

Uncertainty in LUC Estimates Subgroup – Draft Work Plan

Subgroup: Michael O'Hare (chair), Paul Hodson, Stephen Kaffka, Keith Kline, Michelle Manion, Richard Nelson, Mark Stowers, Wes Ingram.

Questions assigned in first EWG meeting:

- a. Conducting a more comprehensive sensitivity analysis and validating land use change estimates with empirical data.
- b. What is robust policy in the face of enduring uncertainty
- c. What are the major areas of uncertainty and how do we address them?
- d. What are the metrics and benchmarks to reduce and measure uncertainty?
- e. Is there empirical data or more site specific data – use in modeling is different than looking at it inferentially through economic models
- f. Policy consequences and implications from uncertainty
- g. Is it possible to choose on the safe side? Which side is that?
- h. Policy choice and the actual consequence and how uncertainty affects it. What is the best consequence
- i. Effectiveness of government policy and law on LUC

Context

The LCFS policy context assigns a global warming index, including a value for ILUC which may be zero, to every fuel involved in the LCFS, necessarily with infinite precision so a fuel blender can make the calculations required for compliance. In turn, this index has consequences for fuel blenders through the average fuel carbon intensity (AFCI) values they calculate annually as a weighted (by energy content) sum of these GWIs, the costs of their product as they blend it with attention to the GWIs and allowances they might sell or buy, and consequences for society as their product is consumed, especially global warming consequences. The GWI of fuel i can be thought of as the sum of GD_i and $GL_{i,}$, respectively the amounts of GHG that would be released directly (i) from fuel production and its intrinsic carbon content, and (ii) from indirect land use change, if an additional (to some baseline) MJ of i were prepared and consumed, and nothing else changed.

The large policy question for ARB is, *considering the information and evidence available at a given time, what ILUC value should each fuel be assigned?*

At least four kinds of uncertainty will be examined by the subgroup. The first, often called *epistemic uncertainty*, surrounds the underlying mechanisms relating land-use changes to crop markets and their description/simulation in models. The second, *parametric uncertainties*, are intrinsic to the available data and model parameters based on them. The third kind of uncertainty is associated with the relationship between GWI as currently estimated and global warming itself (factors other than GWI, such as latent heat, albedo, alternate land uses, reversibility, etc. can play significant roles in global warming). A fourth set of uncertainties

relate to the relationships between policy objectives (reduce global warming intensity of transport fuels), and the effects of regulatory implementation.

- 1) Several proposed topics are more demanding in time and resources than this subgroup could accomplish by November 2010. More detailed sub-task outlines will be developed with specific goals, deliverables, roles and resources defined in the next step in this process.

2) Subtasks

The following are a resorting of the assigned questions a-i above into tasks.

3. 1. Comparative cost of being “wrong” in assigning a value of GL_i : is there a safe side on which to err, especially as regards biofuels? Are there analogous regulatory decisions as precedents? (b,g,f,h) [Wes Ingram]

This task focuses on the distinction between a “best” scientific estimate of GL_i and the value CARB should use in implementing the LCFS, recognizing that the social cost of using a value $x \text{ gMJ}^{-1}$ higher than the “real” value may not have the same social cost as using a value $x \text{ gMJ}^{-1}$ too low. The weight of the evidence indicates that the potential social costs of climate change (and, by extension, inadequate or misguided regulation of climate change) are high and merit precautionary action. Of the various sources of uncertainty in the LCFS, the greatest is the estimation of land use change impacts.

The costs either way are not limited to climate effects; errors can have other unintended consequences such as guiding production toward inefficient or counterproductive measures. In this task, we will attempt to characterize the likely social costs of erring on either side of the optimal ILUC value for a given fuel and if possible the implications for assigning an operative GWI value

3.2. Characterizing the contribution of different issues to the total variance in ILUC estimates: where would further research reduce uncertainty most? (a,c,d) [Steve Kaffka]. [*Note – some of these tasks, especially c,d, and e may overlap with other subgroups and efforts can be reapportioned accordingly*].

