How much biofuel can we produce in the world?

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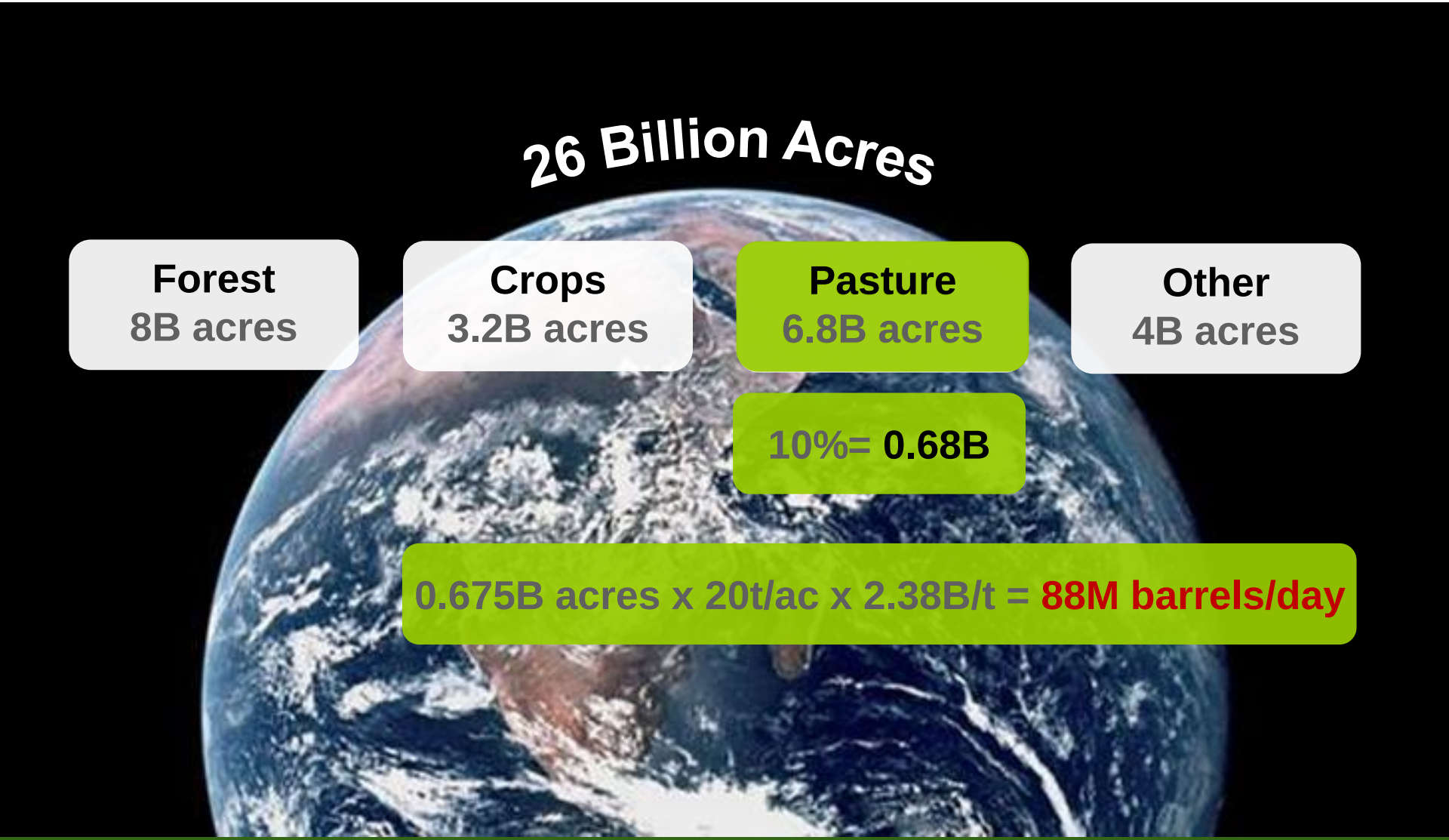
Enough Land For Biomass for Bioenergy?



