Top Ten Steps to Improve Quantification of Land-Use Change Effects of Bioenergy Systems

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Center for BioEnergy Sustainability

Keith Kline

Gbadebo Oladosu, Virginia Dale,

Allen McBride, Nagendra Singh

Center for BioEnergy Sustainability

Oak Ridge National Laboratory

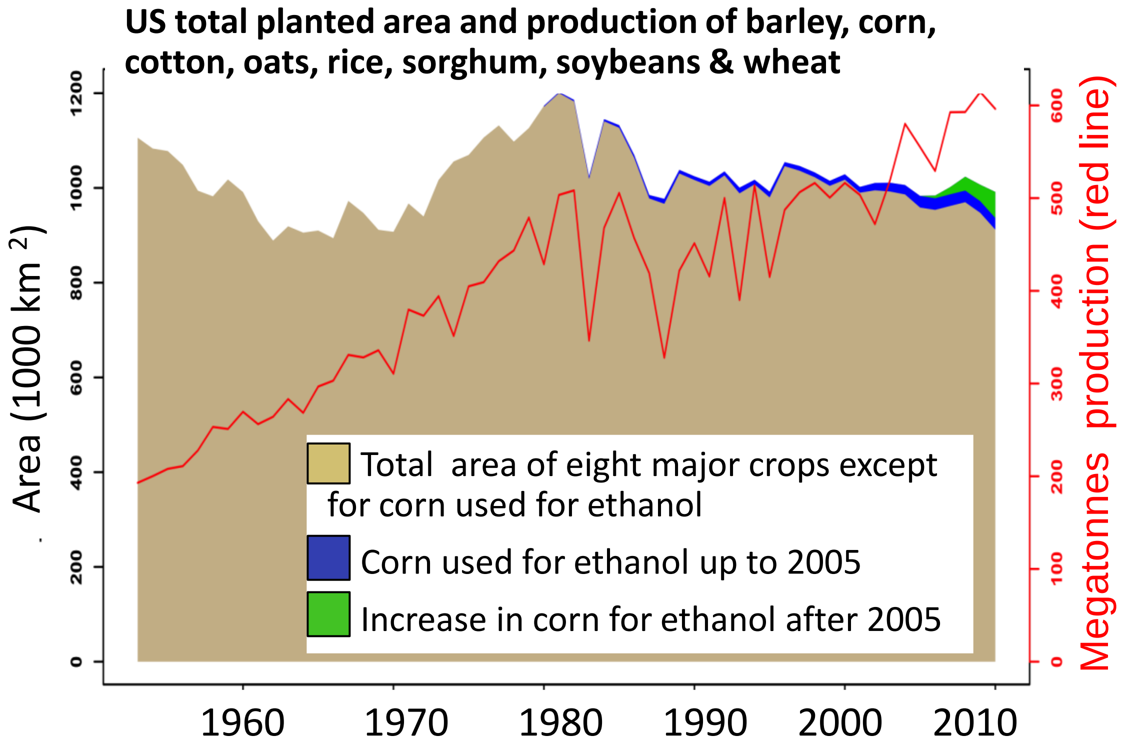
Oak Ridge, Tennessee USA

US Department of Energy

Oak Ridge National Laboratory

1. Representation of policy in model specifications

- Shock in demand?
- Different biofuel policies have distinct land-use & economic/ welfare implications
- Different ways to specify policies may have greater effects
- Policy specifications (assumptions & scenarios) must be calibrated & validated to reflect actual policies



ORNL Chart based on USDA data (A.McBride)

2. Economic decision-making assumptions

- Perfect markets & market information assumed
- Land assumed to be privately owned & managed “rationally” to optimize profits
  - ➢ *Public land clearing is either (a) illegal or (b) policy-driven*
- Need to incorporate
  - Market failures
  - Public land issues
  - Variable effects of bioenergy policy depending on access to information, markets, tenure, security, enforcement, among others

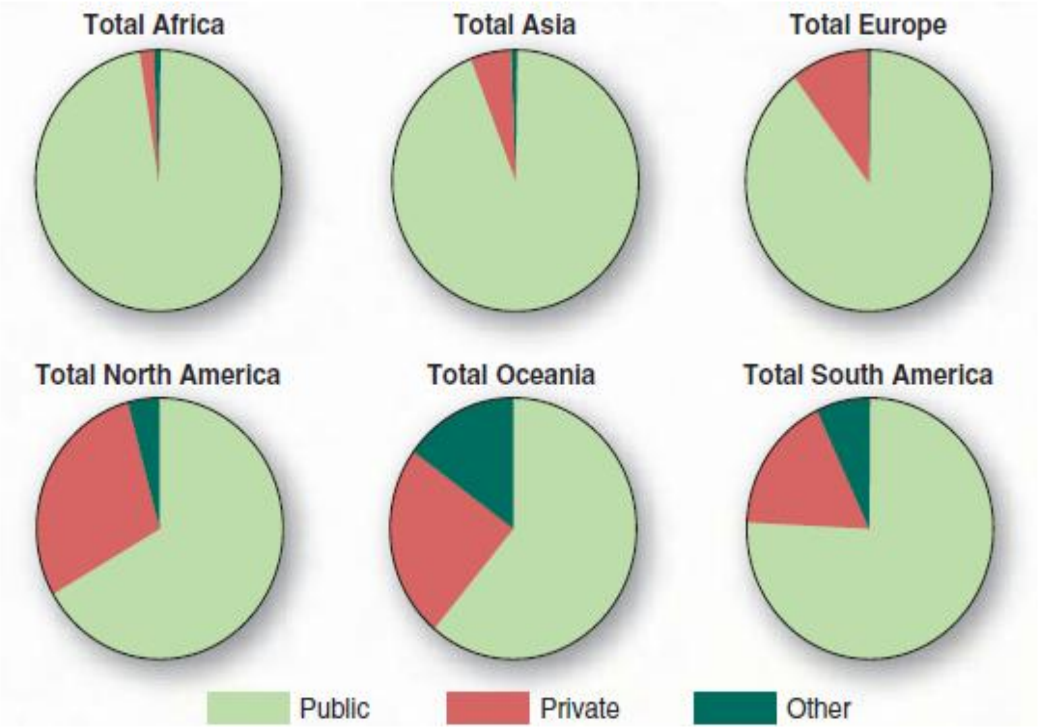
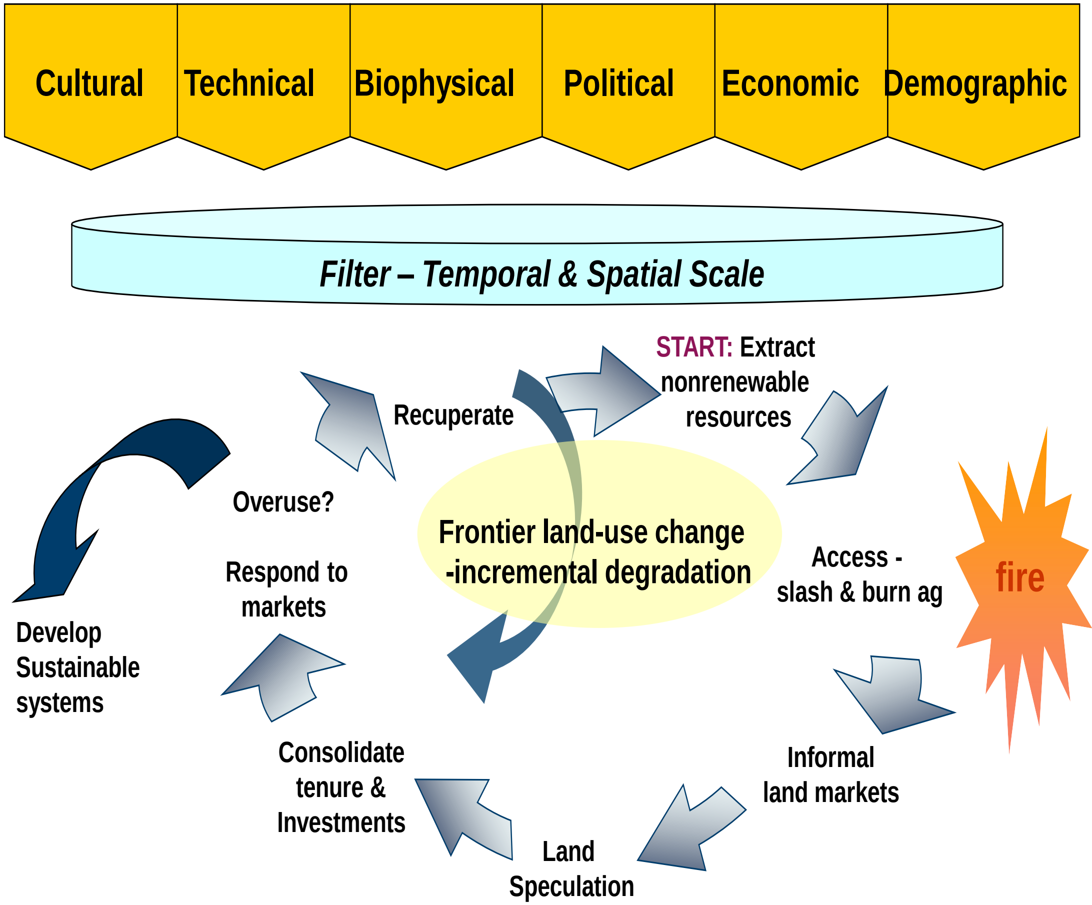


Figure: Agrawal et al., 2008, Science 320 (based on FAO data)

