DRAFT

CARB LCFS Expert Working Group - Sub-task #3

Sub-task Membership: Richard Nelson (chair), Holly Gibbs (co-chair), Bob Larson, Bruce Babcock, Angelo Gurgel, Blake Simmons, John Sheehan

Sub-group Overview

Land cover types – Types of land available for conversion to cropland and effects on land use change estimates.

Alternate Proposed Title: Types of land available for conversion to bioenergy/ commodity crop/new production and effect on land use change.

Major ideas behind potential use of both current and alternate land bases are to:

1) **Maintain and/or enhance existing land bases with respect to environmental quality and eco-system services, energy inputs/outputs, and economic returns, and**

2) **Possibly use other lands with current low productivity and "raise" their profile (e.g., less soil erosion, increased soil tilth/productivity, and/or economic return).**

Prioritized list of topics/questions that the subgroup proposes to address:

Following are the major items to be investigated within this sub-group and whether they are viewed as possibly being resolved in the short-term meaning Fall 2010 (**ST**), long-term (**LT**) after final report at the end of 2010, both (**BSTLT**), or unknown (**UKN**).

a) What types of land cover can we identify as land sources for new agricultural lands (**ST**)

b) State and national global data sets – resolution, timeliness, gaps, are they relevant (**ST**)

c) Definition of marginal land (**ST**)

d) Remote sensing validation (**LT**)

e) Land cover as related to technological reclamation (**UKN**)

f) Elasticity transformation (**ST**)

g) Reconciliation of agricultural land (land transformation elasticity) (**BSTLT**)

h) Elasticity with respect to area expansion for different land cover types (**ST**)

i) Lots of input to bring land up to level of productivity and impacts on GHG (**BSTLT**)

j) What would the land be used for? Take the dynamic development of land into account. What is the long-term dynamic land use baseline? Effect of adding biofuels into this system. (**BSTLT**)

Background Data

a) <u>What types of land cover can we identify as land sources for new agricultural lands</u>.

- Major Land Resource Areas (MLRA's)[1] provide data concerning types of major cropping systems past and present and what has been "accepted practice" in land base production, use, and maintenance. For example, the Corn Belt versus the Southern Great Plains provides considerable contrast with respect to many different geoclimatic variables that directly impact cropping systems from corn to wheat to cotton production, grassland productivity, moisture regimes, and soil texture each of which impact environmental quality, ecosystem services, energy requirements for land maintenance, and economic returns. Land cover utilization will also depend upon markets of all types.

- Table 1 presents 15 separate land base categories as provided by the National Land Cover Database[2] which include major land classifications/types of cropland, pasture, grasslands/herbaceous, forest, etc. Within at least some of these 15 categories separate data exists on a) land capability class, b) field topography (i.e., field slope, etc.), and c) soil texture provided mainly by the SSURGO database.

Table 1. Major land classifications (National Land Cover Database 2001).

Water	Deciduous Forest	Grassland/Herbaceous
Developed, Open Space	Evergreen Forest	Pasture/Hay
Developed, Low Intensity	Mixed Forest	Cultivated Crops
Developed, Medium Intensity	Woody Wetlands	Emergent Herbaceous Wetland
Developed, High Intensity	Shrub/Scrub	
Barren Land		

Lands potentially available for "new" production (commodity crops, dedicated energy crops, etc.) could use these databases as a starting point for evaluating impacts associated with sustained production both pro and con concerning expected environmental quality, ecosystem services, and economic return to the farmer/landowner.

- All landcover databases will also need to have some level of economic return (e.g., net return per acre/hectare) associated with them for comparison purposes with each viable alternative use. This goes directly to the potential availability of various land cover types.

Global land cover databases

- There are a host of satellite imagery types that could be used to estimate the land sources for new croplands across the globe. These include MODIS (500m-1km resolution), Landsat (30m resolution), Spot (20m resolution), VEGETATION (1km), MERIS (300m) and so on. Landsat or Spot are likely ideal in terms of providing the spatial resolution needed to identify the land transition.

- However, there are very few "processed" databases available that provide information the land sources for new croplands. Most simply estimate the change in total area of cropland and other land cover types.

