Union Member States show that bioenergy is expected to remain in 2020 a major source of renewable energy (56.6%), followed by wind (17.6%), hydro (13.3%), solar (6.3%), heat pumps (4.9%) and geothermal (1.1%).

More specifically, the total amount of bioenergy (bio-heat, bio-electricity and biofuels for transport) is expected to rise in EU27 from the 2005 figure of about 2585 PJ to an expected amount of 5880 PJ in 2020, thus with the contribution of bioenergy to the EU-27 energy mix more than doubling. Such substantial result will be obtained at EU27 level by means of an expected yearly increase rate for bioenergy between 4% and 5% for bio-heat and bio-electricity and between 7% and 10% for biofuels. Increase rates vary significantly between Member States. Even if such an increase rate for EU27 is smaller than the one expected for other renewable sources (e.g., about 30% for offshore wind or 15% for Solar PhotoVoltaic), bioenergy will play the major role in the renewable energy mix. As a consequence, the problem of biomass resources availability and mobilisation both in terms of improved biomass exploitation and additional land devoted to bioenergy feedstock production has to be taken into account, especially with increased competition of uses.

A detailed view of the NREAPs for biomass exploitation for energy production will be provided, with a special focus on the availability of biomass in Europe according to the Member States. This issue, crucial in order to reach the RED target, will be discussed on the basis of an estimate of the primary biomass consumption based on a transparent methodology starting from the final energy consumption proposed in the NREAPs and using the efficiency of energy conversion for biomass estimated by AEBIOM for each country.

The case of Italy will be further discussed. For Italy, in 2020, according to the 2009 RED Directive, 17% of final energy consumption should be covered by renewable sources, compared to only 5.2% in 2005. Taking as a reference the energy efficiency scenario proposed in the Italian NREAP, this means that in 2020 the final consumption of renewable energy in Italy should be 22.6 Mtoe, compared with 6.9 Mtoe in 2005. According to the NREAP, the contribution of bio-electricity is expected to increase from 4.7 TWh in 2005 to 18.8 TWh in 2020, to represent 19.4% of RES electricity in 2020, from 8.3% in 2005. Similarly, biomass use for heating and cooling is expected to increase from 1.7 Mtoe in 2005 to 5.7 Mtoe in 2020. In spite of a reduction of the biomass share in the renewable heating and cooling sector (from 86.4% in 2005 to 54.2% in 2020), biomass should remain the main source for renewable heating and cooling at Italian level.

The biofuel consumption in Italy in the transport sector should increase from 179 ktoe in 2005 to 2,530 ktoe in 2020, out of which 400 ktoe are expected to correspond to biofuels produced from wastes, residues, non-food cellulosic and ligno-cellulosic material (biofuels under article 21.2 of the RED). An important part of these biofuels (1 Mtoe) is expected to be imported (800 ktoe biodiesel and 200 ktoe bioethanol/bio-ETBE), representing 40% of the biofuels to be used in Italy in 2020.

The bioenergy targets for 2020 are expected to have a major impact on biomass supply and land use. Based on the NREAPs, we estimate that the gross inland consumption of biomass is expected to increase to more than 180 Mtoe in 2020, from 104 Mtoe in 2009 within the whole EU. In Italy, the gross inland consumption of biomass is expected to increase from 3.5 Mtoe in 2005 to 14.3 Mtoe in 2020. Increasing the biomass supply is a key challenge to meet the bioenergy targets. Based on the NREAPs data and expected biomass demand, a quantification of the different possible impacts (in terms of acreage) on the agriculture, forestry and waste sectors will be made for the EU and the Italian example, based among others on the 2010 AEBIOM scenario (see European Biomass Statistics, p.25, 2010) and EEA 2006.

