Reduction of Yield Gaps to Increase Productivity and Sustainability

Dr. Judith L. Capper

Exploring Sustainable Solutions for Increasing Global Food Supplies
National Academies Food Security Workshop
Washington, DC
May 2-4, 2011

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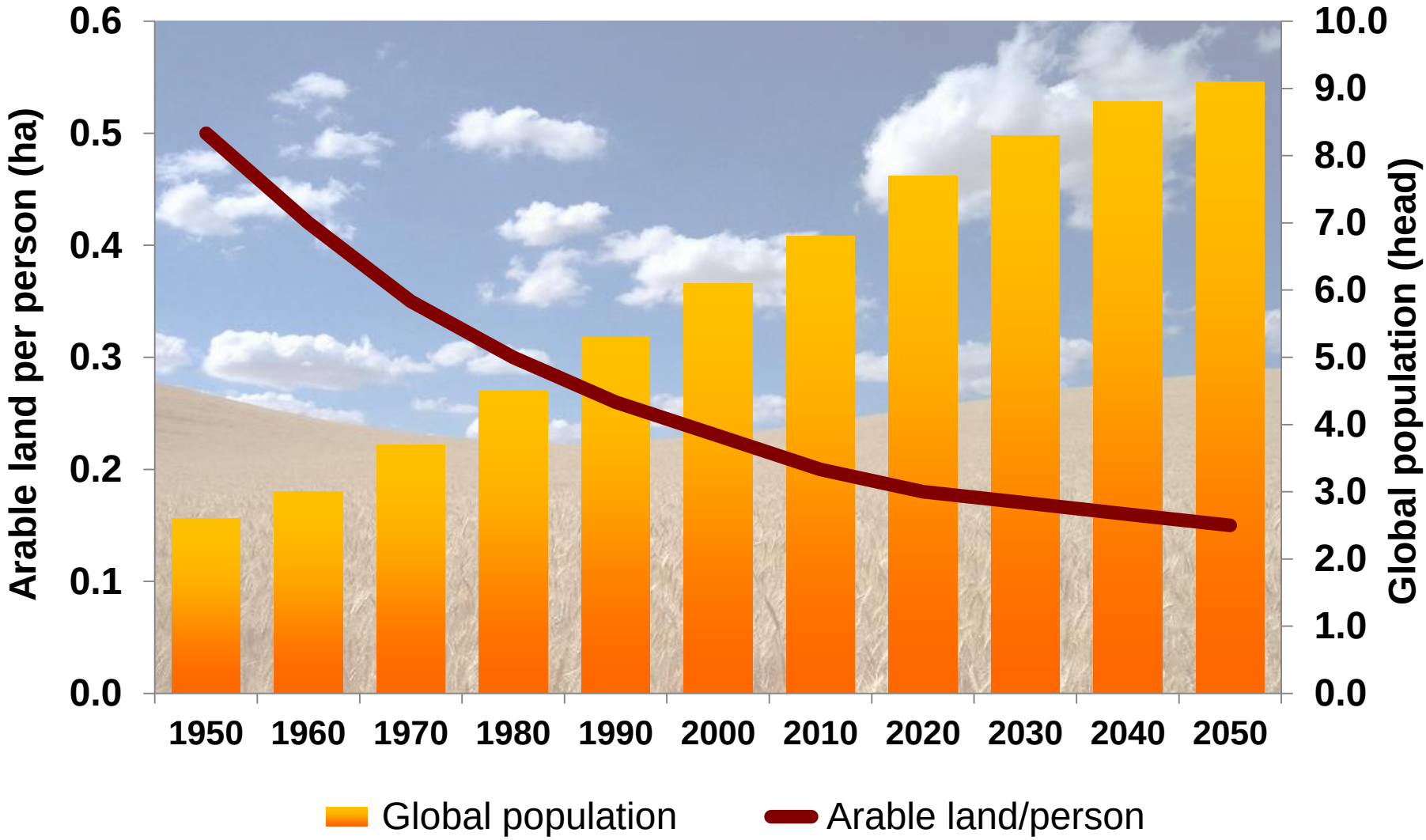
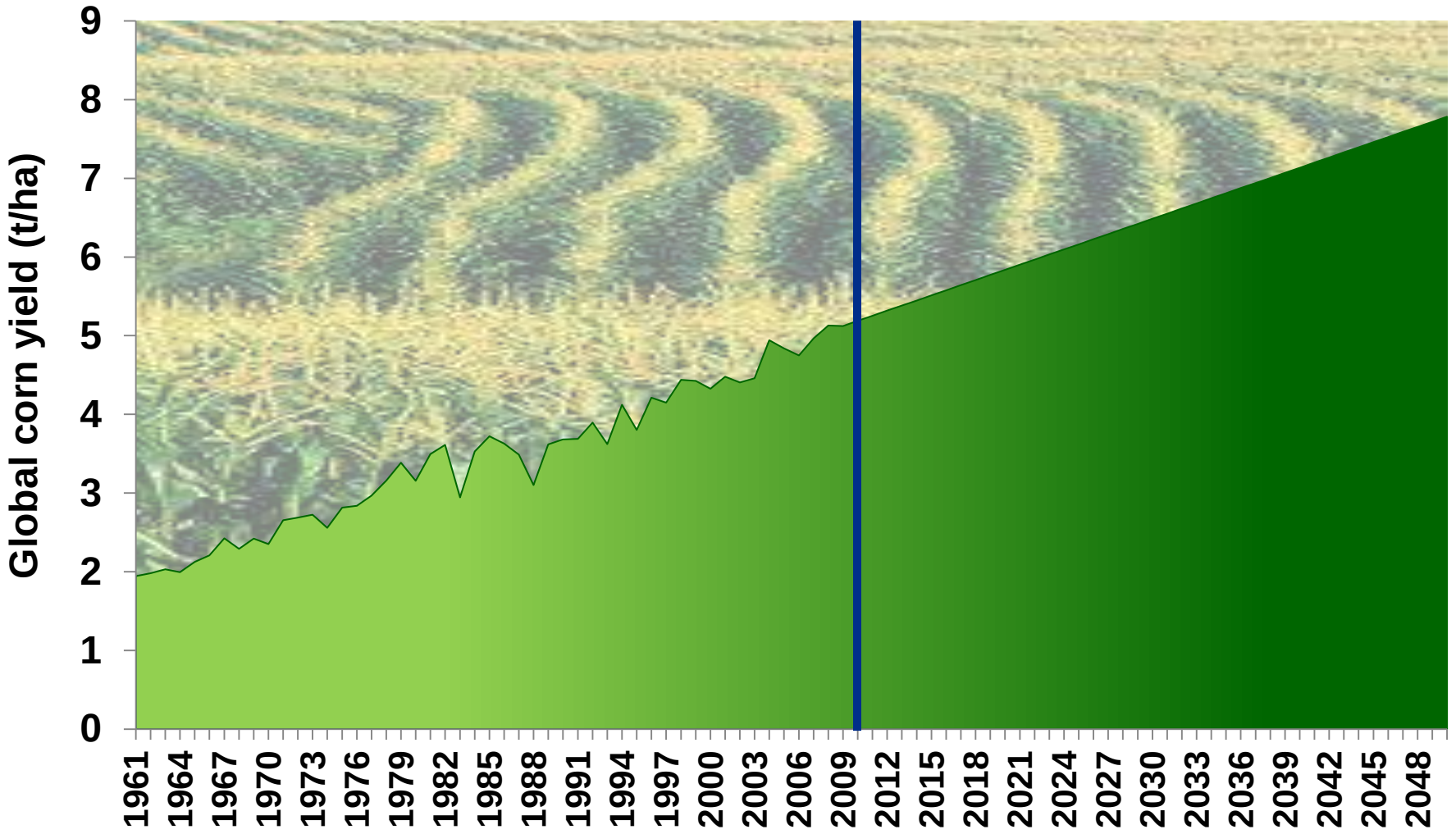
Arable Land Availability is Decreasing as the Global Population Increases



Source: Bauman and Capper (2011) Southwest Nutrition and Management Conference, Tempe, AZ.

Human Requirements Can Only be Fulfilled if Global Corn Yields Continue to Increase

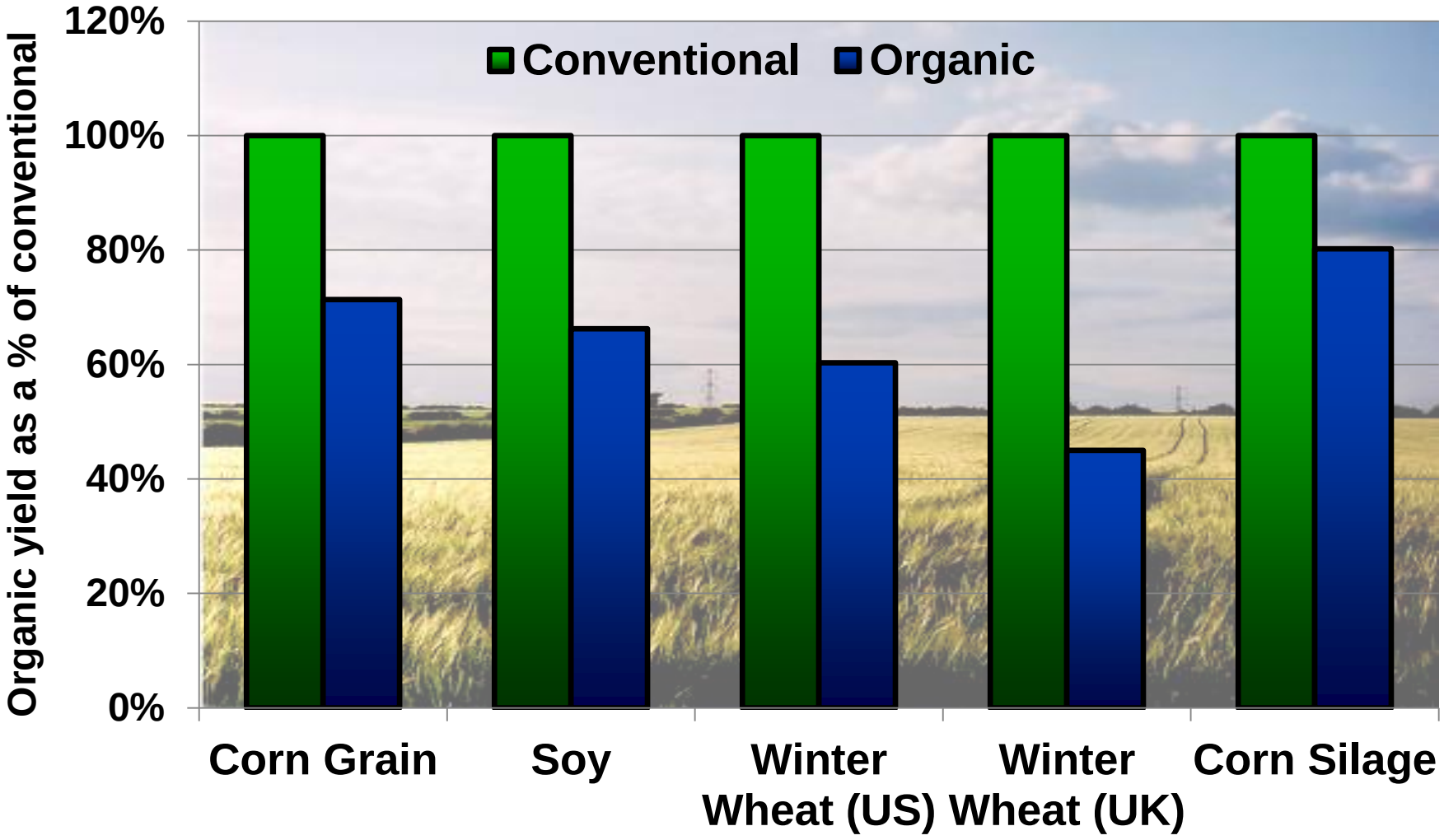


Source: Data and extrapolation from FAOSTAT (2011)

