Land use, land-use change, bioenergy, and carbon:

Global GHG implications of the development of biofuels

Stéphane De Cara

INRA

UMR Economie Publique INRA-AgroParisTech

stdecara@grignon.inra.fr

ADEME

Agence de l'Environnement et de la Maîtrise de l'Energie

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

MINISTÈRE DE L'ÉCOLOGIE, DU DÉVELOPPEMENT ET DE L'AMÉNAGEMENT DURABLES

MINISTÈRE DE L'ENSEIGNEMENT SUPÉRIEUR ET DE LA RECHERCHE

REVUE CRITIQUE DES ETUDES EVALUANT L'EFFET DES CHANGEMENTS D'AFFECTATION DES SOLS SUR LES BILANS ENVIRONNEMENTAUX DES BIOCARBURANTS

20 mars 2012

Rapport final

Etude réalisée pour le compte de l'ADEME par l'INRA (contrat 10-60-C0039)

Auteurs :
Stéphane De Cara (coordinateur, INRA, UMR Economie Publique, Grignon)
Arnaud Gousseba"ile (INRA, UMR Environnement Grandes Cultures, Grignon)
Régis Grateau (INRA, UMR Economie Publique, Grignon)
Fabrice Levert (INRA, UMR SMART, Rennes)
Justin Quemener (INRA, UMR Economie Publique, Grignon)
Bruno Vermont (INRA, UMR Economie Publique, Grignon)

Contributeurs :
Jean-Christophe Bureau (AgroParisTech, UMR Economie Publique, Grignon)
Benoît Gabrielle (AgroParisTech, UMR Environnement Grandes Cultures, Grignon)
Alexandre Gohin (INRA, UMR SMART, Rennes)

Coordination technique :
Antonio Bispo
Service Agriculture et Forêt, Direction Productions et Energies Durables, ADEME (Angers)

INRA

1

Biofuels

The case for policy support to the development of biofuels

- Mitigation of GHG emissions
- Support to farmers' income
- Diversification of energy supply/Energy security

Biofuels and land-use change

What's at stake?

- Biofuels: additional demand for agricultural commodities
  - Price increase
  - Incentives for farmers (domestically and abroad) to increase output (crop for biofuels, but also food)
- Three ways of meeting this additional demand
  - Intensification
  - Substitution
  - **Expansion**

Biofuels and land-use change

What's at stake?

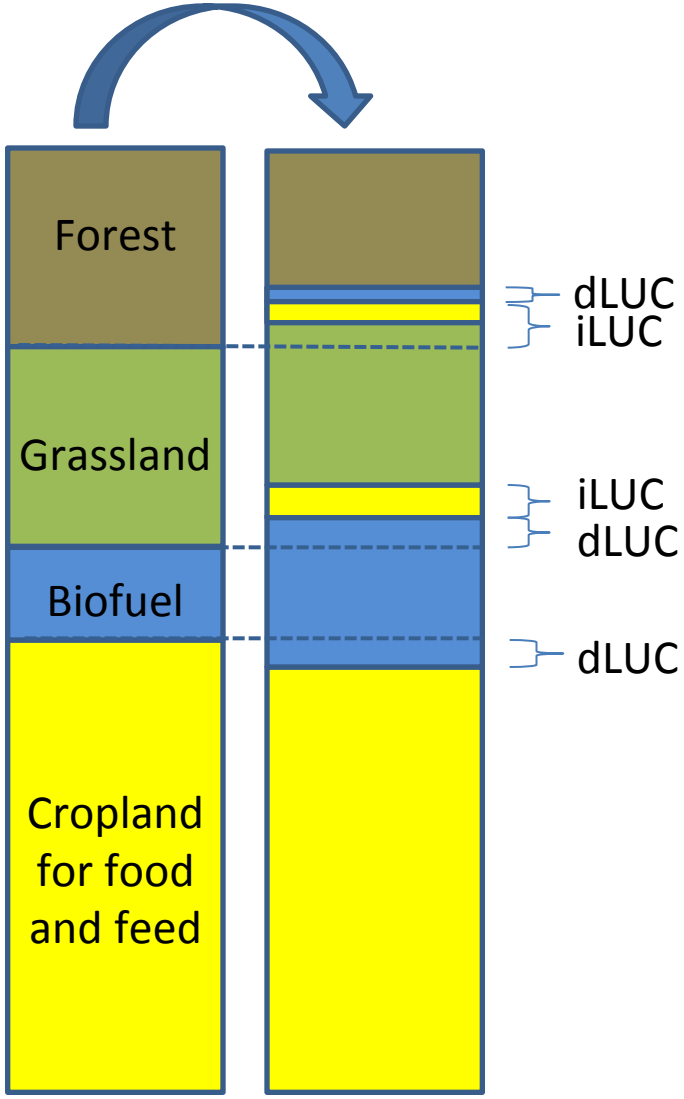
- Direct land-use change

  Land conversions toward energy use (domestically or abroad)