[1] http://soils.usda.gov/survey/geography/mlra/
[2] http://www.mrlc.gov/

- It is critical that an actual change detection procedure be used to estimate the land sources for new croplands, rather than simply subtracting two static land cover maps as has been done for the EPA RFS2 Winrock International analysis.

- There are many examples of local studies in Brazil, Indonesia and elsewhere that have used satellite imagery to estimate land sources for a specific area (e.g., part of Mato Grosso or Rondonia). However, the analysis by Gibbs et al. (in review PNAS) provides the only pan-tropical assessment of land sources for new croplands and this study is limited to the 1980s and 1990s.

- New Landsat-based data sources will likely come available through the FAO 2010 Forest Resources Assessment that should shed light on land sources for new croplands during this decade.

- Beyond that, we critically need funding to encourage remote sensing labs to tackle this issue of cropland expansion pathways.

b) <u>State, national, and global data sets – resolution, timeliness, gaps, are they relevant</u>.

State data sets

Most state-level data (county-level and soil type level) can be obtained from one or more national databases on land cover/land use and soil parameters.

National data sets

The National Land Cover Database has information on use of land such as cropland, forest, grassland/herbaceous, etc. as well as three national soil parameter databases such as SSURGO and STATSGO[3, 4] each representing different resolutions of soil parameter data. Data from both SSURGO and STATSGO have been used to conduct both state-level biomass resource assessments and supply analyses for agriculturally-based cropping systems including crop residues (corn and sorghum stover and small-grain straws)[5,6] and herbaceous energy crops as well as use in national estimates of agricultural crop residues.

The timeliness of the SSURGO and STATSGO databases is appropriate given the level of detail provided. Major gaps do not appear to be evident other than a real need to have data concerning actual commodity crop production on individual soils within a county, specifically rotations across soils. The resolution of SSURGO is at the individual soil type/attribute level and is fairly good with the exception that it treats certain parameters such as field slope and available water capacity across all acres of an individual soil type within a county the same.

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[3] http://soils.usda.gov/survey/geography/ssurgo/description.html
[4] http://soils.usda.gov/survey/geography/statsgo/description.html
[5] Nelson, R.G. 2002. "Resource Assessment and Removal Analysis for Corn Stover and Wheat Straw in the Eastern and Midwestern United States – Rainfall and Wind Erosion Methodology." *Biomass & Bioenergy.* Volume 22 pp. 349-363.
[6] Nelson, R.G., Marie E. Walsh, John J. Sheehan, and Robin L. Graham. 2003. "Methodology to Estimate Removable Quantities of Agricultural Residues for Bioenergy and Bioproduct Use." *Applied Biochemistry and Biotechnology* 113 pp.0013-0026.

Global data sets

Our knowledge of global soil conditions is quite uncertain. The primary dataset is from the ISRIC-WISE database, which is based on 9600 soil profiles and plotted at 0.5 degree by 0.5 degree. Soil carbon, C/N ratios, total water capacity etc. are provided.

http://www.isric.org/NR/exeres/545B0669-6743-402B-B79A-DBF57E9FA67F.htm

c) Definition of marginal land.

Currently, no real accepted definition of 'marginal land' exists via USDA, FAO, or other agriculturally-based organizations or credible entities, but in general it may be something of the order of: "*Land, such as upland, or desert border, which is difficult to cultivate, and which yields little profit or return and may have been the first land to have been abandoned."*

Another definition may be: "*Lands which can not adequately sustain required levels of production to at least maintain necessary soil health."*

To simply define "degradation" is also challenging and likely increases the apparent variance in estimates. However, there is widespread, nearly universal consensus that degradation can be defined as a reduction in productivity of the land or soil. Much of the confusion comes from different temporal and spatial scales, study locations, methodologies and the perspective of those making the assessment. For example, many degradation studies focus on degradation occurring drylands (i.e. desertification), making it difficult to compare results to broader studies including temperate and humid domains. In the past, most seminal efforts focused on *soil* degradation whereas more recent efforts have investigated the broader issue of *land* degradation, which encompasses both soils and vegetation from an ecosystem approach, and this introduces another variation to the subject of degradation. Whether the study is quantifying actual degradation rather than potential (perceived risk) degradation is another confounding factor.

