RCN Conference on Pan American Biofuels & Bioenergy Sustainability

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Technical Program
Wednesday, July 23, 2014: 01:00 PM - 04:00 PM

Wednesday, July 23, 2014: 01:00 PM - 04:00 PM, Boa Viagem Room
Biogeochemical Research Priorities for Sustainable Biofuels and Bioenergy Feedstock Development in the Pan America Region
Chair: Brian Titus, Pacific Forestry Centre, Natural Resources Canada, Victoria, BC, Canada
Co-Chair: Hero Gollany, US Dept of Agriculture, Oregon, USA

Session Overview:
Rapid expansion in biomass production for biofuels and bioenergy in the Pan America region is increasing demands on ecosystem resources required to sustain it. This rapid expansion has outpaced scientific knowledge of biogeochemical processes related to ecosystem sustainability. Abstracts are sought in topics such as the effects of biomass removal on soil organic matter and macro- and micro-nutrients, cation exchange capacity, pH, soil structure and compaction, long-term soil productivity and crop growth, effects of biomass management systems on greenhouse gas emissions, implications on other soil ecosystem services (e.g., contaminant degradation, water purification), and sustainability indicators of soil productivity and their application in land management.

1:00 PM	Biogeochemical Research Priorities for Sustainable Biofuel and Bioenergy Feedstock Production in Pan-America . **H. Gollany**, **B. Titus**, A. Scott, H. Asbjornsen, S. Resh, R. Chimner, D. Kaczmarek, L. Leite, A. Ferreira, K. Rod, J. Hilbert, M. V. Galdos, and M. Cisz
1:25 PM	Soil Organic Carbon Measurement Protocols: A USA and Brazilian Comparison and Recommendation . **M. Davis**, D. Abulebdeh, B. J. R. Alves, M. V. Galdos, D. L. Karlen, and K. Kline
1:50 PM	Advances in the Knowledge on the Impacts of Waste Management Forest Harvesting on Soil Quality of the NE in Argentina . **A. M. Lupi**, R. Fernández, R. Martiarena, N. Pahr, A. Von Wallis, M. D. L. A. Garcia, and J. Aparicio
2:15 PM	Lipid Accumulation and Nitrogen Removal for Chlorella vulgaris and Scenedesmus Obliquus Using Wastewater . **A. Ruiz Marin Sr.** and Y. Canedo Lopez Sr.
2:40 PM	Forest Biomass Harvesting and Site Productivity: Is Policy Ahead of Biogeochemical Science? . **E. D. Vance**, W. M. Aust, B. D. Strahm, R. E. Froese, R. B. Harrison, and L. A. Morris
3:05 PM	Roundtable Discussion of Key Research Issues and Challenges

1:00 PM Biogeochemical Research Priorities for Sustainable Biofuel and Bioenergy Feedstock Production in Pan-America

Hero Gollany[1], **Brian Titus**[2], Andrew Scott[3], Heidi Asbjornsen[4], Sigrid Resh[5], Rodney Chimner[5], Donald Kaczmarek[6], Luiz Leite[7], Ann Ferreira[7], Kenton Rod[8], Jorge Hilbert[9], Marcelo Valadares Galdos[10] and Michelle Cisz[5], (1)USDA, ARS, Pendleton, OR, (2)Pacific Forestry Centre, Natural Resources Canada, Victoria, BC, Canada, (3)USDA-FS, (4)Department of Natural Resources and Environment, University of New Hampshire, (5)School of Forest Resources and Environmental Sciences, Michigan Technological University, (6)Forestry Consultant, (7)EMBRAPA, Brazil, (8)Department of Crop and Soil Sciences, Washington State University, (9)INTA, National Agricultural Technology Institute, Buenos Aires, Argentina, (10)Brazilian Bioethanol Science and Technology (CTBE), Campinas, Brazil

Abstract:
Rapid expansion in biomass production for biofuels and bioenergy in the Pan-American region is increasing demands on the ecosystem resources required to sustain soil and site productivity. We review the current state of knowledge and highlight gaps in research on biogeochemical processes and ecosystem sustainability related to biomass production. Biomass production systems incrementally remove greater quantities of site organic matter, which in turn affects soil organic matter and associated carbon and nutrient storage (and hence long-term soil productivity) and off-site impacts. While these consequences have been extensively studied for some crops and sites, the ongoing and impending impacts of biomass removal require management strategies for ensuring that soil properties and functions are sustained for all combinations of crops, soils, sites, climates and management systems, and that impacts of biomass management (including off-site impacts) are environmentally acceptable. In a changing global environment, knowledge of cumulative impacts will also become increasingly important. Long-term experiments are essential for key crops, soils and management systems because short-term results do not necessarily reflect long-term impacts, although improved modeling capability may help to predict these impacts. Identification and validation of soil sustainability indicators for both site prescriptions and spatial applications would better inform commercial and policy decisions. In an increasingly inter-related but constrained global context, researchers should engage across inter-disciplinary, inter-agency, and international lines to better ensure long-term soil productivity across a range of scales, from site to landscape.

1:25 PM Soil Organic Carbon Measurement Protocols: A USA and Brazilian Comparison and Recommendation

Maggie Davis[1], Dana Abulebdeh[2], Bruno José Rodrigues Alves[3], Marcelo Valadares Galdos[4], Douglas L. Karlen[5] and Keith Kline[1], (1)Environmental Science Division, Climate Change Science Institute and Center for Bioenergy Sustainability, Oak Ridge National Laboratory, Oak Ridge, TN, (2)Systems Engineering & Engineering Management, University of North Carolina at Charlotte, Charlotte, NC, (3)Embrapa Agrobiologia, The Brazilian Agricultural Research Corporation (EMBRAPA), Brasilia, Brazil, (4)Brazilian Bioethanol Science and Technology (CTBE), Campinas, Brazil, (5)USDA-ARS National Soil Tilth Laboratory, Ames, IA

Abstract:
Measuring changes in soil organic carbon (SOC) has received significant attention not only from researchers and policy makers striving to develop climate change mitigation strategies, but also by those focused on the increasing global demand for food, feed, fiber, and most recently feedstocks for bioenergy and bio-product industries. Both efforts have intensified concerns regarding SOC depletion, but there is a lack of consensus on sampling strategies, measurement techniques, and verification

methods. This has created an urgent need for standardized, practical measurement protocols for SOC (Post et al. 2001, Jandl et al. 2014) that will provide a consistent assessment and a comparable product regardless of where studies are conducted (Panagos 2012). Even with a documented lack of consensus on the protocols for measuring, processing, and estimating SOC, this parameter is being used to estimate CO2 flux from agricultural practices and has become a component of lifecycle analyses (LCA) for bioenergy systems (Doran and Jones 1996; Reeves, 1997; USDA, 2006; McBride et al. 2011; Jandl et al. 2014). Bioenergy producers that can show a GHG offset for their fuel could have an advantage in the increasingly competitive global bioenergy market (Cerri et al., 2013). Therefore, LCA results are extremely important to biofuel producers and end-users seeking the most sustainable bioenergy options.