- Indirect land-use change

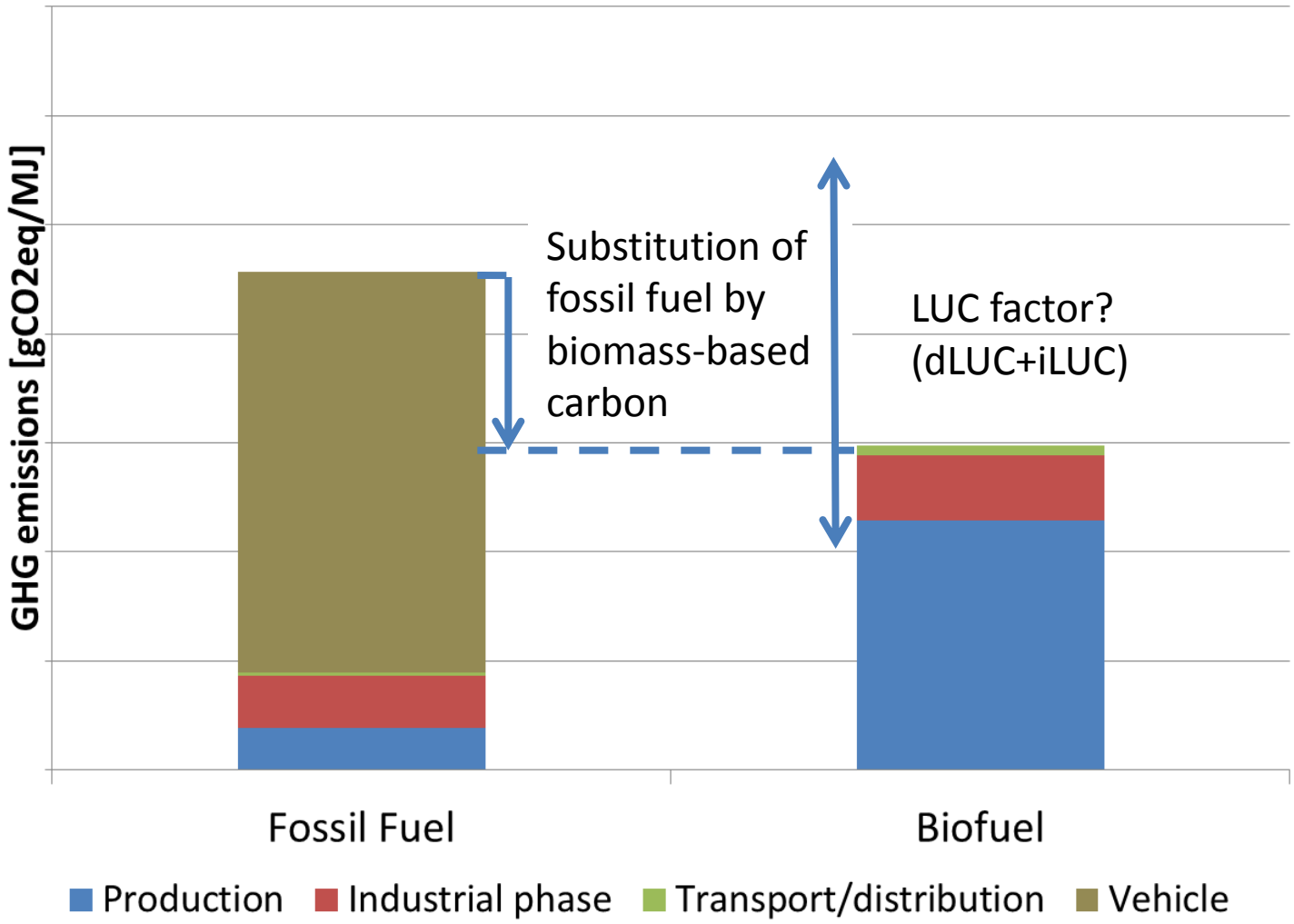
  Land conversions toward non-energy agricultural use (domestically or abroad)

- Difficulties:
  - Many factors have an impact on LUC
  - How to isolate the biofuel effect?
  - Need to rely on models



Biofuels, LUC, and GHG emissions

Fossil fuel vs. biofuel



Biofuels, LUC, and GHG emissions

Three questionmarks

1. **Sign**

   Do LUC effects increase (+) or decrease (-) GHG emissions?

