# Global perspectives and challenges to common assumptions about land-use change, water and biodiversity

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## *Audience survey: What does "land-use change" mean to you?*

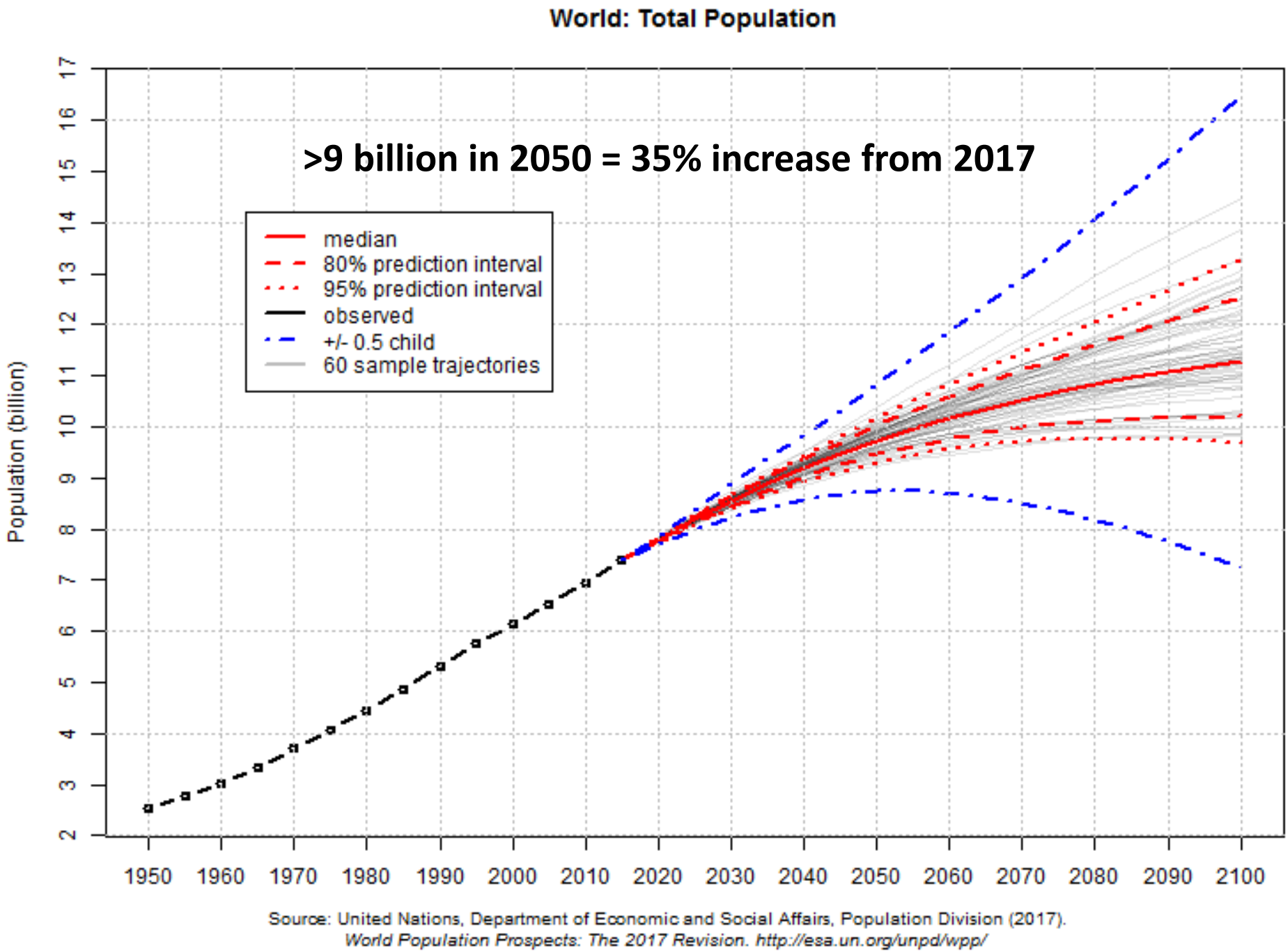
- ❑ Tilled crop field, later managed as no-till
- ❑ Forest land selectively logged (high-graded)
- ❑ Forest plantation plot clear-cut & replanted as forest plantation
- ❑ Forest plantation plot clear-cut & replanted as forest plantation of different tree species
- ❑ Rangeland improved by removing invasive species
- ❑ Unmanaged forest is burned and naturally returns as grasses & shrubs
- ❑ Maize field managed same, but maize used for biofuel one year rather than feed
- ❑ I stop mowing my lawn

# If the definition of LUC is not clear & precise, best science practices cannot be applied.

- Hypotheses
  - Need to be clearly stated & tested via observations
  - E.g., "An increase in US market demand for maize causes an increase in land clearing elsewhere"
- Current LUC models estimate
  - Where and how much LUC
  - But not *if* LUC is expected to occur

***Conventionally, LUC and indirect LUC (ILUC) are determined by the selected land classes, model, & many other underlying assumptions***


Meeting future needs for food, energy, water & nature: when & where does land matter?
Always and everywhere
...focused on land management
KLK photo: Mt. Le Conte, TN 2016


World: Total Population
>9 billion in 2050 = 35% increase from 2017
median
80% prediction interval
95% prediction interval
observed
+/- 0.5 child
60 sample trajectories
Population (billion)
2
3
4
5
6
7
8
9
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11
12
13
14
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16
17
1950
1960
1970
1980
1990
2000
2010
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2030
2040
2050
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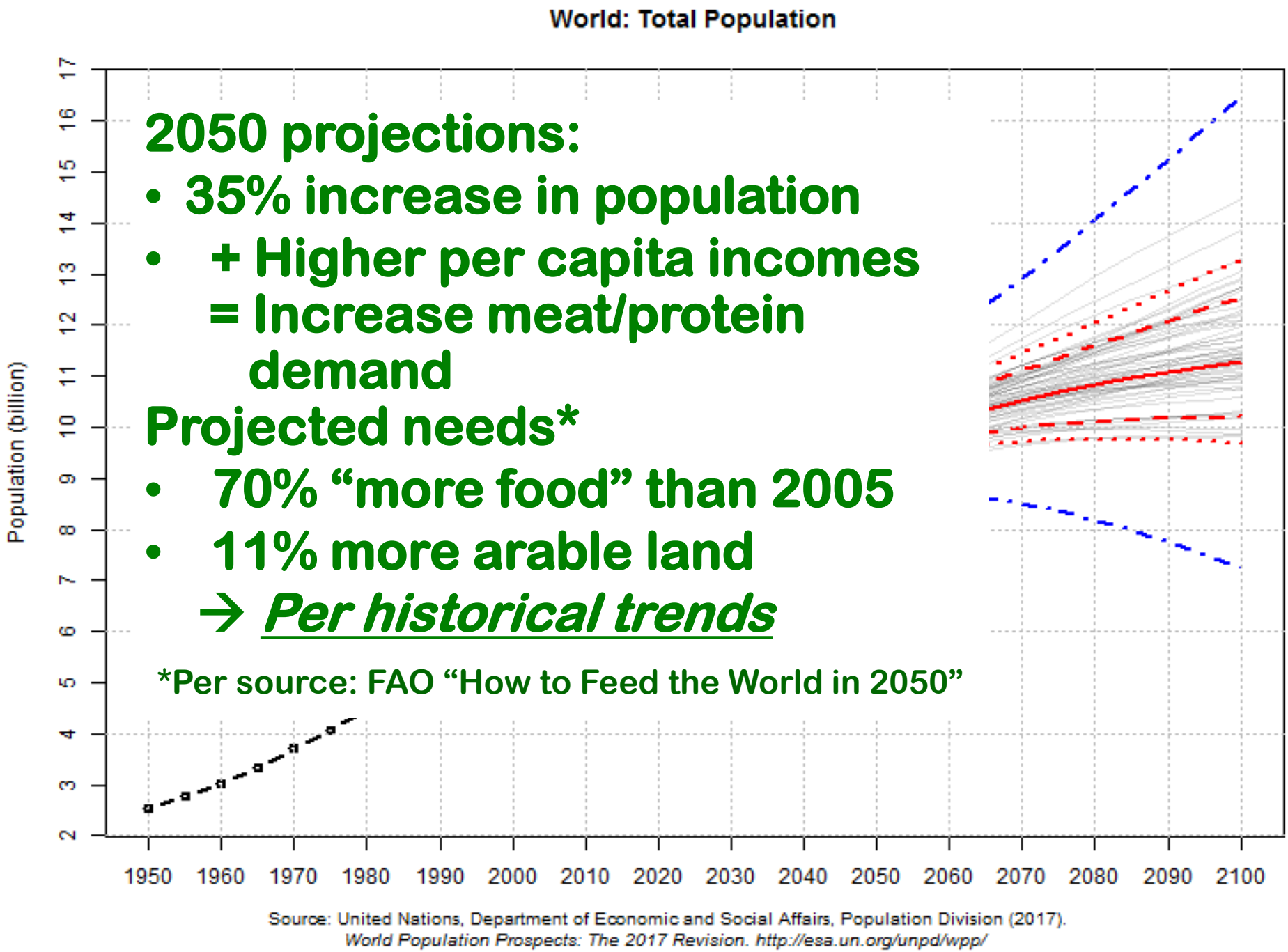
Source: United Nations, Department of Economic and Social Affairs, Population Division (2017).
World Population Prospects: The 2017 Revision. http://esa.un.org/unpd/wpp/