Oral presentation **Pingoud**

GWP factors and warming payback times as climate indicators of forest biomass use cycles

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Rapid reductions in global greenhouse gas (GHG) emissions are required to enable the 2°C degree stabilisation target. Timing of emissions is thereby an essential part of the target. Sustainably managed forests are basically carbon (C) neutral over the rotation. However, any additional biomass harvest creates at least a temporary imbalance or C debt in biogenic stocks with respect to the baseline without above harvest – whether considered at stand or landscape level. Thus additional use of forest biomass could in a notable timeframe even increase the emissions and warming impact, especially when the forest rotation is long, the decay of forest harvest residues used for bioenergy is slow, or when the efficiency of the biomass use cycle – characterized by the displacement factor of fossil C emissions – is low. These are issues to be taken into account when considering mitigation scenarios or developing better climate indicators for LCA of biomass products.

A method for estimating the warming impact of forest biomass harvest and its use with respect to fossil fuel based functionally equivalent alternatives is presented. The method is based on derivation of global warming potentials (GWP) of both the carbon debt of the terrestrial biogenic stock (i.e. the GWPbio factor, recently presented by Cherubini et al. 2011) and of the carbon credit of biomass use cycle due to displacement of fossil carbon and sequestration of biomass into long-lived materials. The method is analogous to that of Schlamadinger and Marland (1996, 1997), but instead of considering just cumulative C balance of the tectonic and biogenic stocks the true warming impact of these C stocks is estimated by the pulse response model based on the Bern Carbon Cycle Model (IPCC 2007, p.231). As realistic examples 1) bioenergy from forest harvest residues to displace fossil fuels and 2) use of wood from long-rotation forests to material substitution are presented. The results show that the cumulative warming impact based indicator leads to longer payback times – i.e., the timeframe needed for the biomass option to be superior to its fossil based alternative – than when just cumulative C balance is considered. Further, if the timeframe of GHG mitigation is fixed, the GWP factors – one for the biomass harvest and the other for the biomass use cycle – provide a single emission-like indicator relating the climate impact of the biogenic C cycle to that of a permanent fossil C pulse emission.

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POTENTIAL EFFECTS OF THE BRAZILIAN BIODIESEL AND PALM OIL PROGRAM ON SOCIOECONOMIC INSERTION OF FAMILY FARMING

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The objective of this paper is to provide an approach to family farming insertion regarding the production of raw material for bioenergy production, with focus on Palm Oil. The socioeconomic insertion lies within Brazil´s National Production and Use Biodiesel Program (PNPB) and the Sustainable Oil Palm Production Program which both allow the participation of family farming with special subsidies and warranties.

The approach consists of a qualitative analysis concerning the review of the public policy and its instruments along with the literature of the effects of contract farming on the quality of life of participant farmers.

The paper enhances the role of public policy in economic development and in inequality reduction, through the participation of the private sector by means of contractual relationships between the latter and the family farmers in Brazil.

The literature review suggests that benefits of contractual forms on family farming insertion are apparent as the gap between the market (the agro industry in this case) and the farmers is reduced, enabling the elevation of their life quality standards and their economic reproduction. Public policy (the government) here allows this gap closure through the institution of instruments that go from agroecological zoning, the “social label”, credit, tax reduction and warranted industrial demand for biodiesel, to the creation of production conglomerates.

Recent evaluation from the Ministry of Agrarian Development (MDA) shows effective insertion of family farmers into the Biodiesel Program, specifically with oleaginous seeds as soybean and castor seed. As for oil palm, the recent Oil Palm program (from 2010) has yet to progress due to the long pre-production crop period (3 years). Brazil is aiming to diversify the sources in order to make space for small farm agriculture in the Biodiesel scenario.