2. **Magnitude**

   If positive, are LUC effects likely to offset the GHG emission savings permitted by the substitution of fossil fuel?

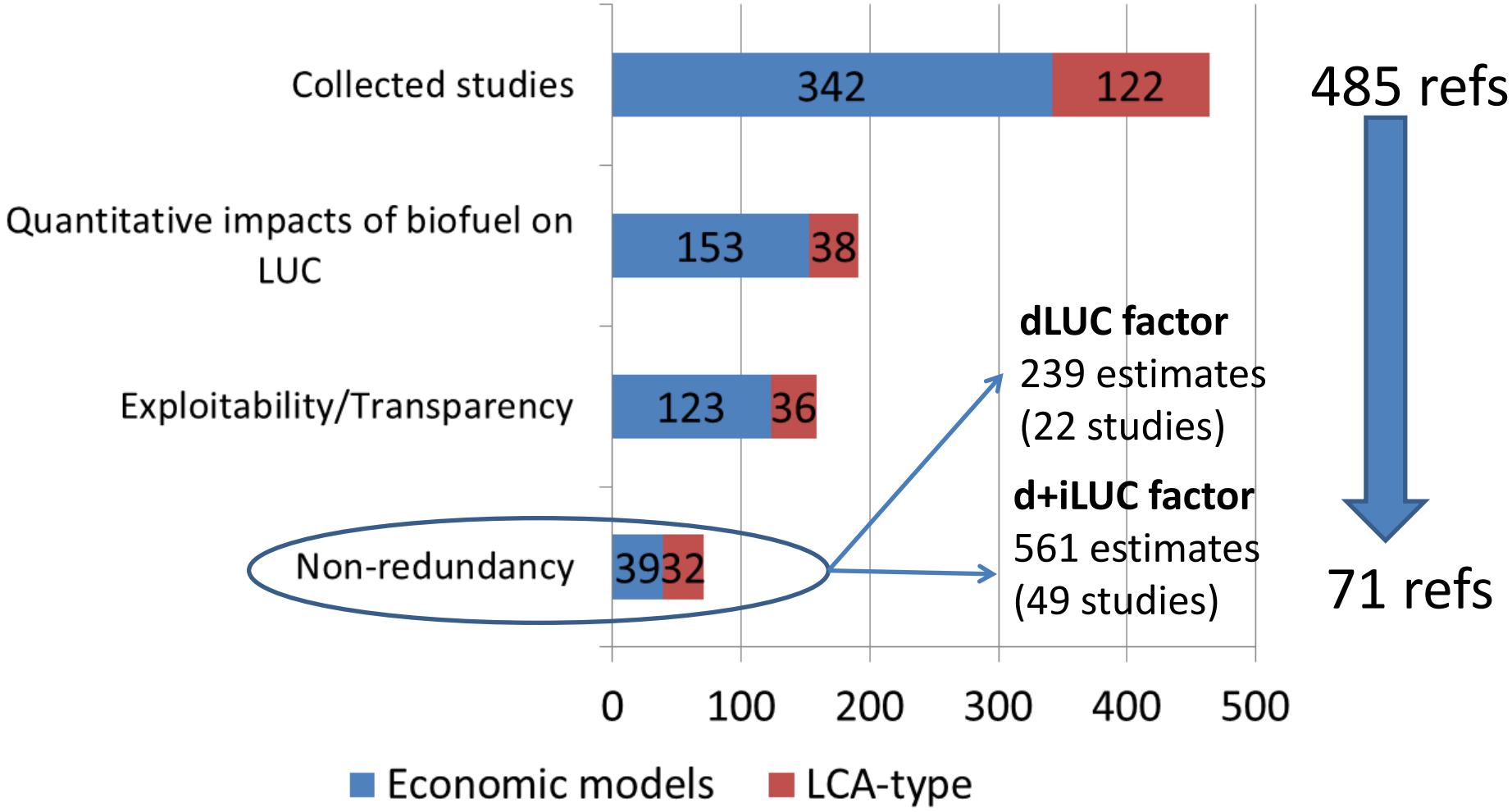
3. **Uncertainty/Variability**

   Large variability in available estimates

   True uncertainty or differences in assumptions and/or scenarios?