Consumers Perceive Organic Foods as Having Desirable Attributes

Source: Raab, C. and Grobe, D. 2005. Consumer Knowledge and Perceptions About Organic Food. Journal of Extension 43 (online)

US Organic Crop Yields Significantly Less Than Conventional Crop Yields

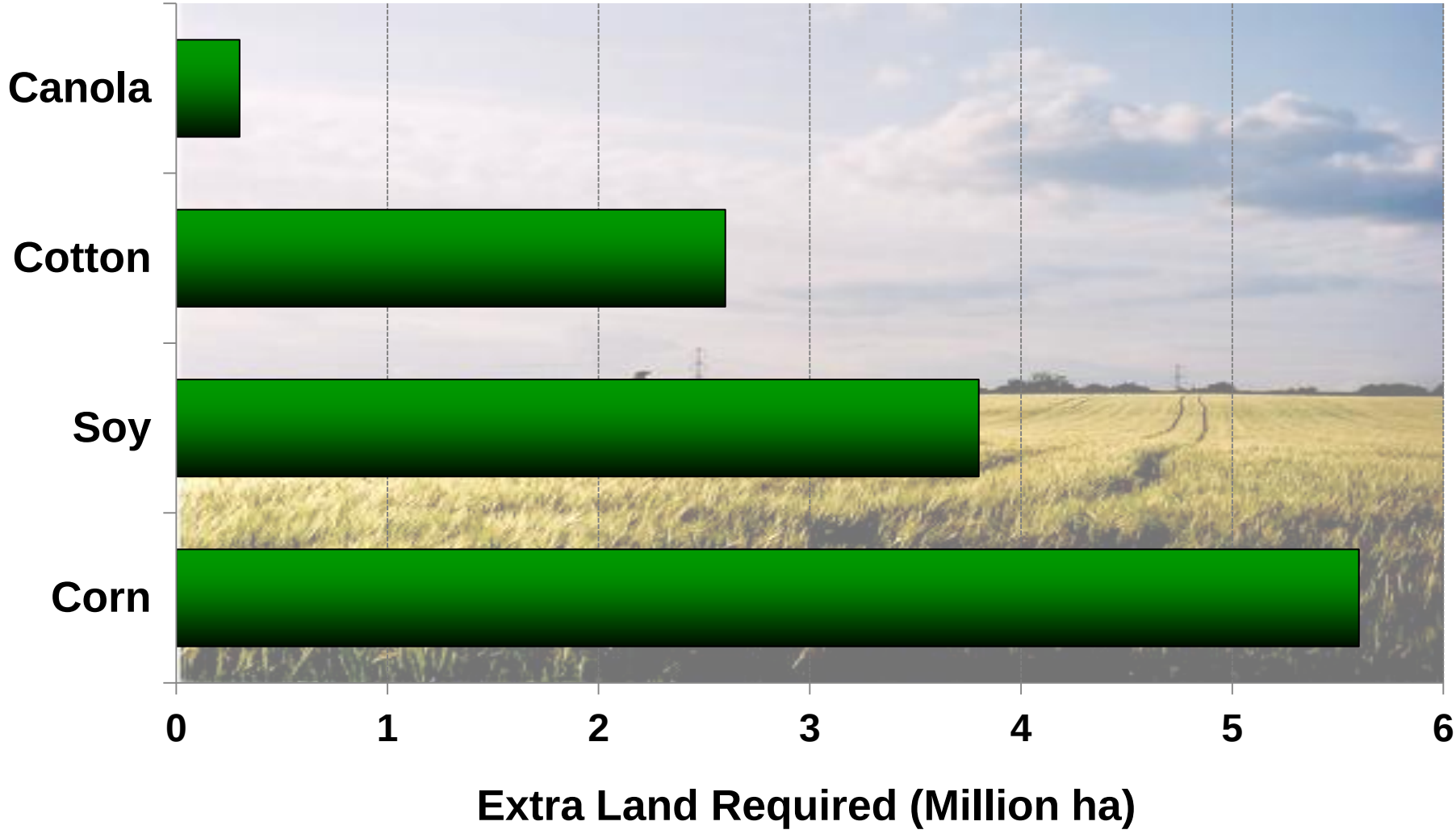


Source: USDA/NASS (2010) 2008 Organic Production Survey; Hodgson et al. (2010) Ecology Letters 13:1358-1367

Social Acceptability of Crop Biotechnology Presents a Huge Challenge

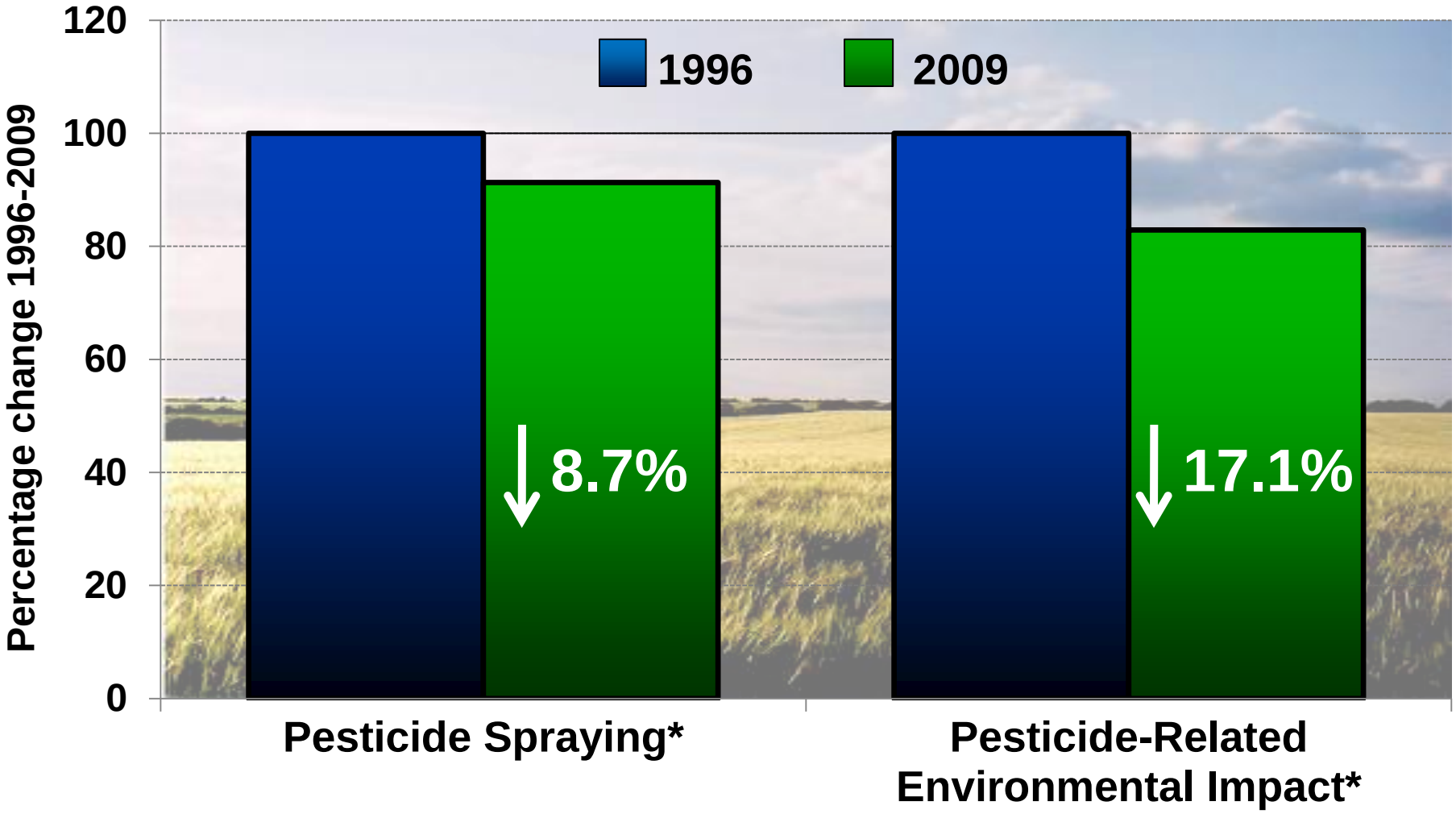
Source: http://2.bp.blogspot.com/_a69Rzr_sQo4/TPE-HewiITI/AAAAAAAAAGI/etmjUf0fqzs/s1600/GMO_Zawleczka.jpg

Additional 12.3 Million ha Required to Maintain 2009 Production Without GM Crops



Source: Brookes and Barfoot (2011) GM Crops: Global Socio-Economic and Environmental Impacts 1996-2009. PG Economics, Dorchester UK

GM Crop Adoption Reduces Pesticide Use and Environmental Impact (1996-2009)



*Values are for biotech crop areas only, not total global cropping area – GM crops account for ~10% of total global cropping area

Source: Brookes and Barfoot (2011) GM Crops: Global Socio-Economic and Environmental Impacts 1996-2009. PG Economics, Dorchester UK