**2050 projections:**

- **35% increase in population**
- **+ Higher per capita incomes = Increase meat/protein demand**

**Projected needs***

- **70% "more food" than 2005**
- **11% more arable land**

**→ *Per historical trends***

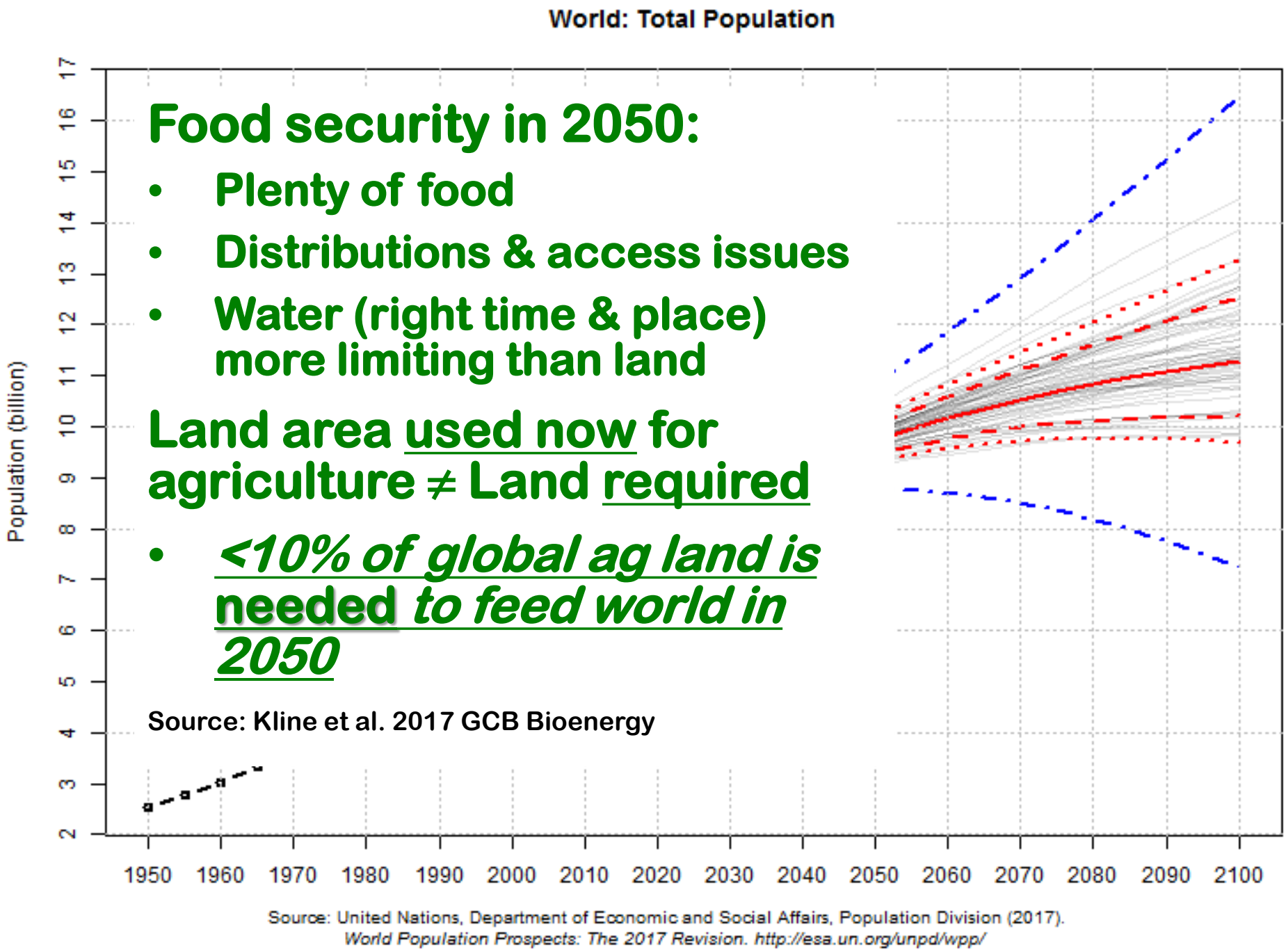
*Per source: FAO "How to Feed the World in 2050"

# Food for thought: about a third of the world's agricultural area is used annually to produce food that is lost or wasted

http://www.fao.org/news/story/en/item/196402/icode/


**No shortage of global land. Shortage of proper land management.**

Kline et al. 2017. GCB-Bioenergy. Food Security & Bioenergy: Priorities…




# Food security in 2050:

- Plenty of food
- Distributions & access issues
- Water (right time & place) more limiting than land

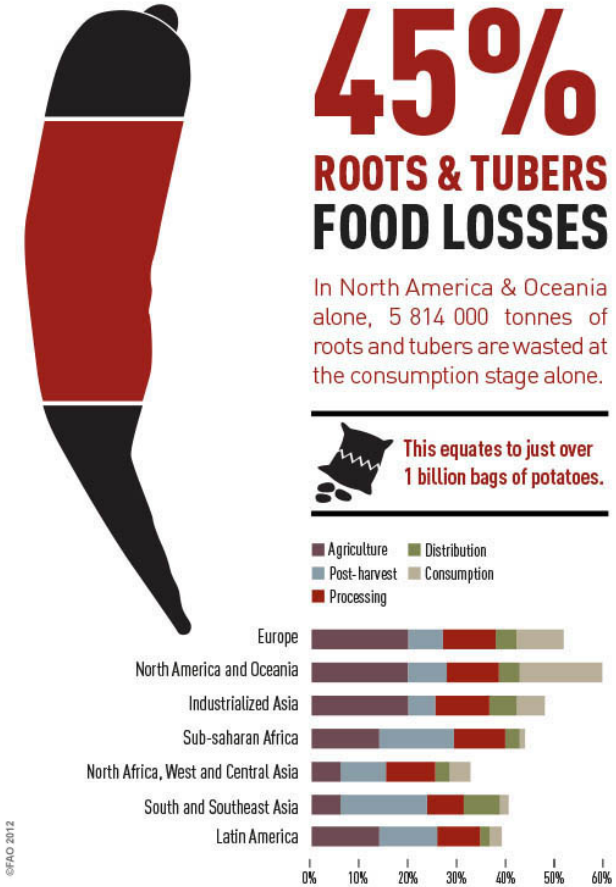
## Land area <u>used now</u> for agriculture ≠ Land <u>required</u>