Developing a framework for monitoring biofuel sustainability: Integrating remote sensing and geospatial analysis to quantify impacts of biofuel expansion

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Land use patterns and changes are central and critical to biofuel sustainability. Land use changes affect carbon stocks, water consumption and nitrogen losses for example that in turn impact GHG emissions, water availability and water quality. Quantifying direct and indirect land use change (dLUC, iLUC) attributable to biofuel expansion requires a baseline against which changes can be quantified. Most data is available in the form of maps of land cover (physical appearance of the land) and statistical information on land use (human interactions with the land). Remote sensing and geospatial analysis (RS-GIS) provide a practical mechanism for reconciling land cover and land use to develop a baseline and monitor changes. At the subnational scale, numerous high resolution analyses exist linking remote sensing data with land use or specific biofuel crops for several countries. However, this approach limits the ability to cover wider geographic scales (e.g. national scale) cost-effectively. In a two part study, the capabilities of RS-GIS monitoring using a sub-national scale dataset applied to a case study: North Dakota (ND), USA are explored. Results from Part 1 of the study show that RS-GIS were able to identify that a 6% expansion of croplands occurred in ND between the years of 2002-2009. The data enable differentiation of crops and the expansion can be seen as predominantly from corn and soy; both crop types relevant to biofuels. Corn and soy expansion occurred primarily through the replacement of other crops such as wheat with little expansion into non-crop land cover such as grassland. These land use changes were easily quantifiable with RS-GIS techniques for ND at the 56-m scale. The cause of iLUC was not quantifiable, but initial results showed that the expansion of corn and soy into other crop types may have resulted in a decline of wheat crops and displacement of other crops into grasslands. However, significant other drivers such as wet weather, disease associated with crops, and technological advances in the production of corn and soy, were factors that could be driving LUC in addition to biofuels. Results of Part 1 of the study demonstrated the capability of RS-GIS for monitoring biofuels at the subnational scale.

In part two of the study (underway), we present a framework for monitoring biofuel sustainability at the national scale considering limitations associated with RS-GIS capabilities, geography, and causality of change, especially as it pertains to iLUC. The framework will be informed by the exploration of methods for improving moderate scale land cover classifications (MODIS, MERIS) for biofuel related analysis by investigating relationships between higher resolution land use analyses and moderate resolution land cover classes, specifically: (1) statistical relationships, (2) utilizing higher resolution land use analyses as training regions for moderate resolution time series, and (3) utilizing time series techniques that extract growing season parameters to enhance moderate scale classifications. A more detailed analysis of the results and conclusions from Part 1 of the study and preliminary results and strategies for Part 2 of the study will be presented.

Poster presentation **Sasu-Boakye**

Greenhouse gas emissions and land use change from the substitution of Brazilian soybean with locally produced protein feedstuff in Scandinavian dairy and pig production

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One benefit of some biofuel systems is with the provision of by-products such as rapeseed meals and DDGS, which used together with other feed products as animal feed substitutes contribute to mitigating the environmental impact of livestock production. In this study we assessed the environmental impact of feed substitution in pig and dairy production in Northern Europe using two feed rations with protein content that are either locally produced (rapeseed meal, pea, clover) or imported soy meal concentrates from Brazil. Specifically, we evaluated the contribution of feed production, animal production and manure management to greenhouse gases (GHG) emissions from feed substitution using a cradle to grave life cycle approach (LCA). Since there is no consensus on a standard methodology for land use change (LUC) related emissions, we analysed the influence of LUC related GHG emissions using three methodological approaches developed in LUC literature.

The calculated GHG emission from the LCA was 5% lower for pig production and 10% lower for dairy production when using the locally produced feed ration. Feed production and methane from enteric production were the main contributors to GHG emission in pig and dairy production, respectively. Land area requirement for each feed ration was an important parameter when estimating the LUC related GHG emissions. Locally produced feed ration in pig production required 5% more land and 15% more land in the dairy production. The influence of LUC related GHG emissions depended on the method applied but the relative difference in GHG emissions of the two feed rations were unchanged. The study shows that substitution towards locally produced protein feedstuffs may be a significant GHG mitigation practice. However, the methods used in this study to estimate the LUC related GHG emissions did not account for the chain displacements of land use that can occur from feed substitution and the associated indirect LUC emissions which can significantly influence the GHG balance of the feed substitution. In a follow-up study, we will assess these chain effects, and the resulting indirect LUC emissions, of substitution of Brazilian soybean with Northern European protein feedstuffs using a partial equilibrium modelling approach paired with a geographically explicit land use description. We expect that this follow-up study will improve the understanding of the regional and global land use patterns related to the vegetable oil and protein feedstuffs markets, in both the food and bioenergy sectors.

