GREAT LAKES BIOENERGY RESEARCH CENTER

Biofuels Done Right: Farmers and Sustainable Bioenergy

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U.S. DEPARTMENT OF ENERGY

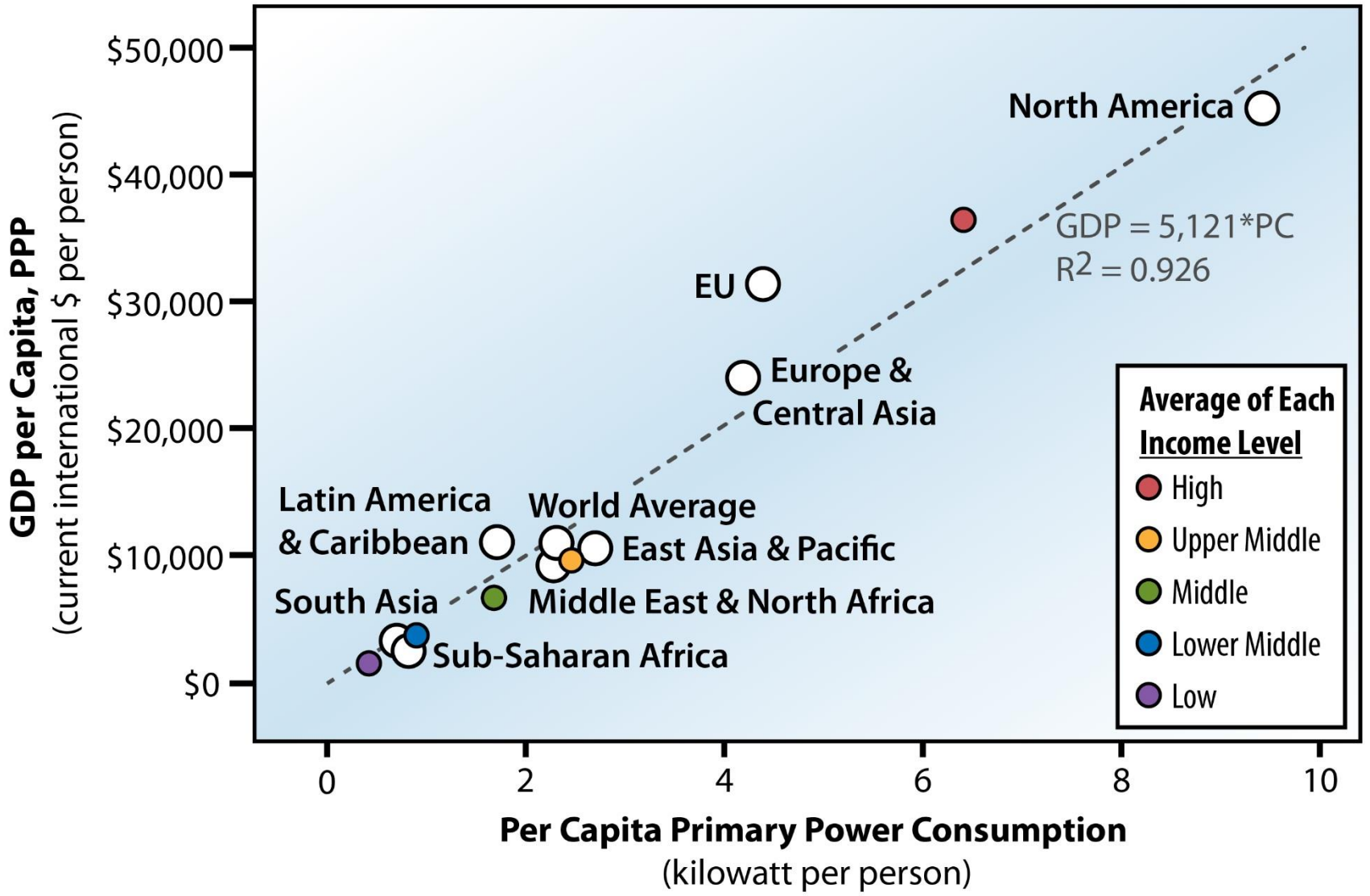
DOE Bioenergy Research Centers

The Bioenergy System: Integrated Collector and Battery

(Renewable) Energy is Critical for Human Well Being

1. Rate of energy use (rate of work done) largely determines national wealth and opportunities for human development
2. Many of those concerned about climate change seem ignorant of or indifferent to this fact: **energy use makes us prosperous**
3. Our current prosperity is based largely on non-renewable fossil fuels—thus our prosperity has an "expiration date"
4. Lack of energy access currently condemns billions to poverty—and will also limit future generations unless….
5. We implement terawatt scale renewable energy systems—in the next few decades
6. Bioenergy is a non-optional part of a renewable energy future
7. Thus farmers—those who own and manage land--must benefit from bioenergy production
8. **So the question is: "How can we "Do Biofuels Right?""**

Power Consumption and GDP (World Regions)



Energy Consumption & Human Well Being are Linked: How Much Energy is "Enough"?