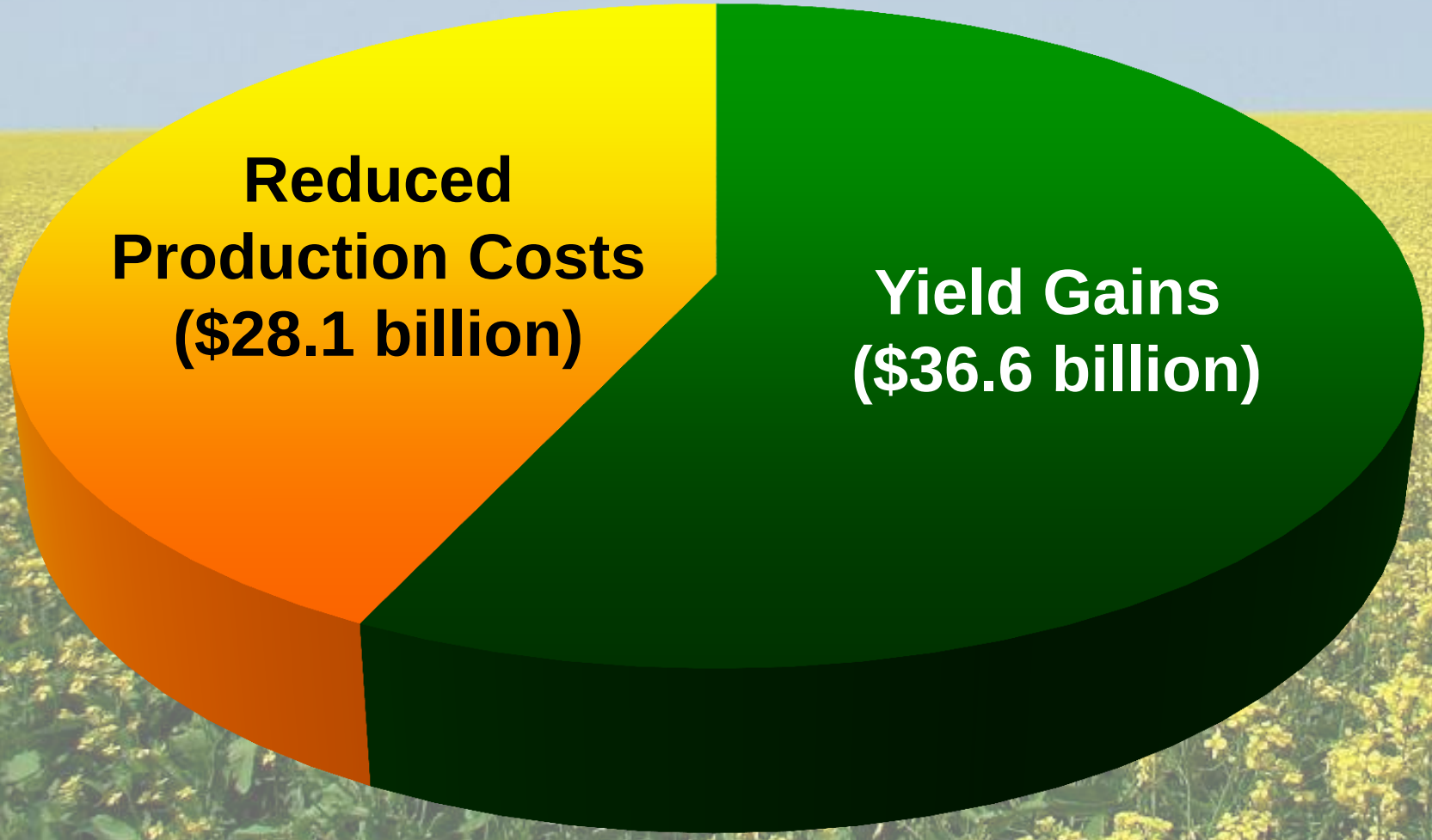
GM Crop Adoption Reduces Agricultural GHG Emissions (1996-2009)

- **Biotech crops facilitate no-till:**
  - **Reduced fuel use**
  - **Increased C sequestration**
- **17.7 billion kg CO_2 reduction**
- **Equal to 7.8 million cars* removed from the road/yr**

***Assumes average passenger car emits 2,250 kg CO_2 per year**

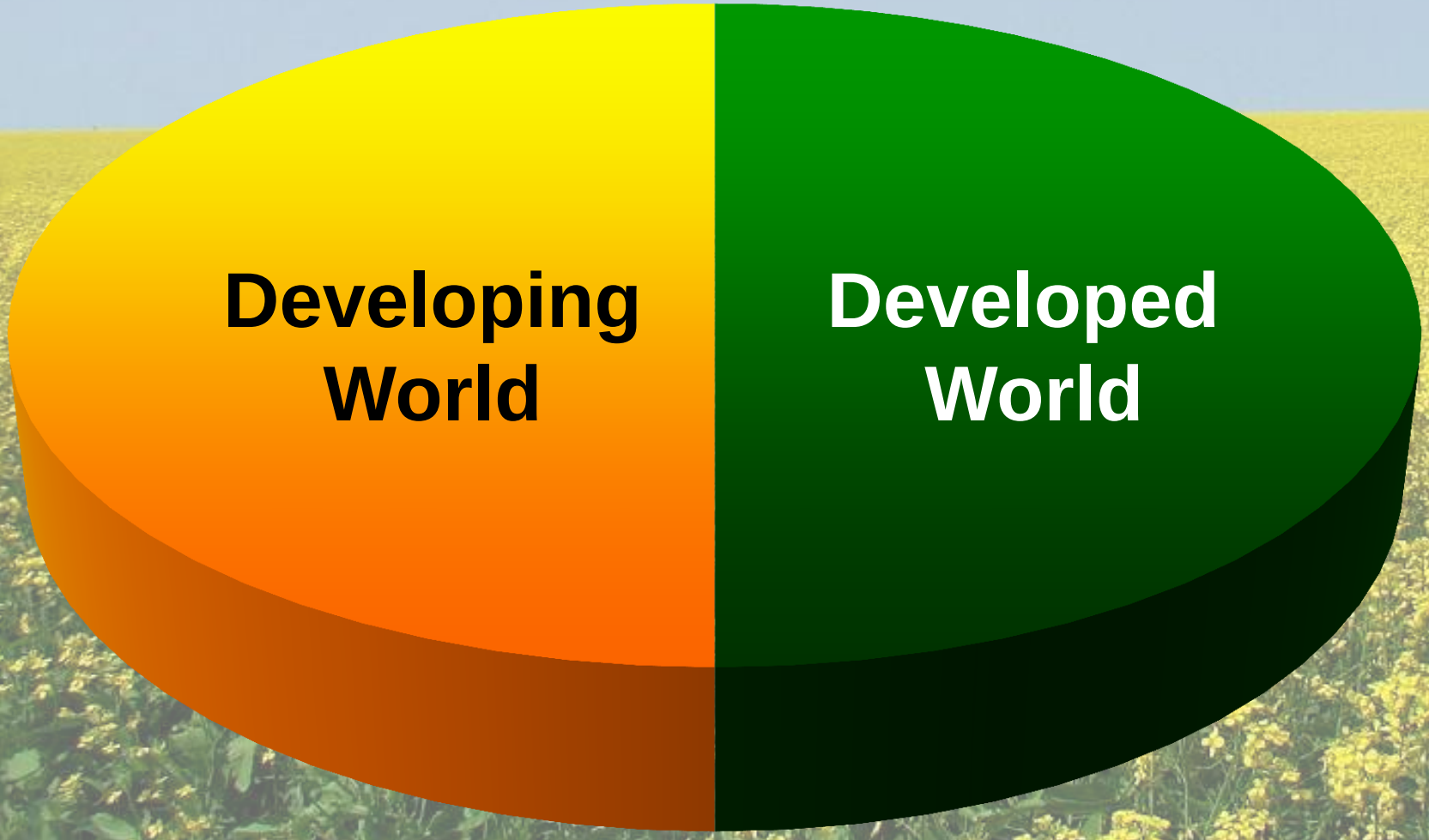
Source: Brookes and Barfoot (2011) GM Crops: Global Socio-Economic and Environmental Impacts 1996-2009. PG Economics, Dorchester UK

GM Crop Adoption Increases Net Economic Farm Income by $64.7 Billion (1996-2009)



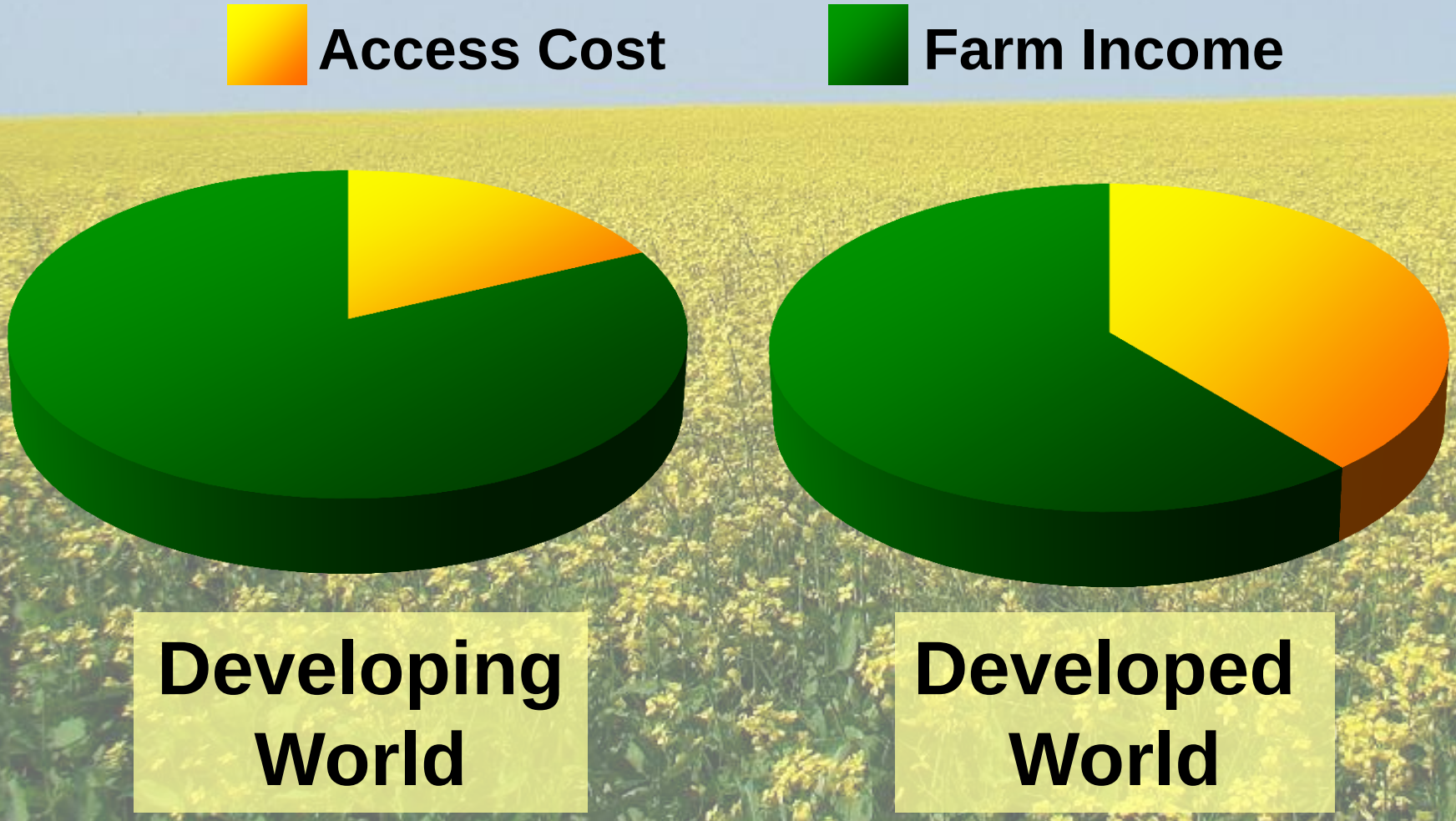
Source: Brookes and Barfoot (2011) GM Crops: Global Socio-Economic and Environmental Impacts 1996-2009. PG Economics, Dorchester UK