Source: FAO Stat database

Amounts of bioenergy that will be produced in the world?

- The amounts of feedstock and thus the amounts of bioenergy created will depend on not the potential—how much land etc. -- but how much of this is realized

- Realization depends on the successful creation of *economically sound, stable and sustainable* production chains
  - Like exists in Brazil for ethanol from sugarcane

Production value chains are complex and multifactoral

Biofuels Value Chain

- **Project Scale**
- **Biomass sources**

- **Agronomic system**
- **Harvest, & transportation**

- **Densification**
- **Storage**
- **Upgrading**

- **Pipeline (?)**
- **Truck/Rail**
- **Barge**

- **Emerging technologies for "Drop-in Fuels or chemicals"**

- **Market potential**
- **Oil price**
- **Mandates/Incentives**

Biomass availability and potential is important, but viability will depend on economic competitiveness with entrenched products

Key economic features of production chains

- Costs of individual components?
- Potential savings from combining technologies and systems?
- Will the product sell in the market at an acceptble price?
- Does the revenue potential, excluding/including incentives provide profitable rewards to all parts of the system?

Key factors governing successful production chains

- Economics
- Government Policies
- Feedstock costs -genetics, agronomy, environment
- Overall product costs relative to competing fuels

Joining both ends of the production chain

- Dilemma: Farmers will not grow crops without right biorefinery contracts but biorefineries cannot be built without guaranteed long-term feedstock supplies

- Builders of biorefineries worry about:
  - Investment capital for building biorefineries
  - Land prices—marginal is cheaper usually
  - Feedstock production yields and costs

Government policies are crucial

- Bioenergy targets and general policies
- Subsidies and incentives
- Loan guarantees to help stimulate businesses
- Land prices
- Net energy efficiency requirement legislation-life cycle analyses, greenhouse gas economics

INTERNATIONAL ALIGNMENTS IN LEGISLATION AND TRADE AGREEMENTS

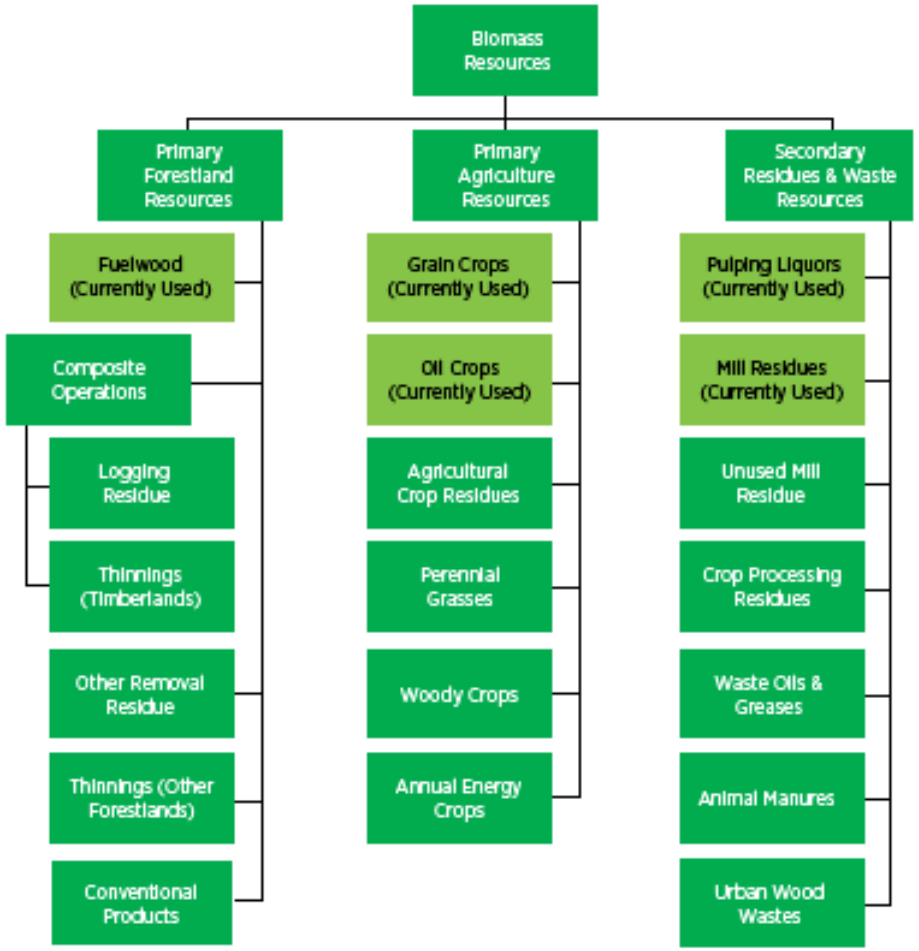
The new US DOE Assessment of biomass potential