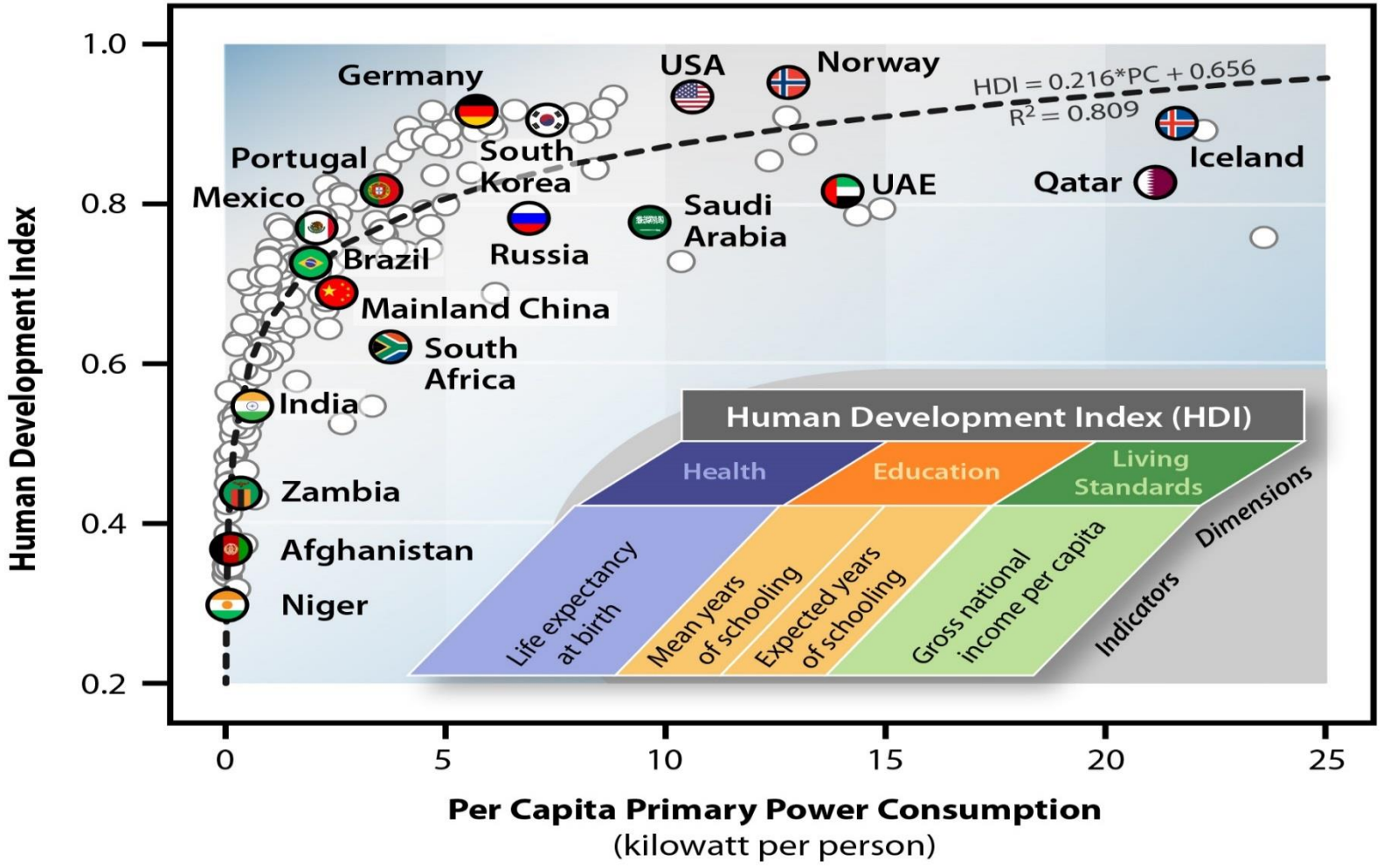
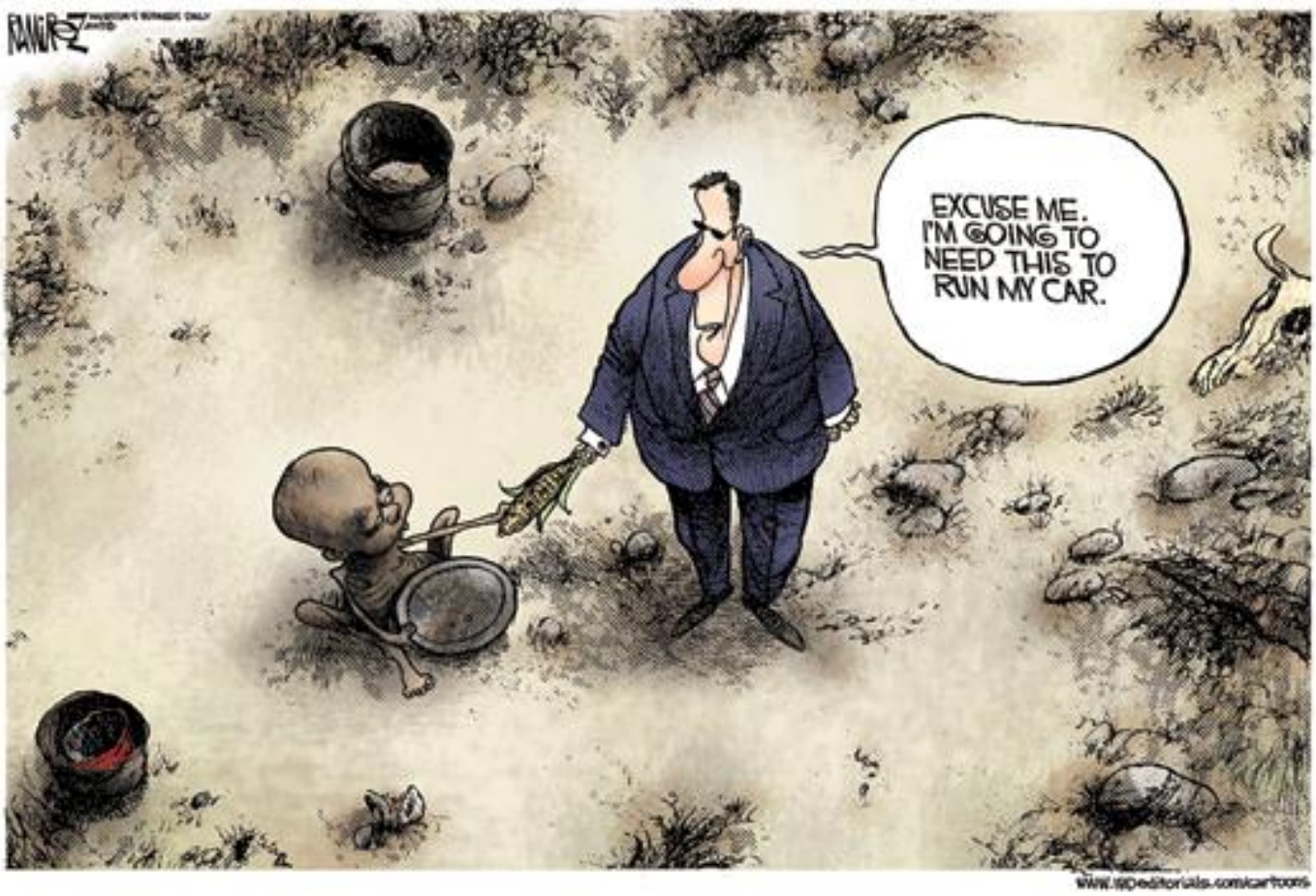


Figure 1. Human Development by Country versus Per Capita Power Consumption in 2010

Biofuels (and Biogas?): A crime against humanity?