- a. **Review uncertainty composition, error bands and variance analysis reported in existing ILUC estimates to identify the major sources of variation where possible.** Compare, if possible, variation owing to model choice to variation resulting from parameter uncertainty. Recommend research focused on factors with the largest contribution to estimate variation.
- b. **Identify and evaluate the critical modeling issues associated with GTAP** and other economic equilibrium models used to make inferential estimates of ILUC. Issues that seem especially important at present include:
 - b.1. One such source of modeling uncertainty involves the “drivers” used to bring ethanol production into the economy in a given model. This task will examine the influence of drivers in the modeling used to support the LCFS.
 - b.2. Another source of uncertainty derives from model simplification or assumption of land characteristics and single step-changes. The GHG flux of lands potentially affected by

ILUC vary greatly; carbon and nitrogen flux, above and below ground carbon stocks, potential productive and storage capacity, are all strongly affected due to disturbance long before land becomes actively cropped. This task will review the literature to identify trends, timelines for disturbance, GHG flux effects and will generate an initial a set of empirical data from selected nations (e.g. where modeling has projected largest ILUC), along with a strategy to continue data collection and improvement.

- b.3. A "shock" of increased ethanol production in an assumed equilibrium world in a CGE model may not match the effects of biofuel policies in a real market growing with constraints over time. This subtask will examine how the shock assumptions may diverge from the influence of actual biofuel policies (CA and US).

A relatively straightforward source of uncertainty peculiar to GTAP and some other models is related to crop aggregation ("coarse grains" includes maize and other crops). This task will examine the issue and develop brackets for the range of outcomes possible due to aggregation.

- c. Identify and suggest ways to improve model weaknesses or areas of uncertainty.**
- d. Evaluate ways that direct intervention in land use change in critical locations can be carried out. Evaluate mechanisms and potential costs for this purpose.**
- e. Assess and review empirical monitoring efforts currently underway to monitor LUC in the developing world.**
- f. Assess and review data on land use change in the United States** and compare it with predictions from GTAP and other models. This task will analyze the actual changes in land use – how agricultural production patterns shifted in response to the biofuel market, along with changes in production levels and exports, a more-scientific starting point for estimating ILUC can be established. The task proposes to consider trends in land, production, and export shares based on USDA data from 1990-2000 (pre-ethanol) and 2001-2010 (as ethanol output increased) to provide insight into what effects on land, production and exports biofuel markets have actually had to date. The task will then consider how improved understanding of the direct LUC effects of biofuel policies in the US could be incorporated to improve modeling parameters and approaches to estimate ILUC.
- g. Review and assess sources of variation in simulation models of local land use change** and other land use change science that is site-specific and compare outcomes of this work to inferential estimates for the same regions.

3.3. Expanding or limiting the scope and type of estimate admitted in ARB rulemaking (more different models, scenario methods, empirical evidence, other jurisdictions). (a,b,d,e) [Mark Stowers]

CARB regulations currently assign GWI values for biofuels from the middle of a range of values generated by a single model (GTAP) with simulations run by a contractor to the agency. Those simulations are based on price and production shocks and task 3.2 above explores

uncertainty associated with that model. This task will explore substituting other possible model approaches and drivers, such as scenario and system dynamic models. The focus of this task will be on uncertainty ranges associated with different kinds of approaches for estimating land-use change effects of biofuel policies to see whether some are intrinsically more precise than others. It will also examine whether combining estimates from different kinds of models in some way can reduce uncertainty (see 3.5 below) in GWI values.