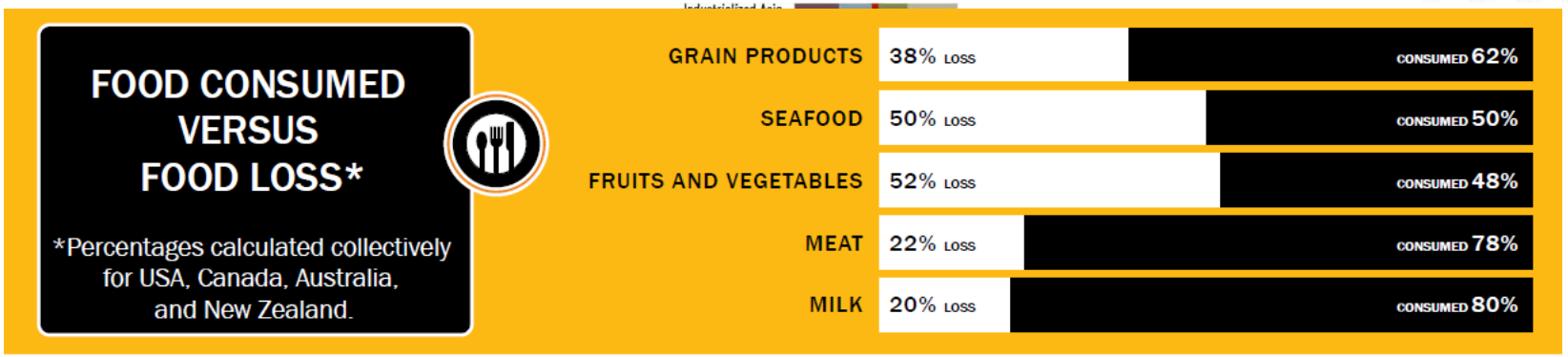
- ***<u><10% of global ag land is needed to feed world in 2050</u>***

Source: Kline et al. 2017 GCB Bioenergy

# Today, we waste about 40% of food

*"Spoiler Alert"* (2016): If wasted food was a country, it would be 3rd largest producer of greenhouse gases (GHGs) in the world, after China and the United States. And food wastes represent ***>1.6 trillion gallons water wasted***

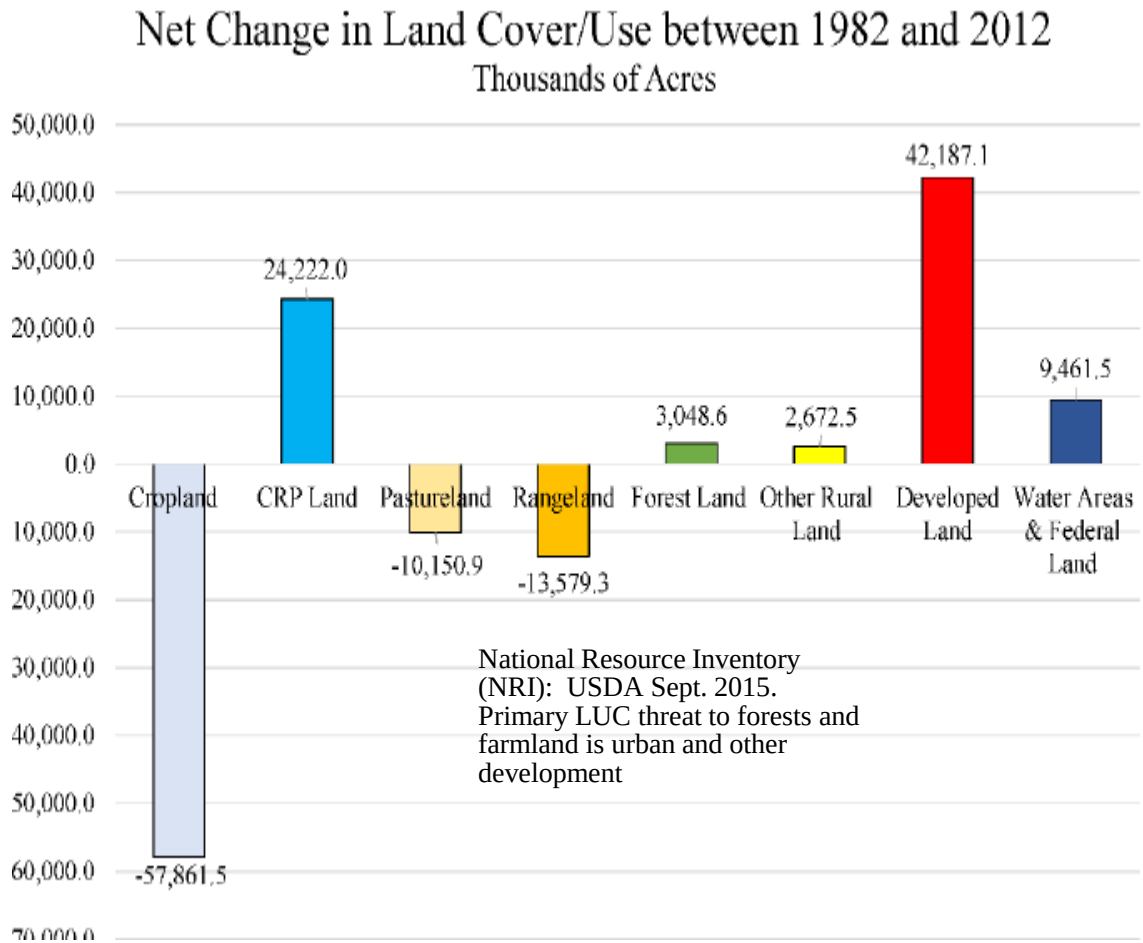

Source: Food and Agriculture Organization 2011

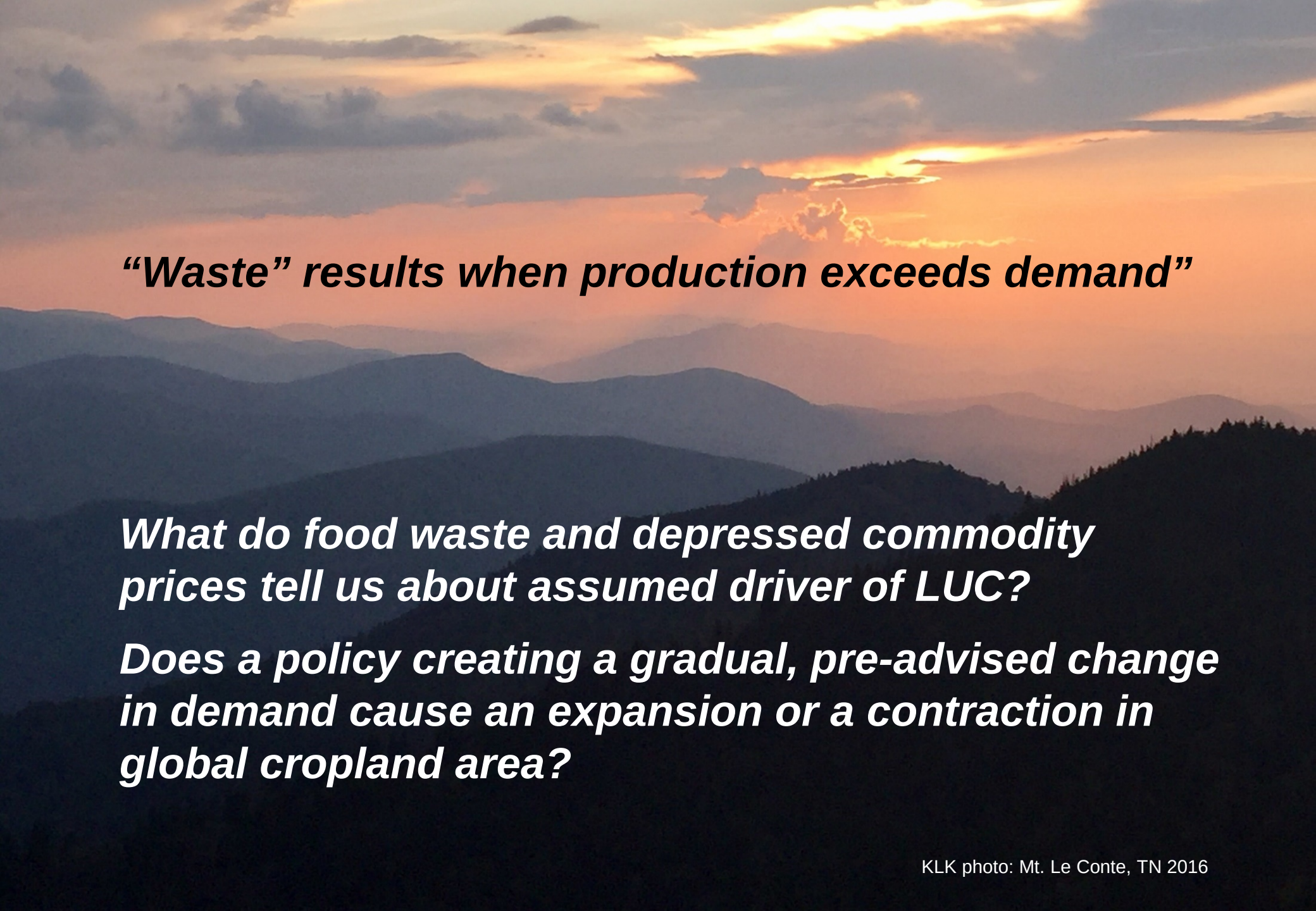
Source: FAO http://www.fao.org/save-food/resources/keyfindings/en/