A quantitative review

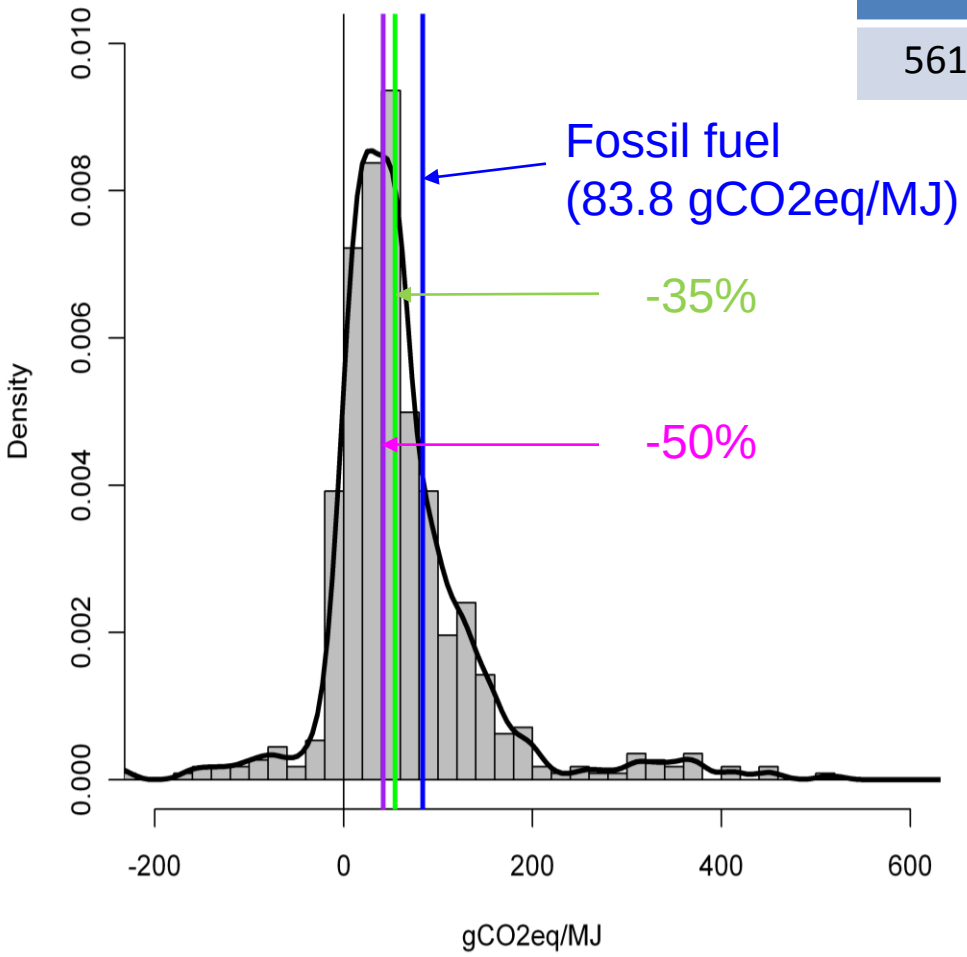
Selected references



A quantitative review

Distribution and descriptive statistics: d+iLUC factor (20 yrs)