- The US Department of Energy new Billion Ton Report is one of the best efforts to assess the amounts of biomass likely to be produced in the US over the coming 20 years

  - Assuming production chains can be set up readily turning lignocellulose into fuels and other biproducts

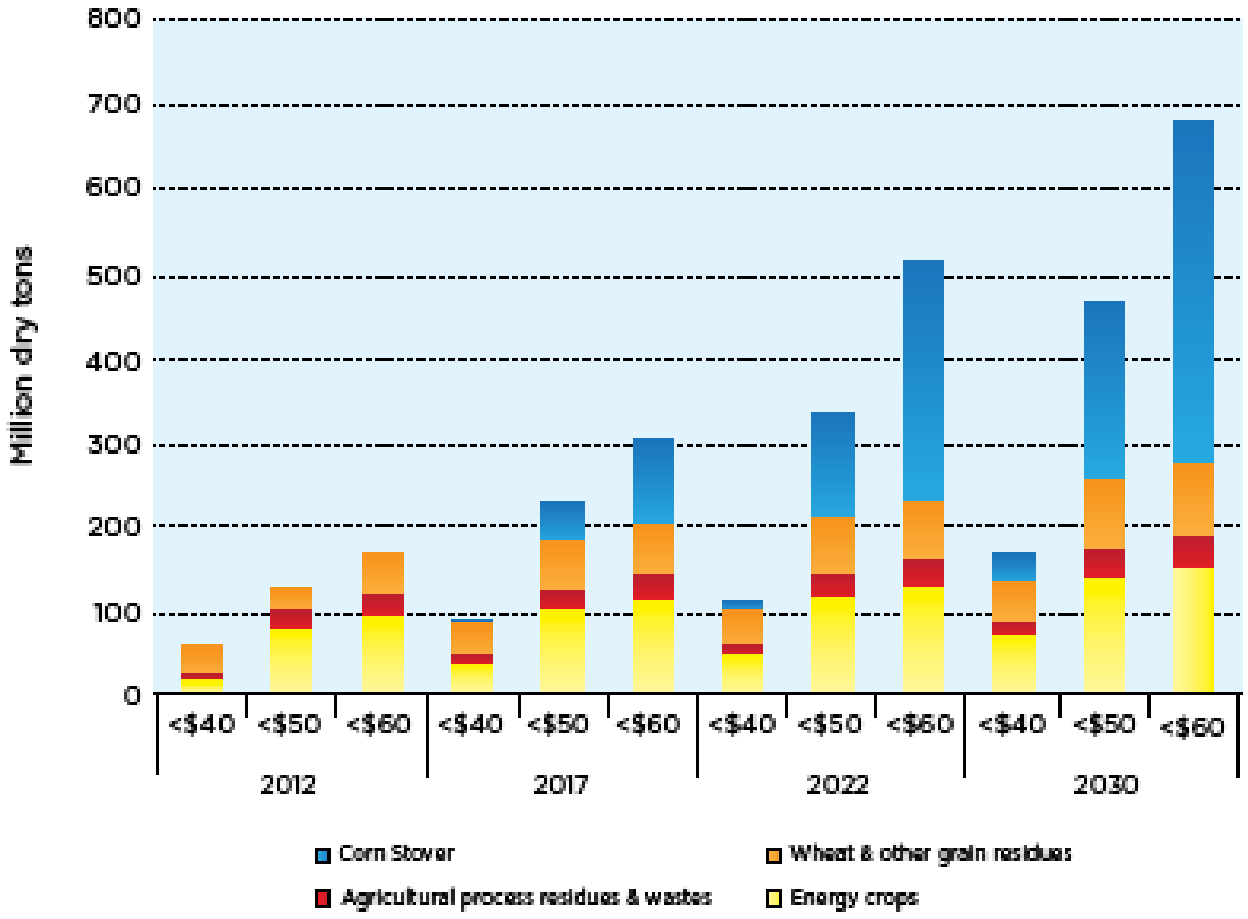
There are many sources of biomass if we can convert lignocellulose into bioenergy/biofuels