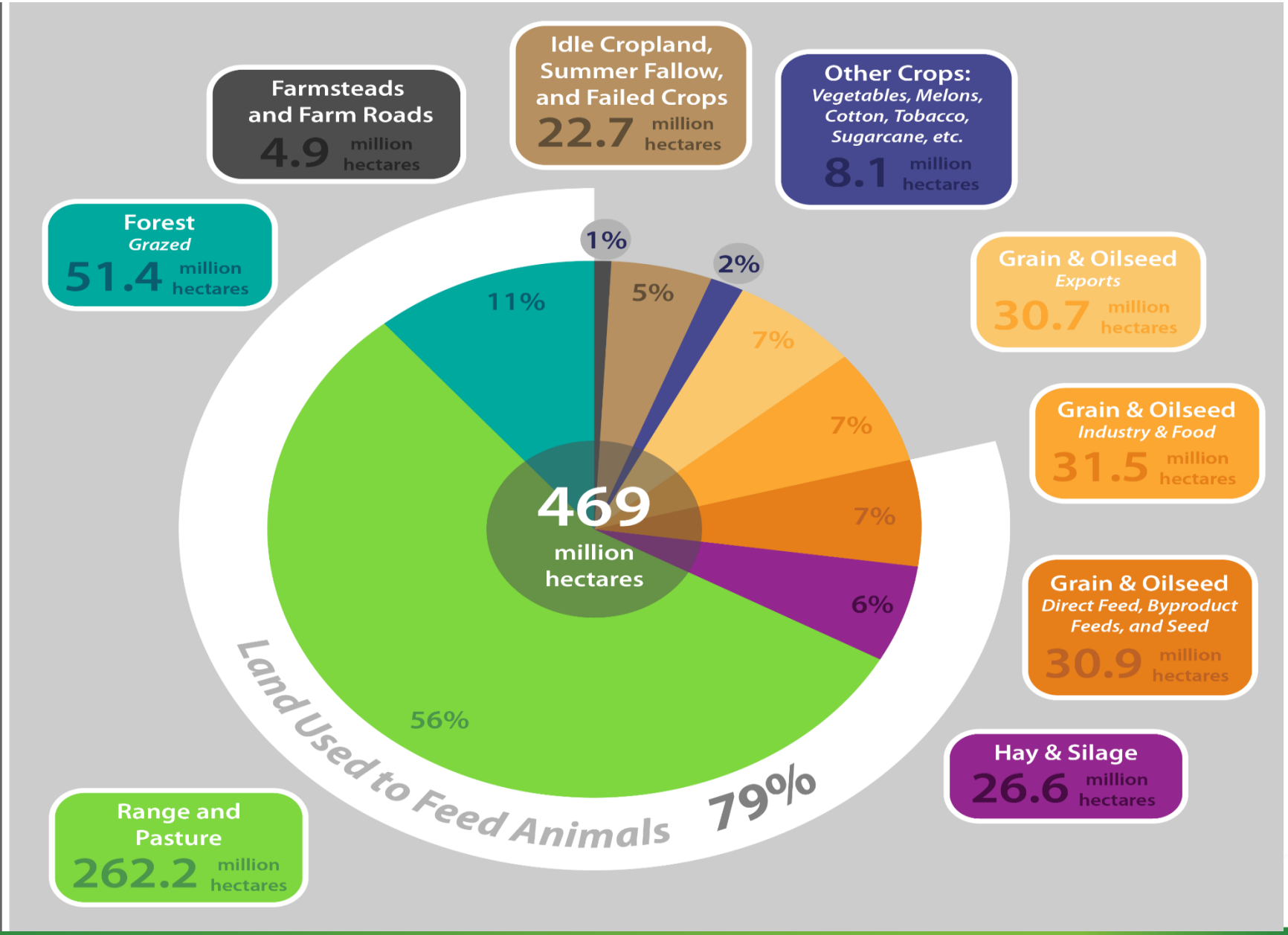


- "[I]t's a crime against humanity to convert agricultural productive soil into soil... which will be burned into biofuel."
  — Jean Ziegler, UN Special Rapporteur, 2007