This presentation focuses on SOC studies conducted in two major bioenergy producing countries with the two primary ethanol feedstock crops – corn (*Zea mays* L.) in the U.S. and sugarcane (*Saccharum officinarum*) in Brazil. We conducted a literature review and have provided a comparison of sampling protocols for measuring SOC to identify and address inconsistencies in SOC assessment between the two countries. In this comparison, we draw significantly on research by Cerri et al. (2013) which identified appropriate methodologies for determining SOC for sugarcane, the US Department of Agriculture's (USDA) Greenhouse gas Reduction through Agricultural Carbon Enhancement network (GRACENet) protocols for soil sampling (Liebig et al. 2010), and the closely aligned Resilient Economic Agricultural Practices (formerly the Renewable Energy Assessment Project) (REAP) protocols (Karlen 2010, Karlen et al. 2011) for assessing sustainability of corn stover production and harvest. We identify sources of significant variance due to methods and discuss options to build consensus for a common SOC assessment approach that could be implemented for future studies.

1:50 PM Advances in the Knowledge on the Impacts of Waste Management Forest Harvesting on Soil Quality of the NE in Argentina

Ana Maria Lupi[1], Roberto Fernández[2], Rodolfo Martiarena[2], Norberto Pahr[2], Alejandra Von Wallis[2], Maria de Los Angeles Garcia[3] and Jorge Aparicio[4], (1)Instituto de Suelos, INTA-CIRN, Buenos Aires, Argentina, (2)INTA EEA, Montecarlo, Misiones, Argentina, (3)INTA EEA, Concordia, Entre Ríos, Argentina, (4)INTA EEA, Bella Vista, Corrientes, Argentina

Abstract:
There is a global debate regarding the effects of the crop residues management on the soil quality in the short and long term. In Argentina this concern has focused on the Mesopotamian region (25 ° 36' 18" and 33 º 54' 51" southern latitude), where is the 75% of the country's forest production. In the last 18 years, the National Institute of Agricultural Technology (Instituto Nacional deTecnología Agropecuaria, INTA) has addressed to evaluate the impacts of forest harvesting and establishment on soil fertility parameters. Until the late 90s, the type of harvesting and traditional land preparation in Mesopotamia was stem extraction and waste burning. During the 2000s, burning and remains conservation were common practices while in the last five years some companies have been incorporated the harvesting of the entire tree. This practice aims to remove some of the residual biomass of the cup for dendro-energetic purposes, which considerably avoids the organic inputs to the soil.

The main issues analyzed include the impact of nutrients, the organic matter (OM), and the physical condition of the soil in a lesser extent. Some of the studies are developed on subtropical red clay soils (Ultisols and Alfisols) in the Misiones region, using Pinus taeda and Araucaria angustifolia plantations. Quantifications performed by Fernández et al, (2000) and Martiarena et al, (2004) indicate that the

amount of the remaining forest residues ranges between 29.1 to 41.1 Mg ha-1 (mulch, leaves, and up to 15 cm length branches). This amount rises to 58-66 Mg ha-1 in Eucalyptus grandis in the Entre Rios region (Lupi et al., under evaluation). From the harvesting of the whole tree in this region, Frangi et al, (1999) estimated that 234, 38 and 119 Kg.ha-1 of N, P and K respectively are obtained. Recently, Fernandez et al. (2014) estimated that a stand of P. taeda generated 25 Mg.ha-1 more residues when the whole tree is harvested than when only the stem is extracted. Under the first system, an additional loss of N, P, and K of 129.5, 7.6, and 33.3 Kg.ha-1 is expected, respectively. Other studies that simulated different harvesting scenarios conclude that the whole tree harvesting contributes the most to the major negative effects. Also, phosphorous (P) and potassium (K) are the are the nutrients that could be critical in future rotations (Goya et al, 2003;. Martiarena et al, 2010;. Martiarena et al, 2011ab; Fernandez et al, 2012ab). Other experiments at regional level analyzed the effect of different alternatives for crop residues management on the levels of total organic carbon (TOC), quality, total nitrogen (TN), and forms of P in soil. Studies under temperate conditions in the Entre Rios region compared the residues and litter removal (ER), residues conservation (CR), and residues burning (QR) considering Vertisols and Molisols. In the short term (<2 years) the CR did not increase the TOC, the Nt, or the TOC fraction associated with the supply of nutrients (particulate OM). Other treatments under the subtropical clay soils of the Misiones region showed similar trends. However, there will be short-term differential effects that are lost with time. Some analyses concluded that after the treatments were applied by 4 years, the ER and QR showed the lowest values of TOC and light carbon (Cl) (Giufre et al.2002; Lupi et al., 2007).

Another study did not detect changes in the TOC when comparing the QR vs. the CR in a similar period (Von Wallis, 2013). However, the chemical fractionation of humus evidenced the existence of changes in the TOC quality, which expose the potential consequences on the nutrient cycle linked to the organic matter. Both the QR and the ER showed an increase in the degree of MO stabilization due to the increase of the humic C-acids to fulvic C-acids ratio and the rise of CO in the most resistant fraction (humins) (Lupi et al., 2012). Recently, a short-term study on a sandy soil in the Corrientes region reported also changes in the MO quality due to the removal of crop residues (Lupi et al., 2013). The analysis of the molecular structure of the MO through the 13C NMR technique showed higher aromaticity and stability of humic acids in treatments without residues (QR or CAC), being the most marked effect on QR. The temporal evolution of chemical fertility parameters in Ultisols after 12 years of applying treatments, did not present enough evidence to conclude that the disposal of waste leads to a decrease in the levels of TOC, N, pH, and available P (Fernández et al., 2010 and Lupi et al., 2014). The input of fresh organic matter that was generated after the close of the cups and corresponding to atmospheric deposition might have offset the observed differences among treatments in the short-term assessments.

P-dynamics on the soils were also analyzed by its separation into fractions of different lability (Lupi et al. Mórtola 2012b and 2013). It was observed that the ER, QR or CR did not produce changes in the total P contained in the studied soils (Ultisol> Mollisol> Vertisol>Entisol). The organic fractions of P in Molisols, Vertisols and Entisols were not affected. The most prominent change in the Vertisols and Entisols was the increase of the available P generated by the burning without modifying the organic fractions. Controlled burning resulted to be tool for rapid nutrients transfer from the biomass residues to the first 5-10 cm of soil. On the other hand, Mortola (2013) concluded that after 9 years, the ER negatively affected the organic P fractions in Ultisols, which affects one of the sources of available P. Author did not consider the adverse effects of QR.

Regarding the physical variables, some studies (Lupi et al., 2012; Von Wallis 2013) examined the effect of different waste managements on the aggregate size in wet, the saturated hydraulic conductivity (Ksat), and the size distribution of the aggregates. It was observed that the distribution pattern of aggregate size depended upon the type of soil (Vertisol, Mollisol or Ultisol). In general, it was observed that regardless of the treatment, during the period prior to crown closure the waste conservation plays a key role on the soil protection against erosion, and on the profile of the soil-water-recharge process. In high-natural stability Ultisols, the QR, and ER in a lesser extent, affected the stability of the largest macro-aggregates, which was negatively correlated with the light fraction of the OM. In soils of the temperate region, the size distribution of aggregates did not change in the Vertisols in less than 2 years of applying the treatments. The opposite situation occurred in Molisols, where the largest macroaggregates were less stable in the ER treatments. In Vertisols the Ksat was higher than in Molisols. Additionally, the Ksat was higher in CR than in ER and QR. This was associated with a higher proportion of continuous and stable macropores, which protects the soil-atmosphere interface. On the other hand, the Molisol was naturally less stable and presented a lower Ksat regardless the presence or absence of soil cover.