N	Mean	StDev	Méd.	Q1	Q3	min	max
561	71	165	48	18	87	-327	2293

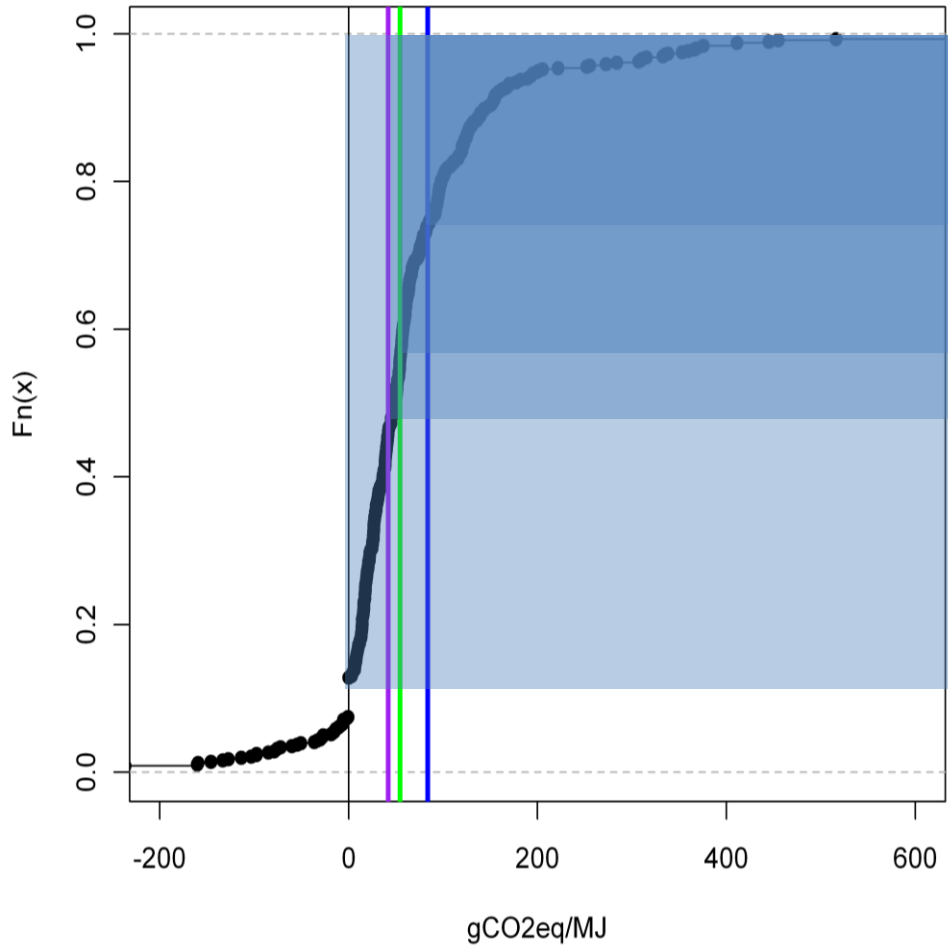


- 561 data points
- Large variability
- Some extreme points

(most of them > 0)

A quantitative review

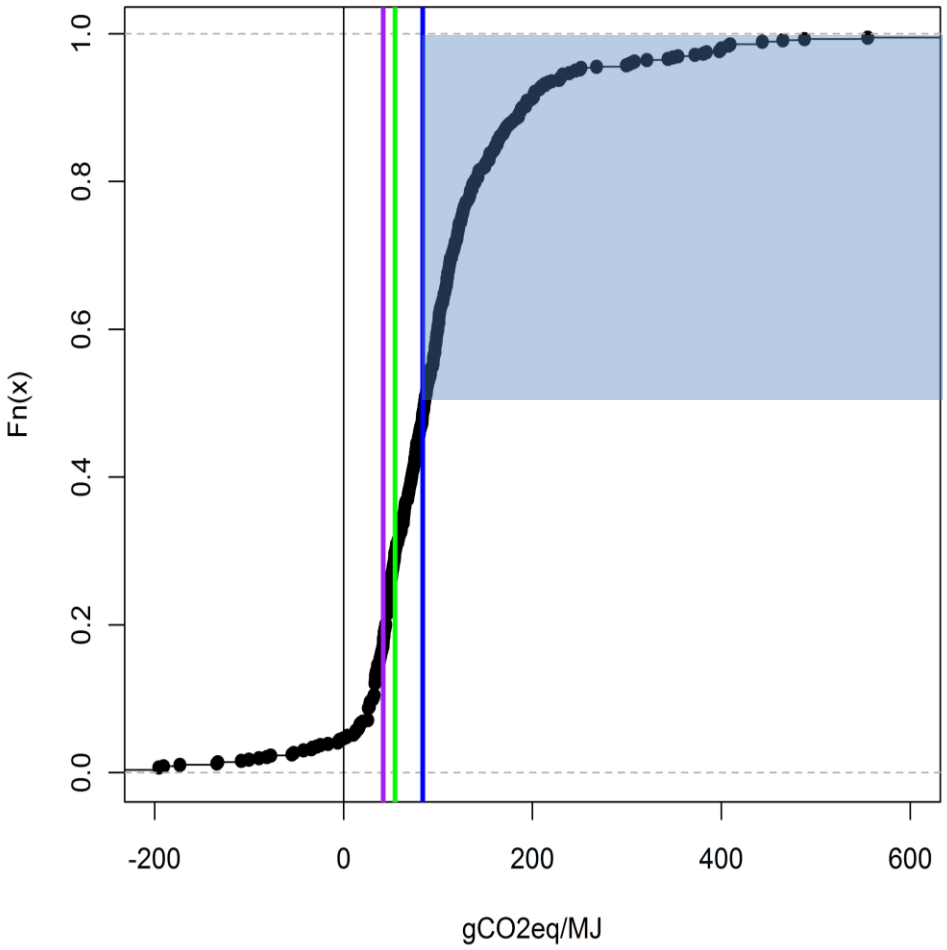
Cumulative distribution: d+iLUC factor (20 yrs)



- 87% > 0 gCO_2e/MJ
- 54% > the 50% threshold
- 44% > the 35% threshold
- 26% > fossil fuel

A quantitative review

Cumulative distribution: d+iLUC factor (20 yrs) + standard LCA



- 95% > 0 gCO_2e/MJ
- 82% > the 50% threshold
- 71% > the 35% threshold
- 52% > fossil fuel
- The estimates differ in
  - Approach used, status
  - Scale, resolution
  - Scenarios, assumptions
- Are we comparing apples and oranges?