# LUC summary findings (BT16 Chapter 3, Kline et al.)

## *Significant biomass available @ no/low-risk of LUC & ILUC*

- LUC estimates depend on model specifications and assumptions.
- All estimates of <u>change</u> depend on a selected <u>reference scenario</u>
- BT16 land allocation for energy crops in 2040 is consistent with historic agriculture land trends (see USDA NRI Figure) →
- Science-based approaches and causal analysis are essential to understand relationships among drivers of LUC
- ***It's not "LUC" that matters but how matter changes that matters.***





***"Waste" results when production exceeds demand"***

***What do food waste and depressed commodity prices tell us about assumed driver of LUC?***

***Does a policy creating a gradual, pre-advised change in demand cause an expansion or a contraction in global cropland area?***

KLK photo: Mt. Le Conte, TN 2016

# Do we *need* to expand agricultural area to meet future needs for food, feed, fiber, energy…?

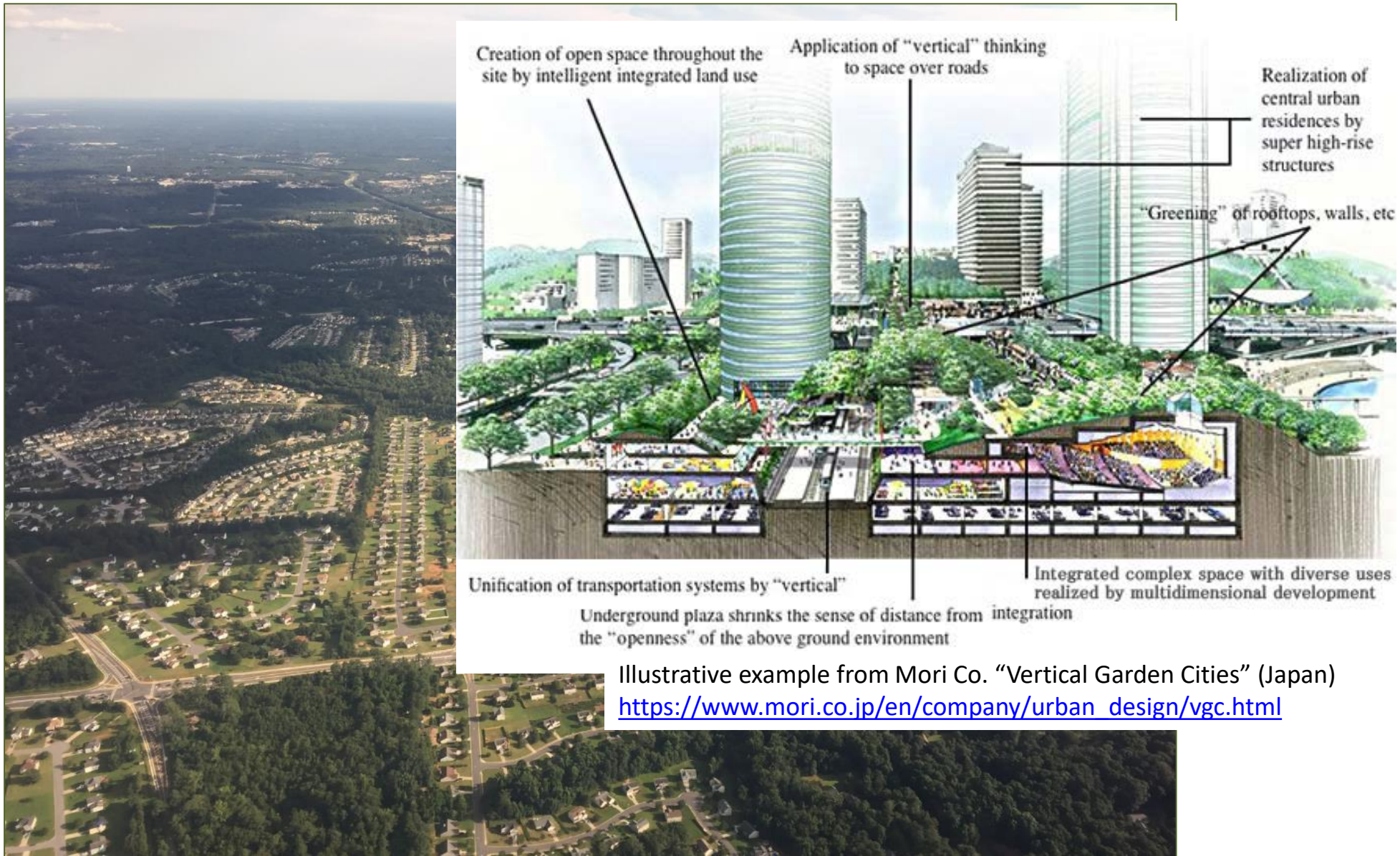
- Absolutely not.
- We do need to invest in managing
  - Productive lands
  - Fresh water / riparian systems
  - Urban resources (nutrient recovery)
- Understand & address local causes of poverty & malnutrition
  - Identify who is at high risk
  - Design targeted interventions
    - Diversify sources of income
    - Build ownership in the process, the monitoring, & the science

*USAID photo - Feed the Future annual report 2015*

To address food security:

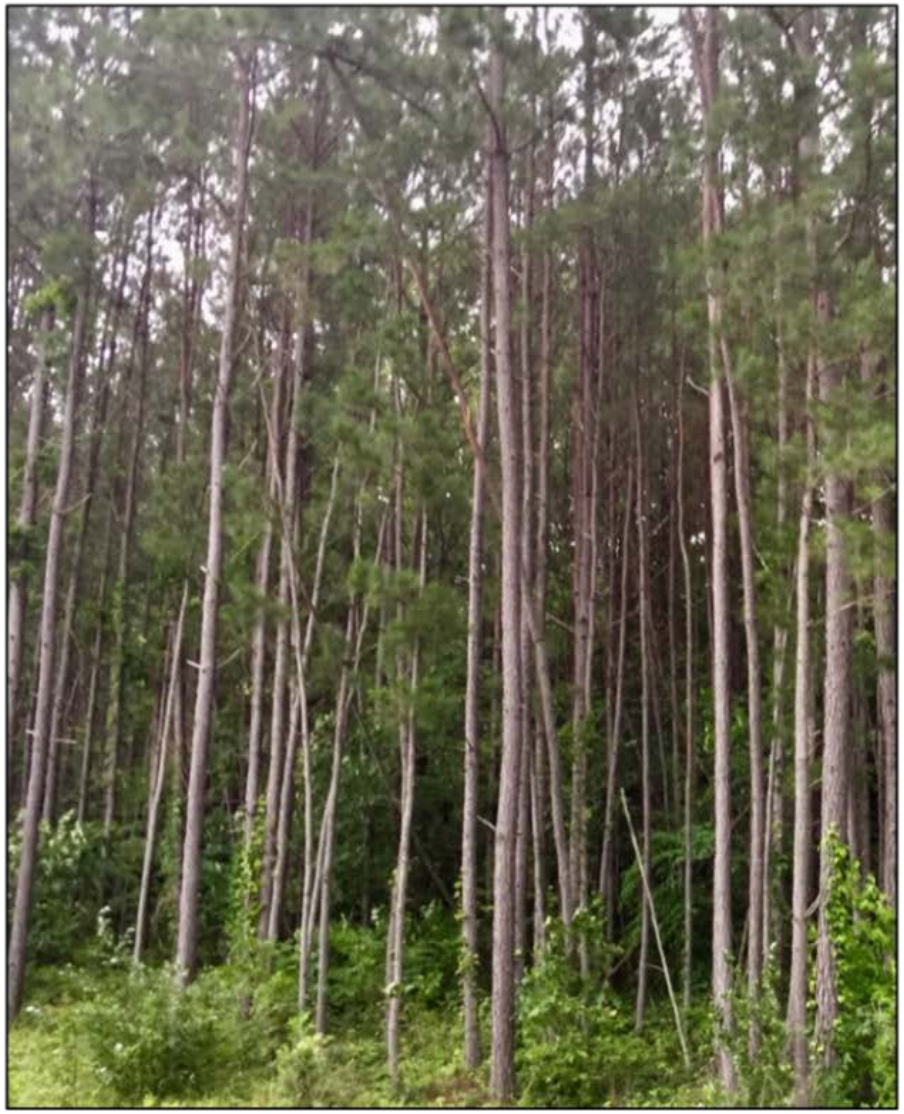
- Engage local leaders, government and civil society to:
  - develop strategies and policies around common goals
  - measure progress
  - apply adaptive management (continual improvement)