Beyond the results presented here, and based on a small number of experiments, our knowledge about the effects of crop residues management on the soil productivity remains limited. However, our results provide trends of the short-term effects. Determination of the degree and extent of the impact of waste management on soil quality requires establishing long-term studies that consider different environments and species of greatest relevance. Such studies must focus on the organic carbon and nutrients dynamics and balances, soil microbiology, soil compaction.

2:15 PM Lipid Accumulation and Nitrogen Removal for Chlorella vulgaris and Scenedesmus Obliquus Using Wastewater

Alejandro Ruiz Marin Sr., biotechnology, Universidad Autonoma del Carmen, Mexico, Campeche, Mexico and Yunuen Canedo Lopez Sr., Chemical, Universidad Autonoma del Carmen, Campeche, Mexico

Abstract:

Nitrogen limitation has been widely proposed as a method to increase lipid content of microalgae in biodiesel-oriented processes. However, this is typically accompanied by a reduction on the growth rate, and as a result, the overall lipid productivity does not necessarily increase. In this study a novel multi-stage nitrogen-reduction process is proposed, in order to promote a balance between growth rate and lipid accumulation which could result in a net increase of lipid-productivity in microalgae, while simultaneously reducing nitrogen concentrations in wastewater. *Chlorella vulgaris* and *Scenedesmus obliquus* were grown initially in nitrogen-rich (90 mg L^{-1}) artificial-wastewater medium, followed by sequential dilutions (50% v/v) in fresh medium with N-NH_4 concentrations of 60, 40, and 20 mg L^{-1}, respectively. The overall lipid productivity was compared to those obtained in various two-stage nitrogen reduction processes, wherein the nitrogen-rich culture was followed by a 50% v/v dilution in fresh medium containing 30, 20, or 10 mg L^{-1} N-NH_4 in the second stage. Increased net lipid-productivity was observed for both species in the two-stage mode, although nitrogen depletion was not achieved in these cases. On the other hand, in the sequential mode only *C. vulgaris* exhibited a net lipid-productivity increment. The highest lipid productivities occurred in the two-stage mode for both *S. obliquus* and *C. vulgaris* (194.9 and 133.5 mg L^{-1} d^{-1}, respectively). The lipid productivities achieved in this study are among the highest reported in the open literature to date, and the fatty-acid profiles are adequate for biodiesel production.

2:40 PM Forest Biomass Harvesting and Site Productivity: Is Policy Ahead of Biogeochemical Science?

Eric D. Vance, National Council for Air and Stream Improvement, Inc. (NCASI), Research Triangle Park, NC, W. Michael Aust, Department of Forest Resources and Environmental Conservation, Virginia Tech, Blacksburg, VA, Brian D. Strahm, Department of Forest Resources and Enviornmental Conservation, Virginia Tech, Blacksburg, VA, Robert E. Froese, School of Forest Resources and Environmental Science, Michigan Technological University, Houghton, MI, Robert B. Harrison, School of Environmental and Forest Sciences, University of Washington, Seattle, WA and Larry A. Morris, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA

Abstract:
Emerging bioproduct and energy markets provide incentives for harvesting greater quantities of biomass at shorter intervals and have raised environmental concerns, including effects on the productive capacity of forested sites. In response to these concerns, governments and non-governmental organizations have developed biomass harvesting guidelines (BHGs) with provisions for retaining specific proportions or quantities of biomass on site and restricting harvests on sites deemed sensitive. These guidelines are largely voluntary but may be incorporated in some form into forest practice mandates and certification systems. BHGs are well intentioned and based on a reasoned, conceptual understanding of the role of harvest residues in sustaining soil organic matter, nutrient availability, and future site productivity. Management restrictions come with economic and environmental costs, however, and the science supporting them deserves greater scrutiny. Field experiments show that forest responses to biomass harvesting vary widely and are often counterintuitive. With site-specific data lacking, BHGs tend to rely on default assumptions supported by best professional judgment. These include (i) the natural or unmanaged state is an ideal frame of reference, (ii) conventional harvesting retains and distributes most residues across the site, (iii) biomass harvesting removes virtually all residues, (iv) decomposing residues always enhance soil C and site productivity, (v) biomass harvesting is conducted without operational practices that alleviate site deficiencies and sustain productivity, and (vi) changes in forest state are equivalent to changes in forest function. While harvesting-induced nutrient deficiencies can be prevented or corrected with fertilizers or other soil amendments, soil disturbance and exposure may warrant greater attention. Effective BHGs are science-based, operationally feasible, and protect values of interest while allowing managers the flexibility to prevent or mitigate potential impacts within constraints imposed by existing forest practice rules, best management practices, and forest certification provisions.

Wednesday, July 23, 2014: 01:00 PM - 04:00 PM, Candeiras Room
Standardization of Environmental Life Cycle Assessments of Biofuels in the Pan America Region
Chair: David R. Shonnard, Michigan Technological University
Co-Chair: Julio Sacramento, Department of Chemical Engineering, Univ Autônoma de Yucatan, Merida Mexico

Session Overview:
Biomass supply chains that are economically feasible, energy efficient, and compatible with environmental and social goals are a requirement for sustainable biofuels and bioenergy development. This session seeks integrated analyses of biomass supply chains for biofuels and bioenergy production utilizing diverse types of biomass and from many different locations in the Pan American region.

1:00 PM	Standardization of Environmental Life Cycle Assessments of Biofuels in the Pan America Region . **D. R. Shonnard**, J. A. Hilbert Sr., B. Klemetsrud, J. Sacramento, F. Navarro, R. Handler, N. Suppen, and R. Donovan
1:20 PM	Biofuel Life-Cycle Analysis: Possible for Standardization? . M. Q. Wang, J. B. Dunn, and **H. Cai**
1:40 PM	Nest Experience in Life Cycle Assessment (LCA) Research and Development Projects Related with Biofuels and Residues Energy Conversion . **M. H. Rocha**, E. E. Silva Lora, and M. M. Vicente Leme
2:00 PM	Environmental Implications of Jatropha Biofuel from a Silvi-Pastoral Production System in Central-West Brazil . **R. Bailis** and G. Kavlak
2:20 PM	Life Cycle Assessment Study on a Soybean Complex Transformation Chain over Three Years of Production of Biodiesel As a Coproduct . **J. A. Hilbert Sr.** and S. Galbusera
2:40 PM	Incorporating Bioenergy into Sustainable Landscape Designs . **V. H. Dale**, K. Kline, J. K. Costanza, C. T. Smith, I. Stupak, A. Walter, and C. O. F. D. Oliveira
3:05 PM	Roundtable Discussion of Key Research Issues and Challenges

1:00 PM Standardization of Environmental Life Cycle Assessments of Biofuels in the Pan America Region