3. Conceptual framework for drivers of initial conversion

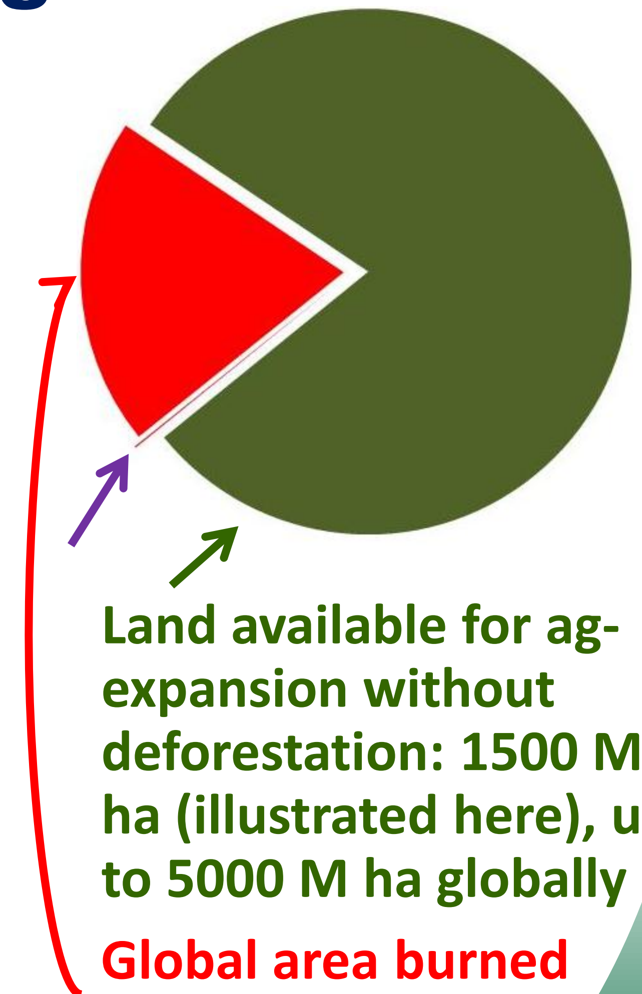
- Key drivers: ***local*** social, biophysical, political, legal, demographic & economic forces, yet LUC models use global price effects to estimate conversion
  - Models should reflect how bioenergy policies interact with drivers of first-time conversion at local scales
  - Should link changes at local-regional scale to global scales



- No single model adequately explains global deforestation, but empirically-based models can explain LUC at regional & local scales

4. Land supply & management specifications

- Models define land assets by “rents”
- Models assume land is fully & optimally used
- Need to incorporate full land supply & potential productivity
- Need to consider multiple uses, urban food production, & double or triple cropping opportunities
- Need to simulate farm-management strategies that increase production without expansion
  - Shifts in rotations
  - More efficient use of field edges, idle land
  - Adjust planting densities
  - Shifts within crop categories



5. Stable/static land conditions* assumed for baseline

- Need to simulate effects relative to moving targets of gross & net change trends in land-cover & land-use*
- Dynamics should capture changing rates, directions & types of land-cover & land-use* at local scales
- Models need to capture historic range of variability in key land* variables

*** Better land metrics and data are required***

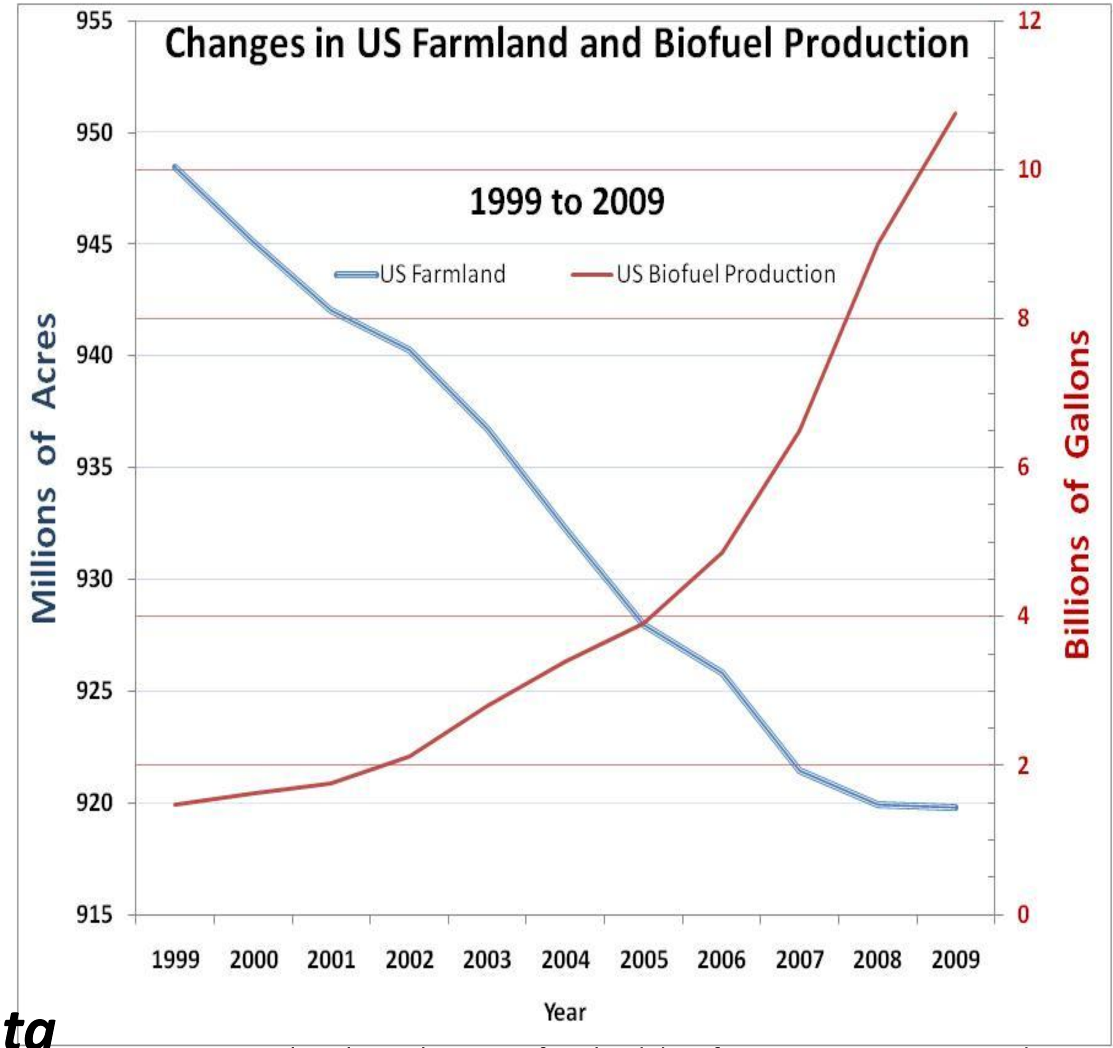
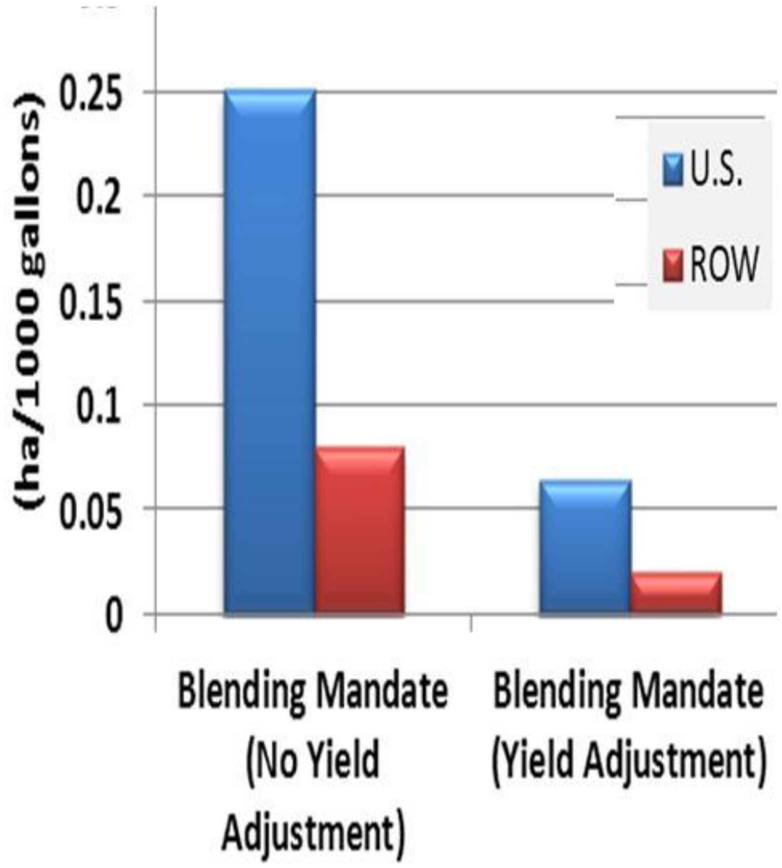


Chart by author using farmland data from USDA NASS 2010 and ethanol production data from the RFA statistics Aug 2011.

6. Yield change modeling

- Yields have fundamental influence on LUC estimates
- Policies & prices induce yield changes in many different ways – including geographic distribution of production of different crops
- What are effects of long-term market expectations on investments that improve efficiency and yields?
- Need accurate estimates of yield changes in response to policy

Simulated LUC with and without adjustment for actual yields



Policy simulations using GTAP-ORNL. Oladosu et al. 2009.