Means to possibly evaluate land bases for marginal lands/acreages include:

- Acreages in current Conservation Reserve Program (CRP) {wouldn't use this as an absolute, only a possible beginning}
- National Resource Conservation Service (NRCS) – erosion index (EI) which is still used in the CRP program as one criteria
- Land capability classification[7] (LCC I-VIII)
- Rates/levels of commodity crop production (e.g., USDA Census of Ag 2002 and 2007)
- Select soil physical properties (e.g., bulk density, field slope, available water capacity, sand/silt/clay, etc.)

Global databases on "marginal land" (based on review paper by Gibbs 2009)

- Expert option method: The Global Assessment of Soil Degradation (GLASOD) commissioned by the United Nations Environment Program was the first attempt to map human-induced degradation around the world (Oldeman et al. 1990, 1991, 1994). Oldeman et al. (1990) developed a set of relatively uniform mapping units and then asked experts to

[7] http://www.mn.nrcs.usda.gov/technical/nri/findings/cropland_lcc.htm

estimate the status of soil degradation in terms of the type, extent, degree, rate and causes of degradation within each mapping unit (roughly 1945-1990). Accuracy of this data is highly questionable.

- Remote sensing approach: Generally speaking it is very challenging to use satellite imagery to map degraded lands. However, an on-going assessment within the FAO's Global Assessment of Lands Degradation and Improvement project (GLADA) is quantifying more recent degradation events during 1981-2003 by using this relationship between NDVI and productivity (Bai et al. 2008). The GLADA project defines land degradation as the long-term decline in ecosystem function and uses the satellite record from the Global Inventory Modeling and Mapping Studies (GIMMS) to assess these changes. Specifically, GLADA utilizes satellite-derived NDVI measurements collected from the Advanced Very High Radiometer (AVHRR, 8km record) as a proxy for net primary productivity (NPP). Deviations from normal NDVI may indicate land degradation once other factors that may be responsible such as rainfall, climate and land use are taken into account.
    - It is important to note that while these satellite-based assessments may capture recent or on-going degradation by measuring changes in productivity, they will not capture the full picture of all degraded lands, rather only those being actively affected by the processes of degradation. This means that lands degraded long ago, such as parts of West Africa or India, will not be represented by most satellite studies. Satellite data will also struggle to distinguish the fine gradients such as between degraded and non-degraded grassland and may be further limited by potentially confounding biophysical conditions (e.g., seasonality in drylands). Thus, it is unlikely that remote sensing will be able to map all cases of land degradation unequivocally, but the approach does provide valuable clues and has the potential to identify hotspots of on-going degradation (Wessels et al. 2008). Moreover, future advances in remote sensing, including hyperspectral data, may allow finer distinctions between land cover classes to be made, thereby enabling a more complete mapping of vegetation and soil degradation.

    - Abandoned agricultural land: Another way to identify degraded lands is to look for areas that were once croplands but have since been abandoned due to decreased productivity or political and economic reasons. The benefit of focusing on these lands is that it captures the longer time frame of the expert opinion approach but quantifies the actual conditions as opposed to potential risk. Moreover, this approach is empirically driven, for it relies on the details of agricultural census data combined with the global consistency provided by satellite mapping.

    - Recent satellite advances have enabled new global-scale datasets of agricultural land cover, developed by merging satellite-derived land cover maps and ground-level agricultural inventory data sets. Early work by Ramankutty and Foley (1999) pioneered the development of a statistical ‘‘data fusion’’ technique to merge national and sub-national agricultural statistics with land cover maps to create global maps of the world’s croplands in the early 1990s and their historical changes since the year 1700.

    - A second cropland database produced using satellite and census data, the History Database of Global Environment 3.0 (HYDE), has also been used to assess the area of abandoned cropland (Goldewijk 2001, Goldewijk et al. 2007). The HYDE database also provides information on pastures not captured by Ramankutty and Foley (1999). Field et al. (2008) quantified abandoned areas of each map grid cell in

HYDE where agricultural area was decreasing over time. Areas of agricultural land that now support forests or have become urbanized were removed from the abandoned cropland estimates by masking the data with a MODIS land cover map. Campbell et al. (2008) refined this approach by addressing transitions between pasture and cropland in a more internally consistent way. They also quantified the extent of abandoned cropland around the world.

d) Remote sensing validation.