David R. Shonnard[1], Jorge Antonio Hilbert Sr.[2], Bethany Klemetsrud[3], Julio Sacramento[4], Freddy Navarro[5], Robert Handler[1], Nydia Suppen[6] and Richard Donovan[7], (1)Sustainable Futures Institute, Michigan Technological University, Houghton, MI, (2)Ingenieria Rural, Instituto Nacional de Tecnología Agropecuaria, Villa Tesei, Argentina, (3)Chemical Engineering, Michigan Technological University, Houghton, MI, (4)Department of Chemical Engineering, Univ Autônoma de Yucatan, Merida, Mexico, (5)Universidad Autonoma de Yucatan, Merida, Mexico, (6)CADIS • Centro de Análisis de Ciclo de Vida y Diseño Sustentable, Mexico City, Mexico, (7)Henry Samueli School of Engineering, University of California-Irvine, Irvine, CA

Abstract:
One of the key challenges for the evaluation of large-scale biofuels and bioenergy systems is understanding the environmental impacts of these renewable energy systems compared to a continued reliance on fossil energy. Life Cycle Assessment (LCA) provides a comprehensive analysis of potential environmental effects across the entire production and utilization chain, yet there are many challenges and a wide variability in methodology such as data quality, impact indicators (environmental performance and impact categories), scale of production, system boundaries, co-product allocation, and other study features. The purpose of this article is to conduct a critical evaluation comparing environmental LCA of biofuels and bioenergy from several conversion pathways and in several countries in the Pan America region, and to make recommendations on a standardized guidance of LCA methodology with respect to inventory data, impact indicators, study assumptions and reporting practices. The environmental management implications of the proposed guidance will be discussed within the context of different national regulatory environments using case studies. The results from this study will help focus LCA research on gaps in knowledge and on high priority inputs and inventory data, and will lead to analyses of biofuel and bioenergy pathways with greater accuracy, transparency, and comparability across regions.

1:20 PM Biofuel Life-Cycle Analysis: Possible for Standardization?

Michael Q. Wang, Jennifer B. Dunn and **Hao Cai**, Energy Systems Division, Argonne National Laboratory, Argonne, IL

Abstract:
Biofuels are being promoted worldwide to reduce fossil energy use and greenhouse gas (GHG) emissions and to promote rural economic development. Regulations in North America and Europe are in place to regulate biofuel GHG emissions on the basis of life-cycle analysis (LCA). Numerous studies have been conducted to address biofuel GHG emissions. Attempts are being made globally to reconcile different studies, harmonize key assumptions, and possibly standardize biofuel LCAs.

In the past several years, Argonne National Laboratory has been addressing some of the key issues for biofuel life-cycle analysis with its Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET™) model. Such issues include different generations of biofuels with a variety of feedstocks, technology changes over time, LCA system boundary, treatment of co-products in biofuel LCAs, and land use change carbon emissions. This presentation will propose potential reconciliation and harmonization for biofuel LCAs. It will discuss the difficulty of biofuel LCA standardization. Finally, it will summarize updated GREET biofuel LCA results with these issues and their LCA impacts considered.

1:40 PM Nest Experience in Life Cycle Assessment (LCA) Research and Development Projects Related with Biofuels and Residues Energy Conversion

Mateus H. Rocha[1], Electo Eduardo Silva Lora[2] and Marcio Montagnana Vicente Leme[2], (1)Institute of Mechanical Engineering, Federal University of Itajubá (UNIFEI), Itajubá, Brazil, (2)Federal University of Itajubá (UNIFEI)

Abstract:
There is an increasing interest in intensifying the production and use of biomass and wastes (residues) to replace fossil fuels for the production of heat, electricity, transportation fuels (biofuels), and various types of chemicals, plastics and other materials (Koçar and Civaş 2013, Limayem and Ricke 2012, Rabelo et al. 2011). The use of biomass, biofuels and wastes (agricultural and municipal) for energy production is encouraged because it can generate profit, contribute to the mitigation of climate change, can help countries diversify their energy sources and achieve energy security, can promote the creation of new options for agriculture and wastes disposal, also including the appeal of new jobs and improved work conditions, all factors that can be associated with food security without any remarkable negative impact on food availability (Castanheira et al. 2014, Nogueira and Capaz 2013). Currently, there is a recent trend to integrate economic, environmental and social aspects in the assessment and optimization of biomass, biofuels and wastes energy conversion supply chains. In regards to the environmental impacts assessment of renewable energy systems the Life Cycle Assessment (LCA) methodology represents an important methodology, to determine quantitatively the environmental impacts comparison of the different types of renewable energy production. The LCA could be used to estimate the positive or negative impacts, in all the stages of the biomass, biofuels and wastes energy recovery utilization life cycles (Carvalho et al. 2014, Chiaramonti and Recchia 2010).

In this sense, the main goal of this presentation is to discuss the major technological changes related to renewable energy production through biofuels and wastes energy conversion. The results presented in this presentation were obtained from the Excellence Group in Thermal Power and Distributed Generation (NEST) from the Federal University of Itajubá (UNIFEI) located in Minas Gerais State in Brazil. Since 2004 NEST/UNIFEI has been carrying out different Research and Developments (R&D) projects related to LCA of biomass and biofuels production and utilization and Municipal Solid Wastes (MSW) energy recovery. A important overview of the programs, projects and technologies related to the use of biofuels in Brazil, as well as, the evaluation of the availability of biomass to electricity generation potential for different industrial and agricultural sectors in Brazil is presented by Lora and Andrade 2009.

Lora et al. 2011 and Escobar et al. 2009 analyzed the main environmental impacts of programs that encourage biofuels production, farmland land requirements and the impacts on food security. The key aim of these studies was to establish what is the level of sustainability of biofuels, through the development of a framework for sustainability indicators as a tool for performance assessment. The most used indicators to measure the biofuels sustainability was indicated as net energy relations, land use utilization and environmental impacts categories. Rocha et al. 2014 carried out a study to evaluate and compare the main environmental life cycle impacts and energy balance (net energy ratio) of ethanol from sugarcane and biodiesel from soybean and palm oil using the LCA tool. A process based on cradle-to-gate attribution LCA method, was applied as the technique to assess the health and environmental impacts of ethanol and biodiesel production systems. The assumed functional unit was 1.0 MJ of energy released by combustion of the analyzed biofuels. The biofuel production systems with higher agricultural yields and extensive use of co-products in its life cycle provided the best environmental results.

In relation to ethanol production currently the technological changes and sustainability concerns of sugarcane ethanol industry is undergoing a huge transition due to recent innovations that could be defined as new paradigms. A detailed description of this trends was included in Lora et al. 2014a and Lora et al. 2014b. The generation and use of co-products in the ethanol production process can grant to the bioenergetics system good indicators in energetic, economic and environmental terms. In ethanol production, it can be observed the generation of bagasse, stillage, filter cake and ashes. The application of the stillage on the sugarcane plantation is influenced by environmental issues and the high cost of fertilizers. In this sense, Rocha et al. 2010 and Rocha et al. 2008 carried out a LCA to evaluate the mass and energy balance of stillage treatment and disposal, showing a fertilizer mass savings of 100% for the potassium, 35% for nitrogen and 20% for phosphorus in the manure, when stillage is applied to 40% of the area of plant and ratoon. In addition, the sugar and alcohol sector has great potential for increasing overall production efficiency in the future by the combined production of ethanol and other biofuels such as methanol from thermochemical pathway through the bagasse gasification for synthesis gas production and subsequent utilization in a Biomass-to-Liquid (BtL) route. Renó et al. 2011 carried out a study to evaluate the environmental impacts of the methanol production from sugarcane bagasse, taking into consideration the balance of the energy life cycle and its net environmental impacts, both are included in a LCA approach. The evaluation was done as a case study of a 100,000 ton/year methanol plant, using sugarcane bagasse as raw material.