7. Questions of time & scale

- Choice of boundaries, resolution, data sets
- Baseline, reference case & calibration issues
- Land-use change is local, but available data are often unreliable or inconsistent at local scales
- Need high resolution & high quality temporal & spatial data for tracking changes* at local scales

Per pixel comparison and aggregation shows no crop rotation for some areas for the Cropland Data Layer (CDL)

ORNL analysis, Nagendra Singh

8. Fire & other disturbances (and how policy/management interact with these phenomena)

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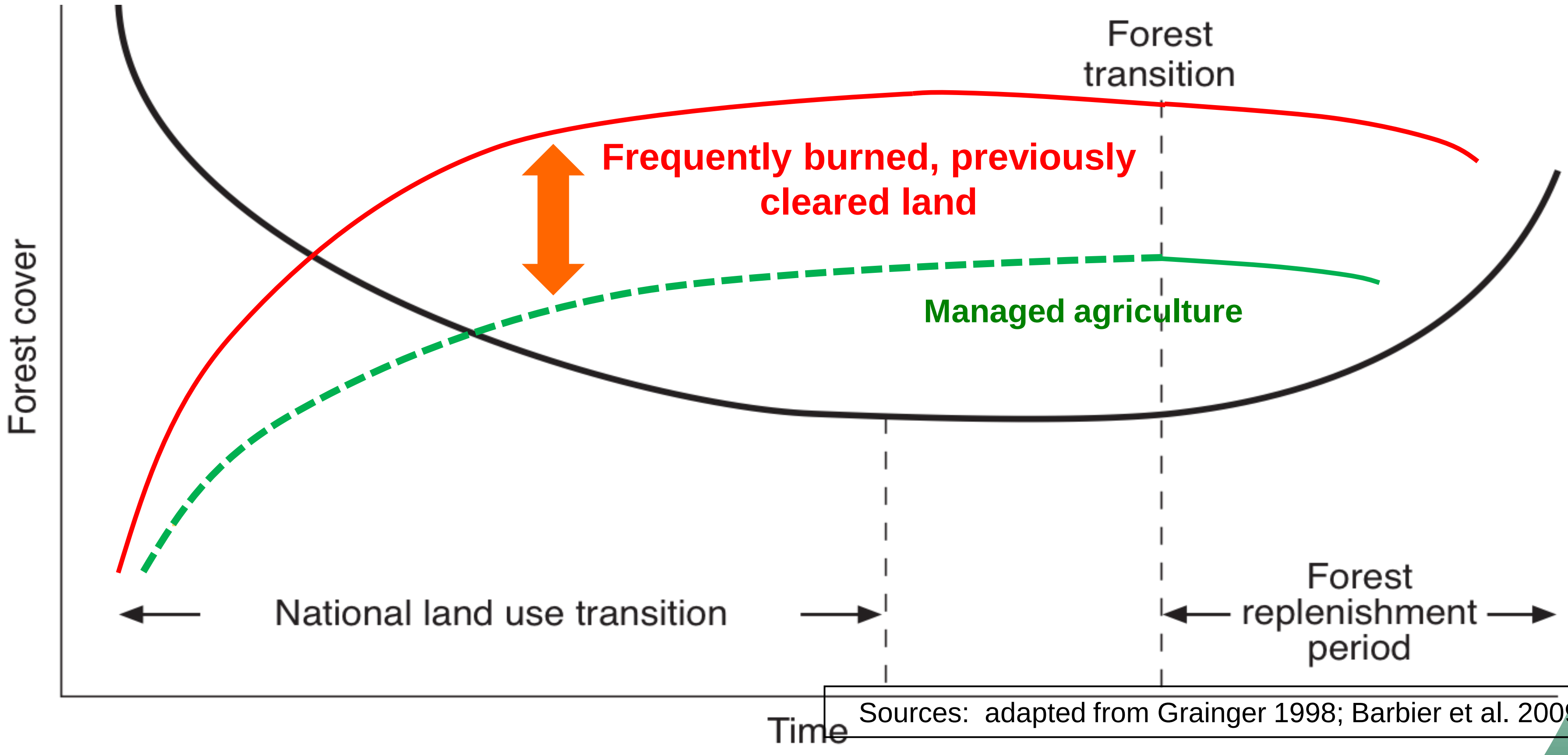
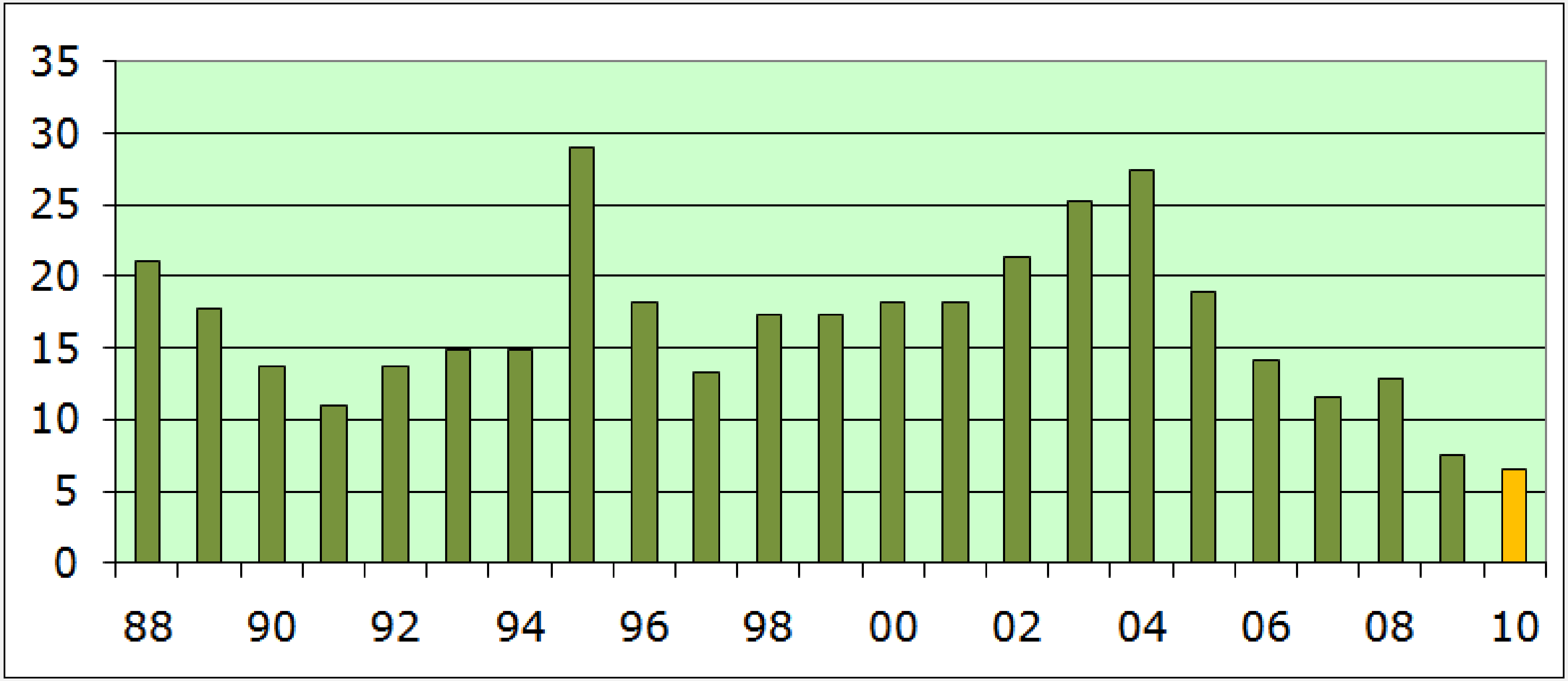


Sources: adapted from Grainger 1998; Barbier et al. 2009

9. Correlation versus causation

- **FAO, 2010: Global tropical deforestation rate (avg. annual loss) fell > 20% compared to prior decade, led by decline in Brazil (chart below)**

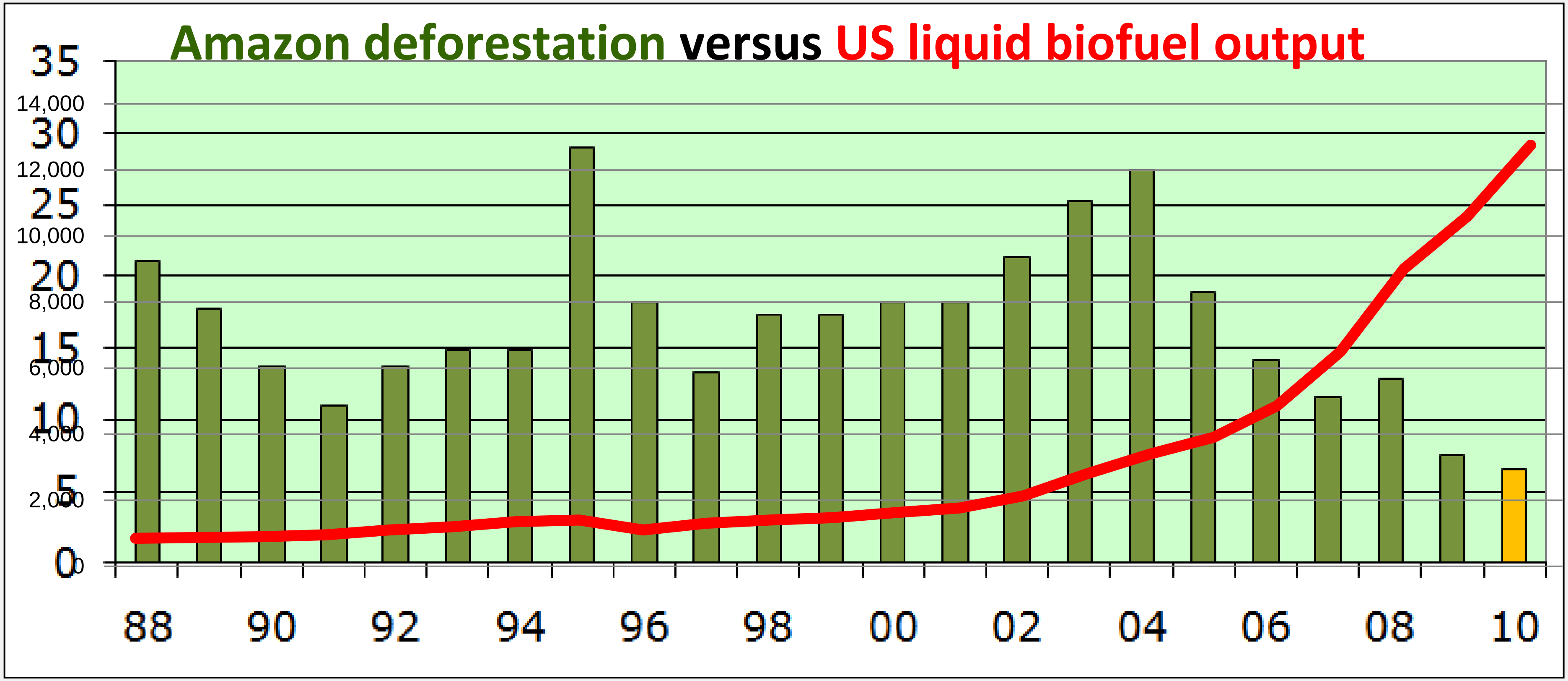


Deforestation rate in Brazil's Amazon, thousands square km per year

Source: INPE-PRODES Brazil Space Agency: http://www.dpi.inpe.br/gilberto/present/prodes_taxa2010.ppt Yellow bar for 2010 indicates preliminary result of analysis.

