

**Final Progress Report**  
**Sustainability Science Program, Harvard University**  
**Term: September 1, 2011 – August 31, 2012**  
**Submitted: July 2012**

**Name:** Francisco Fujita De Castro Mello

**Your field(s):**

biofuel, climate change, soil science, agriculture and environment, sustainability science

**Your degree program, institution and (expected) graduation date:**

PhD, Chemistry in Agriculture and Environment, Center of Nuclear Energy on Agriculture, University of Sao Paulo, Brazil. Expected: December 2012

**Faculty host(s) at Harvard name and department:**

Noel Michele Holbrook, Dept. of Organismic and Evolutionary Biology

**Description of SSP-related research activity:**

**Title:** Land Use Change in Sugar Cane Agrosystem to Ethanol Production in Brazil

**Abstract:** Brazilian sugar cane production has more than 400 years of history. The use for energy purposes is more recent, and was stimulated by “Pro-Álcool program” in the 70’s. Nowadays Brazil’s figures as the biggest sugar cane producer in the world, responding for 50% of cultivated areas. Almost half of this production is used for energy purposes, and as result of increasingly demand of ethanol is expected that others 6 millions of hectares of sugar cane will be needed next decade to provide energy for flex fuel vehicles. This modification in landscape can be harmful to environment and increase Greenhouse Gas Emissions (GHG) if deforestation is promoted. In the other hand, the conversion of degraded lands for sugar cane can avoid GHG emissions, and even promote carbon sequestration due soil organic matter accumulation. Besides the importance that sugar cane represents to Brazil, is correct to highlight that there are few published information related to sugar cane expansion and its impact in CO<sub>2</sub> emissions/ or soil carbon sequestration due land use change. The aim of this research project is to evaluate the effect of land use change due sugar cane expansion in Brazil on soil organic matter and estimate their result in GHG emissions or soil carbon sequestration. It’s expected that results might be used to promote good policies for sugar cane expansion in order to promote sustainable development in such important sector for Brazilian economy.

**Identification of the problem you address:**

Sugarcane cultivation in Brazil experienced an important expansion on last decade, with approximately 3 million hectares that were incorporated to sugarcane industry. Data from 2007-2008, shows that expansion is overcoming rangelands (42-48%), agriculture (56-50%), citrus (1-2%), and others land uses, including native vegetation (1-0%). These substitutions can result in modifications on soil organic matter stocks, which can be degraded by microorganisms and promote green house gas emissions, mainly CO<sub>2</sub>, or being incorporated and increase soil organic matter stocks, reflecting on higher soil carbon stocks.

**Key question asked about the problem:**

Knowing about the LUC promoted by sugarcane expansion, its important to understand what happen to soil carbon stocks when sugarcane overcome different land uses in Brazil. In this case, the key question should be “Does LUC promoted to sugarcane expansion in Brazil leads to Carbon Debt?”

**The methods by which you answered that question:**

To evaluate soil CO<sub>2</sub> emissions, the methodology described in the “2006 Guidelines for National Greenhouse Gas Inventories” (IPCC, 2006) has being adopted. The Tier 2 level will be used, and it consists of three basic aspects: (i) Soil CO<sub>2</sub> emission estimates must be quantified from the soil organic carbon

(SOC) changes in a certain time period; (ii) soil carbon reference must be determined for the specific conditions of the study area; and (iii) is necessary to generate specific factors to soil carbon changes as result from land use change. For this purpose, chronosequences were chosen to establish transformation points of SOC emissions or removals on the 100 cm soil layer during a 20 years period. According to the IPCC (2006), this factor reflects period necessary for the SOM to stabilize after the LUC phase and to represent only the effect of the implemented crop.

**Principle literature upon which the research drew:**

Greenhouse gas inventories can determine which are the “leaks” of production systems and provide substantial information to find better initiatives towards sustainability. It’s possible to affirm that there is no information related to what sugar cane expansion will promote to soil carbon stocks and their impact on green house gas emissions. This research project aims to provide this information by deriving LUC’s standard values for the sugarcane expansion in Brazil.

**Empirical data acquisition description:**

The search for specific sampling sites started in 2009-2010 with travels (accounting more than 8,000 km) and interviews with people from sugarcane mills, associations and farmers. This activity allowed finding the Soil Sampling Potential Areas (SSPA) through all South-Center Brazil, which includes states of Sao Paulo, Minas Gerais, Goias, Mato Grosso do Sul and Parana. After the selection, several months were taken to have the authorization and begin the soil sampling, which started on 2011 and ended in February 2012. About 150 soil sites in Brazil were sampled, including sugarcane, pastures and native vegetation, representing ~60 comparison pairs and 5,000 soil samples.

**Geographical region studied:**

South-Central Brazil, including states of Sao Paulo, Minas Gerais, Goias, Mato Grosso do Sul and Parana.

**Recommendations that might be relevant for your problem:**

Sugar cane mills are promoting management modifications, from burned to unburned sugar cane, and as result, soil carbon stocks might increase. Our data set include areas under both management (burned and unburned), but considering management modifications were recently (~1-2 years), we might not be able their impact over soil organic matter.

**A description of the final product(s) you have/are aiming to produce:**

Publish paper in a peer reviewed journal.

**Description of major other intellectual or professional advancement activity(ies) over the past academic year:**

Volkoff, B.; Mello, F.F.C.; Maia, S.M.F.; Cerri, C.E.P. 2012. [Landscape and soil regionalization in southern Brazilian Amazon and contiguous areas: methodology and relevance for ecological studies](#). *Scientia Agricola* 69(3): 217-225.

**Citations for reports, papers, publications and presentations that built on your fellowship research:**

Symposium - Dialogue for a Brighter Future. Harvard Business School. October, 2011.  
[http://www.harvardenergyclub.org/symposium\\_agenda/](http://www.harvardenergyclub.org/symposium_agenda/)

Conference – MIT Latin America Conference. March, 2012.  
<http://mitlac.com/>

Presentation - Land use change in sugar cane agrosystem to ethanol production in Brazil: 04/11/2012. SSP Spring seminar. Harvard Kennedy School of Government. Cambridge, MA.

Presentation - Land use change in sugar cane agrosystem to ethanol production in Brazil: 04/17/2012. Holbrook Lab meeting. Dept. of Organismic and Evolutionary Biology, Harvard University. Cambridge, MA.

Conference - ISO Data-Agro New York Sugar Conference 2012. May 16<sup>th</sup>, 2012.  
<http://www.isodatagroconferences.com/>

Peer Reviewer/ Book Chapter – “Science, Policy and Politics of Modern Agricultural System”, Springer 2012

Peer Reviewer/ Article - Journal “Biofuels” - 2012  
<http://www.future-science.com/loi/bfs>

MELLO, F.F.C. et al. Sugar cane expansion in South-Central Brazil: the effects of land use change over soil carbon stocks. UNU-Wider Conference on Climate Change and Development Policy. Submitted 06/2012.  
<http://website1.wider.unu.edu/?q=climate12>

**Principal collaborators outside Harvard (list name and institution):**

University of Sao Paulo (Brazil): Prof. Carlos Clemente Cerri, Prof. Carlos Eduardo Cerri  
Colorado State University: Keith Paustian  
Insitute du Recherche pour le Developpement (IRD, France): Martial Bernoux, Boris Volkoff

**Awards or grants that you have received this year for the current or coming year:**

Scholarship:

CNPq (Brazil): US\$15,000.00 (12 x 1,300.00). From 09/2011 to 08/2012.

Research support:

FAPESP (Brazil): US\$ 110,000.00