Biomass resources considered in the update to the 2005 *BTS*



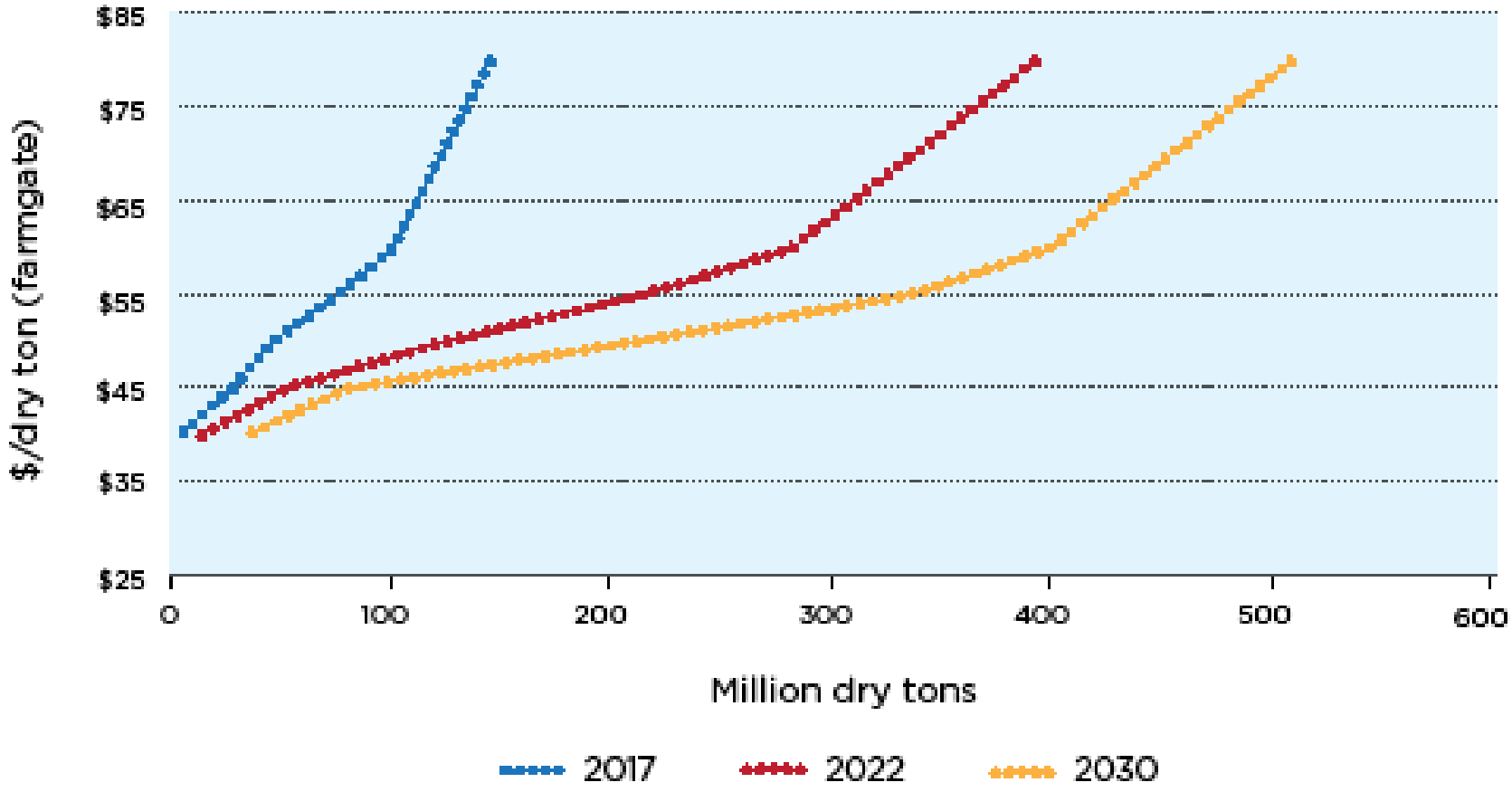
“Biomass produced depends on price—more than yield rates”