Impacts of sugar cane cultivation on physical-chemical, biochemical and microbiological properties of yellow and red oxisols under different management in the microregion of Quirinopolis, Go, Brazil

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To assess soil quality indicators is necessary to use soil attributes that are intended to quantify the environmental changes caused by different management systems in relation to a reference system, which is generally considered to be the native forest. The qualitative or quantitative knowledge on changes in soil properties are the best impact indicators (Melloni et al., 2008). Chemical indicators are related to aspects of plant nutrition, water quality and the permanence of soil nutrients. They have direct effect in the case of macro- and micronutrients, or indirect, when it comes to the presence of soil organic matter (Mesquita et al., 2000). Biological indicators can be defined by species or group of microorganisms, the biological presence and activity in a given area, the existence of a specific environmental condition. However, it is important to consider the soil organic matter within a biological attribute. Among the soil organic matter attributes, the total soil microbial biomass acts as an important reservoir of nutrients for plants. Respiration is the most widely used method to quantify the metabolic activity in soils, which can be accessed through the release of CO2 (Moreira & Siqueira, 2006). However, in order to give a more interpretive approach and to establish more dynamic relations between biomass and activity, Anderson & Domsch (1990) proposed a specific measure of metabolic activity, called metabolic quotient (qCO2). This measurement reports the release of CO2 per unit of biomass and time (C-CO2/C-minc h-1), which corresponds to a specific activity index of heterotrophic biomass. This study aimed to evaluate the morphological, physical, chemical, and biological properties of two classes of soils, the Red Oxisol distroferric (ROdf) and Red-Yellow Oxisol dystrophic (RYOd), under four types of sugar cane management and native Cerrado. In this paper we report the results on soil biomarkers used to evaluate the impacts of sugar cane cultivation on soil quality.

The revision of the Brazilian forest act: increased deforestation or a historic step towards balancing agricultural development and nature conservation?

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Almost two-thirds of the Brazilian territory still has prevalence of natural vegetation. Although not all pristine, much of these areas have high conservation value. 170 Mha of the natural vegetation is located within public parks. Most of the remaining 367 Mha is on private lands used for agriculture, where the Forest Act is the most important legal framework for conservation.

In July 2010, the Brazilian parliament began the analysis of a substitutive legislation for the Forest Act (FA). The main motivations for the revision is that, on the one hand, the FA is considered ineffective in protecting natural vegetation, and on the other hand, it is perceived as a barrier against development in the agriculture sector.

The outcome of the FA revision will have strong influence on future land use in Brazil, affecting also the possible size of dLUC and iLUC emissions associated with bioenergy expansion. The substitutive FA as it presently stands does not represent a balance between existing standpoints and objectives; it may drive development towards either more private protection through market-driven compensation actions, or increased deforestation and less nature protection/restoration.

The proposed contribution to the workshop uses outcomes from GIS based modeling analyses to discuss weaknesses of the substitutive FA and suggest possible improvements – and also describes how the substitutive FA could influence the future of Brazilian land use.

Developing and field testing a Certification Module for Low Indirect Impact Biofuels

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Objective: Developing and field testing a certification module for sustainable bioenergy feedstock production that prevents displacement of food/feed production, thereby minimising the risk of indirect impacts.

Approach: Ecofys has developed a field-testing version of a certification module for biofuels with a low risk of unwanted indirect effects. Field tests are carried out in four international pilots in different countries with major bioenergy supply chains and different solutions to minimise indirect impacts: a) Sugarcane cattle integration in Brazil, b) Smallholder palm oil yields increase in Indonesia, c) Jatropha on unused land in Mozambique, and d) Vegetable oil residues in South-Africa. An independent verifier will visit all four pilots to establish the low risk of indirect impacts. Based on the experiences in the pilots, improvements will be made to the field testing version, resulting in the final version of the certification module. The organisations involved in the project are (excluding consulted stakeholders and experts): WWF International, Roundtable on Sustainable Biofuels, Ecofys, Wageningen University, University of Sao Paolo, WWF Indonesia, WWF Mozambique, Biogreen and DNV.