# Choice: urban sprawl vs efficient cities that recycle water, energy & nutrients for food production




Illustrative example from Mori Co. "Vertical Garden Cities" (Japan)
https://www.mori.co.jp/en/company/urban_design/vgc.html

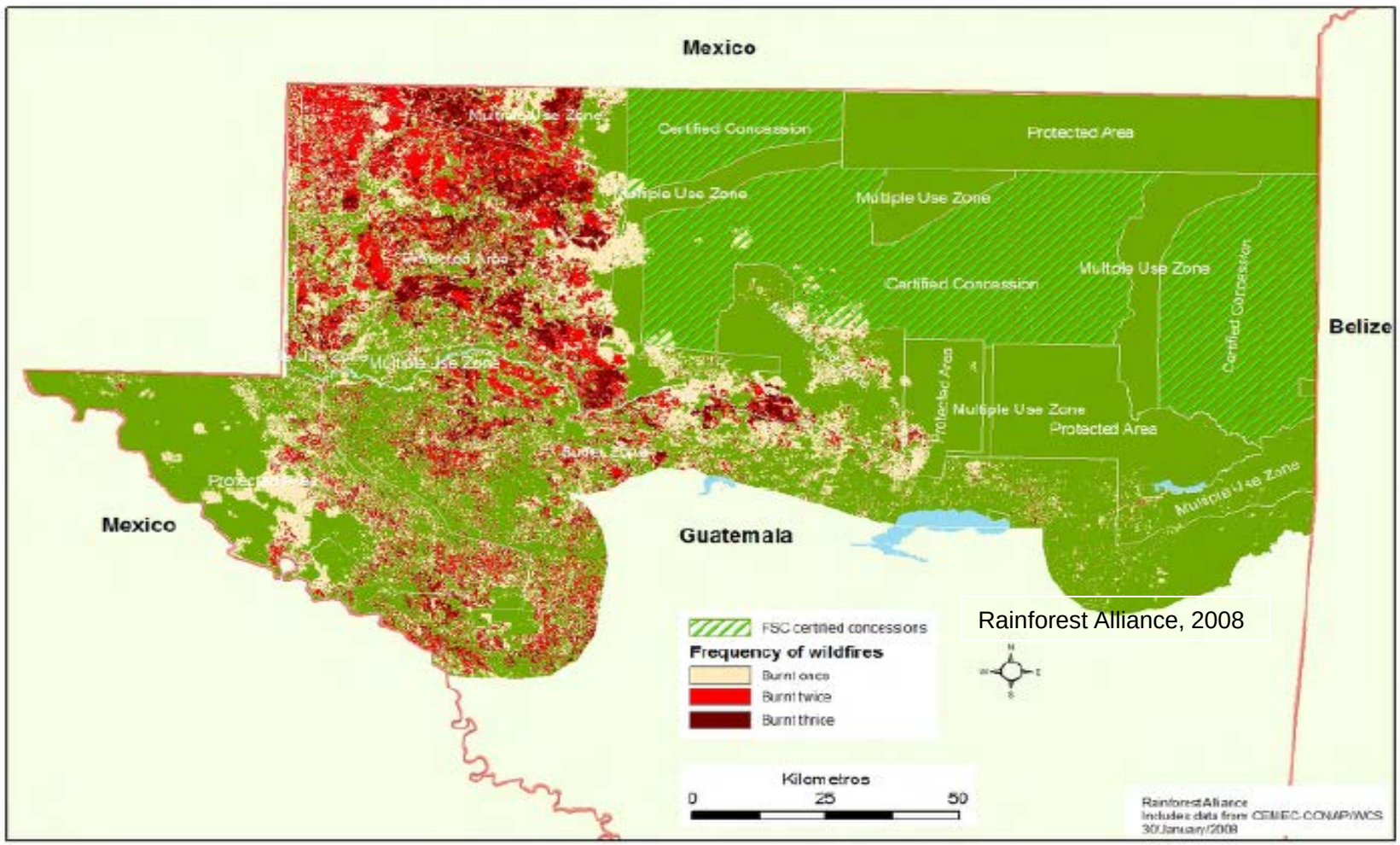
# Income from pellet exports helps to encourage SE US forest owners to invest in good forest management (e.g., thinning)



From E. Parish, V. Dale, K. Kline (2017) *World Biomass*

# Challenge: As long as deforestation persists, concerns about 'limited land' & biodiversity will persist.
## → Critical to understand actual CAUSAL Drivers