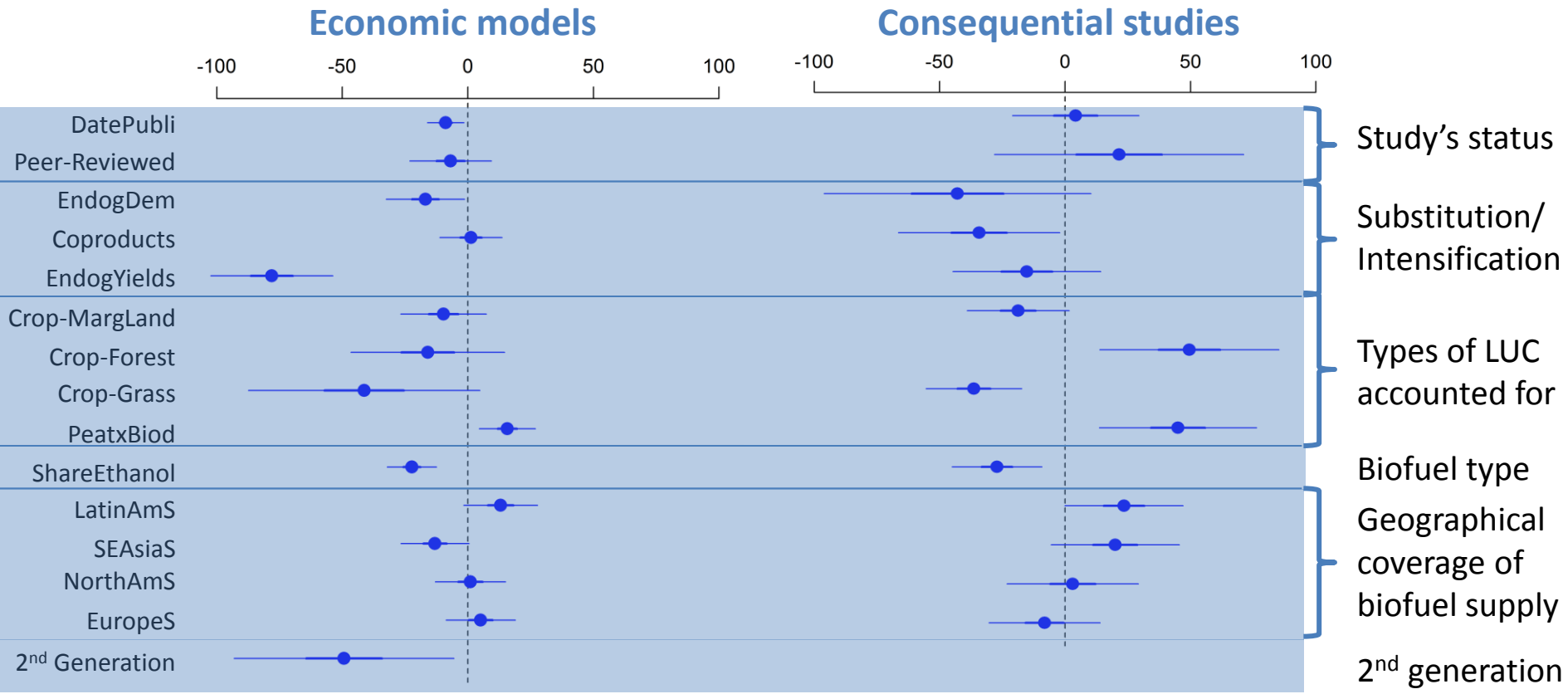
Meta-analysis

Principles

- Not another model, but a statistical treatment of results from the literature
- Use of results from various studies/models as “controlled experiments”
- Quantify the effect of various characteristics and assumptions on the evaluation of the d+iLUC factor
- Estimate a meta-model that allows to compare/predict results from various studies/models « all other things being equal »