Biodiesel, another important biofuel, is also currently the focus of intense research. The use of biodiesel produced from the transesterification of vegetable oils with methanol is currently seen as an interesting alternative to diesel fuel. Yáñez et al. 2009 carried out a study to evaluate the life cycle energy assessment to quantify the total energy flow and assess the overall efficiency of the process of biodiesel production from palm oil in Brazil and Colombia. The authors used the Output/Input energy indicator to analyze the life cycle biodiesel production. The calculated results showed differences between the values attained for the two cases. The Output/Input energy relation for the evaluated cases ranged from 3.8 to 5.7, with an average value of 4.8.

In relation to waste energy recovery, Leme et al. 2014 carried out a study to evaluate the environmental assessment for MSW energy recovery in Brazilian. Four scenarios were designed current situation without any energy recovery, mass burning system in a waste-to-energy facility, landfill biogas utilization in internal combustion engines and landfill biogas utilization in gas turbines, whose environmental behavior were studied applying the LCA approach. The results show the landfill systems as the worst waste management option and that a significant environmental savings is achieved when a wasted energy recovery is done. The best option, which presented the best performance based on considered indicators, is the direct combustion of waste as fuel for electricity generation.

Financial Support: The authors wish to thank the Brazilian National Research and Development Council (CNPq). The Research Support Foundation of the Minas Gerais State (FAPEMIG) and the Coordinating Body for the Improvement of Postgraduate Studies in Higher Education (CAPES) for the funding of Research and Development (R&D) projects. The support of graduate students and the production grants that allowed the accomplishment of the research projects whose results are included in this paper.

2:00 PM Environmental Implications of Jatropha Biofuel from a Silvi-Pastoral Production System in Central-West Brazil

Robert Bailis, School of Forestry and Environmental Studies, Yale University, New Haven, CT and Goksin Kavlak, Engineering Systems Division, MIT

Abstract:
We present a life cycle assessment of synthetic paraffinic kerosene produced from *Jatropha curcas*. The feedstock is grown in an intercropping arrangement with pasture grasses so that Jatropha is coproduced with cattle. Additional innovations are introduced including hybrid seeds, detoxification of *Jatropha* seedcake, and cogeneration. Two fuel pathways are examined including a newly developed catalytic decarboxylation process. Sensitivities are examined including higher planting density at the expense of cattle production as well as 50% lower yields. Intercropping with pasture and detoxifying seedcake yield co-products that are expected to relieve pressure on Brazil' s forests and indirectly reduce environmental impacts of biofuel production. Other innovations also reduce impacts. Results of the baseline assessment indicate that innovations would reduce impacts relative to the fossil fuel reference scenario in most categories including 62– 75% reduction in greenhouse gas emissions, 64-82% reduction in release of ozone depleting chemicals, 33-52% reduction in smog-forming pollutants, 6-25% reduction in acidification, and 60-72% reduction in use of nonrenewable energy. System expansion, which explicitly accounts for avoided deforestation, results in larger improvements. Results are robust across allocation methodologies, improve with higher planting density, and persist if yield is reduced by half.

2:20 PM Life Cycle Assesment Study on a Soybean Complex Transformation Chain over Three Years of Production of Biodiesel As a Coproduct

Jorge Antonio Hilbert Sr., Ingenieria Rural, Instituto Nacional de Tecnología Agropecuaria, Villa Tesei, Argentina and Sebastian Galbusera, COmunicacion Nacional, Sec Medio Ambiente, Bienos Aires, Argentina

Abstract:
The objective of the study was to use a develop tool that enable the calculation follow up and evaluation of improvement in the different stages of production of biodiesel and other products in an integrated plant placed in Frias in the province of Santiago del Estero during three years. This case had special interest since it is not placed in the core of soybean and industrial process area in Santa Fe over the Parana River. Santiago del Estero is a lower income province and needs to increase its industrialization and generation of products that can enlarge the end value of products being produced and exported.

The areas ofproduction in the north west region of the country are exposed to grater climate variations that reflects in higher difference in yields between years. Since yield values can alter the final GHG savings of the different products a three year period was chosen.

For the calculations the 2006 IPCC directives for national GHG inventories, DIRECTIVE 2009/28/CE European Union Parliament and council April 23 2009, EB 50 – Executive MDL board "Guidelines on apportioning emissions from production processes between main product and co-and by-products " and ACM0017 Methodology "Approved consolidated baseline and monitoring methodology Production of biodiesel for use as fuel" were used. The system covered the farm production of crops, short and long transport to the crushing facilities, all the industrial stages and the end transport to port and overseas.

The data entered in the tool was provided by the company electronic database that runs under a SAP system were every step in the company is entered and can be verified and audited. The source of the raw material came primarily by own farms placed in the provinces of Salta, Tucuman and Santiago del

Estero. The analysis and presentation of the results were devided into the different stages included in the overall process (farm production, freights of raw material, production of biodiesel and co products and final freight. The final results were calculated in three different ways according to how the final allocation of emissions was considered: energy content, mass balance and price of the different products and co products. The differences in numbers between the three alternatives reached a maximum of 20 %. The overall emission reduction of the integrated process reached a value of 73 % in Grs.CO2eq/Mj well above the default value included in the European Union Directive. This results were heavily affected during the last years of poor field yields producing an important decrease in GHG savings. If the whole soybean biodiesel chain of Viluco is considered the total emissions reach 88.860 Tons de CO2eq per year (including the industrial stage). Of the total emissions 69% belong to the industrial phase, 14% to the production in own farms, 13% from soybean purchased to other farmers and 4 % to transport and freights.

At the industrial stage the emissions associated with energy use were responsible of 65 % and key input materials as methanol has a weight of 32 % in the overall analysis. s per year.

Although there are still several uncertainties in the methodologies there is strong work in progress in order to improve the estimation factors of the agricultural phase of production mainly looking at nitrogen oxide emissions and organic matter balance.

Final numbers are very important since they have relations to present regulations in the international markets. The study showed that single studies don't cover one of the main important factors in agricultural production as the variation between each year crop yield. In order to obtain more realistic figures a certain amount of statistical information on crop behavior in each region must be taken into account.