**Map 4. Frequency of wildfires for 2003, 2005 and 2007 fire seasons in the MBR.**



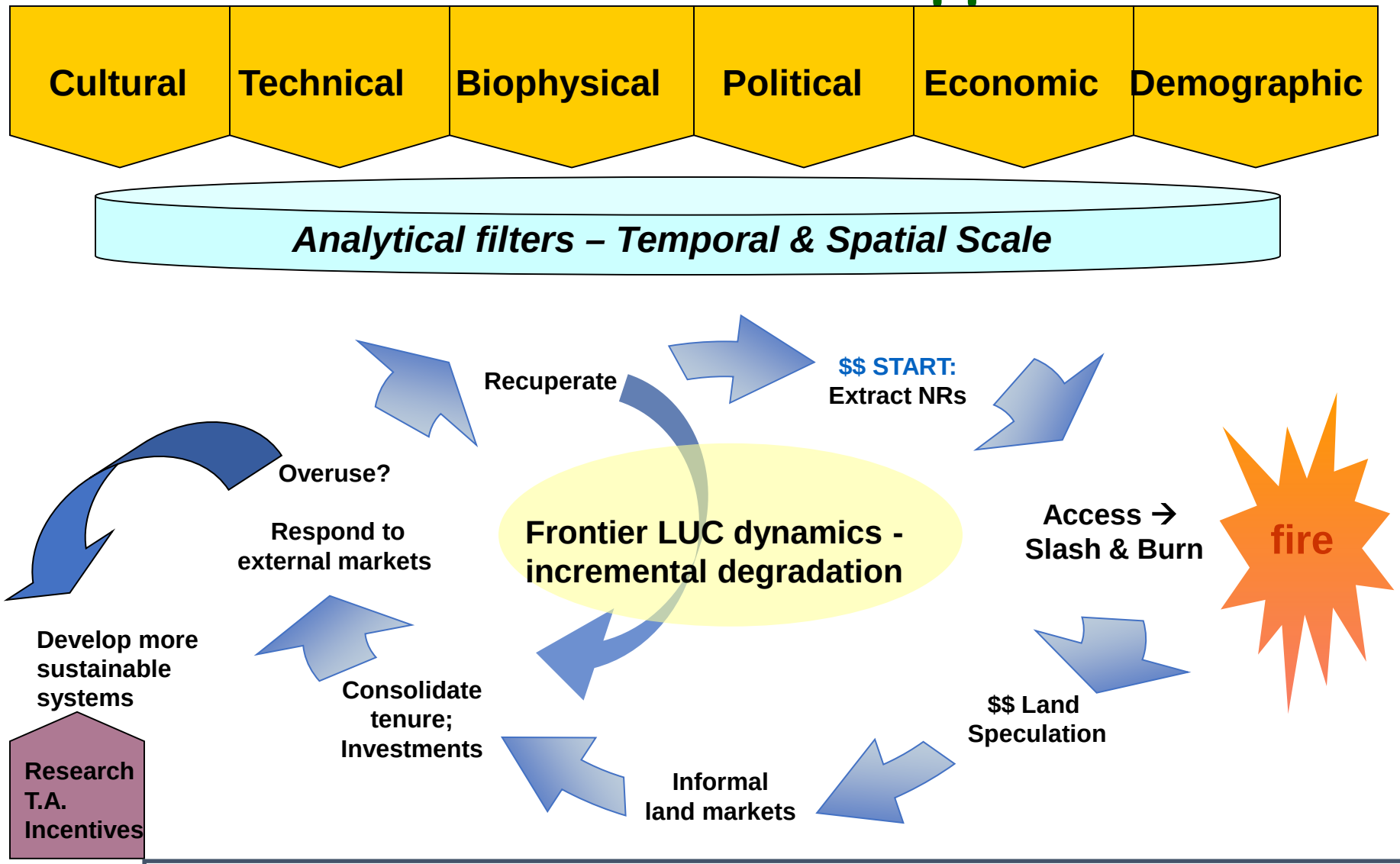

Rainforest Alliance, 2008

***Maya Biosphere Reserve (MBR) 500,000 Ha, Northern Guatemala.***

***Habitat loss, contamination of water and soil, and new settlements are legacies of oil and illegal trafficking, not a need for agricultural land.***

—*K.Kline, MBR Project Manager (1990-2000)*
—*N.Schwartz, Univ. of Delaware, author of Peten: A Forest Society.*

# Drivers of deforestation:
## confluence of local actors & opportunities

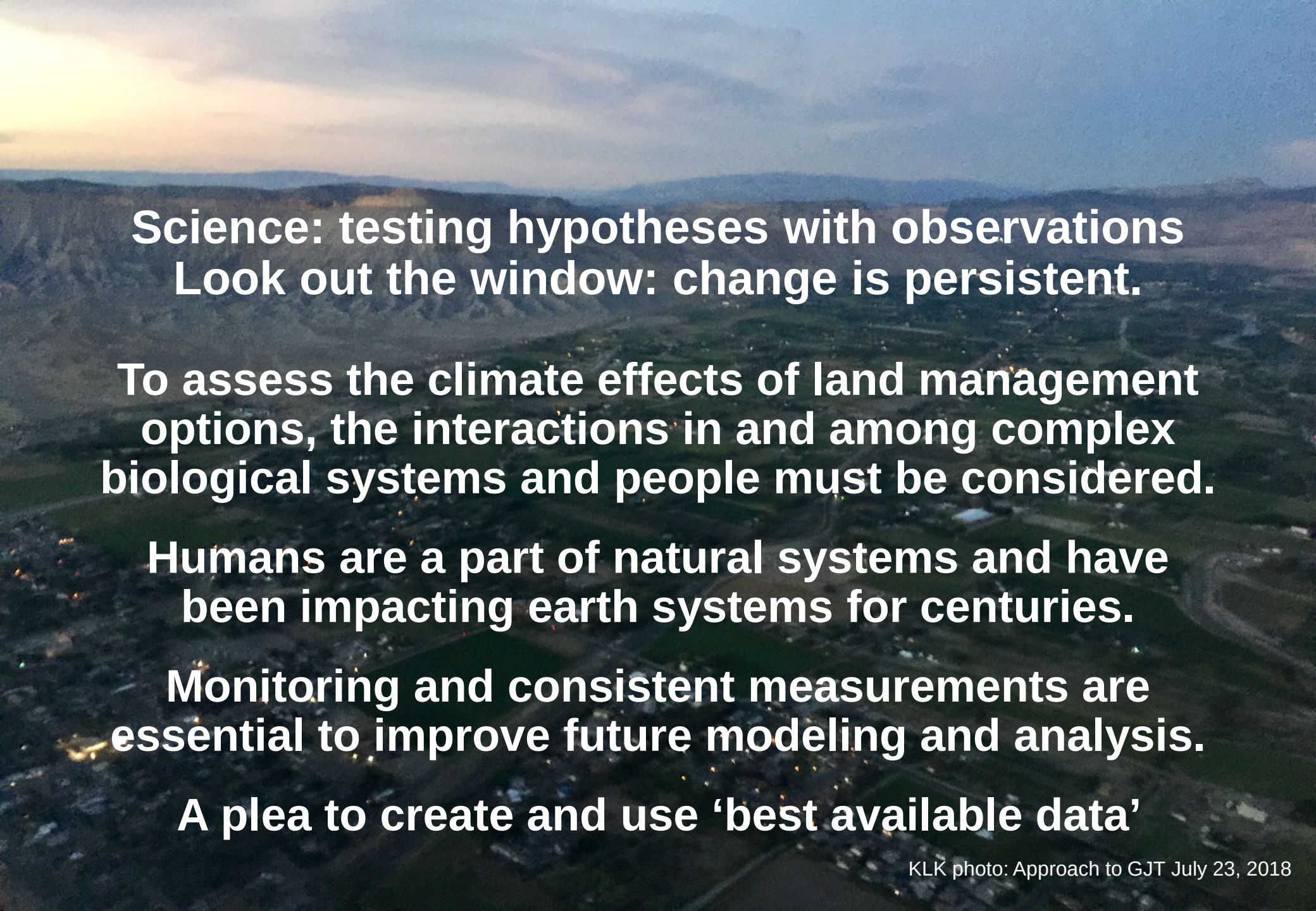



Important drivers of initial conversion: extractive industries/access; land scams, poverty... Where & how do the levers interact with these processes?

# Biofuels and Biodiversity – Inter-disciplinary research across the Americas

- Concerns for biodiversity and ecosystem protection are high, prompting:
  - Agro-ecological zoning (e.g., Brazil)
  - Increased monitoring
  - Certification schemes
  - Legal and regulatory reforms
  - Pressures to improve enforcement and rule of law
  - Research on making bioenergy systems more harmonious with conservation goals
- Identified need to improve management of previously disturbed lands
  - Policy incentives, market incentives
  - Bioenergy helps identify options

Kline et al. 2015. Bioenergy and biodiversity… Enviro Mgmt 56: 1377-1396



**Science: testing hypotheses with observations**
**Look out the window: change is persistent.**

**To assess the climate effects of land management options, the interactions in and among complex biological systems and people must be considered.**