Figure ES.2 Estimated agricultural biomass under baseline assumptions

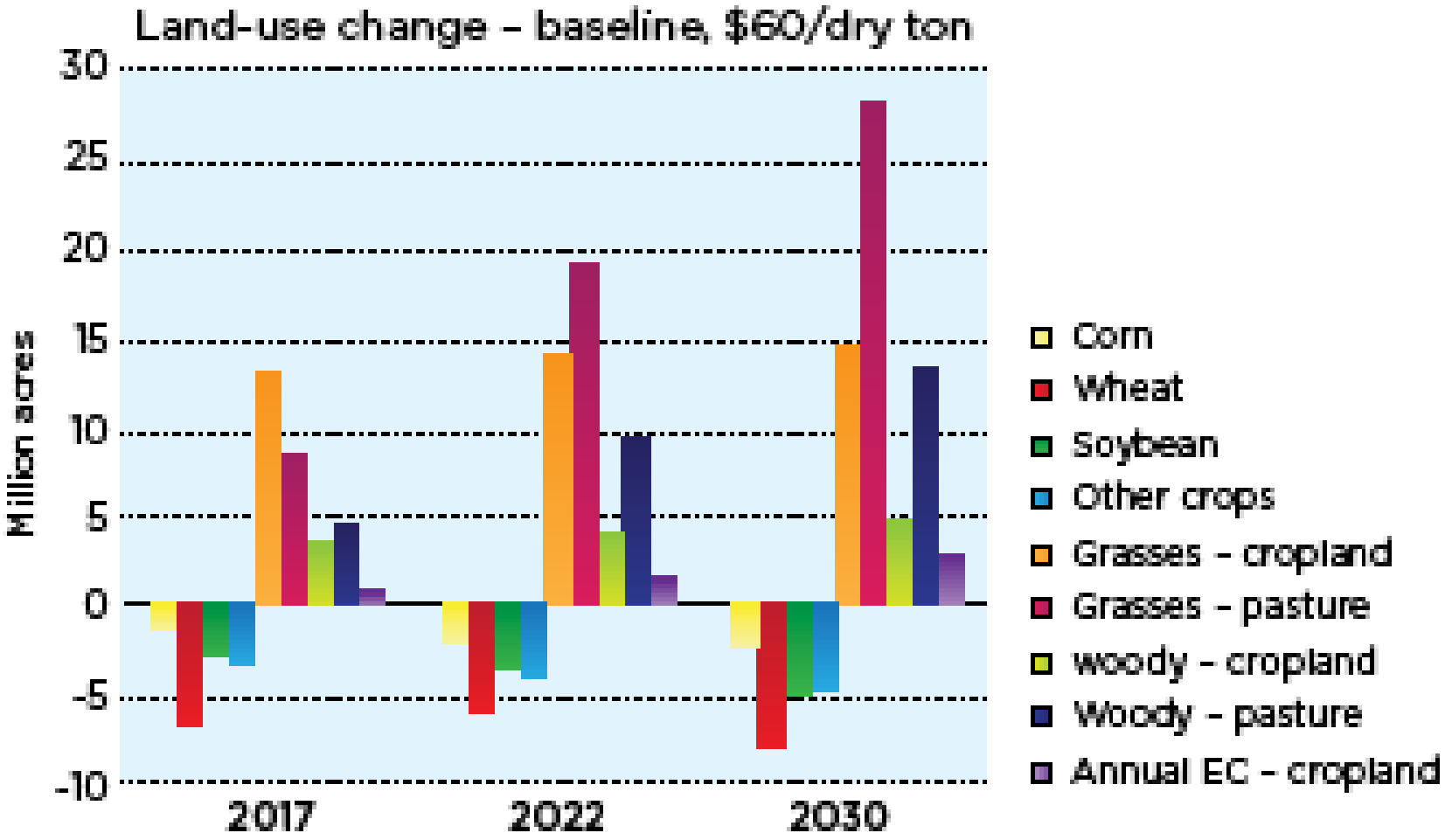


Feedstock prices are critical

Figure 5.17 Supply curves for all energy crops at selected years in baseline scenario