Meta-analysis

Estimated impact of various characteristics on the d+iLUC factor (20 yrs, gCO_2e/MJ)



n=241 (10 models)
R^2 corr=0.65

n=246 (18 studies)
R^2 corr=0.4

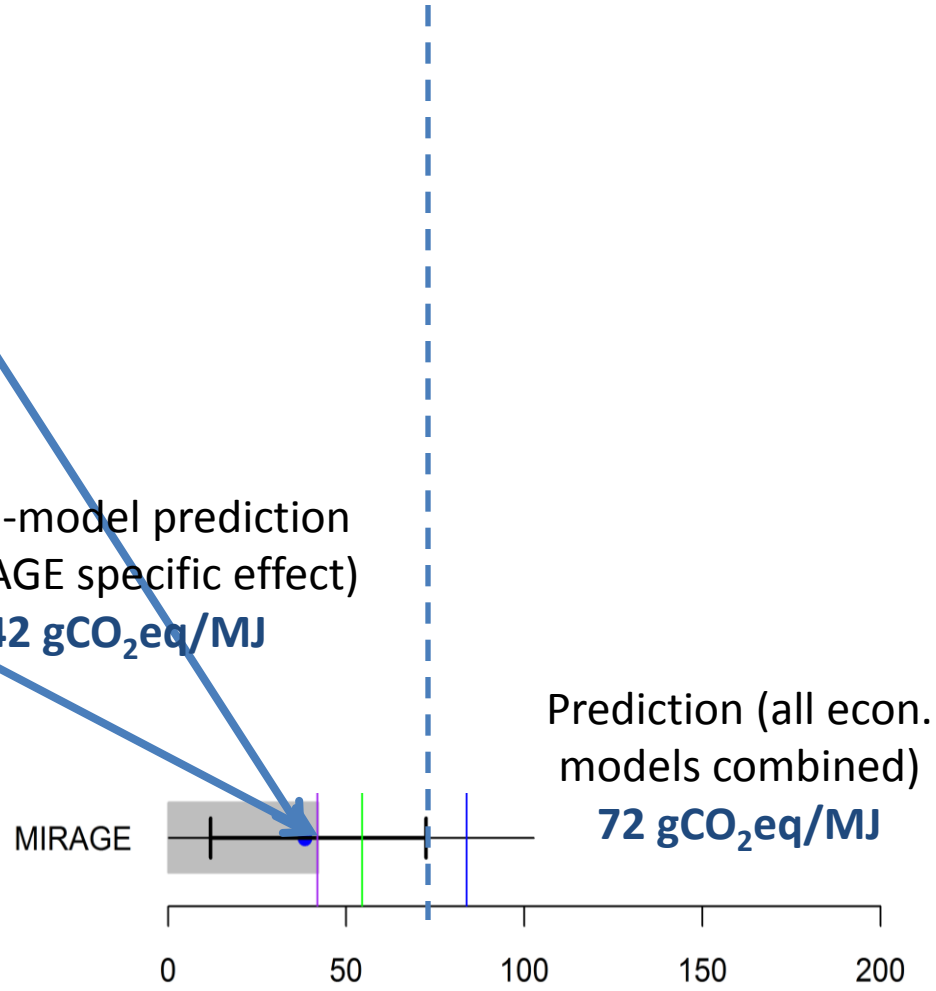
Meta-analysis

d+iLUC factor prediction: Laborde's assumptions (2011, for the EC)

d+iLUC Factor (20 yrs)	38.4
Literature	Econ.
Model	MIRAGE
2nd Generation	0
EuropeS	1
NorthAmS	1
SEAsiaS	1
LatinAmS	1
ShareEthanol	0.35
PeatxBiod	1
Crop-Grass	1
Crop-Forest	1
Crop-MargLand	1
EndogYields	1
Coproducts	1
EndogDem	1
Peer-Reviewed	0
DatePubli	2011 (4)

Meta-model prediction
(MIRAGE specific effect)
42 gCO_2eq/MJ

Prediction (all econ. models combined)
72 gCO_2eq/MJ



Prediction range (model-specific effect)
From 42 to 107 gCO_2eq/MJ

Conclusion

Main findings: determinants of d+iLUC factor

- **The approach matters**
  - Economic models (+) vs. consequential studies (-)
- **The type of biofuel matters**
  - Ethanol (-) vs. biodiesel (+), 2nd generation (-)
- **The type of LUC considered matters**
  - Peatland effect (+), deforestation in South America (+)
- **Market mechanisms matter**
  - Endogenous price effects: yields (-) and demand (-)

Conclusion

Key messages

1. **Sign**

   LUC effects tend to increase GHG emissions

   ⇨ **Should be accounted for in the assessment of biofuels**

2. **Magnitude**

   The meta-model gives a d+iLUC factor of 72 gCO_2eq/MJ

   (EU context, all economic models, excl. standard LCA emissions)