9. Correlation versus causation

- **Need causal analysis of models and input assumptions**
- **If, when, how, and in what ways, do changes in biofuel policy affect deforestation trends?**



Deforestation rate in Brazil's Amazon, thousands square km per year

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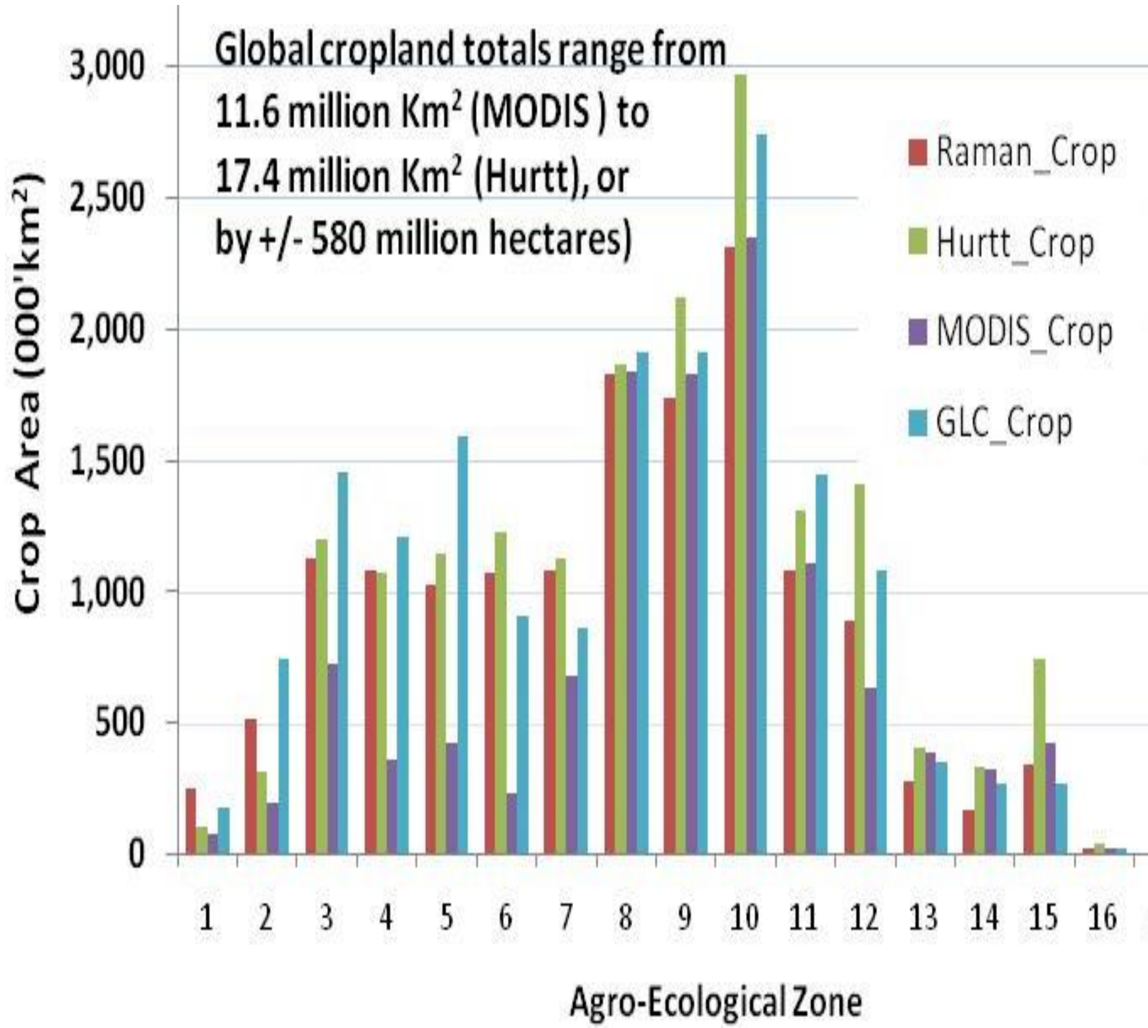
10. Data issues

- Confusing land cover with land use
- Limitations of uses of available data
  - Classification systems
  - Remote sensing interpretations
  - Class/use definition
- Magnitude of compounding uncertainties versus magnitude of effects being modeled
- Data aggregation

Estimates of Global Cropland circa 2000 can vary by over 100% within Agro-Ecological Zones (AEZ)

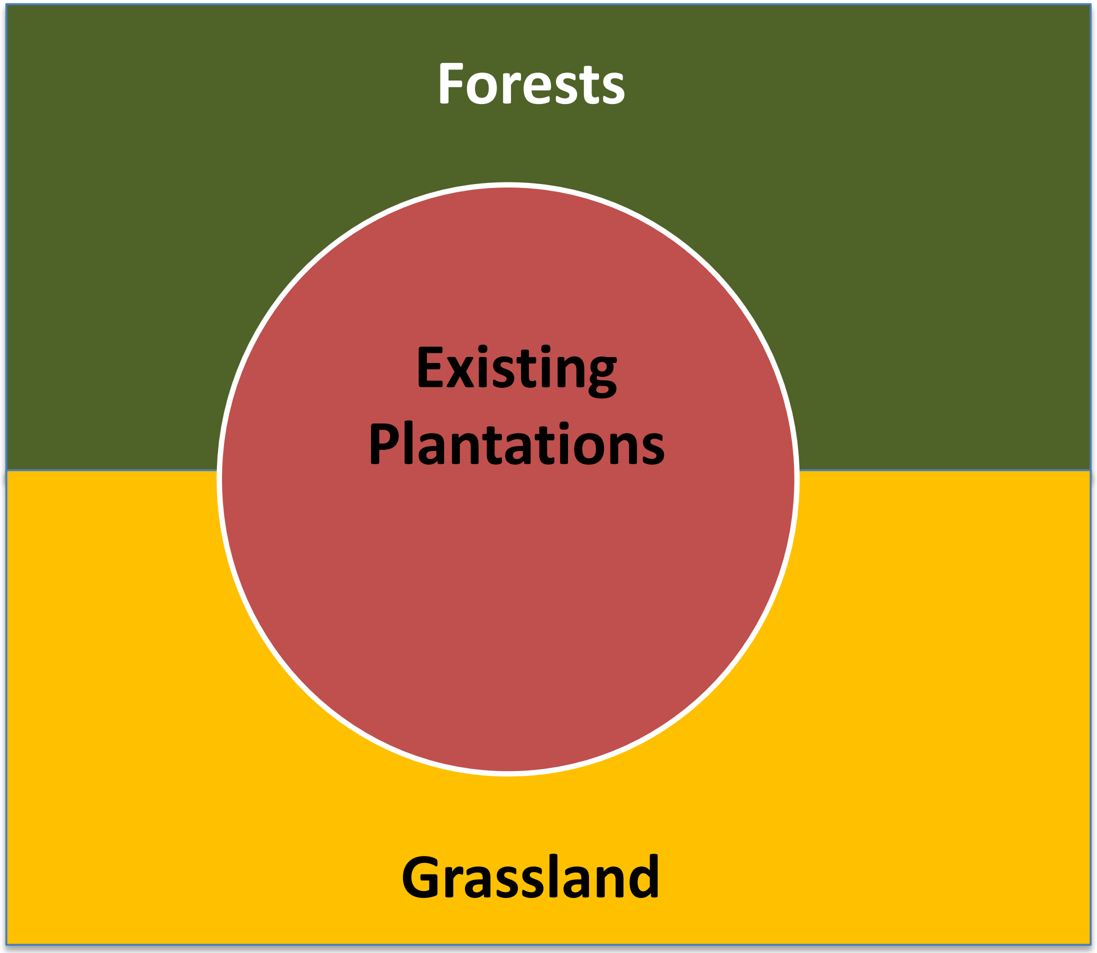


ORNL analysis, Nagendra Singh; See Kline et al. 2011

What are effects of bioenergy policy on land?