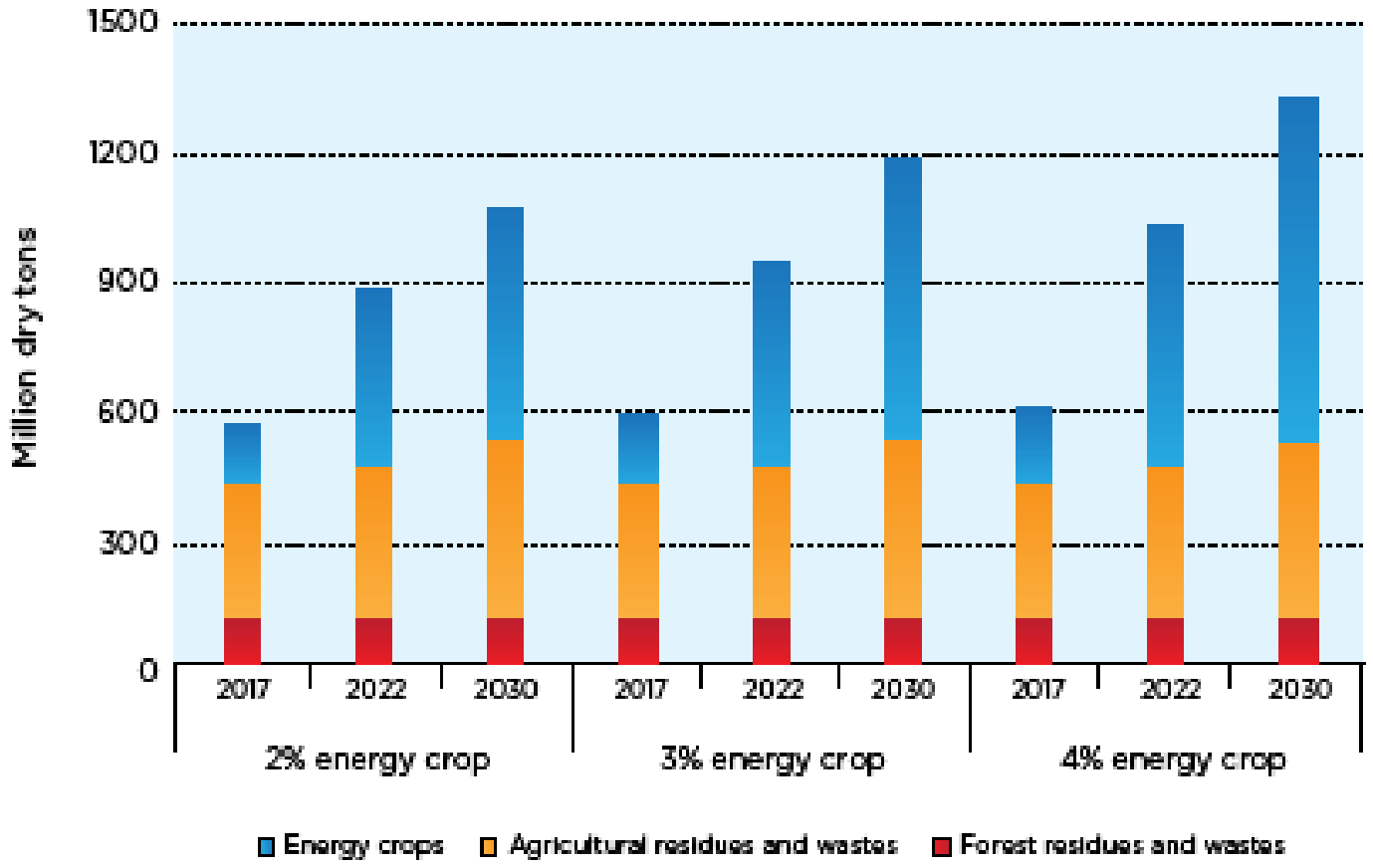


There will always be many consequences that have to be acceptable