Agriculture and Biofuels: *we must ask the right questions*

- We are asking: Can we impose a large new demand for biofuels on the existing agricultural system that otherwise does not change?
- We should be asking: Can we redesign US (and world) agriculture to produce biofuels (including biogas), food/feed & large, positive environmental services, including GHG reduction?
- Agriculture has changed before; *it can, should (must) change again—and farmers are key to that change*
- Examine actual land uses: most land is used for animal feed—not for human food
- One solution: think about the whole system and use land efficient animal feeds to boost total biomass output per acre—doing so more sustainably (and more profitably)…"Biofuels Done Right"
- Example of Italian Biogas Consortium: "Biogasdoneright"

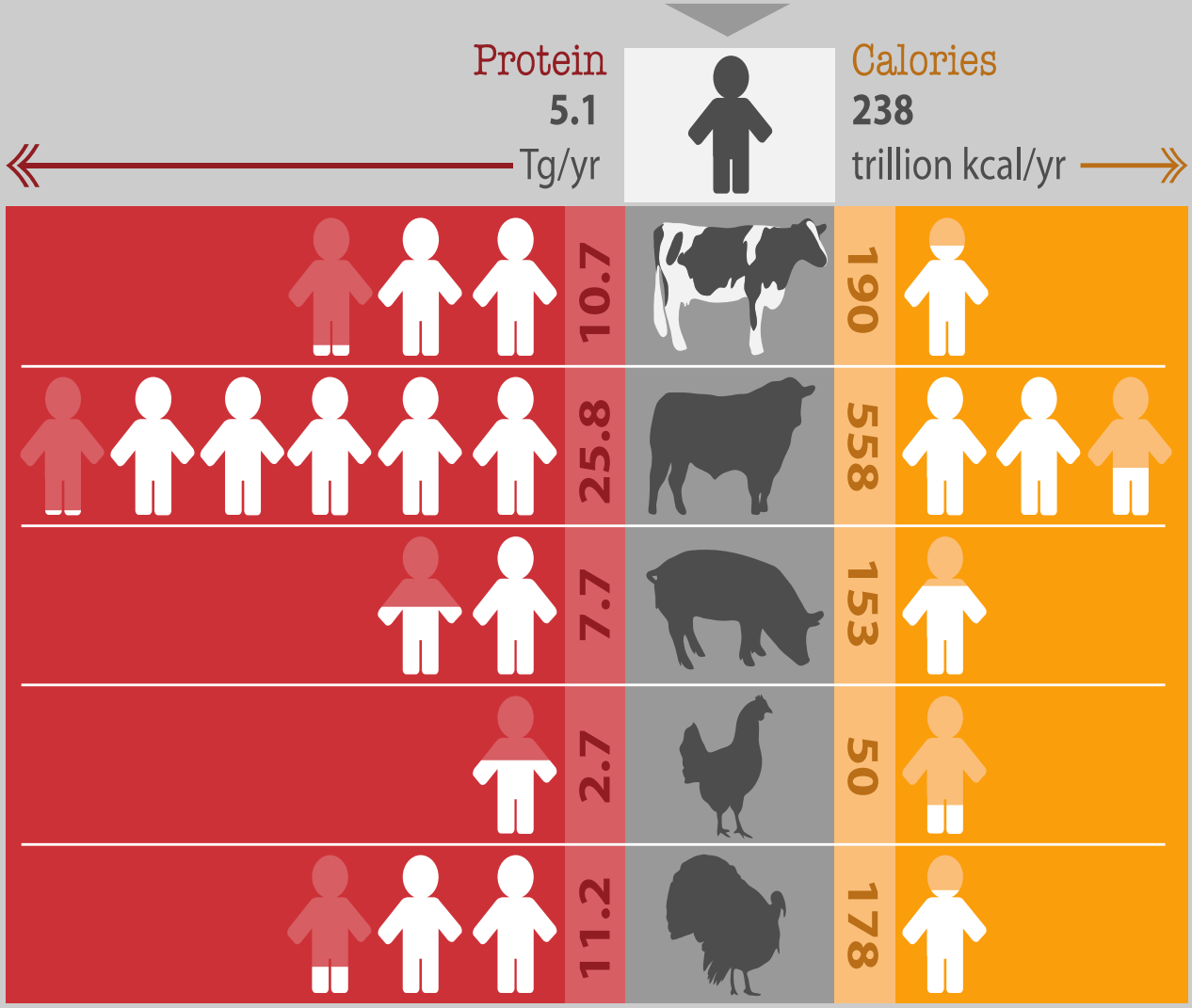
Land Use Patterns in the United States



Nutritional Requirements: **Livestock** vs. **Human**

NUTRITIONAL REQUIREMENT OF ALL U.S. LIVESTOCK IN TERMS OF THE...

NUTRITIONAL REQUIREMENT OF THE ENTIRE U.S POPULATION



U.S. livestock consumes

11.4 X and **4.8 X**

the amount of PROTEIN and CALORIES that would **fulfill** the nutrtitional requirements of the U.S. population

All data from 2010/2011. Livestock population data from USDA-NASS, human nutrition from USDA/USDHHS, U.S. population data from U.S. Census Bureau and animal nutrition from Dale et al., "Protein feeds coproduction in biomass conversion to fuels and chemicals".