Share of Farm Income Gains (1996-2009) from GM Crops Split Equally



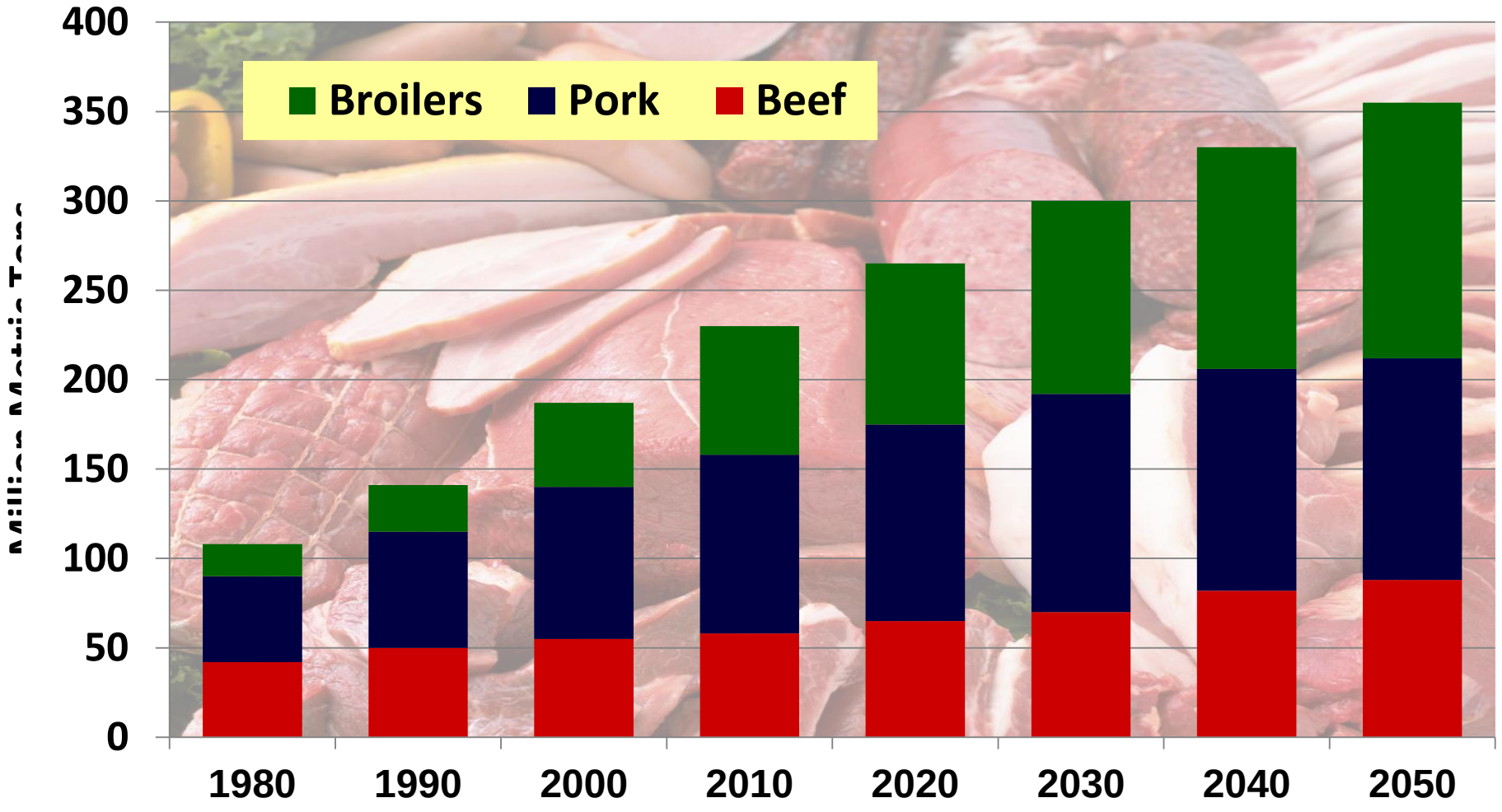
Source: Brookes and Barfoot (2011) GM Crops: Global Socio-Economic and Environmental Impacts 1996-2009. PG Economics, Dorchester UK

Developing Countries have Higher Share of Total Technology Gains as Farm Income (2009)



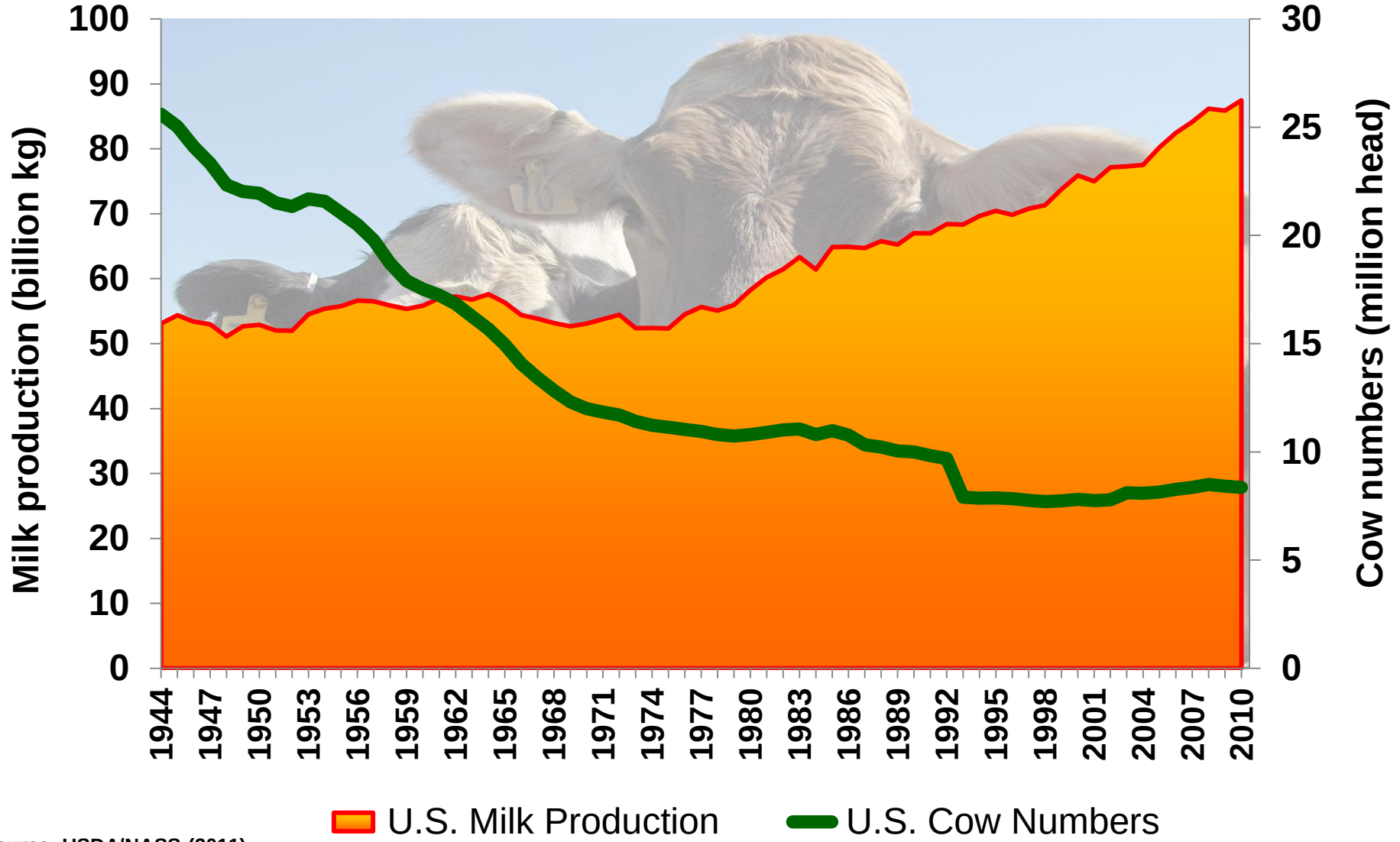
Source: Brookes and Barfoot (2011) GM Crops: Global Socio-Economic and Environmental Impacts 1996-2009. PG Economics, Dorchester UK

World Beef, Pork and Poultry Consumption: 1980 - 2050



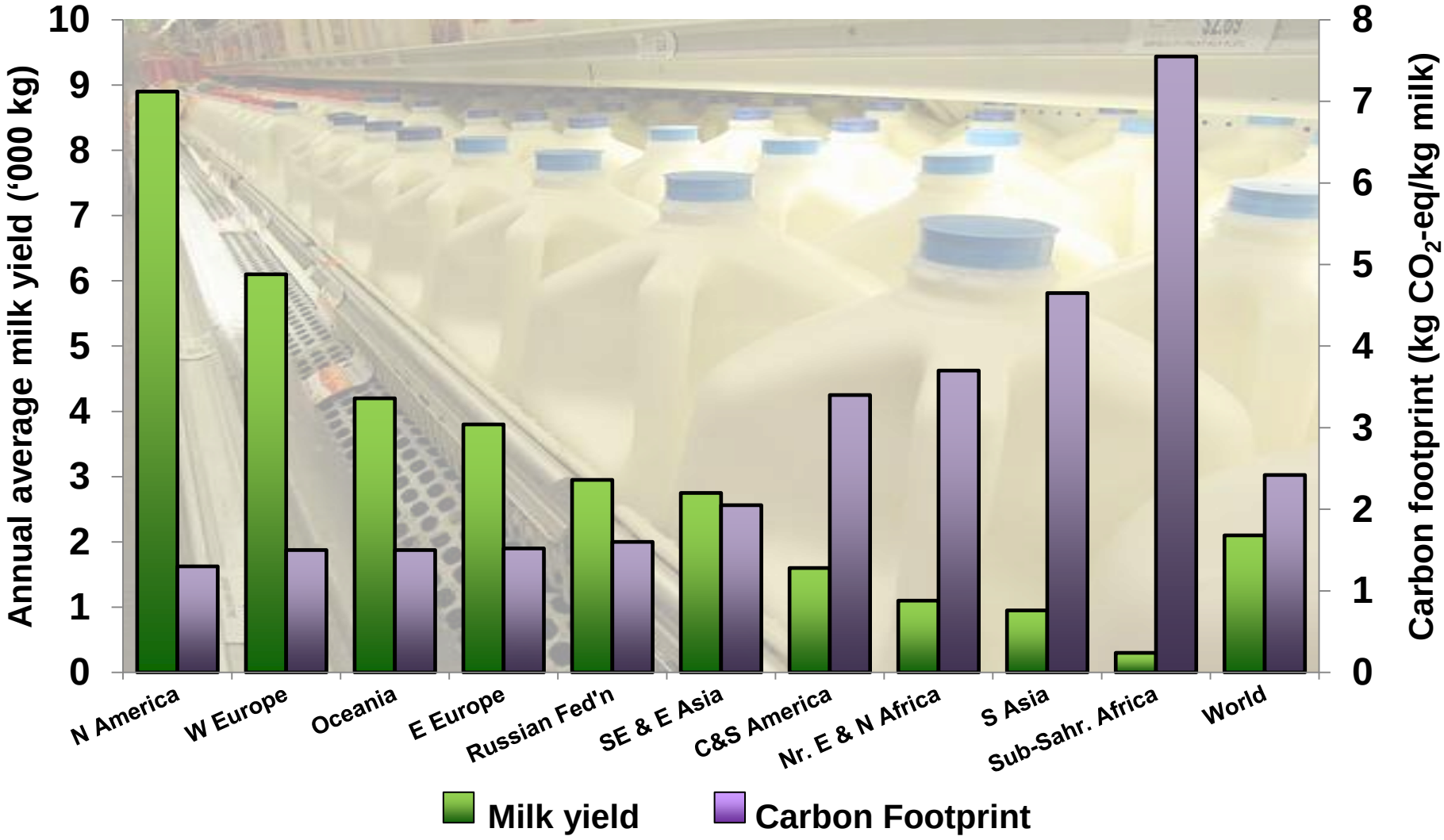
Sources: Global Insight Demand Analysis to 2050