- (a) Causal analysis and risk assessment – Regulations are preferably based on values that can be measured and objectively verified. Task goals are to identify scientific approaches that can substantiate an allocation for biofuel policy among many other variables and attributions of LUC (role of bioenergy policy among drivers of change). This task will begin with identification of studies and examples from other sectors based on a literature review. The task will attempt to identify or at least outline the plausible pathways (conceptually and using a systems approach) and risk factors by which bioenergy policy influences deforestation and new land conversion. This task will initiate a process to determine the extent to which LUC drivers can be adapted to epidemiological methods to assess causation and discern relative values of cause-and-effect of biofuel policy among the other different drivers and types of land-use change. This may initially involve a process to screen for risk factors and causal relationships (or test for assumed relationships) using existing scientific approaches from more mature disciplines. This task will be initiated by the subgroup but will require more time and research to complete. In this phase, the task will develop recommendations and propose a scope of work for future research, including available and required data sources, methods, and potential collaborators and experts in relevant fields.
- (b) Choosing an appropriate metric for LUC effects. The use of GWI based on emissions per unit energy produced is a reasonable approach for comparing relative global warming effects for two fuels with similar production pathways and effects in a properly bounded LCA. But a problem that arises from the chosen metric is that the effects of fossil fuels are assumed to be “insignificant” in large part due to a large denominator per unit of land assumed for production (e.g. the large amount of energy assumed to derive from each well). This task will explore the effects of this choice and identify alternatives that could provide outcomes that more efficiently and effectively support LCFS goals to reduce global warming with more sustainable transportation fuels.
- (c) Could alternative approaches or proxy measures to more efficiently address global warming? To reduce global emissions and environmental damage and protect the world’s remaining forests, there is consensus that incentives for more sustainable land use practices are needed. Increased value to well-managed agricultural and forestry lands is essential or they will continue to be mismanaged and burned. This task will explore the question of whether more effective policy tools could achieve CARB goals to send the “right signals” to more effectively, efficiently and legitimately favor practices that reduce global warming and increase sustainable provision of eco-system services. In this phase, the subgroup will review the

literature as well as emerging voluntary efforts to better align incentives and create tools for improved land management practices in high-risk areas. This task will explore the relative benefits and drawbacks of a more empirical approach to mitigating the risks of land use change in comparison to economic modeling approaches, and will recommend a proposed scope for additional work in this area.

3.4. Policy design issues beyond GWI and GL_r. (b,f,g,h,i) [Keith Kline]. This task will consider how the consequences of uncertainty in current ILUC policy could be managed through approaches that go beyond the current ILUC and GWI assignment and APCI-based regulation. To address these issues, this task proposes to: (i) Evaluate recommendations to improve the legal and scientific robustness of ILUC while conserving policy objectives. This includes a review of US legal precedents for when indirect effects may be considered and strategies to strengthen the legal standing of the LCFS while achieving policy goals; (ii) Analyze policy options within a framework of the “precautionary principle” and looking at impacts beyond just GWI; and (iii) Develop a framework for considering and comparing options that could improve the efficiency and effectiveness of the LCFS policy without being limited to only a GWI metric. These steps will require literature review, contributions from external experts, proposed workshop discussions and the development of proposals in discussion papers for comment.

3.5. Statistical and inferential methodology (meta-analysis, weighting, Bayesian updating, etc.). (a,d) [Mike O’Hare]. A variety of statistical tools are available by which data and evidence can be systematically applied to characterizing uncertainty. These are especially useful when the uncertainty applies to a quantity that can be thought of as a random variable with a probability density function. Among these are Bayesian updating of prior distributions, maximum-entropy methods that assign distributions with the least extra-evidentiary information to a small set of observations, classical statistical inference and efficient estimators, and more. In many fields, standard methods of meta-analysis (combining the evidence from different studies with different data) have been used similarly.

Under this task, we will review these methods, looking beyond environmental science and conventional regulatory practice where possible, to see which would be useful, and how to apply them, in sharpening understanding of the appropriate distribution to use for the ILUC term in fuel GWI values.

3.6. Epistemic Uncertainties deriving from the underlying hypothesis relating indirect land-use changes to crop markets. [Keith Kline]. An uncertainty in current ILUC modeling derives from the assumed relationship between crop markets and deforestation. This task will examine this uncertainty by applying scientific methods and available research on production and land conversion to assess (and to degree possible, begin to test or identify methods to test) three hypotheses:

- Hypothesis A: Biofuel policies cause U.S. farm output to divert to fuel (rather than food) which induces higher food prices, inducing farmers in other countries to clear new land (deforestation or conversion of “natural” grassland and savannah).
- Hypothesis B: Biofuel policies lead to expectations of higher returns, inducing more efficient production and investment. The effects outside the US focus on previously cleared and underutilized lands and reduces pressure to clear new forests.

DRAFT

- Hypothesis C proposes that biofuel policies do not change the ultimate amount of land conversion in any nation as conversion is inevitable and determined by biophysical and policy issues (previously modeled as “forest transition” or “Mather curve”). U.S. biofuel policy may affect the rate of change and how lands are managed after initial conversion occurs.

In each case, the significance in terms of influence on climate change drivers will be assessed. land-use GHG emissions.