Environ. Sci. Techr

Biofuels Done Right: Land Efficient Animal Feeds Enable Large Environmental and Energy Benefits

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There is an intense ongoing debate regarding the potential scale of biofuel production without creating adverse effects on food supply. We explore the possibility of three land-efficient technologies for producing food (actually animal feed), including leaf protein concentrates, pretreated forages, and double crops to increase the total amount of plant biomass available for biofuels. Using less than 30% of total U.S. cropland, pasture, and range, 400 billion liters of ethanol can be produced annually without decreasing domestic food production or agricultural exports. This approach also reduces U.S. greenhouse gas emissions by 670 Tg CO_2-equivalent per year, or over 10% of total U.S. annual emissions, while increasing soil fertility and promoting biodiversity. Thus we can replace a large fraction of U.S. petroleum consumption without indirect land use change.

Reconfigure U. S. Agriculture to Produce Animal Feed, Biofuel and Large Environmental Services

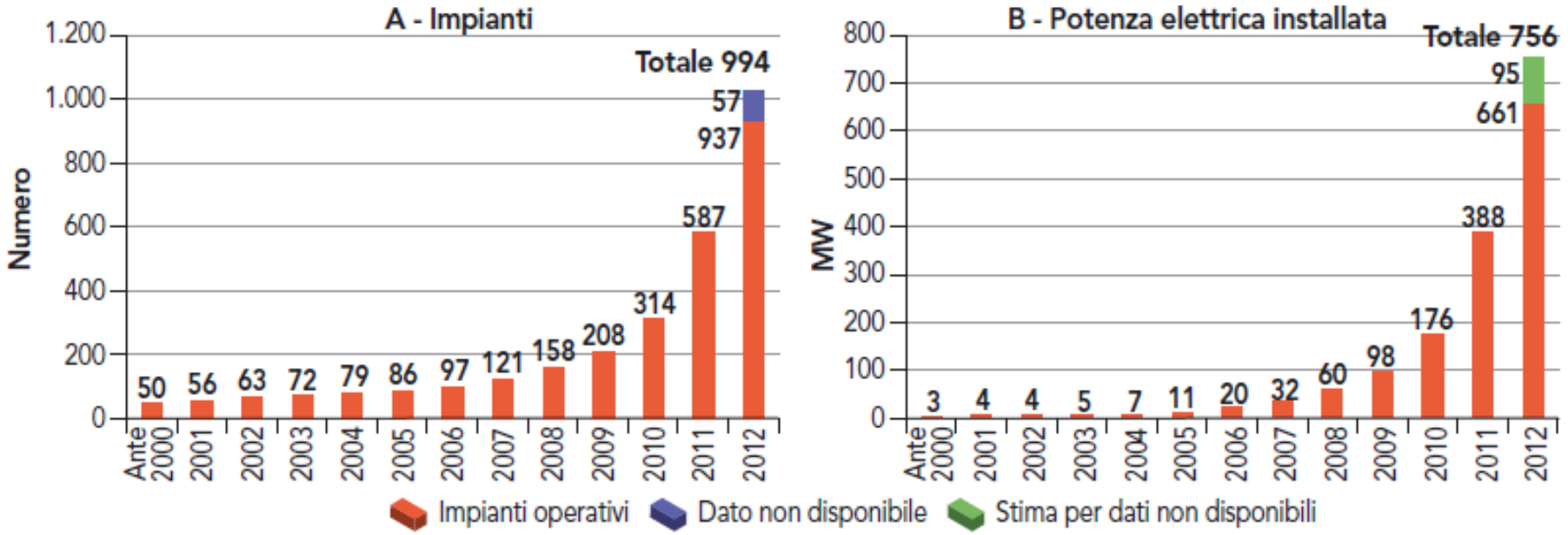
Modeling approach: Use double cropping, etc., to provide biomass for animal feed and fuel ethanol