Improved Efficiency Allows More Milk to be Produced Using Fewer Cows



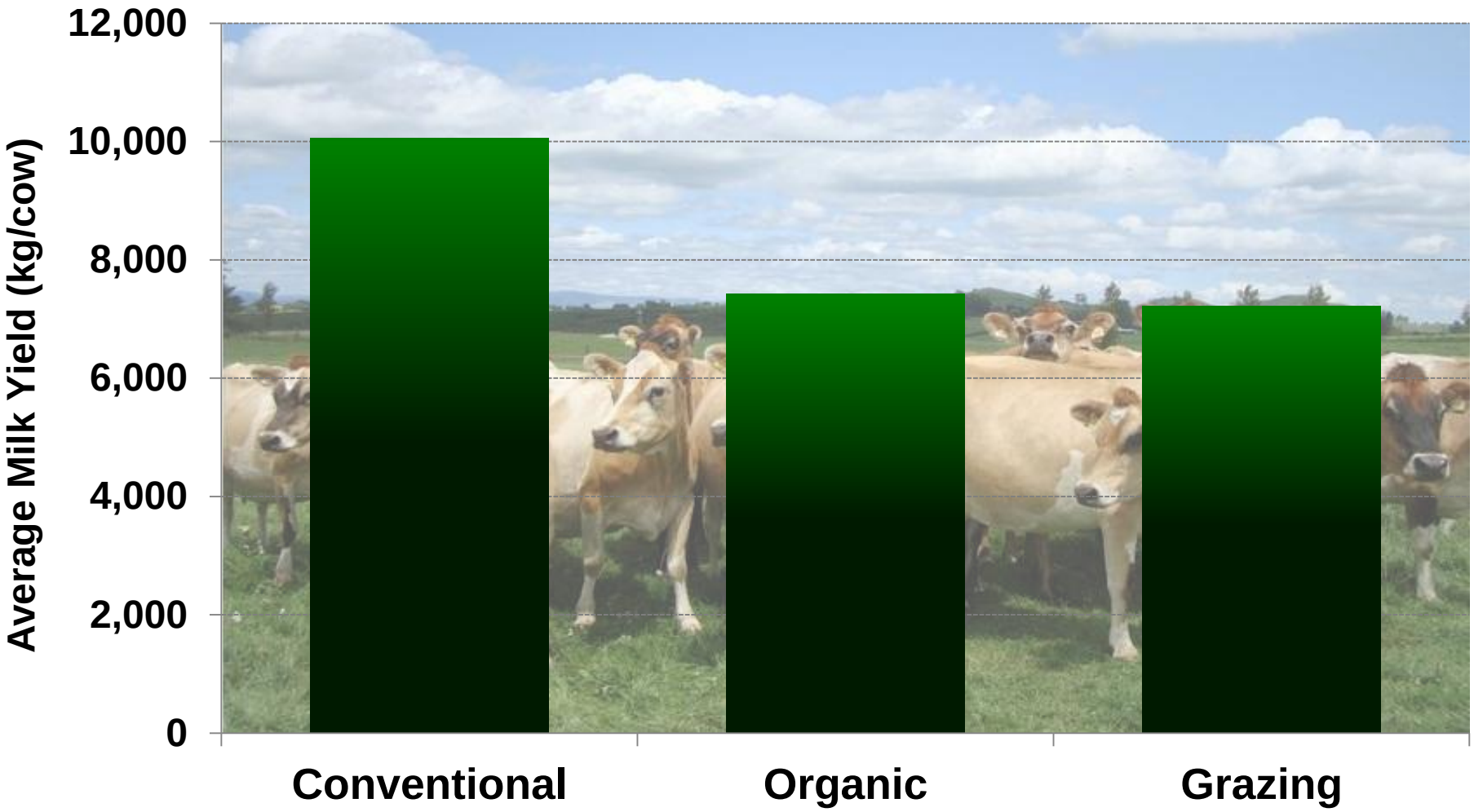
Source: USDA/NASS (2011)

Globally, Carbon Footprint per kg Milk is Correlated with Milk Yield



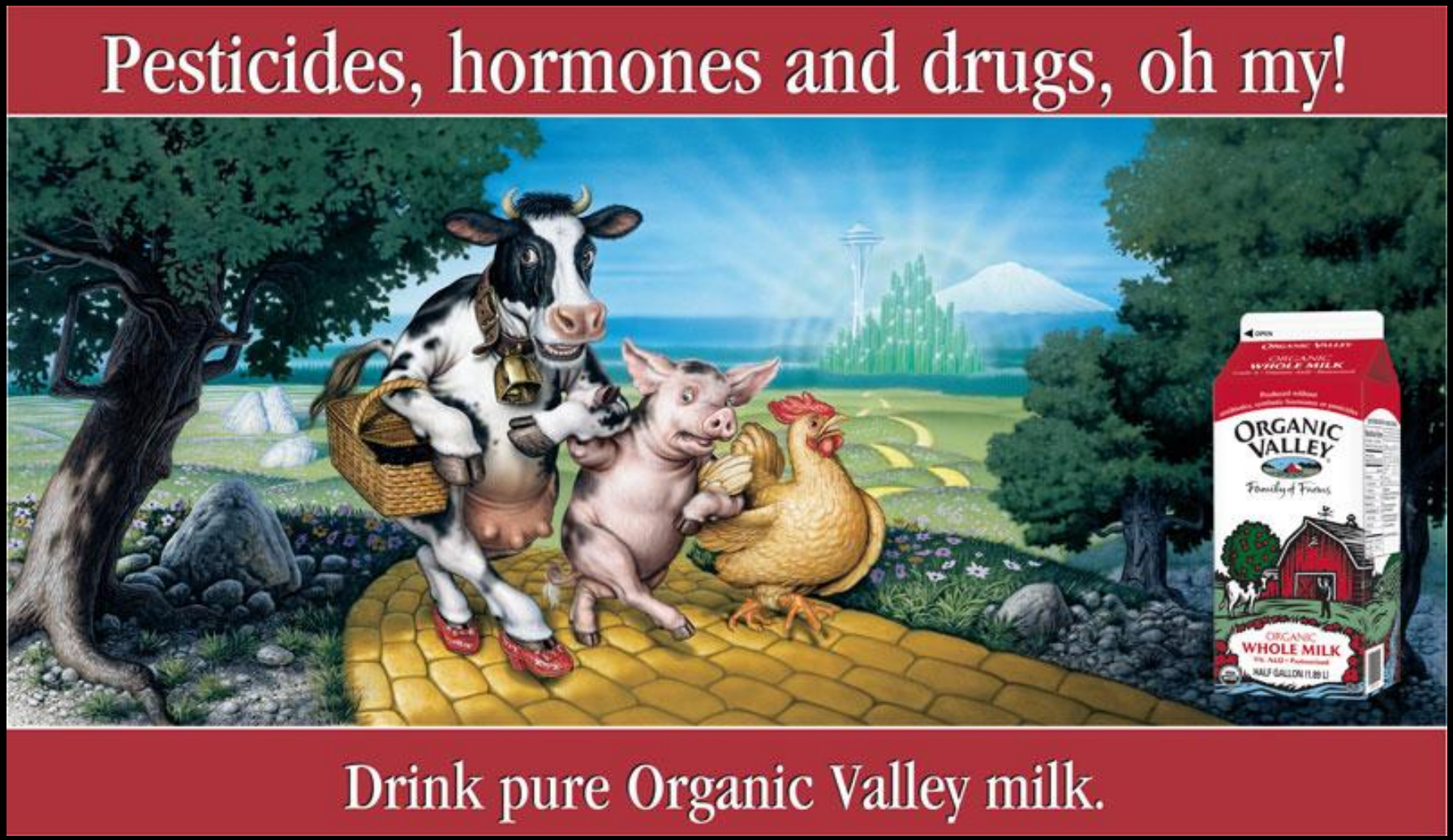
Source: Adapted from FAO (2010) Greenhouse Gas Emissions from the Dairy Sector: A Life Cycle Assessment

Milk Yields are Higher in Conventional Systems than Alternative Systems



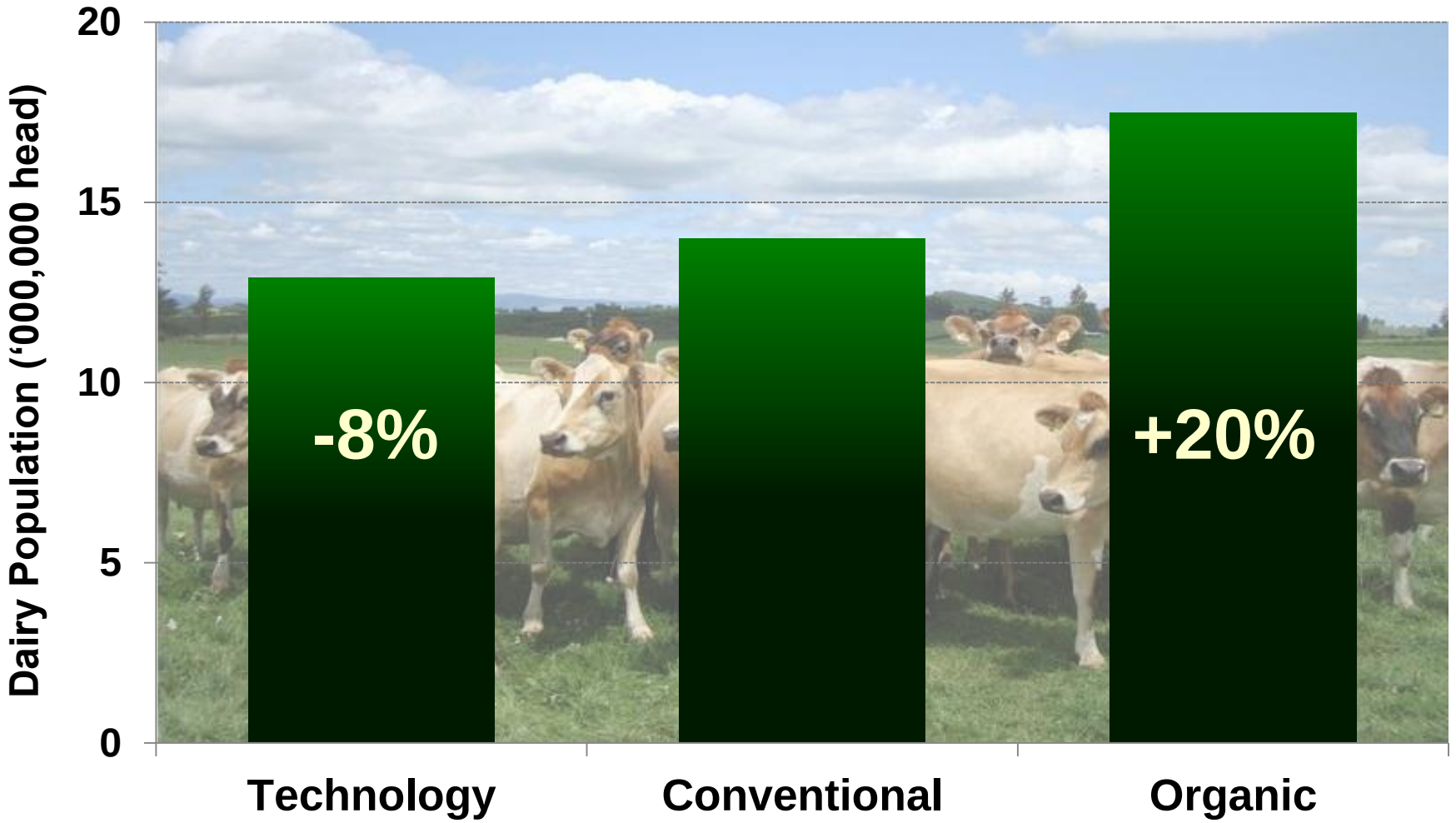
Source: USDA APHIS (2007) NAHMS Dairy 2007 Pt 1.