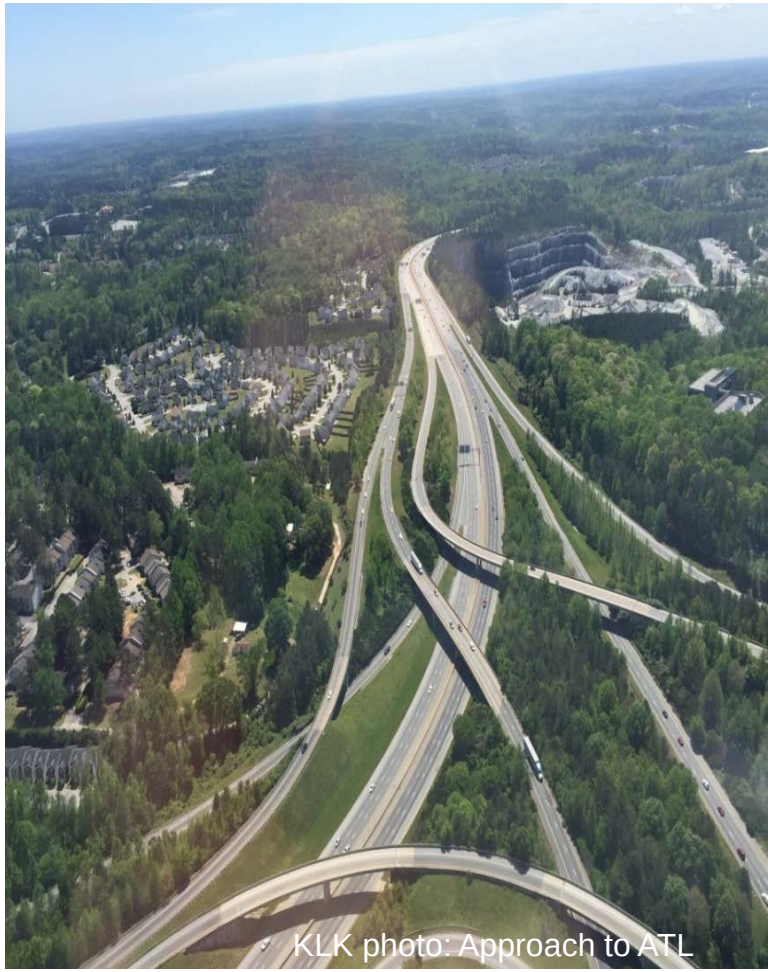
**Humans are a part of natural systems and have been impacting earth systems for centuries.**

**Monitoring and consistent measurements are essential to improve future modeling and analysis.**

**A plea to create and use 'best available data'**

KLK photo: Approach to GJT July 23, 2018

**Biological systems productivity, land cover and management <u>are essential</u> to perform full-chain analysis (LCAs, TEAs, compliance with standards)**



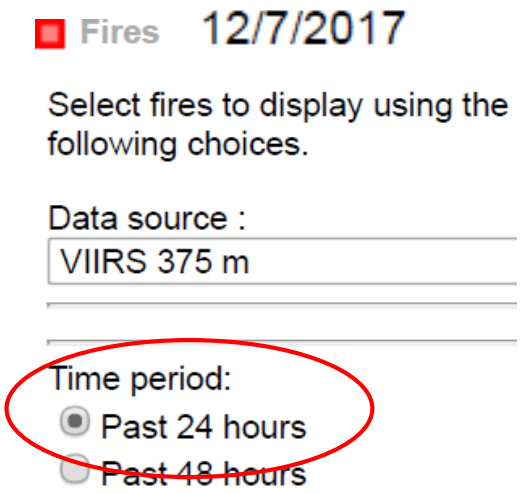

**To quantify effects of a proposed option, we need to agree on facts:**

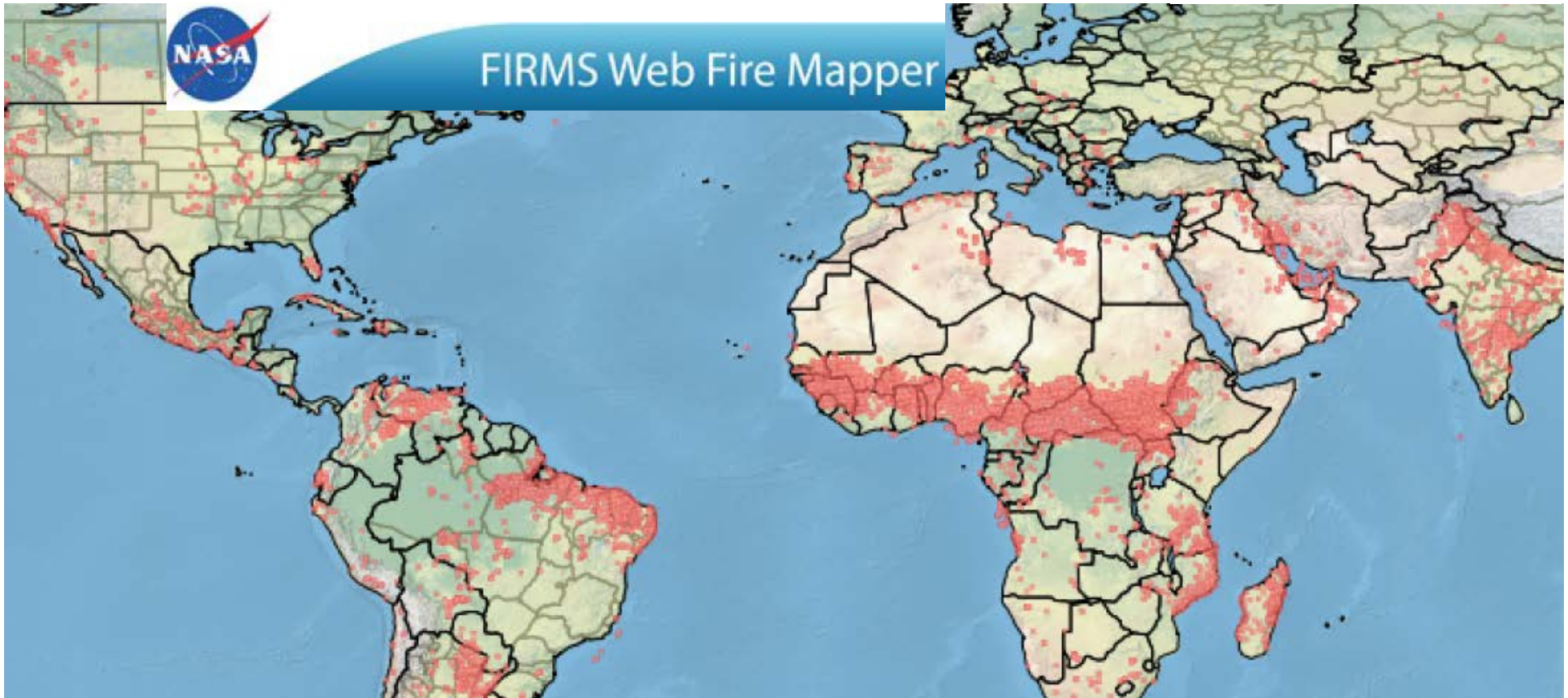
- ✓ **Where we are?**
- ✓ **Where have we been?**
- ✓ **Where will we go if we continue on current path?**
- ✓ **Targets**
  - **Setting future goals for "change"**
  - **Desired Future Conditions (or *undesired future conditions*)**

Dale et al. (in review BioScience) An Operational Definition of Sustainability

# *Where are we? Biomass to BURN!*

- ***400-550 million hectares burn every year***
  *(Randerson et. al., 2012; Giglio et al. 2010; Doerr and Santin 2016)*
- ***Millions more impacted by other disturbances*** *(disease, pests, droughts, floods, hurricanes…)*
- ***Management matters!*** *(Andela et al. Sci. 2017)*



# How to properly account for carbon when assessing our effects on land?

## Definitions matter

"Management…"

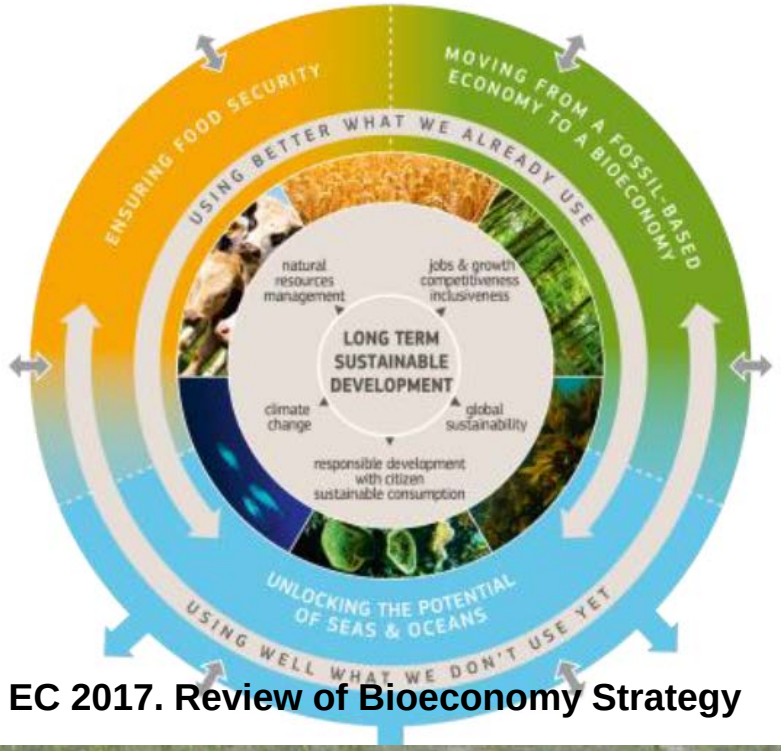
"Negative emissions…"

"Waste"

"Sustainable _____"

"LUC accounting…"

➢ Change compared to what?