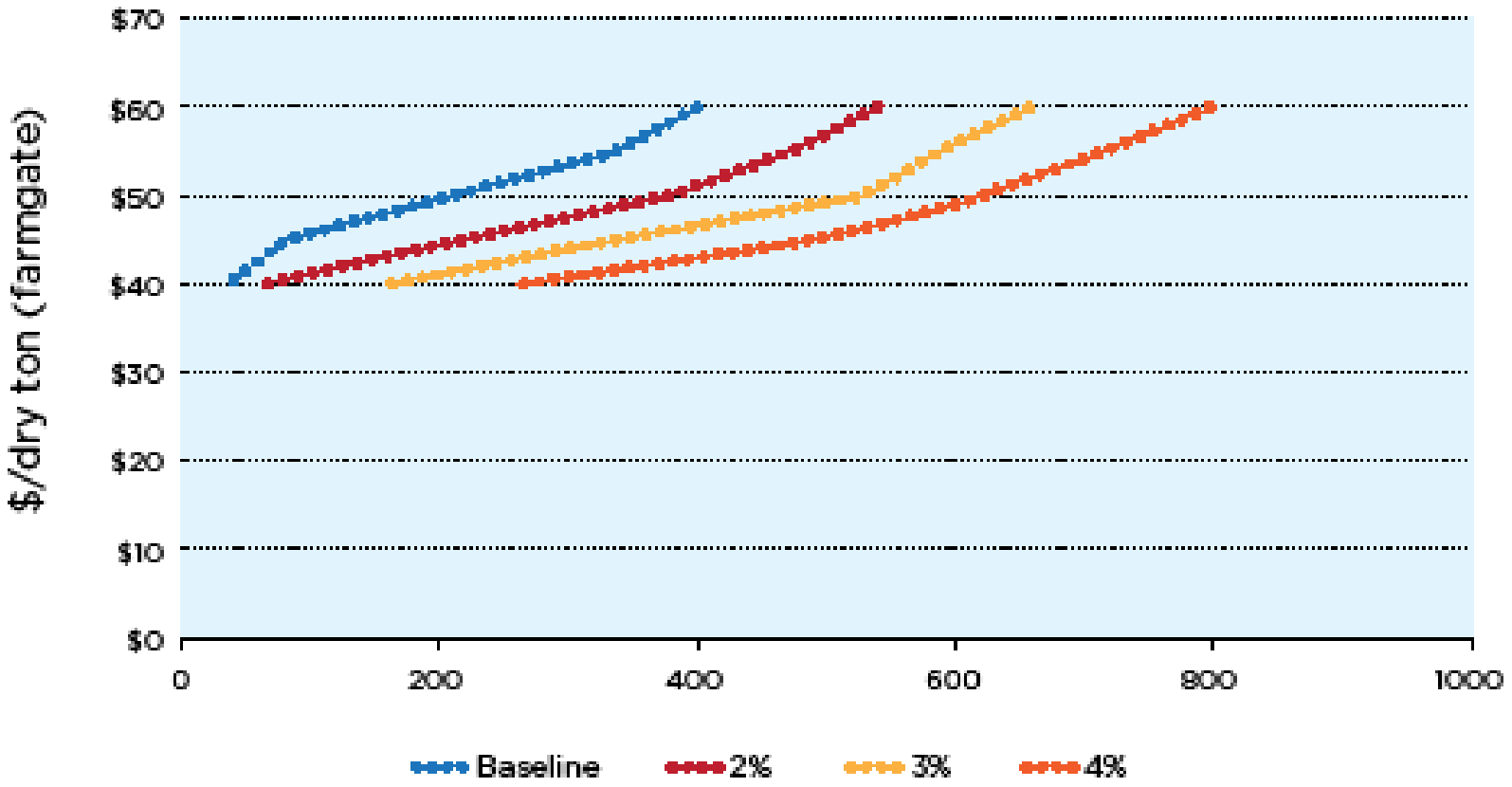
Improvements in production technology should make better economics