Conventional Agriculture is Often Demonized by the Organic Industry



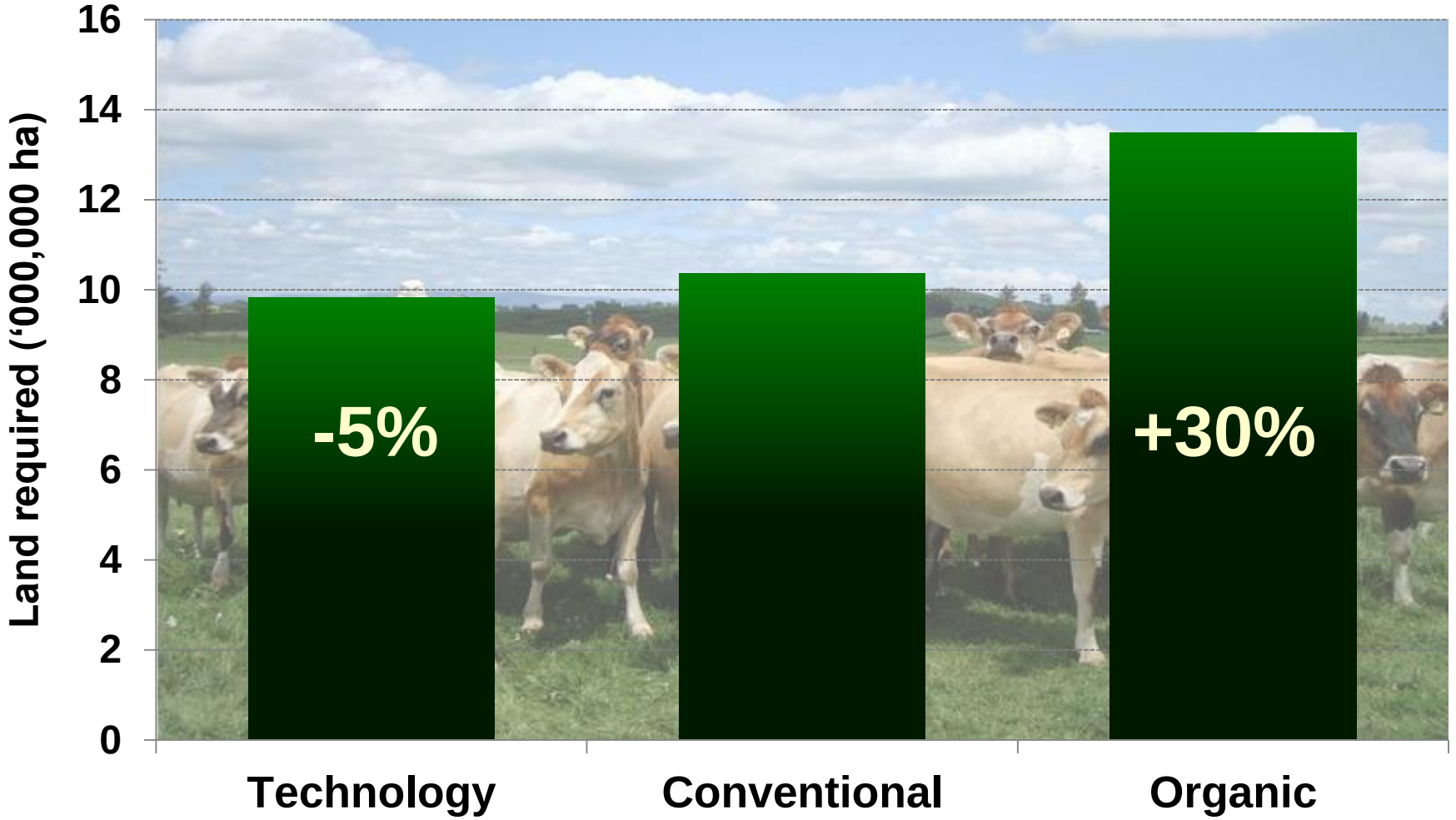
Source: Organic Valley (2010) http://www.organicvalley.coop/trade/retail/retail-resources/national-posters/pesticides-hormones-and-drugs-oh-my
Last accessed June 22, 2010

Future U.S. Demand for Dairy Products Best Met via Improved Productivity



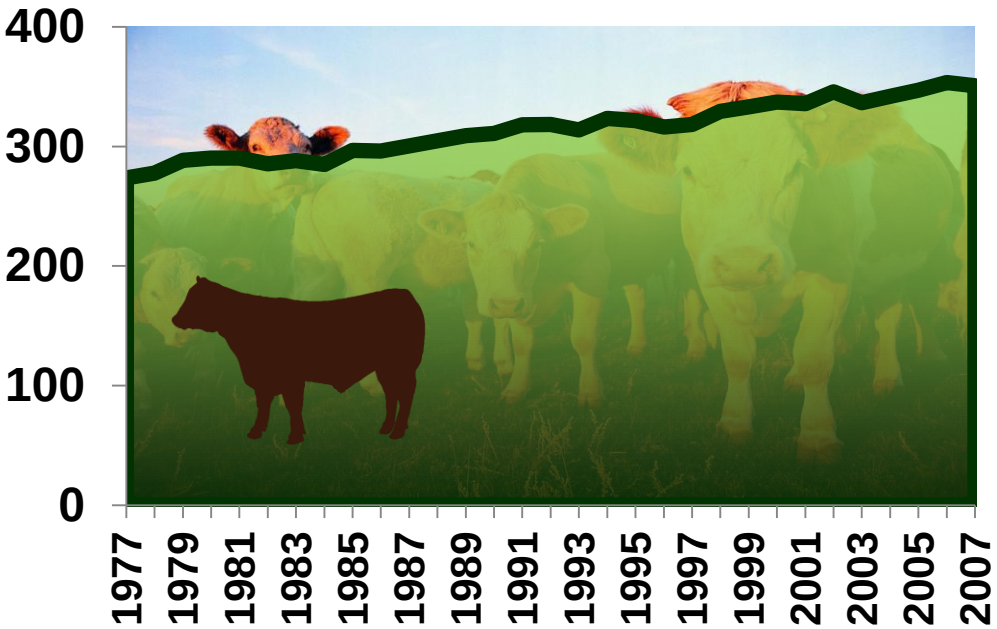
Source: Adapted from Capper et. al. (2008), PNAS

Future US Demand for Dairy Products Best Met via Improved Productivity



Source: Adapted from Capper et. al. (2008), PNAS

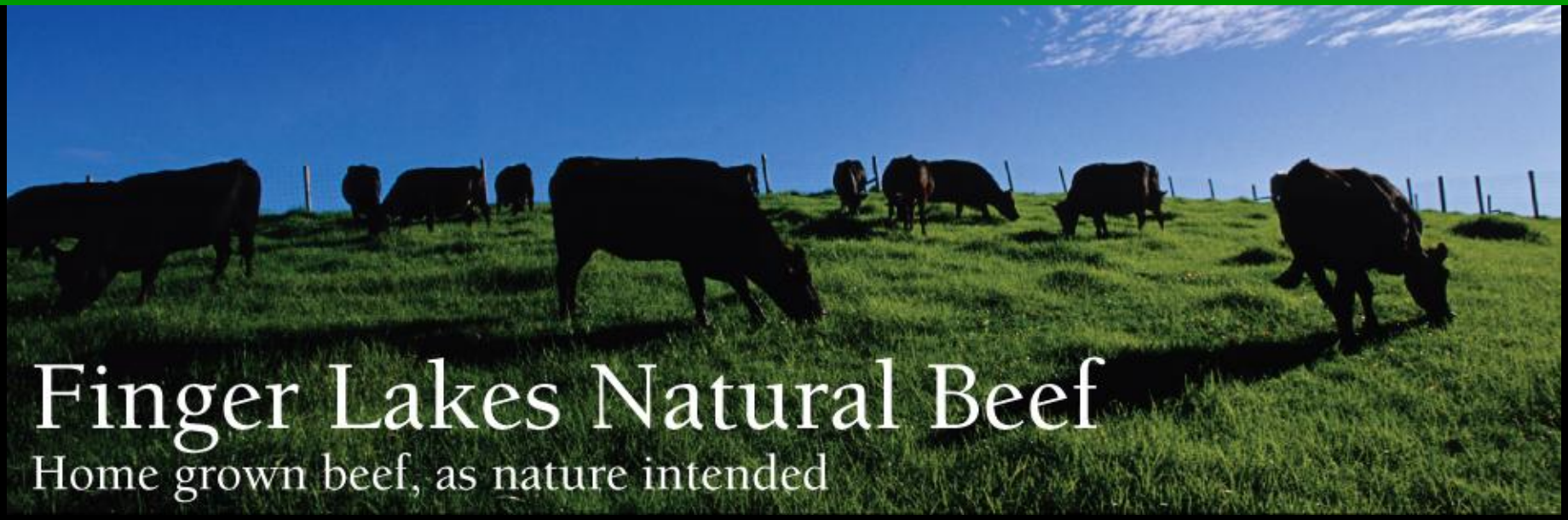
Livestock Productivity Ceilings Have Not Yet Been Reached



- **Record-Producing Cow (2010): 32,726 kg/365 d**
- **Beef yield/animal increased 31% 1977-2007**
- **Beef growth rate increased 61% 1977-2007**