Scientific innovation and relevance: The certification module builds on the concepts of the first practical methodology to prevent indirect land use change (ILUC) from energy crop cultivation, the RCA methodology. Building on this methodology, the certification module enables economic operators to independently and objectively verify the low risk of indirect impacts of their biofuels.

Results: The certification module can be incorporated into voluntary schemes, such as the Roundtable on Sustainable Biofuels (RSB), as well as into regulatory schemes, such as the biofuel and bioliquids sustainability scheme of the European Renewable Energy Directive (RED).

Conclusions: Indirect impacts of biofuels form one of the key challenges of large scale sustainable bioenergy production. Most of the current work on indirect impacts is focused on ‘sizing the problem’ – to estimate the amount of indirect impacts from a certain amount of biofuels and the GHG-emissions associated with this. Less is currently done on how biofuels can be produced with a minimum risk of indirect impacts.

The four international pilots demonstrate ways to avoid/mitigate negative indirect impacts from bioenergy production. Having a practical and cost-effective certification module enables economic operators to objectively claim the low risk of indirect impacts of their biofuels.

Oral presentation **Stevens**

Decomposition Analysis of Empirical Data to Recognize Potential Land-Use Effects of Bioenergy

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Purpose: To better understand future effects of bioenergy, it is helpful to carefully assess available data to document the effects of recent bioenergy expansion.

Relevance: The use of corn for ethanol production in the United States quintupled between 2001 and 2009, generating concerns that this could lead to the conversion of forests and grasslands around the globe, known as indirect land-use changes (ILUC). Estimates of ILUC and related "food versus fuel" concerns rest on the assumption that the corn used for ethanol production in the United States would come primarily from displacing corn exports and land previously used for other crops. A number of modeling efforts based on these assumptions have appeared in the literature and projected significant ILUC to be caused by U.S. ethanol production.

Approach: The current study tests the veracity of these assumptions through a review and systematic decomposition analysis of the empirical data between 2001 and 2009. An index decomposition analysis using the logarithmic mean Divisia index, type I (LMDI I), was used to estimate contributions of different factors in meeting the corn demand for ethanol production.

The results show that about 85 percent of the net change in corn used for ethanol production can be allocated to changes in the distribution of total domestic corn consumption among different uses. Increases in the level of total domestic corn use contributed only about 5 percent. The remaining contributions were 12 percent from added corn production, and a -2 percent net contribution from stock changes. Yield change accounted for more than half of the 12 percent production contribution.

Conclusions: The results of this study provide little support for large land-use conversion or diversion of corn exports because of ethanol production in the United States during the past decade.

Oral presentation **Stromman**

Radiative Forcing Impacts of Boreal Forest Biofuels: A Dynamic Study for Norway in Light of Albedo

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Recent policies of Nordic Europe lend support to expanded use of boreal forest resources for climate mitigation objectives. Many are often guided by research limited to the carbon cycle and to reductions in atmospheric CO2 concentrations, although it is becomingly increasingly demonstrated in the scientific literature that biophysical land surface factors can influence climate through a variety of other mechanisms. In high latitude boreal regions with significant annual snow cover, like Norway, land surface albedo has been shown to be the dominant biophysical factor in direct opposition to the carbon cycle. It is therefore important to attribute this so-called ”albedo effect” to the climate balance of the forestry sector and to forest product systems like biofuels.

Perturbations to the global radiation budget prior to any feedbacks, such as changes in land surface albedo, can be compared directly with the effects of the carbon cycle through the concept of radiative forcing. Our main objective is to assess the radiative forcing impact due to a changing surface albedo when forests in Norway are harvested more intensively for biofuels. This impact is compared and added to that associated with changes in the forest carbon cycle and avoided life cycle fossil fuel emission.