   ⇨ **Risk that biofuels be worse than fossil fuel w.r.t emissions**

3. **Uncertainty**

   Part of the variability comes from differences in assumptions

   ⇨ **Variability alone cannot justify inaction about LUC effects**

References

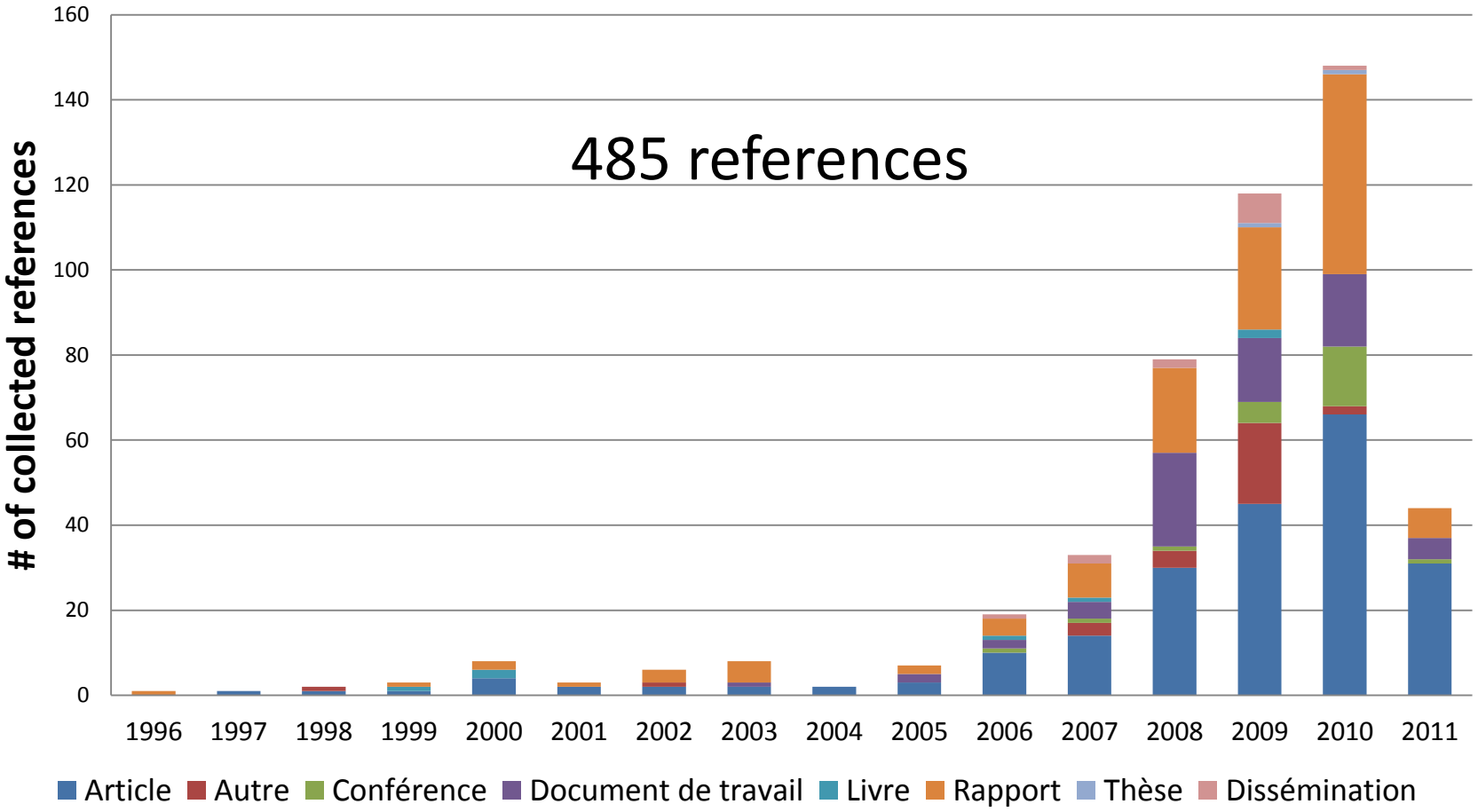
De Cara, S. (coord.); Goussebaille, A.; Grateau, R.; Levert, F.; Quemener, J.; Vermont, B. (2012), *'Revue critique des études évaluant l'effet des changements d'affectation des sols sur les bilans environnementaux des biocarburants'*. Final report. Study financed by ADEME. INRA UMR Economie Publique, Grignon, France, 96 pp.

Laborde, D. (2011), *Assessing the Land Use Change Consequences of European Biofuel Policies*. Final report. Study financed by the European Commission, DG Trade. IFPRI, Washington, DC, USA.

ADDITIONAL MATERIAL

A quantitative review

Collected references



A quantitative review

Approach

- Systematic and exhaustive search for available estimates in the literature (economics, consequential LCA, causal-descriptive)
- Bibliographic database
- Analysis of the collected references in order to define a set of relevant characteristics/assumptions
- Selection of studies based on a set of transparent/reproducible filters
- Description of the studies & variable coding
- Meta-analysis