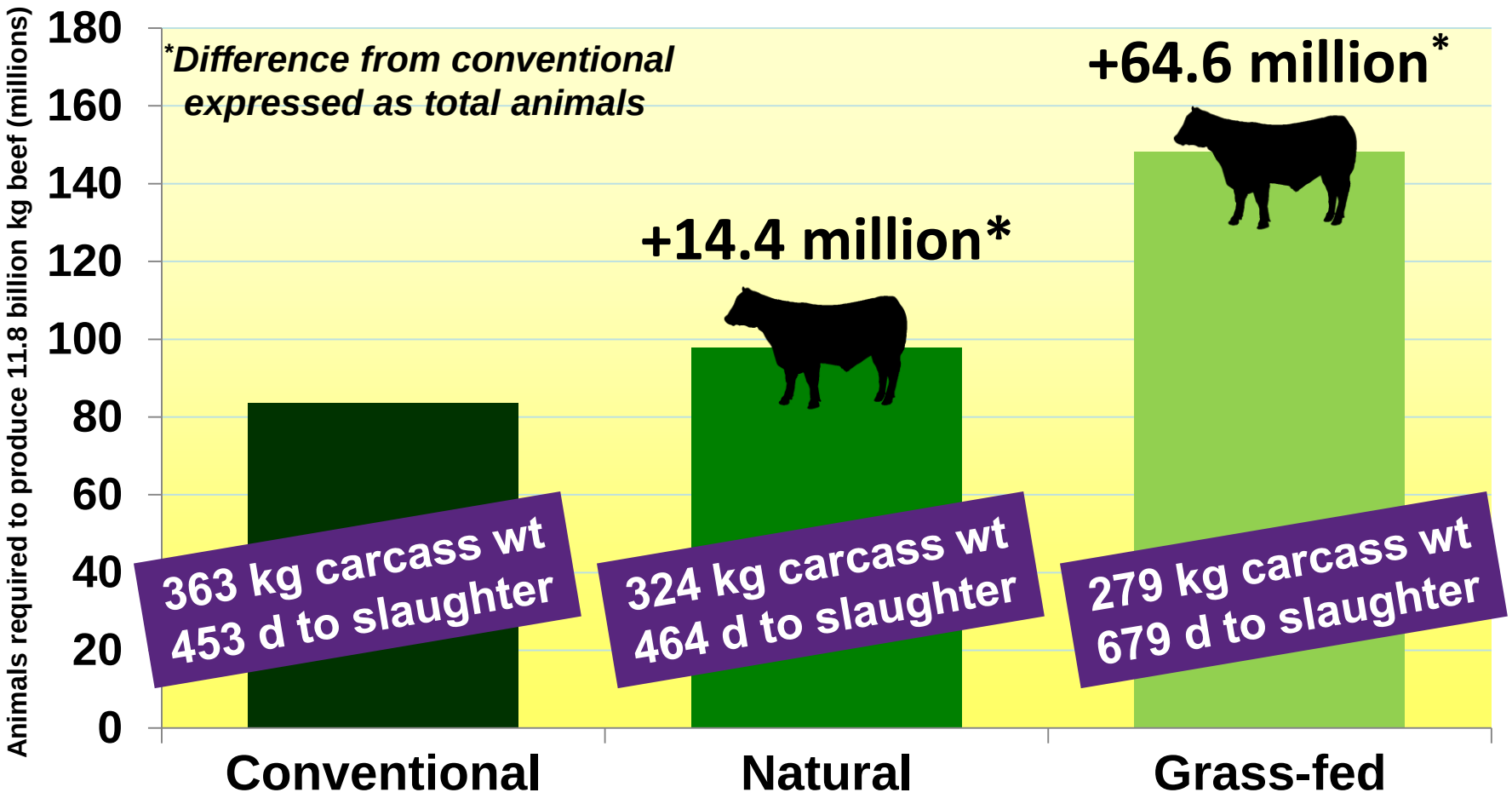
Source: USDA-NASS (2009) http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/ Last accessed, 9/15/09

“Natural” and “Grass-fed” Beef is Marketed as a Sustainable Alternative to Conventional Production



Source: http://www.fingerlakesnaturalbeef.com/storage/homeHeader.png and http://www.a7ranche.com/wp-content/header-images/banner_alberta_beef.jpg

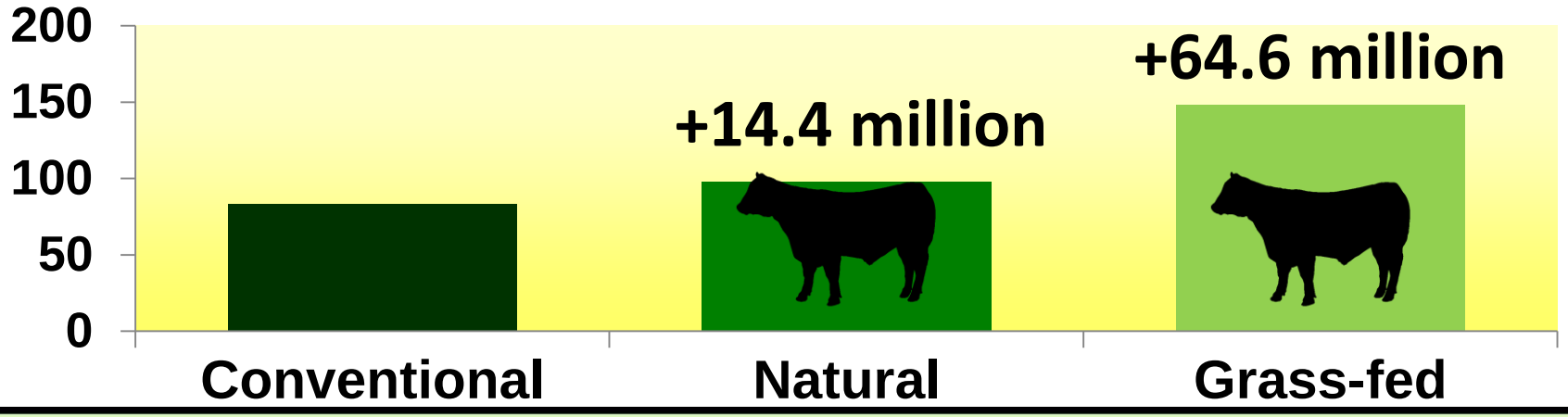
Removing Technology from Beef Production Considerably Increases Animal Numbers



*Animal refers to cows, calves, heifers, bulls, stockers and finishing animals

Source: Adapted from Capper , J. L. (2010). The Environmental Impact of Conventional, Natural and Grass-fed Beef Production Systems. Greenhouse Gases and Animal Agriculture Conference, Banff, Canada

Removing Technology from Beef Production Increases Resource Use and GHG Emissions

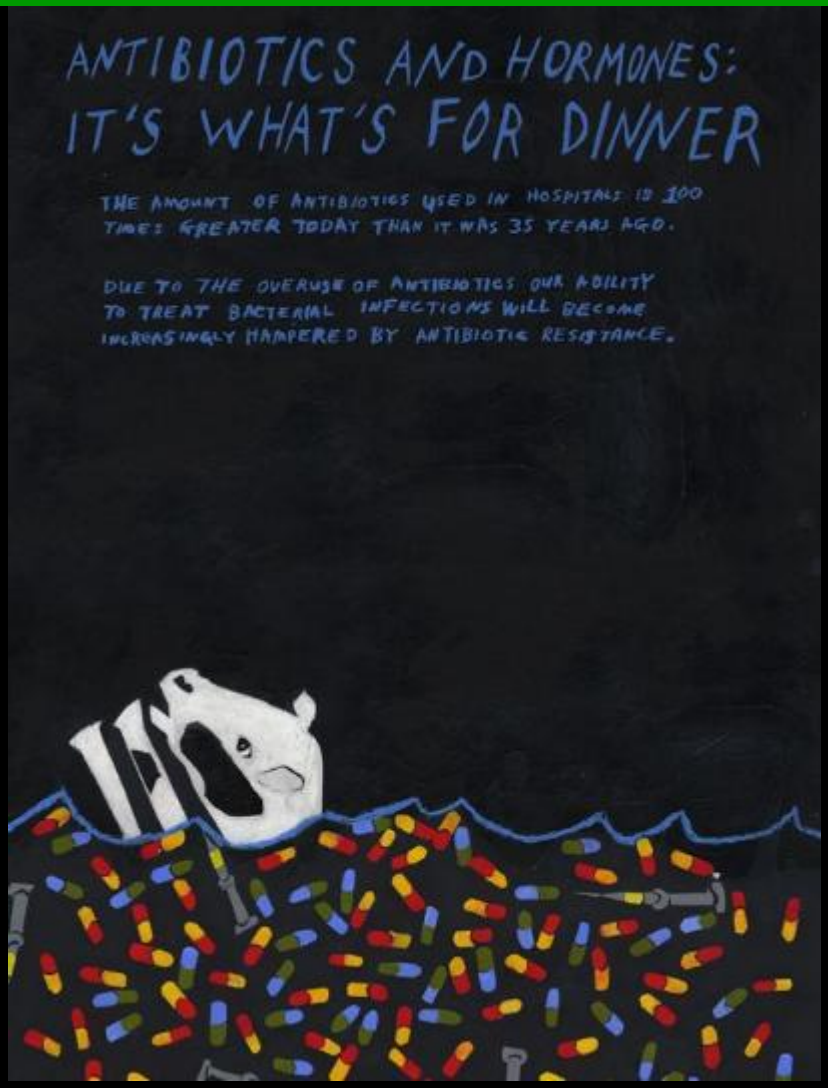


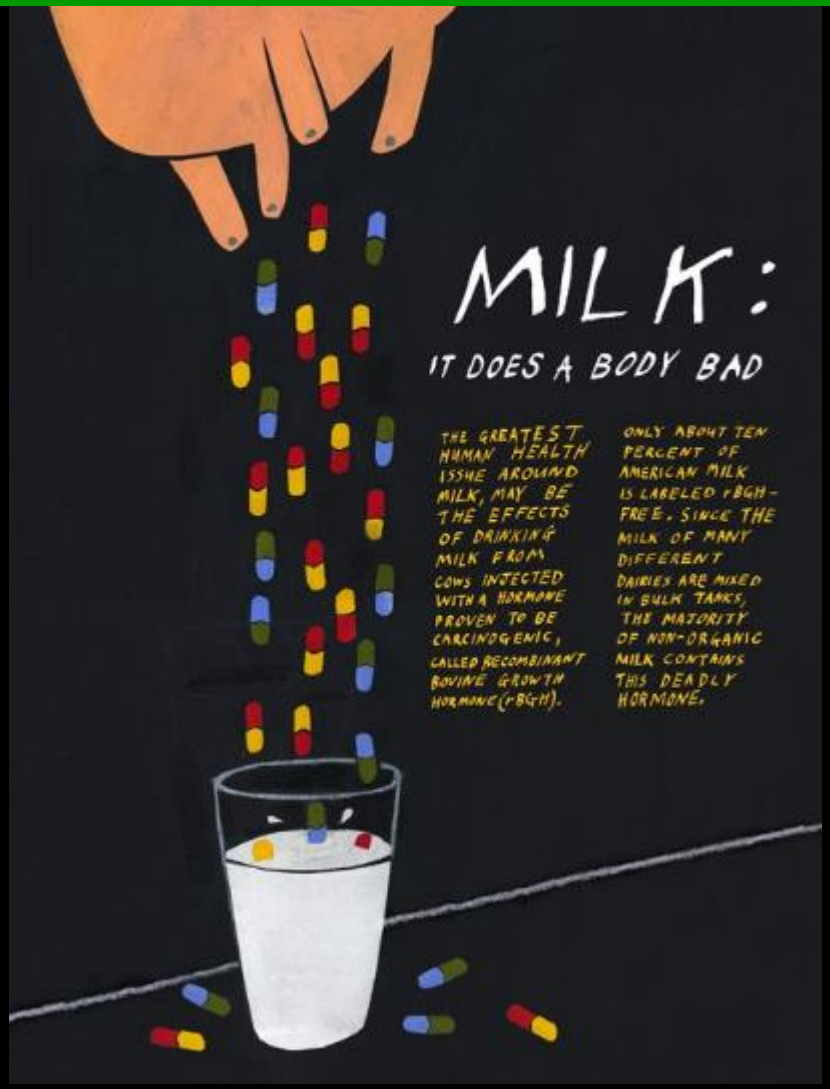
If all U.S. beef was grass-fed, it would increase:

- **Land use by 53.1 million ha = 75% land area of Texas**
- **Water use by 1,773 billion liters**
  - **Equal to annual usage by 53.1 million U.S. households**
- **GHG emissions by 134.5 million t CO_2-eq**
  - **Equal to annual emissions from 26.6 million U.S. cars**

Source: Adapted from Capper , J. L. (2010). The Environmental Impact of Conventional, Natural and Grass-fed Beef Production Systems. Greenhouse Gases and Animal Agriculture Conference, Banff, Canada

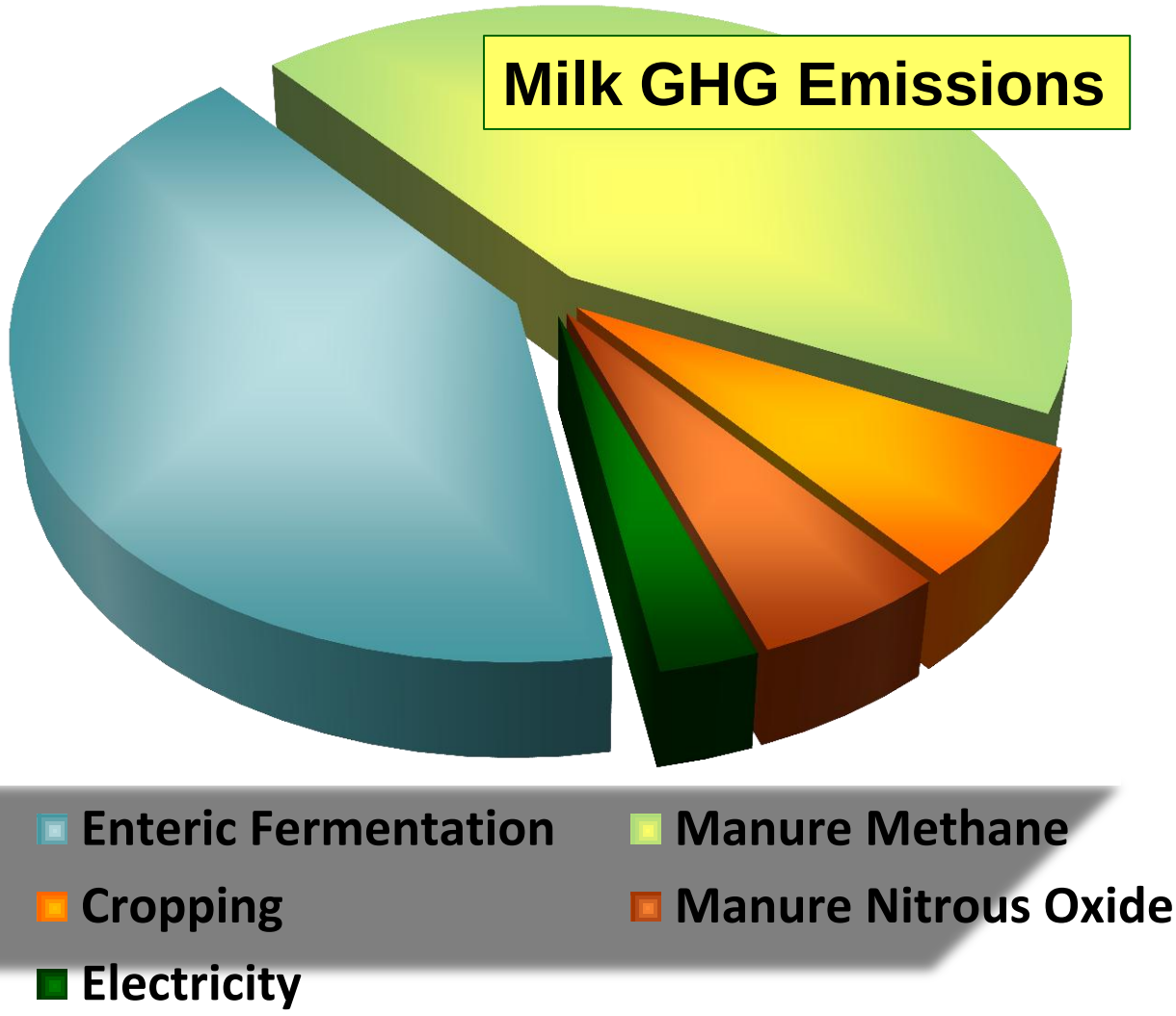
Social Acceptance of Animal Technologies Presents a Huge Challenge





Source:Maggie Suisman http://www.maggiesuisman.com/factory.html Accessed 01/08/2011

Methane Vaccines Show Promise But Are Unlikely to be Available in the Near Future



- Enteric methane comprises 42% of GHG emissions (CO_2-eq)
- Vaccines against methanogenic bacteria show promise
- Barriers:
  - Cost
  - Application
  - Lag time

Source: Created by Jude Capper, Washington State University Based on full LCA of Holstein milk production

Transgenic Animal Opportunities Dependent on Economics and Social Acceptance

Source: http://www.commonground.ca/iss/227/pics/enviropig.jpg **and** http://www.anunews.net/blog/wp-content/uploads/2010/09/aa-cloned-food.jpg

Consumer Perception of the Extent of Transgenic Animal Use may be Inflated

"Genetically modified corn and soybeans, cloned animals, McNuggets — none of these technological marvels existed in 1970… <*food elitism issues*> may be irritating. But they generally don't sicken or kill people. And our current industrial food system does."
- Eric Schlosser, Washington Post

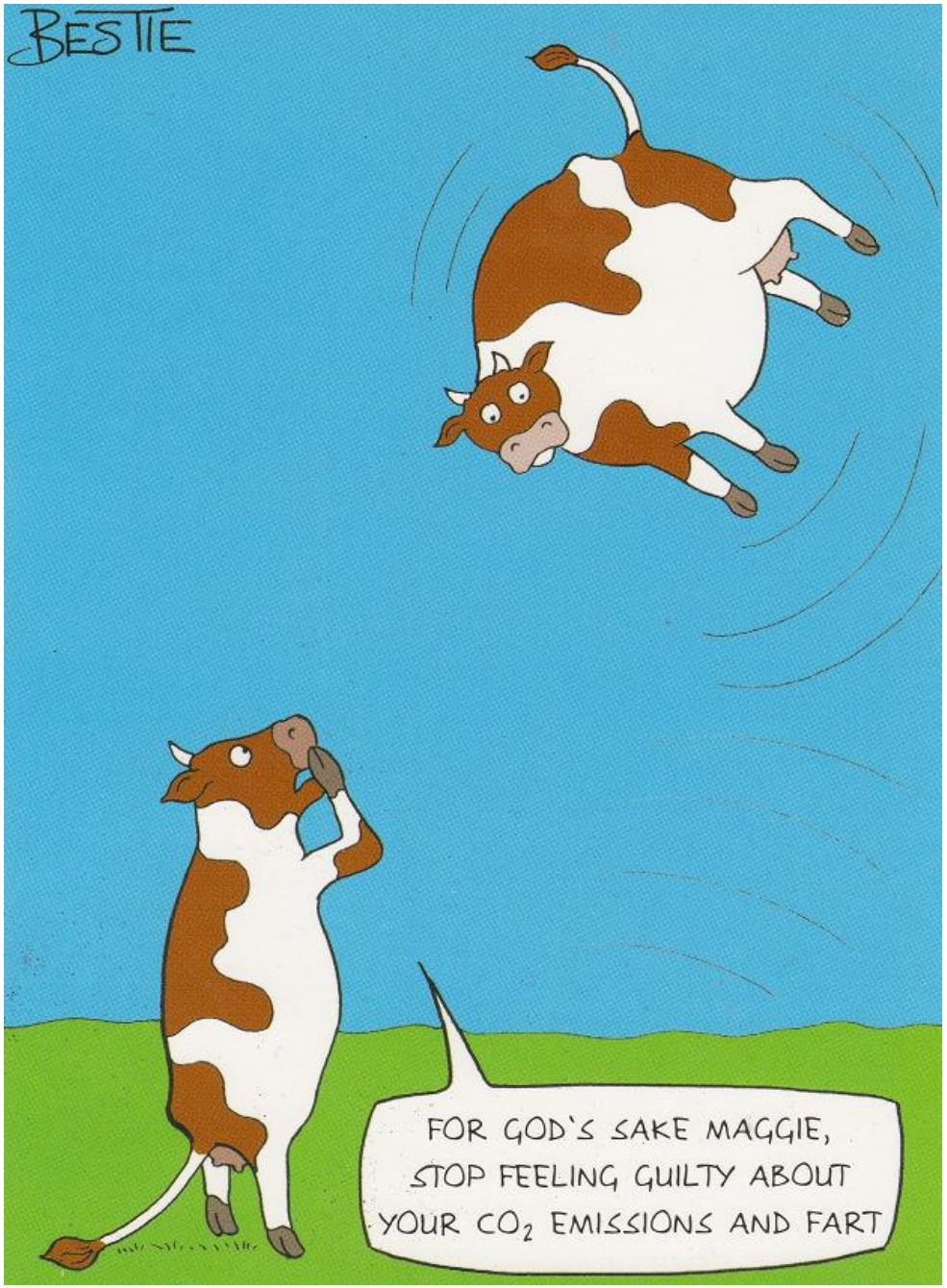
"600 cloned cattle exist in the USA and 120 in Europe
- Then & Tippe, Testbiotech report

Sources: Schlosser (2010) Why Being a Foodies Isn't Elitist. Washington Post 4/29/2011; Then, C. and R. Tippe (2010) Cloned farm animals - a 'killing application'? Risks and consequences of the introduction of cloned animals for food production. Testbiotech Report prepared for Martin Hȁusling MEP

Source: Alexis Rockman “The Farm”

Conclusions

- ✓ **Improving productivity is essential to meet the nutritional needs of the growing global population**
- ✓ **Crop and animal biotechnologies offer opportunities to improve productivity and reduce environmental impact**
- ✓ **Organic approaches gain consumer trust but have negative effects on productivity and resource use**
- ✓ **Overcoming social acceptability issues will be key to increasing productivity through biotechnology**



Thank you!

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