Predictions:

- 30% of U.S. cropland, pasture and range provide ~100 billion gallons/yr of fuel ethanol
- U.S. GHGs reduced by ~700 Tg- carbon dioxide/yr
- Soil fertility increased (carbon sequestered in soil)
- Food (actually animal feed) production unchanged
- Nitrogen and phosphorus losses reduced by ~75%

Executive Committee Meeting of Italian Biogas Consortium: “Biogasdoneright”
Cremona, Italy May 8, 2015

GRAFICO 1- Andamento del numero di impianti biogas e della relativa potenza elettrica installata nel settore agrozootecnico



Per quanto riguarda il numero di impianti, il dato relativo all'anno di operatività è disponibile per il 94% degli impianti, i 57 impianti per i quali il dato non è noto sono stati contabilizzati nell'ultima annualità. In merito alla potenza installata, invece, il dato è disponibile per l'87% degli impianti, per i restanti impianti è stata assunta una stima sulla base della taglia media degli impianti per cui è disponibile il dato.
Fonte: Crpa.

Nel corso del biennio 2011-2012 il numero degli impianti censiti è aumentato del 95%, mentre la potenza elettrica è aumentata del 116%.

- Italian feed in tariff led to 4 billion € investment over 4 years
- 1,200 biogas plants total with ~1 gigawatt of capacity
- 8,000 GWh/yr electricity generated
- 12,000 well-paying, permanent jobs created
- Uses 0.25 million ha of Italian crop land (6.5 million ha total)

Guiding Principles: "Biogasdoneright"

- Grow regular crop for feed/food– no "food vs. fuel" conflict
- Grow a double crop to feed the anaerobic digesters (plus manure, other locally-available "wastes")
- Burn biogas on site to generate electricity for grid- use waste heat
- Fertilize fields with digestate liquid → reduce purchased fertilizers (and associated GHGs)→ reduce irrigation water
- Till in the residual digestate solids → rising soil carbon levels→ increased fertility and farm productivity→ low cost carbon capture & storage
- Pursue opportunities for increased resilience/value added:
  - Methane to biodegradable polymers for irrigation piping
  - Methane-powered tractors
- Improve profitability—increase income and resilience, reduce expenses
- We will be documenting/analyzing the Italian biogas experience in the journal *Biofuels, Bioproducts and Biorefining*
- ***Their farms are beautiful….***

Stefano Bozzetto‘s farm: 2 biogas plants of 1 MW each.
Daily feeding plan: 90 tons cow manure, 90 tons cow slurries, 38 tons eggs laying chicken manure, 10 tons rabbit manure, 5 tons spent mushrooms litter, 10 tons sugar beets, 30 tons corn silage, 5 tons rye grass (all wet weights)

Some Concluding Thoughts

- Energy use is critical to human prosperity
- We need about 2-4 kW/capita— a portion of which must be bioenergy
- We probably cannot limit GHGs without involving farms and farmers who manage land
- Agriculture can provide food, feed, and large environmental services, *if redesigned to do so*.
- Start incentivizing/involving farmers to produce lots of energy, sustainably