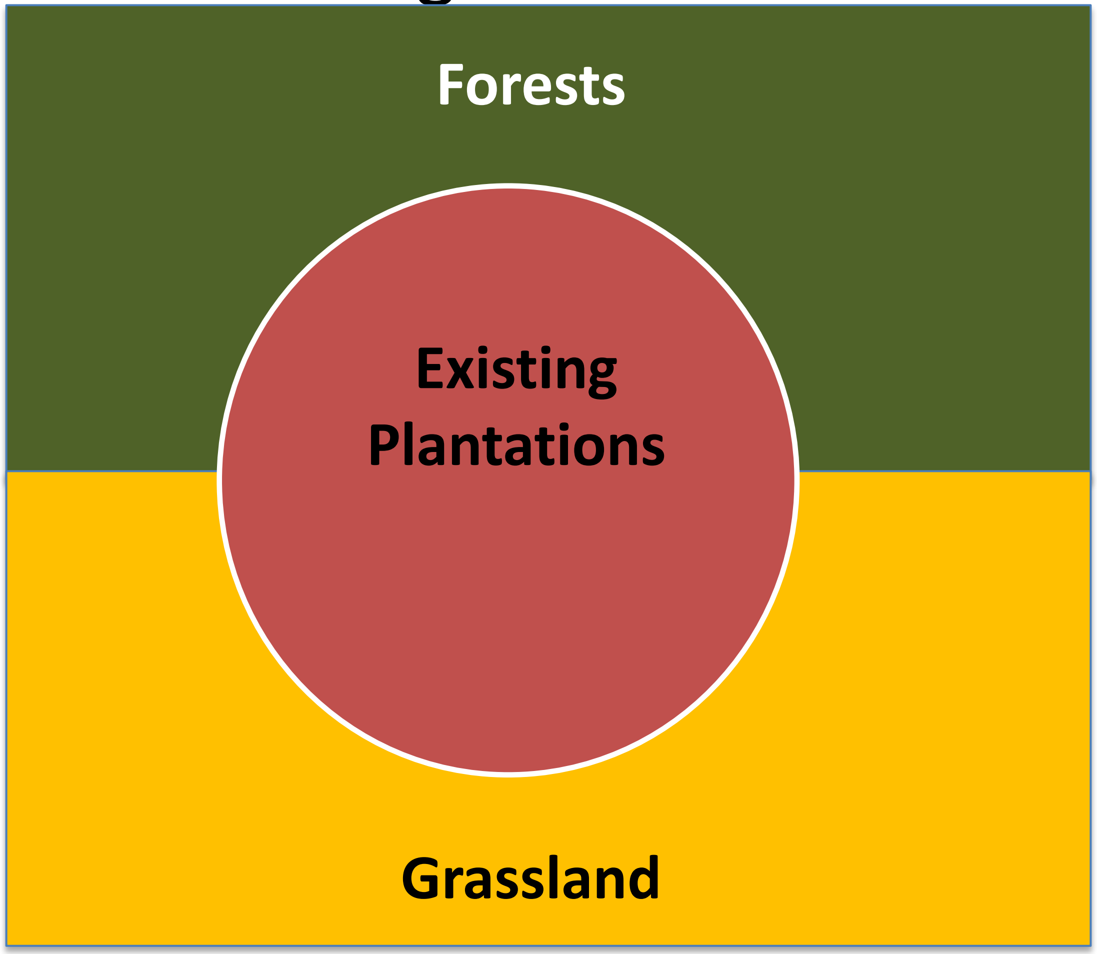
It depends

Models for land-use change begin with simplified representations of land cover



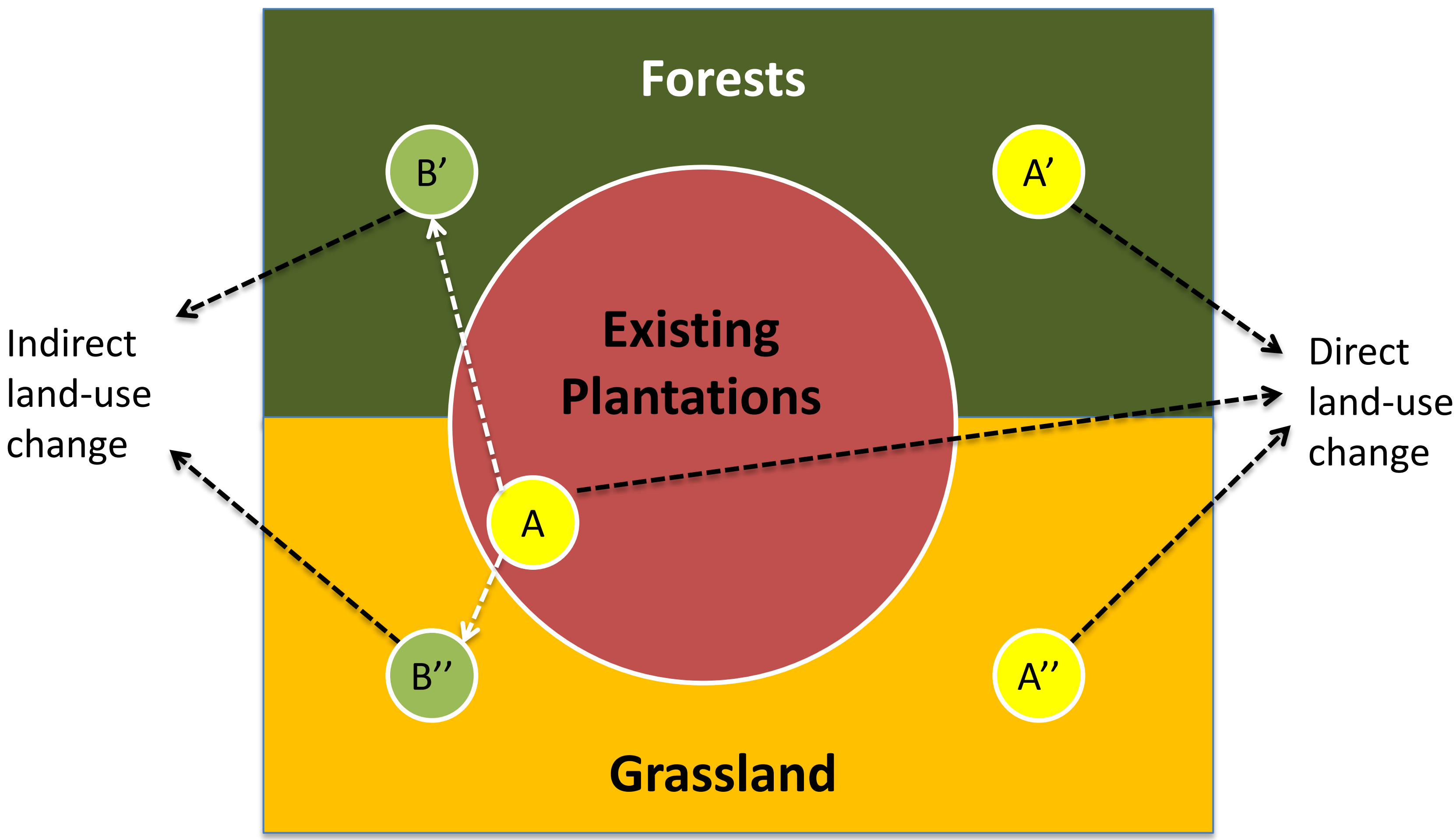
Adapted from Fritsche et al. 2011 (ILUC Study for European Parliament), Ecofys 2010 (Dehue), Ecofys 2011, OEKO 2010 and others

Any model that starts with this representation presumes that ILUC occurs and will merely be estimating 'how much'



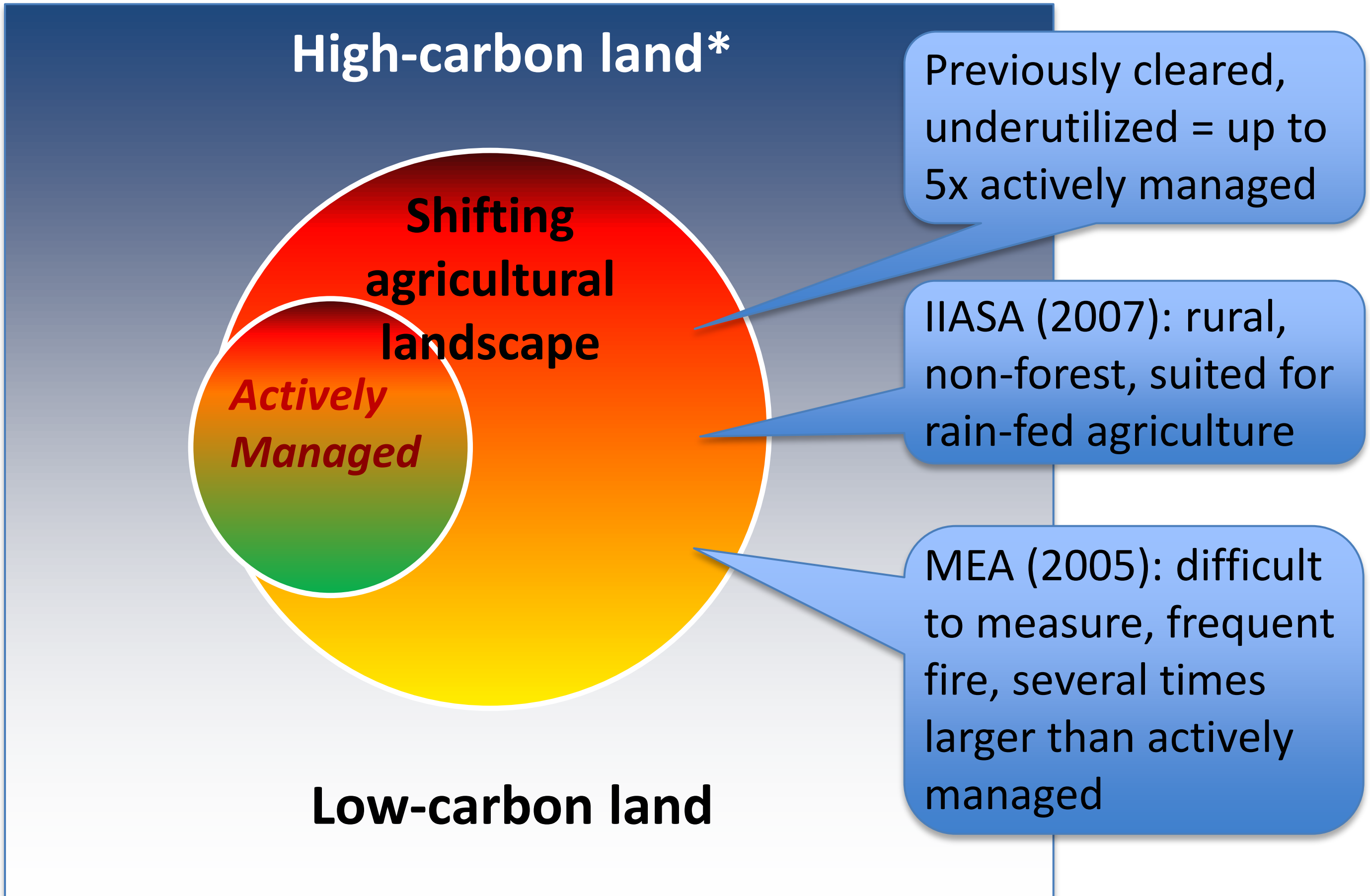
Adapted from Fritsche et al. 2011 (ILUC Study for European Parliament), Ecofys 2010, Ecofys 2011, OEKO 2010 and others