2:40 PM Incorporating Bioenergy into Sustainable Landscape Designs

Virginia H. Dale, Center for BioEnergy Sustainability, Oak Ridge National Laboratory, Oak Ridge, TN, Keith Kline, Environmental Science Division, Climate Change Science Institute and Center for Bioenergy Sustainability, Oak Ridge National Laboratory, Oak Ridge, TN, Jennifer K. Costanza, North Carolina State University, Raleigh, NC, C. Tat Smith, University of Toronto, Toronto, ON, Canada, Ingrid Stupak, Univeristy of Copenhagen,, Copenhagen, Denmark, Arnaldo Walter, University of Campinas-Unicamp, Campinas, Brazil and Camila Ortolan F. de Oliveira, UNICAMP/University of Campinas, Campinas, Brazil

Abstract:
An approach for landscape design that focuses on bioenergy production systems and integrates it into other components of the land, environment and socioeconomic system is described. Landscape design is a spatially explicit collaborative plan for integrating sustainable management of landscapes and supply chains. Landscape design involves multiple scales, fits into existing land and resource allocation systems, and maintains or enhances social, economic and ecosystem services. The design for a particular area is developed with the involvement of key stakeholders including both private and public land owners and those benefitting from or impacted by services provided by resource use. Appropriately applied, landscape design can guide choices toward more sustainable provision of bioenergy and other services. This approach encapsulates monitoring and assessment of a suite of indicators for soil quality, water quality and quantity, greenhouse gases, biodiversity, air quality, and productivity as well as socioeconomic considerations. The landscape design approach requires attention to site selection and environmental effects when making choices about locations, type(s) of feedstock, transport of feedstock

to the refinery, refinery processing, and distribution of bioenergy products and services. The approach includes monitoring and reporting of measures of sustainability along the bioenergy supply chain within specific contexts. Examples of the landscape design are presented. Key barriers are that up-front planning is required, coordination is complex and requires much effort, initial costs may be higher, and the process may be stymied by insufficient data and communication across the supply chain. Landscape designs should be coordinated by a planning team in a way that is doable from the perspective of producers along the supply chain. An impetus for coordination is critical, and that incentive may be demand from the private sector. Hence it requires clear communication of environmental and socioeconomic opportunities and concerns to both the participants in production and stakeholders.

Wednesday, July 23, 2014: 01:00 PM - 04:00 PM, Piedade Room
Opportunities and Challenges for Biomass Supply Chains in the Pan-American Region
Chair: Pasi Lautala, Rail Transportation Center, Michigan Technological University, MI USA
Co-Chair: J. Richard Hess, Idaho National Laboratory, Idaho Falls, ID, USA

Session Overview:
Life Cycle Assessment (LCA) provides a comprehensive analysis of potential environmental effects across the entire production and utilization chain, yet there are many challenges and a wide variability in methodology such as data quality, impact indicators, scale of production, system boundaries, co-product allocation, and other study features. This session seeks abstracts addressing the standardization of biofuel and bioenergy life cycle assessments in the Pan American region, how study assumptions affect study results, and importance of biofuel and bioenergy policy on LCA methodology.

1:00 PM	Opportunities and Challenges in the Design and Analysis of Biomass Supply Chains . **P. Lautala**, T. Laitinen, R. Bittencourt, A. M. Valente, M. R. Hilliard, E. Webb, I. Busch, R. Handler, J. R. Hess, M. Roni, and J. A. Hilbert Sr.
1:25 PM	Biomass Transportation Systems in Brazil: The Cases of the Ethanol Industry and the Constrains for Exporting Pellets . **A. Walter**
1:50 PM	Tropical Maize and Lipid Cane As Sustainable New Bioenergy Crops . **V. Singh**
2:15 PM	Lignocellulosic Biomass Residues Identification and Selection in Five Countries of Latin America, As a Feedstock for Second Generation Ethanol Production . **E. Ruz**
2:40 PM	Uncovering System Behaviors in Biofuels Supply Chain Network Using an Agent-Based Simulation Approach . **D. B. Agusdinata**
3:05 PM	Roundtable Discussion of Key Research Issues and Challenges

1:00 PM Opportunities and Challenges in the Design and Analysis of Biomass Supply Chains
Sangpil Ko[1], **Pasi Lautala**[2], Tuuli Laitinen[3], Roger Bittencourt[4], Amir Mattar Valente[4], Michael R. Hilliard[5], Erin Webb[5], Ingrid Busch[5], Robert Handler[6], J. Richard Hess[7], Mohammad Roni[8] and Jorge Antonio Hilbert Sr.[9], (1)Michigan Technological University, Houghton, MI, (2)Rail Transportation Center, Michigan Technological University, Houghton, MI, (3)Lappeenranta University of Technology, (4)LabTrans, Universidade Federal de Santa Catarina, (5)Oak Ridge National Laboratory, (6)Sustainable Futures Institute, Michigan Technological University, Houghton, MI, (7)Idaho National Laboratory, Idaho Falls, ID, (8)Biological and Chemical Processing, Idaho National Laboratory, Idaho Falls, ID, (9)Ingenieria Rural, Instituto Nacional de Tecnología Agropecuaria, Villa Tesei, Argentina

Abstract:
The biomass supply chain is one of the most critical elements of large scale bioenergy production and in many cases a key barrier for procuring initial funding for new developments on specific energy crops. Most of the large scale productions of liquid biofuels rely on complex transforming chains linked to feed and food markets. The term 'supply chain' covers various aspects from cultivation and harvesting of the biomass, to treatment, transportation and storage. After the energy conversion, the product must be delivered to final consumption, whether it is in the form of electricity, heat, or more tangible products, such as pellets or ethanol. Effective supply chains are of utmost importance for bioenergy production, as biomass tends to possess challenging spatial distribution and low mass, energy and bulk densities. Additionally, the demand for final products is often dispersed, further complicating the supply chain.

The goal of this presentation is to introduce key components of biomass supply chains and provide examples of modeling applications available for supply chain investigations. The paper will introduce a concept of integrated supply systems for sustainable biomass trade, followed by three modeling tools developed to help users to understand the factors influencing the biofuel supply chain landscape. The final section will concentrate on various aspects of transportation logistics, ranging from alternative modal / multimodal arrangements to introduction of two analytical support tools, one from U.S. and one from Brazil. Conclusions and research recommendations are also outlined to facilitate the future direction for this area of study.

1:25 PM Biomass Transportation Systems in Brazil: The Cases of the Ethanol Industry and the Constrains for Exporting Pellets
Arnaldo Walter, University of Campinas-Unicamp, Campinas, Brazil

Abstract:
Brazil is worldwide the second largest producer of fuel ethanol, which is totally produced from sugarcane. Large-scale production has started in the late 1970s and the supply chain is well established in the Southeast (where is the bulk of the production) and in the Northeast (the most traditional area) regions. Recently, sugarcane and ethanol production has expanded towards the Central region, and the lack of adequate infrastructure has been a constraint for reducing costs and accessing international markets.

On the other hand, despite the fact that Brazil has a large potential for pellets production, due to the large land availability, adequate weather conditions and the available know-how for planting and harvesting short-rotation coppices, the production itself is very small. A big constrain has been the logistics that implies high final costs and no feasibility in the European market (the largest consumer and importer).

In this paper some issues related with the supply-chain of ethanol and pellets production in Brazil are analyzed. Figures of the current supply chain in both economic sectors, transportation costs and the available infrastructure are presented. The challenges for enhancing the production and exports are presented and discussed.

Along the paper, the points of view of the public and private sectors are presented. Recently, some of the investments in Brazil have been done by companies that want to be in a solid position in short term to medium term.

1:50 PM Tropical Maize and Lipid Cane As Sustainable New Bioenergy Crops

Vijay Singh, Agricultural and Biological Engineering, University of Illinois at Urbana-Champaign, Urbana, IL

Abstract:

Two new sustainable bioenergy crops have been recently developed for the US. One is Tropical maize, a high-biomass, high-sugar corn hybrid that accumulates sucrose in the stalk and produces negligible grain. Second one is Lipid cane, a sugarcane engineered to produce non-food oil, as drop-in fuels, in place of sugar. Both these crops present excellent potential to serve as a renewable fuel crops.