EC 2017. Review of Bioeconomy Strategy

## Choices matter:

- Temporal & spatial scales
- Data resolution
- Class ontologies

UNFPA photo

Koponen et al. (2017) Renew & Sust Energy Rev. / Dale et al. (in review, BioScience)

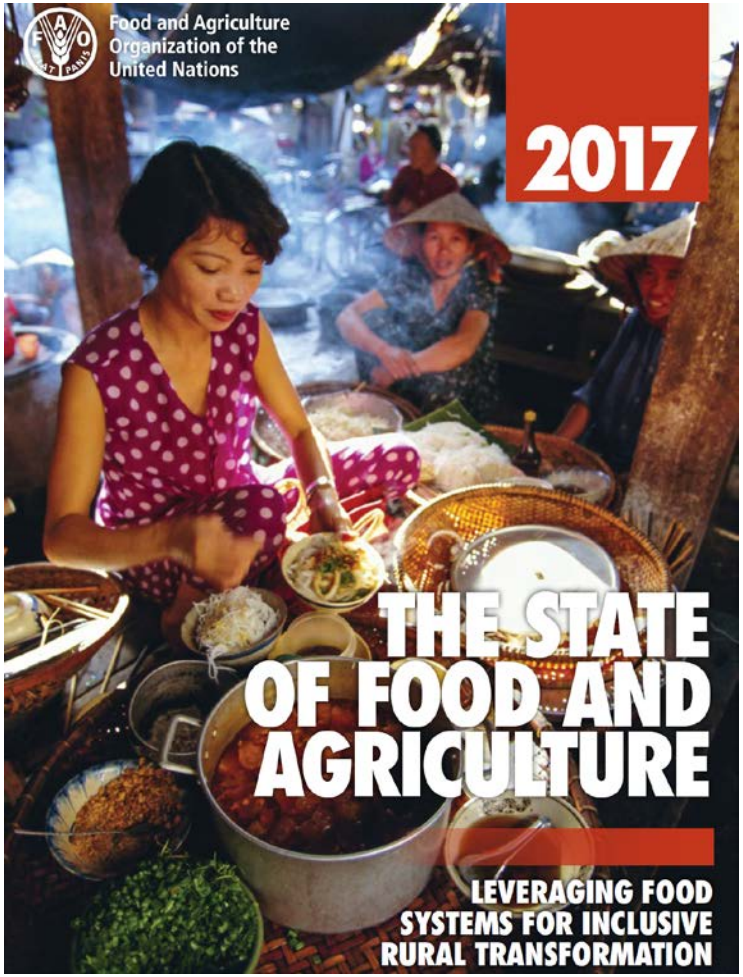
# Challenge: as long as hunger persists, food security will remain a concern

***Despite major increases in global food stocks, more people hungry today than 2015:*** 815 million people chronically undernourished (FAO 2017), vs 793 million (FAO 2015).

Achieving SDG to reduce hunger "***depends crucially on progress in <u>rural areas</u>, which is where most of the poor and hungry live***."

**Constructive actions: <u>policies</u>** supporting successful "rural transformation" are expected to improve food security:

- Facilitate access to inputs;
- Foster sustainable management practices;
- Better access to credit and markets;
- Mechanization;
- Effective extension systems;
- Strengthen land tenure rights;
- Equitable supply contracts; and
- Stronger links between rural areas and towns.



# Summary of recent analyses

- Land area & commodity output do not limit global food or bioenergy production[1,2,3,4,5]
- The land *required* to feed the world in 2050 is a fraction (<1/10th) of the area currently classified as agricultural land[1]
- Land scams, tenure issues, poverty, & market distortions cause land clearing (see CBES & 1,4)
- Ag system responses to demand are quick and rely on existing production systems (e.g., intensification) rather than new land clearing[1]
- "Growing more" is not the solution when 40% of production is wasted & commodity stocks are at historic highs (FAO & others, see following slides)

***We need policies to stimulate investments in new markets & clean, renewable production to displace non-renewable inputs***

BEFS
Bioenergy and Food Security Projects

**Hunger, famine and food insecurity are context-specific, often politically driven, and not due to a shortage of food at global scale[5].**


Sources
1. Kline et al. 2009, 2011, 2017
2. Thornhill et al. 2016
3. Leonardo et al. 2015
4. SCOPE 72 (Souza et al. eds.) 2015.
5. Thurow and Kilman 2009. *Enough: Why the World's Poor Starve in an Age of Plenty*

# *Questions for discussion:*

- ***Who defines LUC, "deforestation" and related impact factors?***
- ***Can we establish consistent incentives to improve management for ALL areas? (regardless of land class, wetland, marine systems...)?***
- ***What are "best available data"?***
  - ***Transparent*** ***Defensible***
  - ***Representative*** ***Realistic***
  - ***Credible*** ***Publicly available***
  - ***Support replicable analyses***

Kk photo: View from Mt. Le Conte

# *Questions for discussion*

- ***How can the tool be more useful for guiding decisions?***
  - ***What subsidies/market distortions cause observed "problems" and increase carbon losses & "wastes"***
  - ***How can performance-based policies be established with the flexibility to find best local solutions?***
  - ***How to pay for desired services and penalize undesired effects?***
- ***What are the best management opportunities to achieve goals in a given context?***
- ***What data are needed to guide land management to increase C-storage capacities, storage rates, & improve resilience to disturbance?***

Kk photo: View from Mt. Le Conte

# Thank you!

Oak Ridge Reservation, ORNL in valley, Oak Ridge TN. Photo: ORNL

# Epilogue for scientists: Do we have the right tools for the job?

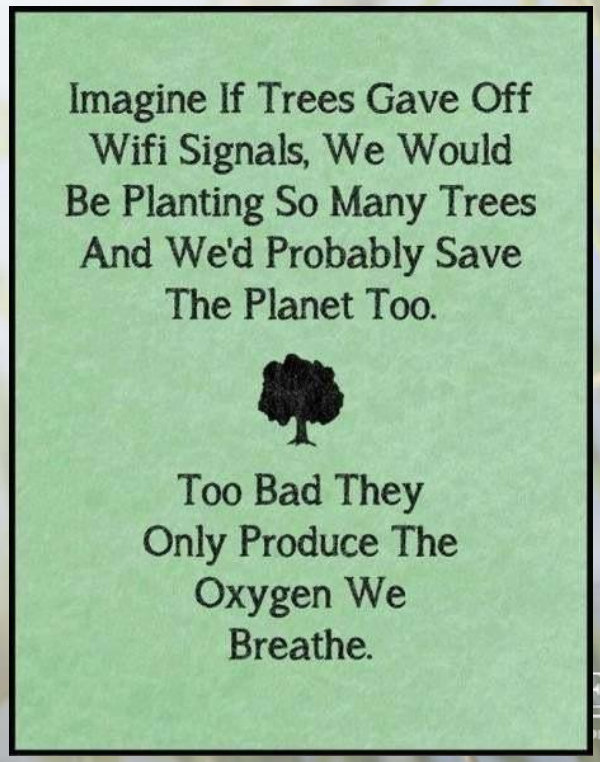
*"I used to think the top environmental problems were*

- *Biodiversity loss*
- *Ecosystem collapse*
- *Climate change*

*And thought science could address these problems… I was wrong.*

*The top environmental problems are greed and apathy, and to deal with those we need a cultural, spiritual transformation. Scientists don't know how to do that."*

*– attributed to Gus Speth*



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