Our framework integrates life cycle emission data together with a dynamic land use model that tracks carbon flux and area changes in productive forests over a 100-yr. time horizon. Land use carbon accounting follows the “Gain-Loss”” method of the IPCC. MODIS surface albedo data is used together with climatic information on cloud cover and cloud properties to estimate local net shortwave radiation fluxes at the top of the atmosphere (deltaSW TOA) over productive forest areas. Radiative forcing from albedo change at any given time step is the difference in the global deltaSW TOA flux between a control scenario and a biofuel scenario. Instantaneous forcing is both integrated over time and converted into annual CO2-eq.-emission pulses.

Depending on the albedo uncertainty, and uncertainty about the geographic distribution of future logging activity, we report a range of results, thus only general conclusions about the magnitude of the carbon offset potential over time due to changes in surface albedo can be drawn. Nevertheless, our results have important implications for how forests might be managed for mitigating climate change in light of this additional biophysical criterion, and in particular, on future biofuel policies throughout the region. Future research efforts should be directed at understanding the relationships between the physical properties of managed boreal forests and albedo, and how albedo changes in time as a result of specific management interventions.

Oral presentation **Wicke**

Improved modeling and mitigation of land use change related to bioenergy production

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This study reviews the current status, uncertainties and shortcomings of modeling (indirect) land use change (LUC) and its greenhouse gas (GHG) emissions as result of biofuel production to date and suggests improvements and further analysis work. This study also explores strategies for mitigating direct and indirect LUC and its effects. The literature review shows large variations in LUC-related GHG emissions within and across different feedstock-conversion routes. The variations are explained mainly by differing underlying datasets of the economic models, differing assumptions with respect to crop yield increases and livestock intensification, the level of geographical resolution, type of land converted to bioenergy feedstock production, and co-product allocation. These differences emphasize that ILUC and more generally all LUC largely depend on agricultural crop and livestock management and its improvements. Therefore, an approach for minimizing LUC of bioenergy production needs to integrate all land uses, particularly agriculture.

The literature review also showed that, despite recent improvements and refinements of the models, still large uncertainties, particularly those related to the underlying data of the economic models, and shortcomings, particularly those related to proper uncertainty analyses, exist in the current modeling efforts. Therefore, showing how (indirect) LUC can be minimized may now be more useful than more detailed, but still highly uncertain results on (indirect) LUC. Consequently, (indirect) LUC modeling should include different scenarios to determine under which conditions (indirect) LUC effects are minimized. Important to include in these scenarios are sustainability criteria as well as different strategies for minimizing undesired LUC and its negative effects, such as more efficient agricultural crop and livestock production, optimized bioenergy chains, using perennial feedstocks (particularly those produced on degraded and marginal land), and using agricultural and forestry residues and by-products. Assessing the effect of sustainability criteria and mitigation strategies on LUC induced by biofuels production with a model that integrates bottom-up analysis and macro-economic models can then provide new insights in the different biomass value chains, their potentials and their sustainability and can deliver more concrete input for developing proper policy strategies.

Market-Mediated Land Use Change and Biofuel Policy: Towards An Evaluation of Mitigation Options

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Research to date to measure land use change (LUC) and associated emissions from biofuel policy points to a real and potentially substantial effect that is nonetheless not yet robustly quantifiable. While some uncertainty in estimates stems from controllable differences across analyses, a good part of it – from knowledge gaps about real-world responses to price change (and how best to model them) or projections about future economic and biophysical conditions – will persist indefinitely. Biofuel policy design thus must account for continued uncertainty surrounding LUC consequences. Against this backdrop, mitigation options are receiving more attention as ways to improve biofuels' global GHG performance and to offer producers opportunities to improve their own emissions profiles. Considerable work remains to bridge the gap between discussion of biofuel LUC mitigation options and concrete policy design. This work aims to help bridge that gap, moving towards a framework for critical assessment of biofuel LUC mitigation options on the table, with particular attention to the timeframe in which they might become workable. Evaluation criteria should include effectiveness, efficiency, implementability, enforceability, and equity.