Tropical maize can produce large amounts of biomass (9-11 ton/acre, dry weight) and accumulate high levels of sugar (10% sucrose) when grown without supplemental nitrogen (N). Theoretical ethanol yield from combined plant components is very impressive: 1500 gal/acre when grown with supplemental N (180 lb/acre) and 1175 gal/acre when produced without supplemental N. Additionally, tropical maize is well-adapted to many regions of the U.S., unlike sugarcane. Because tropical maize grows vigorously with little or no N fertilizer, it also provides excellent nitrogen use efficiency, making it very positive from an agricultural sustainability perspective. The subequatorial origins of tropical maize's genetic background provide the photo-period sensitivity trait. When grown under the short-night environment of our Midwestern latitudes, tropical maize displays delayed flowering and remains in the vegetative state much longer than commercially grown U.S. corn hybrids, resulting in very tall (15 ft.) plants that produce little, if any, grain. Reduced grain production is offset by accumulation of sucrose in the stalk and also decreases the need for nitrogen fertilizer.

Lipid cane is a crop suitable for land in the South Eastern US that is marginal, or unsuited, for food crop production. At the current yields of sugarcane in the SE US, this would produce about 33 barrels of oil per acre, compared to about 1 from soybean. By increasing the photosynthesis, even higher barrels of oil per acre can be produced. Sugarcane is far less demanding on soils and fertilizers than food crops in general, and can be grown on land unsuited to food/feed crops. The US south-east has large areas of land that have dropped out of food and fiber crops agriculture, a decline that continues to this day. Yet this area receives high rainfall, sufficient to avoid the need for irrigation, and the long growing season maximizes the amount of sunlight these crops can capture over the year. By modifying the plant's own triaclyglyceride (oil, TAG) pathway to up-regulate synthesis in the mature stem and down regulate consumption, so causing accumulation. TAGs, in lipid cane are similar to those of soybean and can be easily converted to biodiesel. Preliminary estimates indicate that using the 23 billion acres of marginal land in the SE US that is not in food production, more than 50 billion gallons of oil could be produced with these crops. Fermentation data of tropical maize and techno-economic evaluation of lipid cane as biofuel crops will be presented.

2:15 PM Lignocellulosic Biomass Residues Identification and Selection in Five Countries of Latin America, As a Feedstock for Second Generation Ethanol Production

Emilio Ruz, PROCISUR, Montevideo, Uruguay

Abstract:

This presentation is part of a recently completed project: "New feedstock and innovative transformation process for a more sustainable development and production of lignocellulosic ethanol" (BABETHANOL) www.babethanol.com, a collaborative project for specific international cooperation actions SICA, Grant agreement N° 227498 of the 7th framework program of the European Commission.

The main objective of the BABETHANOL project was to develop new solutions for a more sustainable approach of second generation ethanol production, based on a "moderate, environmental-friendly and integrated" pre-treatment process of lignocellulosic biomasses. This pre-treatment of the biomass has been the main barrier to overcome in second generation ethanol. The new process, called CES (Combined Extrusion-Saccharification), is an alternative to the current pre-treatments of the state-of-the-art, requiring much energy, water, chemical products, detoxification and waste treatments. It has been developed and tested up to TRL 5 (Technology Readiness Level) from laboratory to pilot scales with seven selected biomasses covering a large range of diversified feedstock.

In parallel to the process development, a feedstock catalogue of diversified crop and agroindustrial wastes was built along the project from investigations run in Argentina, Brazil, Chile, France, Germany, Italy, Paraguay, Spain, United Kingdom and Uruguay, by one partner in each continent. The main idea was to identify concentrated amounts of indigenous lignocellulosic wastes currently available at local/regional scales for the prompt deployment of small, medium or large size second generation ethanol plants near the biomass production sites once the new process will be ready for industrialization.

We are hereby presenting the results of IICA-PROCISUR research in five countries of South America: Argentina, Brazil, Chile, Paraguay and Uruguay.
The final selection of the feedstock was performed after investigating: 1) the biomass availability taking into account current situation with competition for other uses (soil cover, animal feeding and/or bedding and energy); 2) the chemical compositions of the preselected biomasses; and 3) the concentration of feedstock at local level (within 100 km radius) to supply at least 30,000 t dry matter/year.

Argentina
Although Argentina is one of the largest producers and exporters of agricultural goods generating large amounts of residues, originated by the agricultural and agro-industrial sector, only a few were selected according to the required characteristics, availability and geographical dispersion. Precautious measures were taken into account for agricultural production systems since there are most under no tillage, and therefore, cover and organic material and nutrients must be reserved in the soils in order to avoid a rapid deterioration. In the case of agro-industrial products, competitiveness with other uses, physical and chemical characteristics and availability in volume and dispersion during the year were the main concerns. The biomasses found as the most suitable feedstock for the production of ethanol with the CES process were: corn cobs, vineyard pruning, sugar cane field residues (tops and leaves) and bagasse, and eucalyptus field and industrial residues. Less important was wheat straw because of its relatively low amount of cellulose.

For corn cob, three departments in the province of Cordoba: Marco Juarez, Unión and Río Cuarto, producing each of them over 100,000 t/year corn cob, were highlighted since they could match with minimum volume availability requirements. For vineyard pruning, the provinces with higher volumes of residues were San Juan and Mendoza. Two supply basins in a 25 km radius were detected at San Martin (100,000 t/year) and Maipu (35,000 t/year) departments in the province of Mendoza. For sugar cane field residues, two supply areas for ethanol plants were identified: the north, with 260,000 t/year and the south, with 220,000 t/year, both in a 20 km radius. For sugar cane bagasse, a main supply basin was identified around Concepción sugar cane mill in the province of Tucuman with 100,000 t/year bagasse available in 5 km radius and almost 200,000 t/year in a 30 km radius. Eucalyptus residues are concentrated in the provinces of Corrientes and Entre Rios. Forest residues amount to 170,000 and 230,000 t/year respectively.

Brazil

With regards to chemical composition and availability, sugarcane residues (bagasse and trash) are the only feedstock convenient and currently available for ethanol production. The residues from the production chains of soybeans, maize, banana, wheat, coffee and pineapple, with suitable chemical composition which are not available now-a-days under current uses, may offer a second list of additional feedstock that have the potential of being used in the future if the production of second generation ethanol picks up. In Brazil, the most logical alternative would be to locate a production unit of second generation ethanol, in an already existing or close to a processing unit of sugarcane. In this respect, there is a high concentration of industrial plants in the following states: Alagoas and Pernambuco (Northeast region), Goiás and Mato Grosso do Sul (Centre-West region), Sao Paulo and Minas Gerais (Southeast region) and Paraná (South region).

The minimum amount of residues required for the operation of a 30,000 tons of dry material per year processing capacity plant is guaranteed in the following situations: if the trash is not used (or if it is unavailable), in industrial plants with processing capacity of over 2 M tons of sugarcane per season and with the use of trash, in industrial plants with processing capacity over 0.5 and 2.0 million tons of sugarcane per season. There are several industrial plants of sugarcane in Brazil with processing capacities in these ranges, located in the CO/SE/S and N/NE regions. Moreover, there are areas with high concentration of industries in these regions.