Current LUC models: assumptions define direct (A) & potential indirect effects (B)



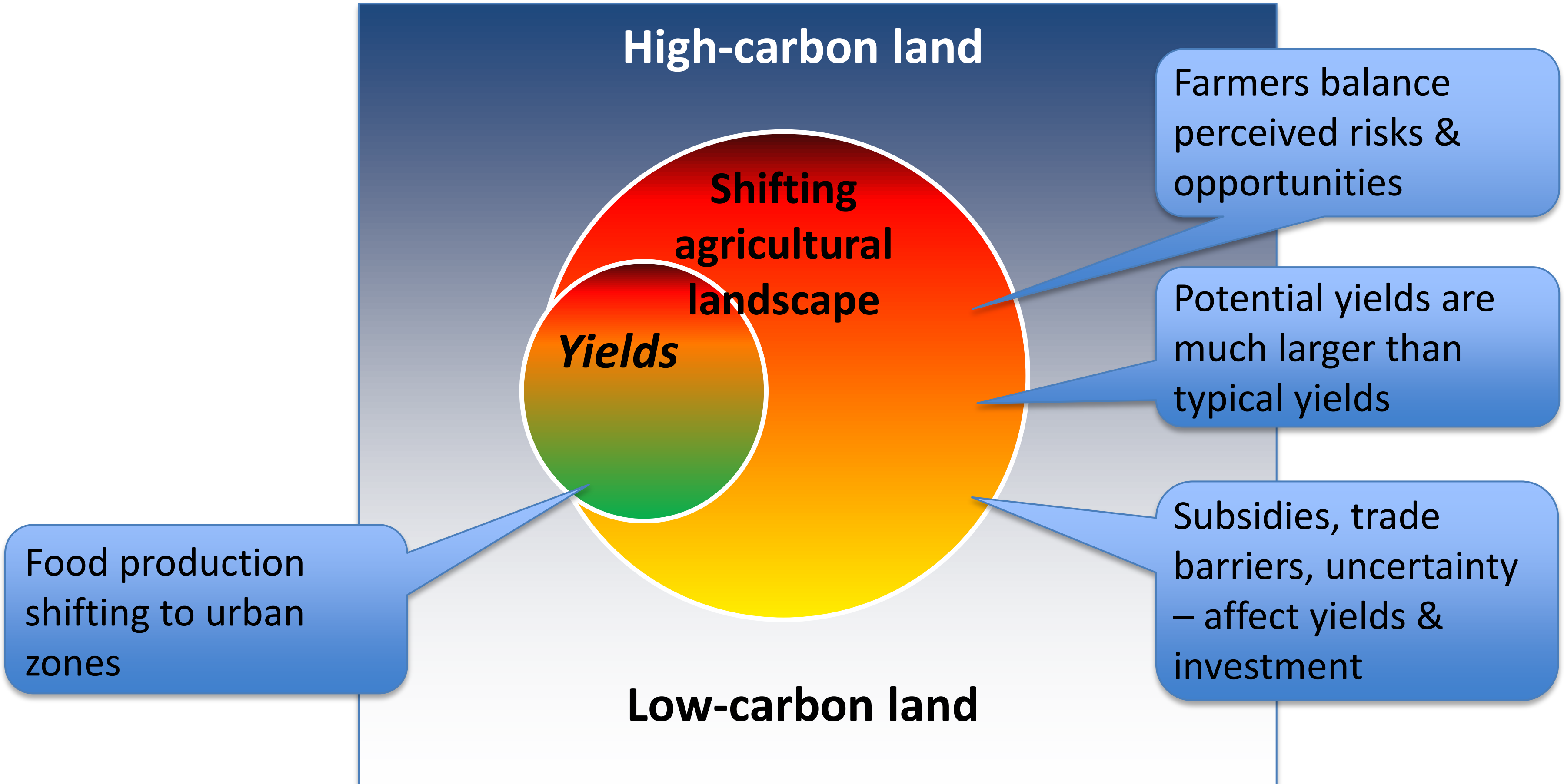
Adapted from Fritsche et al. 2011 (ILUC Study for European Parliament), Ecofys 2010, Ecofys 2011, OEKO 2010 and others

Difficult to represent complex dynamics of observed land cover & land use changes

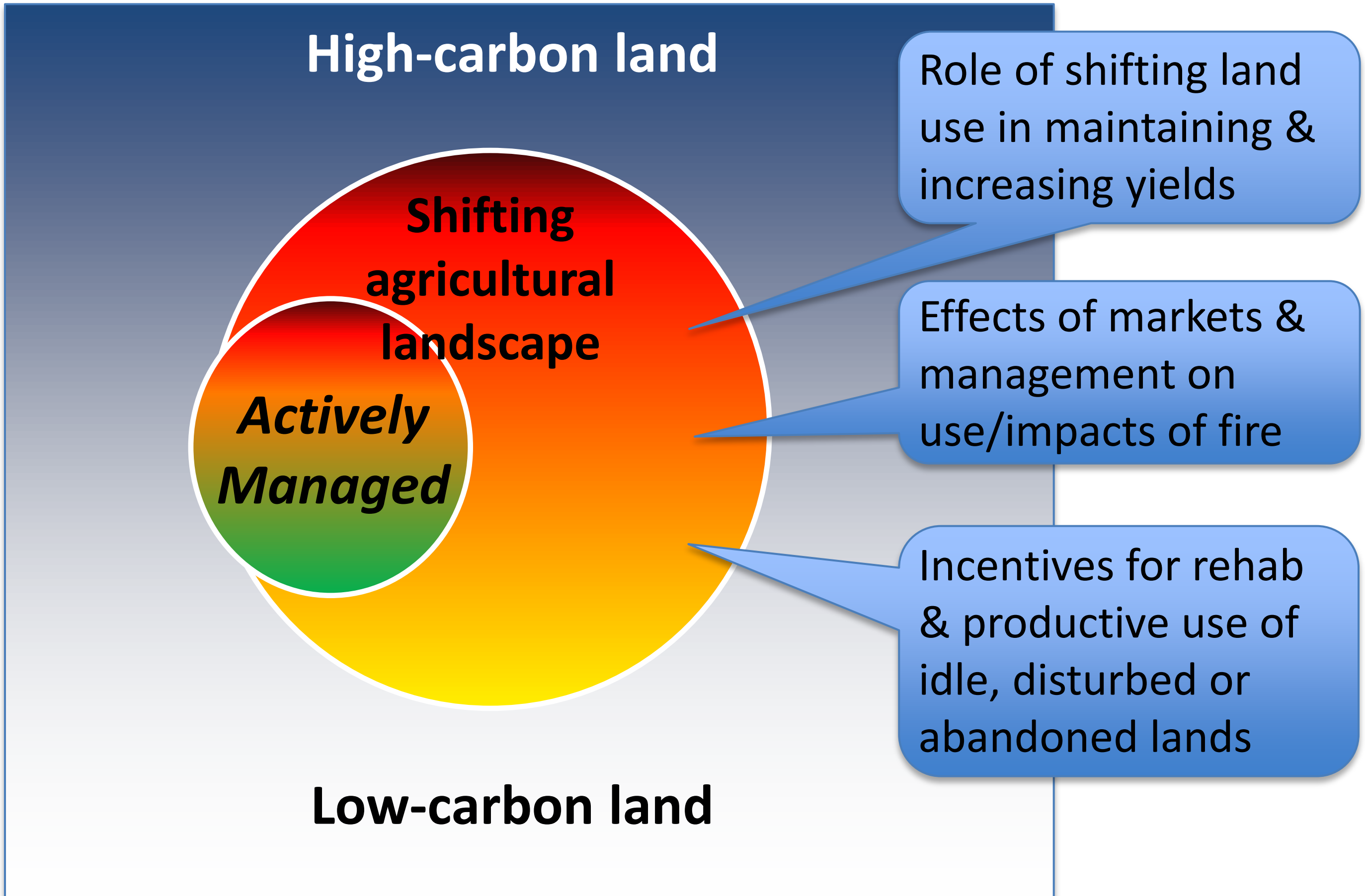


*Nutrient cycling, productivity, environmental services – stocks, flows & potential capacity – all important (not just carbon)

Definitions of "land use," changing yields, urbanization trends, add to complexity