We present three 'prongs' for a policy approach addressing LUC from biofuel policy: 1) alter the feedstock mix to rely less on land; 2) lower LUC risk for land-based feedstocks; and 3) reduce the scope for LUC through broader investments. A strategy list/policy 'menu' of options, including these examples, fleshes out the three-pronged approach into a hierarchical logical structure for policy evaluation and consideration. The broadest categories differentiate mitigation options on the basis of where the policy target sits with respect to the biofuel supply chain (which affects options' implementability and enforceability). Within these broad categories, some mitigation approaches (e.g., limiting feedstocks, boosting yields) are listed; the lowest tier of the logical structure is reserved for specific proposals. Evaluation tools include stakeholder consultation, existing literature and secondary data, and modeling. The same broad categories indicating where policy action for mitigation is targeted suggest what types of models might be best suited to use in the evaluation. We illustrate possibilities for model-based evaluation of LUC policy design options using two linked partial economic equilibrium simulation models (BEPAM/IMPACT).5 While the modeling addresses only a subset of mitigation options presented (including an 'iLUC factor'), it illustrates how this approach can shed light on the geographical distribution and magnitude of LUC resulting from specific policy designs.

The work builds on and advances existing discussion of biofuel LUC mitigation options by bringing biofuel LUC mitigation options into a systematic structure to aid in evaluation, and pointing to pros and cons of using economic models to help with evaluation. Findings include the need to pull from strategy options as from a menu, combining proposals as needed. In particular, the exercise highlights the need to bridge strategies that limit biofuel LUC in the short run, with investments that improve the longer run outlook for sustainable use of land for all purposes – bioenergy and beyond.

[5] Developed at the University of Illinois, Urbana-Champaign, and International Food Policy Research Institute, respectively.

Explanatory Material: The list below, currently under development, includes biofuel LUC mitigation option categories and specific examples; it includes a delineation of where the policy target sits vis-à-vis the biofuel feedstock supply chain (useful for implementability and modeling).

Strategy List/Policy Options 'Menu' to Reduce LUC from Biofuel Policy

(Exclusively) Inside the Biofuel Supply Chain

Policy Aim: Alter Feedstock Mix to Lower LUC Risk

1. Prioritize Low-LUC Risk Feedstocks (*waste, residue, algae*)

- create incentives for low-risk LUC feedstocks — (EU-RED double counting, R&D funds)
- set targets for low-LUC biofuel volumes — (US-RFS2 high volumes for 'advanced' fuels and biodiesel)

2. Discourage Land-Using Feedstocks

- cap biofuel volumes/feedstock production areas for higher risk feedstocks — (US-RFS2 capped volumes for higher carbon 'renewable' fuels)
- exclude high-risk LUC feedstock pathways for meeting policy requirements — (one of NESCAUM proposals – 'qualitative')
- create disincentives for high-risk LUC feedstocks (via ILUC factor) — (US-RFS2, CA-LCFS, NESCAUM 'quantitative' and 'uncertainty factor' proposals)

Inside or Inside/Outside the Biofuel Supply Chain[i]

Policy Aim: Lower LUC Risk from Land-Using Feedstocks

3. Limit LUC via Controls on Feedstock Production Conditions

- confine feedstock production primarily to more 'marginal land' (little accumulated biomass or productive use) — (some projections for cellulosics)
- promote use of more 'marginal land' — (EU-RED carbon intensity 'bonus' for severely degraded land, LIIB[ii] certification for use of 'non-provisioning' land)
- encourage 'additional' feedstock production from areas already under cultivation — (LIIB certification for 'additional' output from higher yields or integrating production systems)[iii]

4. Offset LUC with Credits

- allow emissions offsets for LUC effects — (link to carbon credit programs - REDD, CDM)
- allow yield offsets for feedstock production — (Virtual Yield Bubbles[iv])

Inside and Beyond the Biofuel Supply Chain[v]