Chile

From all the materials originally considered and assessed wheat straw and corn stover field residues as well as vineyard and orchard pruning residues were selected as potential feedstock suitable for the production of ethanol under the CES process. Best residues supplying basins were identified in the following areas: wheat straw in the Araucania region with over 500,000 t/year; corn stover in the O'Higgins region with over 500,000 t/year; apple and vineyard pruning residues in five regions (Coquimbo, Valparaíso, Metropolitana, O'Higgins and Maule) with amounts varying from 150,000 to 280,000 t/year in each region.

Paraguay

In general, the climate of Paraguay characterized for high temperatures and humidity all year round, influences the dynamic of the degradation of organic matter left in the fields, accelerating the decomposition process which requires that most of the crop residues should not be removed from the soil for sustainability reasons. For this reason, field residues from major cultures like sugar cane, soya, wheat and corn are not collected and therefore not available for other uses. Sugarcane bagasse is the only residue produced in large quantity which is available and suitable for ethanol production and the CES process. Although it is already used to produce energy, there are seasons when there would be sufficient surplus to supply 2nd generation ethanol plants. The province of Guaira appears as the best location for the supply of bagasse with 54,000 t/year in a 30 km radius.

Uruguay
Among a wide variety of residues of the Uruguayan agro-industry, the ones that apparently were most suitable as feedstock for the CES process were wheat, rice and forestry field residues, as well as rice and forestry industrial residues. During the chemical screening both rice residues presented a chemical composition that was not suitable for the production of ethanol with the CES process: for straw the cellulose was too low, for the hull the lignin was too high and for both of them the mineral content was too high. Although wheat straw had better chemical composition, cellulose content was slightly under the limit. So wheat straw was considered as a second choice feedstock. Among the forestry residues, Eucalyptus presented very high cellulose content and good content for all the other compounds, except for forestry industrial residues with lignin slightly above the limit. Several country departments produce sufficient biomass to supply ethanol production plant, especially Rivera, Paysandú, Río Negro and Rocha with amount available ranging from 90,000 to 140,000 t/year within a 30 km radius or less in some zones. So Eucalyptus forestry residues are considered first choice feedstock for the production of ethanol and for the CES process in Uruguay.

2:40 PM Uncovering System Behaviors in Biofuels Supply Chain Network Using an Agent-Based Simulation Approach

Datu B. Agusdinata, Industrial & Systems Engineering and Environmental Studies, Northern Illinois University, DeKalb, IL

Abstract:
The second generation biofuel feedstocks such as camelina, short rotation woody crops, algae, and switchgrass have been investigated to minimize the impact on the food chain. In order to achieve a significant market penetration of the second generation biofuels, some significant challenges must be addressed. These include improving feedstock yield and conversion efficiency. Another critical challenge, which is the focus of this study, is a viable and well-functioning supply chain (SC). To add to these challenges, some undesirable behaviors at a system level have been observed in the corn-based ethanol industry. For instance, as a result of the Energy Independent and Security Act of 2007 mandating ethanol production, refining capacity was added at a faster rate resulting in high ethanol inventories. Increased price of corn has squeezed refineries' profit margin below the sustainable level. A stabilizing price of oil has made ethanol less economically attractive. For producers, the financial pressure has been exacerbated by dried up capital due to the credit crunch and the recent expiration of a federal subsidy for ethanol blenders. Natural factor plays a role too. Recent drought has caused a spike in corn price leading to temporary shut down or scale back production of many ethanol refineries
An agent-based simulation approach is pursued to understand the dynamics of biofuels SC network. The approach treats each actor along the life cycle stages as an entity with distinct decision rules. The approach can deal better with the fact that some actors do not always act rationally due to bounded rationality. Actors also often use heuristics to generate solutions. It can also factor in the fact that actors learn over time and may change their decision rules as a result. This approach is in contrast to most equation-based models such as system dynamics or utility-based methods, which are based on the assumption that actors are rational and share common interests.

The interests of three supply chain actors are represented: users, biorefineries, and farmers. Each actor type has a binary decision option: adoption or non-adoption of biofuels. This SC network model is characterized by distributed control, time asynchrony, and resource contention among actors and who

make decisions based on incomplete knowledge and delayed information. The decision dynamics of these actors are modeled using a computational ecosystem construct. A preliminary set of coupled payoff function for each actor type and each decision is developed to represent interdependencies among SC actors. The SC network behavior is observed in terms of fraction of actors adopting the biofuel option. The SC network shows behaviors ranging from fixed point equilibrium under no delay and perfect knowledge to periodic and chaotic oscillations.

The simulation model was used to evaluate three sets of simple and straightforward subsidy policy. The first policy setup involves a constant subsidy level across the simulation period of 120 months or 10 years. Second type of policy is a subsidy scheme that is evaluated periodically. In the model, every 2 years, the relative payoff between biofuels and non-biofuels options is compared. When biofuels are at disadvantage, the subsidy is implemented. Otherwise, no subsidy is put in place. This policy setting is similar to a situation in which regulators like the U.S. Congress deciding whether or not to continue a certain subsidy scheme. The last type of policy is the subsidy that will be phased out over time. This arrangement is similar to special feed-in tariffs established to incentivize adoption of solar energy.

When Constant subsidy policy is implemented during the 120 months of simulation period, the SC network shows a steady increase in the adoption of biofuel options and reaches equilibrium in about 48 months. As a result of the assumed coupled payoff functions, each actor type arrives at different equilibrium states. At most times past year 4, all 1000 farmers adopt biofuel crops whereas the fraction of refineries dedicating for biofuels (out of 100) fluctuate from about 80% to 100%. The fraction of motorist users hovers at around 42%.

Next, Policy2: Declining subsidy, provide incentives for actors to take biofuel options similar to the effect of Policy1. After around year 6, however, the decreased subsidy level starts to take effect. Biorefineries and users begin to drop biofuel options followed by farmers 2 years later. The attractiveness of biofuel options temporarily picks up again afterwards but eventually drops further at lower level when the subsidy has been completely terminated. Lastly, Policy3: Periodic interval subsidy results in periodic pattern of SC network behavior. For the 10 years period, there is a trend that the peak of each cycle of biofuels adoption increases as time progresses.

A sensitivity analysis reveals that the following parameter impacts on system behavior can be observed: Reduced payoff uncertainty lowers the actual number of actors opting for biofuel options. As actors know with more certainty about the payoff, their preference will be slightly downgraded and hence the slightly lower adoption level. However, the pattern of system behavior does not change significantly. Reduced re-evaluation rate results in a smoother transition to biofuel options for the three actors. Reduced delay time leads to quicker action by actors to take biofuel options as they become favorable. Lastly, the combined effect of reduced values of the three parameters results in a quicker and smooth transition and stable equilibrium.

One major implication of these findings is that when supply chain actors have more updated information about the decision of other actors and less uncertain knowledge about the payoff of their decisions, they can reduce the oscillations in the SC network. Overall, the simulation model framework provides a basis for further development including identification and assessment of policies to control undesirable behaviors in a supply chain network. The modeling framework can be adapted and applied to other renewable energy applications such as wind and solar energy.