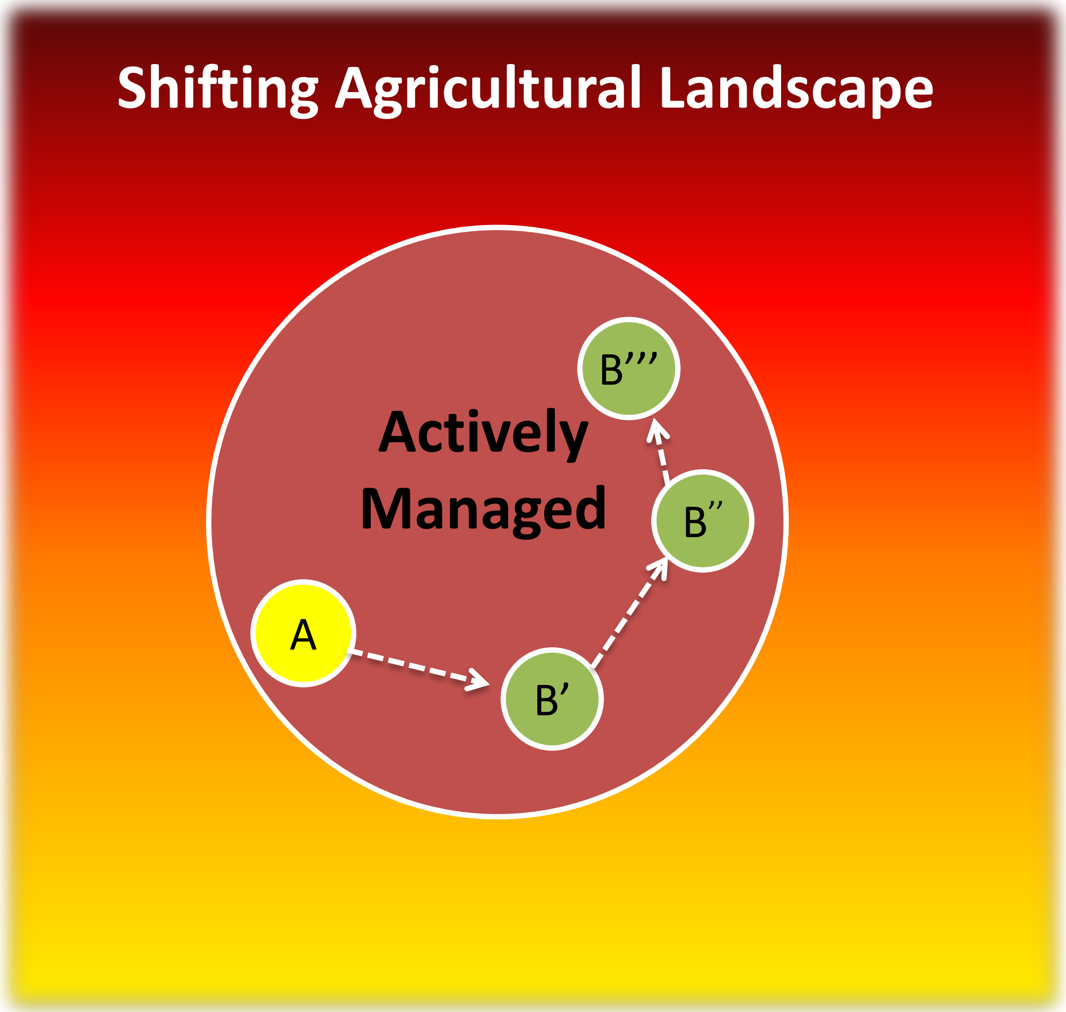


Many data needs (spatial, temporal) for more accurate representation of historic trends



Let's focus on the shifting agricultural landscape…

Interactions among new markets & product diversification are complex



As observed in U.S.:

Net changes: reduced cotton, sorghum pasture; reduced rate of farmland loss

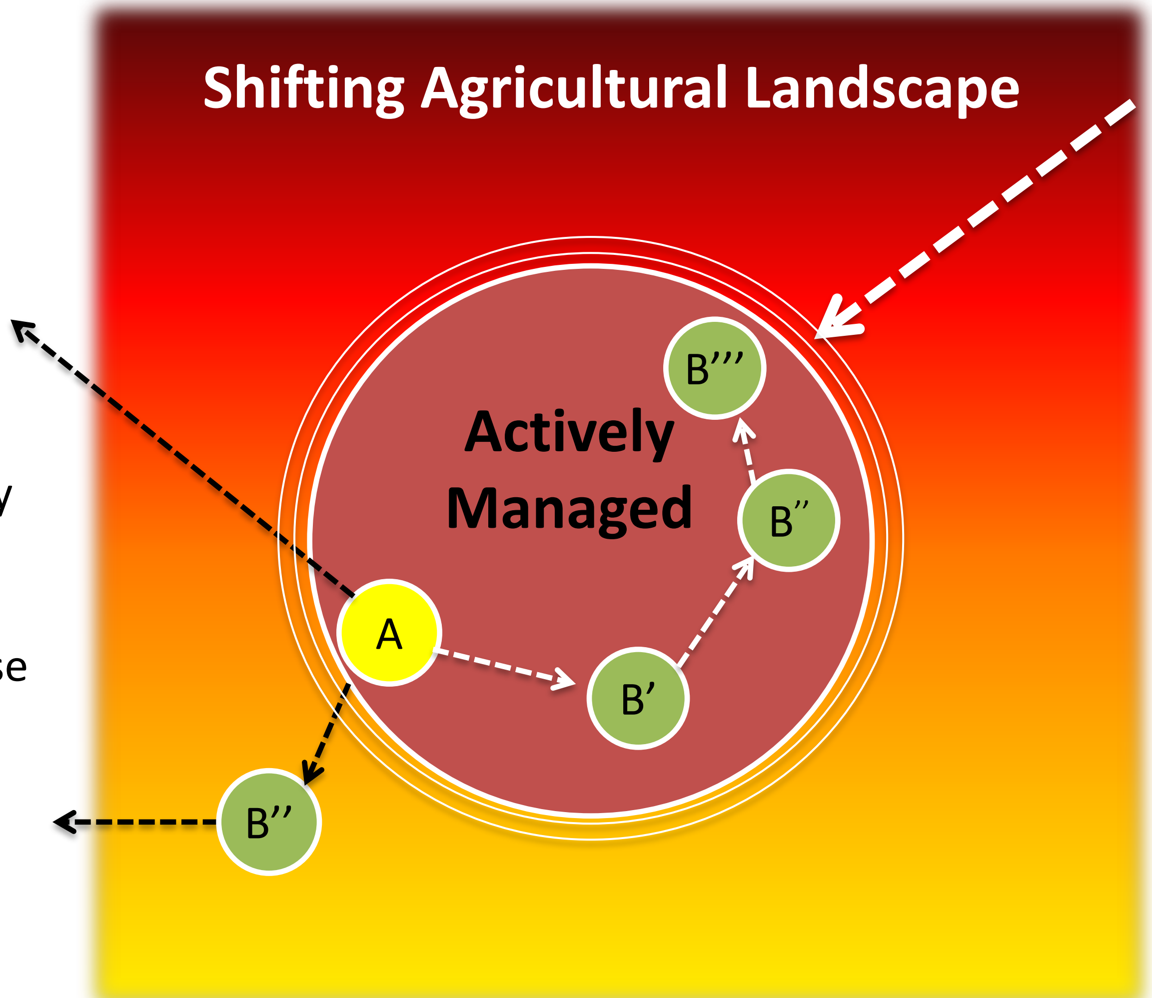
More double-crops; higher yields

Displacement of idle land & lower yield grains – increased feed/DDGs exports

Interactions among new markets & product diversification are complex

Maintenance of productive farmland: LUC or "change avoidance?"

What are policy effects outside US on historic trends – e.g. use of shifting agriculture and use of fire?



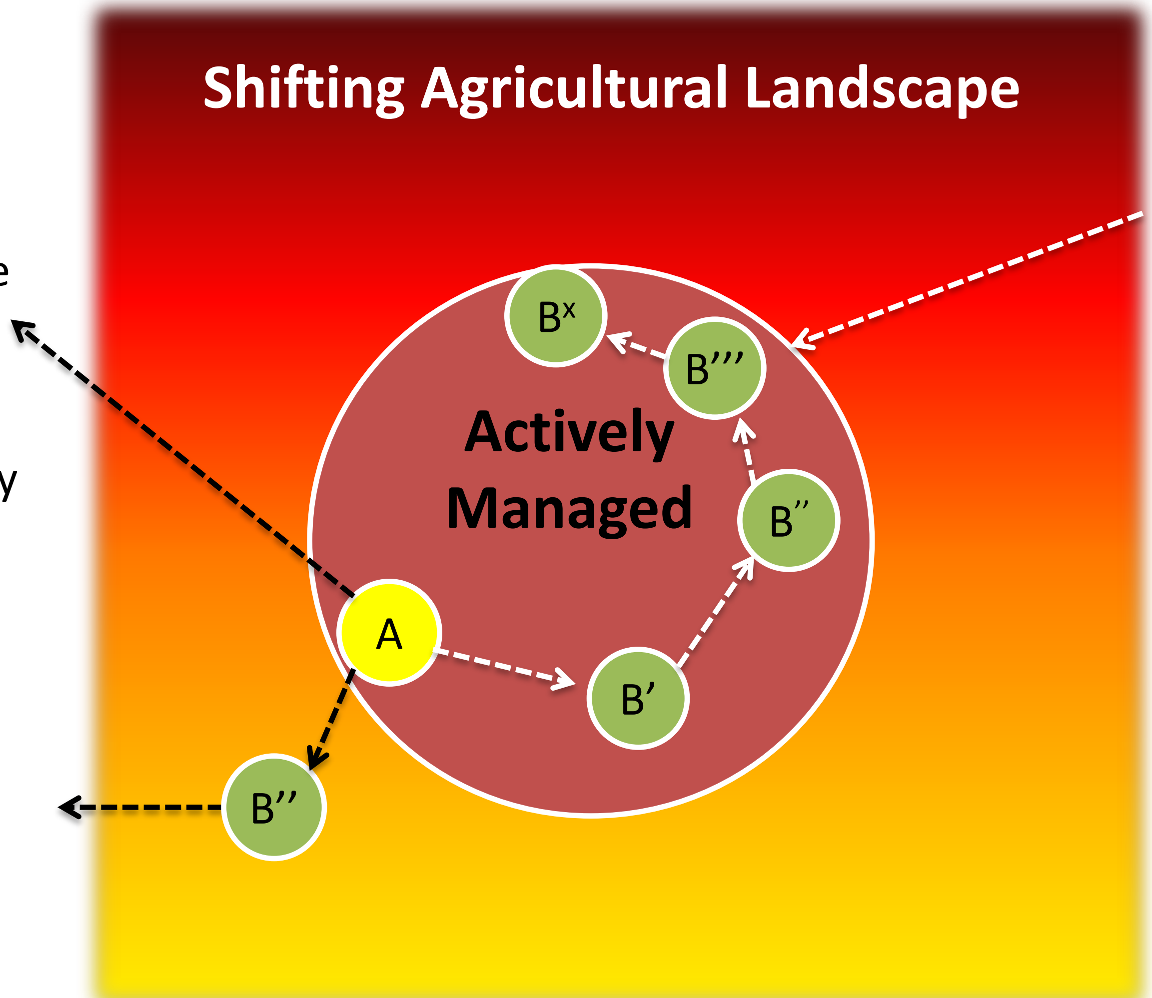
(Circle gets smaller) Actual net change includes continued loss of farmland, although at slower rate than pre-bioenergy policy

"LUC": Use of idle land, double crops, displacement of lower yield grains…

Interactions among new markets & product diversification are complex

Maintenance of productive farmland – LUC or change avoidance?