Satellite imagery can be used to validate the land sources but is currently limited by few studies as discussed above.

e) Land cover as related to technological reclamation.

Research into this topic on-going and to be further assessed.

f) Elasticity transformation.

1. Translate GTAP constant elasticity of land transformation into own and cross price supply elasticities and calculate implied elasticities for important AEZ's (U.S. and Brazil at a minimum).
2. Determine "reasonable" estimates of own and cross price elasticities taking into account time period
3. Compare GTAP AEZ elasticities to reasonable estimates. Determine the feasibility of calibrating GTAP with the reasonable elasticities with and without new programming.

g) Reconciliation of agricultural land (land transformation elasticity).

Research into this topic on-going and to be further assessed.

h) Elasticity with respect to area expansion for different land cover types.

1. Develop procedures and estimate elasticity of crop yields with respect to area expansion in the U.S. and Brazil for multiple crops.

2. Develop a procedure to allow for the possibility of increasing productivity of pasture in response to higher livestock returns.

3. Review available data to determine if pasture productivity response can be estimated.

i) Lots of input to bring land up to level of productivity and impacts on GHG.

Depending upon the cropping system employed, the levels on input energy, soil amendments, variable costs, etc.) required could vary significantly. In addition, how the land was used and managed directly impacts each area of input. For example,

grassland/herbaceous acreages in western Kansas with relatively low productivity could possibly be converted to low-input, high-yield (~ 40% oil) oilseeds (e.g., *Brassica Juncea*) produced in low precipitation regimes with relatively little amounts of diesel fuel, fertilizer, and chemicals (herbicides) with the added advantage of having the meal from the crushing operation being used for cattle feed. Even though these inputs are greater than what is currently attributed to the land, they may be significantly less than other alternatives for liquid fuel production (corn-based ethanol, petroleum) to meet increasing demand.

j) <u>What would the land be used for? Take the dynamic development of land into account. What is the long-term dynamic land use baseline? Effect of adding biofuels into this system</u>.

Function of:

- many other sub-topics
- past use and management
- commodity and energy markets
- national and global sustainability criteria
- geo-climatic "conditions" (e.g., soils, precipitation, temperature)

Adding biofuel production into the mix can possibly provide long-term improvement to the total eco-system service of the land depending upon type of biofuel (corn production versus low-input, high-yield oilseeds or dedicated energy crops such as energy sorghums or herbaceous energy crops). Each 'case' will need to be evaluated on an individual basis at the most detailed resolution economically possible.

Invited technical advisors and other additional support needed:

Andre Nassar, a economist from the Brazilian Institute for International Trade Negotiations – ICONE, as an expert about land use dynamics in Latin America

Jon Foley, University of Minnesota, Institute on the Environment

John Blair or Jesse Nippert, Kansas State University

Alan Knapp, Colorado State University

Others?

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TOPICS	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
What types of land cover can we identify as land sources for new agricultural lands									
- literature review	x								
- research		x							
- talking to other experts	"y"		x						
State and national global data sets – resolution, timeliness, gaps, are they relevant									
- literature review		x							
- research			x						
- talking to other experts		"y"		x					
Definition of marginal land									
- literature review			x						
- research				x					
- talking to other experts			"y"		x				
Remote sensing validation									
- literature review				x					
- research					x				
- talking to other experts				"y"		x			
Land cover as related to technological reclamation									
- literature review						x			
- research							x		
- talking to other experts						"y"		x	
Elasticity transformation									
- literature review	x								
- research		x							
- talking to other experts			x						
- re-running GTAP				x					
- sensitivity analysis	"y"				x				
Reconciliation of agricultural land (land transformation elasticity)									
- literature review		x							
- research			x						
- talking to other experts				x					
- re-running GTAP					x				
- sensitivity analysis		"y"				x			
Elasticity with respect to area expansion for different land cover types									
- literature review			x						
- research				x					
- talking to other experts					x				
- re-running GTAP						x			
- sensitivity analysis			"y"				x		
Lots of input to bring land up to level of productivity and impacts on GHG									
- literature review				x					
- research					x				
- talking to other experts				"y"		x			
What would the land be used for? Long term dynamic, adding biofuels into system									
- literature review						x			
- research							x		
- talking to other experts						"y"		x	
Report with results and recommendations to CARB									