Policy Aim: Reduce the Scope for Biofuel (and other) LUC through Investments	
5. Take Pressure off the Land Base	
• create incentives for higher land productivity on cleared and 'marginal' land	(map and target high-risk LUC areas, support defined local property rights, R&D, extension)
• reduce agricultural supply chain losses (harvest, storage, transport)	
• generate land-saving coproducts	(encourage coproduct development from feedstock production and processing)
• ease demand for land-using feedstocks through efficiency gains	(extract more energy from feedstock)
6. Protect Carbon Stocks/Encourage Carbon Sequestration	
• target high-carbon areas for protection	(EU-RED 'no-go' and US-RFS2 'go' areas for feedstock production; efforts to protect peatlands, tropical forests)
• promote GHG accounting in land sector	(EU-RED unilateral agreements)
• add carbon value for land use	(carbon tax on land, emissions tax on land-based products, cap-and-trade for land-based emissions)
• add carbon value in all sectors	(carbon tax, cap-and-trade)

[i] Coordination of those inside and outside the supply chain is required when land involved has multiple owners (can happen under 3., does happen under 4.).

[ii] LIIB stands for Low Indirect Impact Biofuels, formerly called "Responsible Cultivation Areas" (Dehue, Cornelissen, and Peters 2011).

[iii] Other methods to increase land productivity (listed under category 3A), with proper verification of additionality, offer additional possibilities.

[iv] The idea is discussed in Fritsche, Hennenberg, and Hünecke (2010).

[v] Policy targets: A=within the biofuel supply chain, B=particular geographic areas or land uses; C=global efforts. Moving from A-C requires increased coordination across sectors and/or jurisdictions.

Oral presentation **Zulka**

Approaches to quantify the biodiversity effects of biofuel production

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Objective
Biofuel production and biodiversity conservation require area. A large increase in biofuel production might thus affect the biodiversity of agricultural landscapes. Compared to the well developed life cycle assessment framework that is available to quantify the greenhouse gas emissions of biofuels, quantification of the biodiversity effects of biomass production induced land use changes is still in its infancy. In this contribution, the potential of several quantification approaches is explored.

Approach
Biodiversity is a multifaceted, multi scale quantity, thus several approaches are needed. We estimated the effects of biofuel production on landscape level species richness using a biodiversity model of 38 Austrian agricultural landscapes. Additionally, responses of Austrian vertebrate species were evaluated with a score system, which uses species occurrence, Red List threat status, habitat dependence and habitat conversion effects as input. The approach can be further refined if the habitat relationship estimates are not just based on expert knowledge, but on modeling using a MaxEnt niche description approach. If population data are available, the effects of habitat conversion can be quantified in more detail by comparative metapopulation viability analysis. We tested this possibility on three metapopulations of the European Ground Squirrel (Spermophilus citellus), a threatened farmland species of which Austrian populations have been monitored since 2006.

Scientific innovation and relevance
A system to estimate the biodiversity implications of biomass production appears urgently needed; the possible ingredients of such a system are tested and explored in this contribution.

Results
As shown by our landscape biodiversity model, landscape scale species richness is reduced by 3– 14 %, depending on the organism group, if fallows are converted into biofuel production areas. The score system revealed a negative influence on many farmland species if oil seed rape or maize fields replace set asides. If grassland is converted into poplar or willow short rotation coppice, effects are less negative on threatened farmland species, and even positive on many widespread species, in particular at higher altitudes. MaxEnt modeling revealed a negative effect of rapeseed production increase on many threatened farmland birds, however, some species benefited. In two Ground Squirrel metapopulations, the extinction risk remained almost unchanged even if fallow area is converted into biofuel production area, but in a third metapopulation occupying large fallow areas, the extinction risk is increased substantially.

Conclusions
The score system explored here appeared as a flexible tool and thus seems particularly promising to be developed into a generic biodiversity quantification system. Basic data requirements can be met by expert knowledge, literature data and estimated values. However, if more detailed species studies are available, their results can be plugged in as well. In the future, biomass production systems should not only be judged and compared based on their greenhouse gas emission reduction potential, but also on their implications on regional and global biodiversity.