What are policy effects outside US on historic trends in shifting ag landscapes & use of fire?



Indirect effects likely include acceleration of historic trends toward higher efficiency, higher returns and higher yields

Summary: Top Ten Improvements

1. Representation of policy in model specifications
2. Economic decision-making assumptions
3. Conceptual framework for drivers of initial conversion
4. Land supply & management specifications
5. Assumed land use dynamics (scenarios, baseline choice)
6. Modeling yield change
7. Issues of time, scale
8. Fire & other disturbances
9. Correlation versus causation
10. Many data issues to resolve

Thank you!

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Extra slides
and
References

Review of Land Use and Yield Change

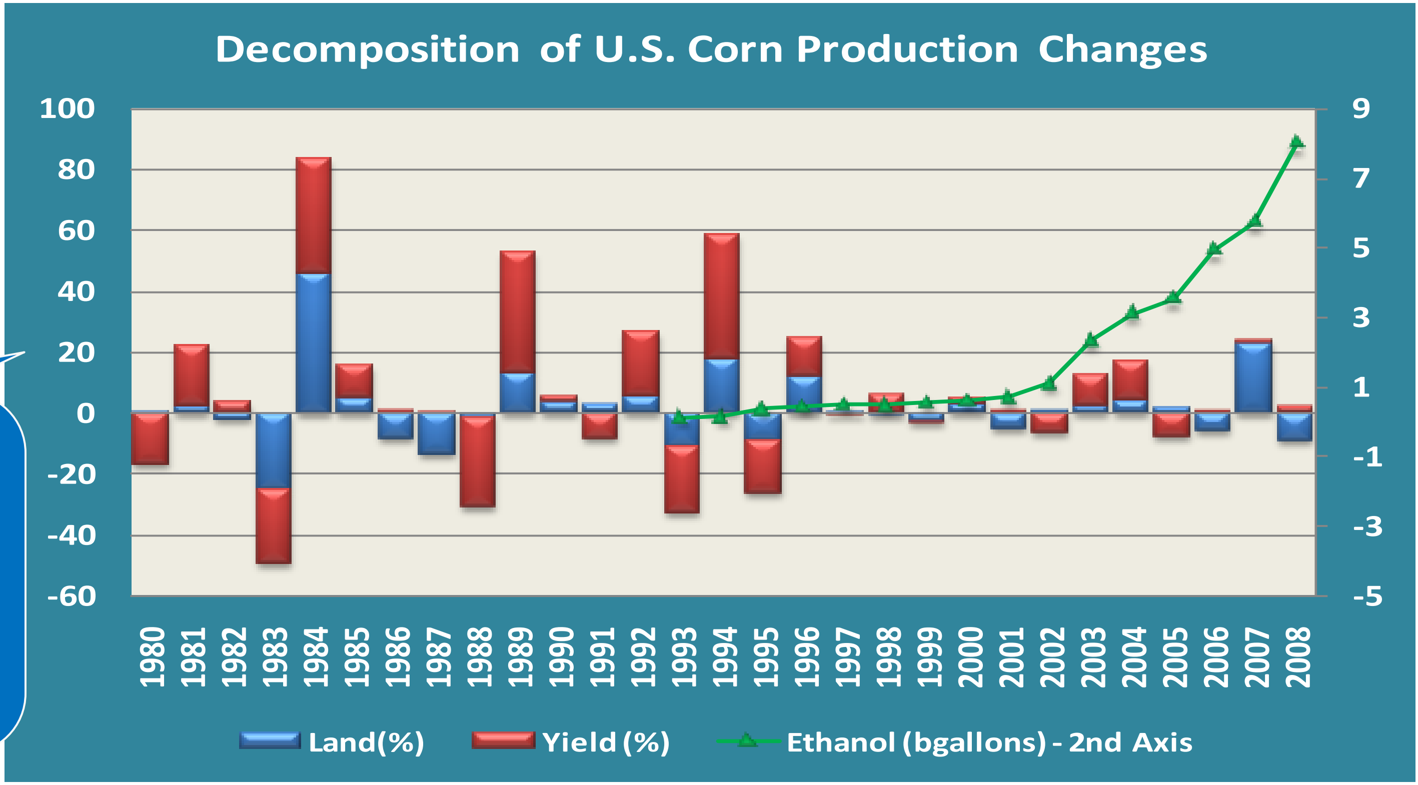
Production equation:

$$Q = Y.L$$

Decomposition:

$$\Delta Q/Q = \Delta Y/Y + \Delta L/L$$

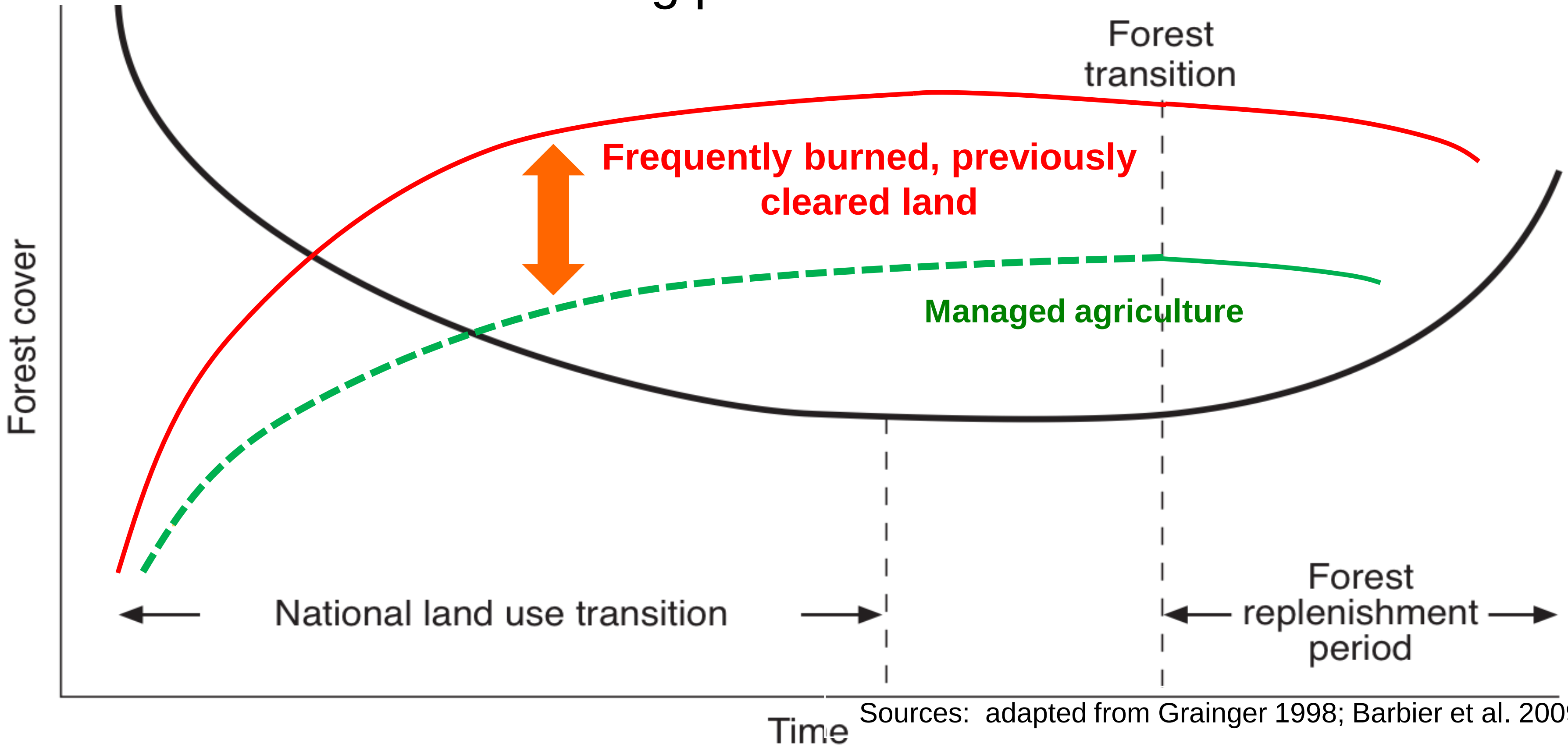
Note changes in volatility over time. Also, land and yield contribution tend to change in the same direction



- **Yield contribution to growth in production is substantial**
- **Since 2001, land share exceeds yield share in only 3 years***
  - 2002 & 2005 were both years of net negative output growth
  - 2007 positive output growth dominated by land increase

*** Yield data are not normalized for weather**

ILUC effects may be opposite of those assumed in current models – bringing previously cleared lands into productive use and reducing pressure on forests



Sources: adapted from Grainger 1998; Barbier et al. 2009

- FIRE is a management tool for large areas of previously cleared, under-utilized land.
- 330-430 million hectares burn each year (Giglio et al. 2010)

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