Figure ES.3 Estimated forest and agricultural biomass availability at $60 per dry ton or less under high-yield assumptions

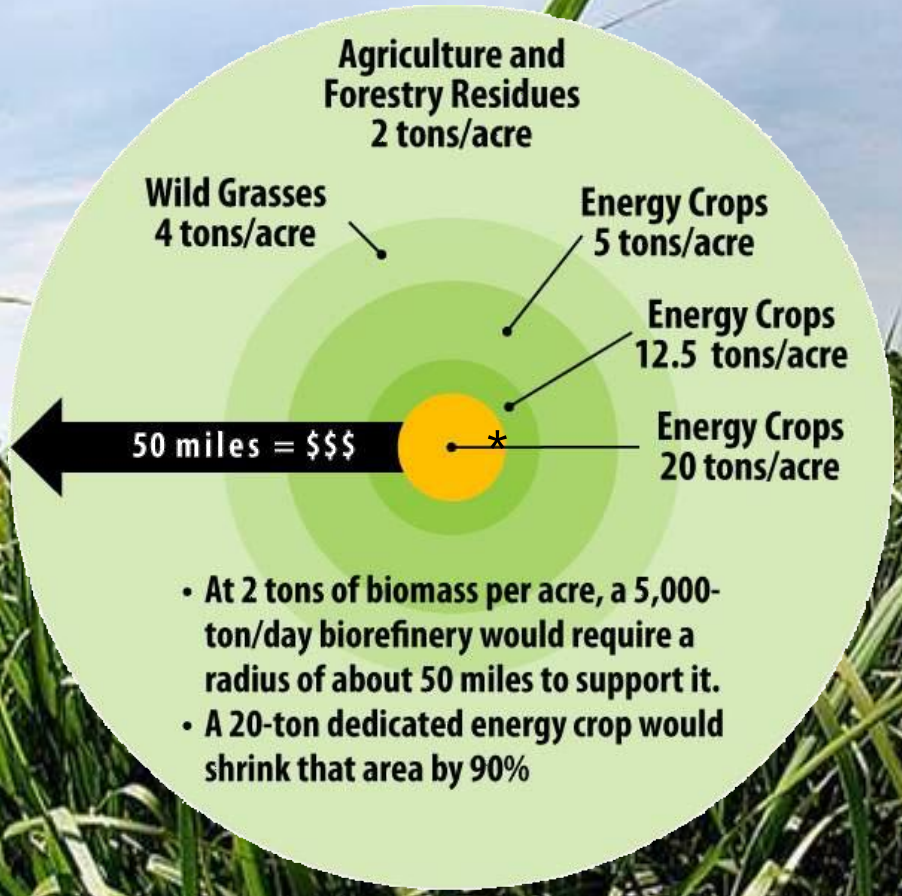


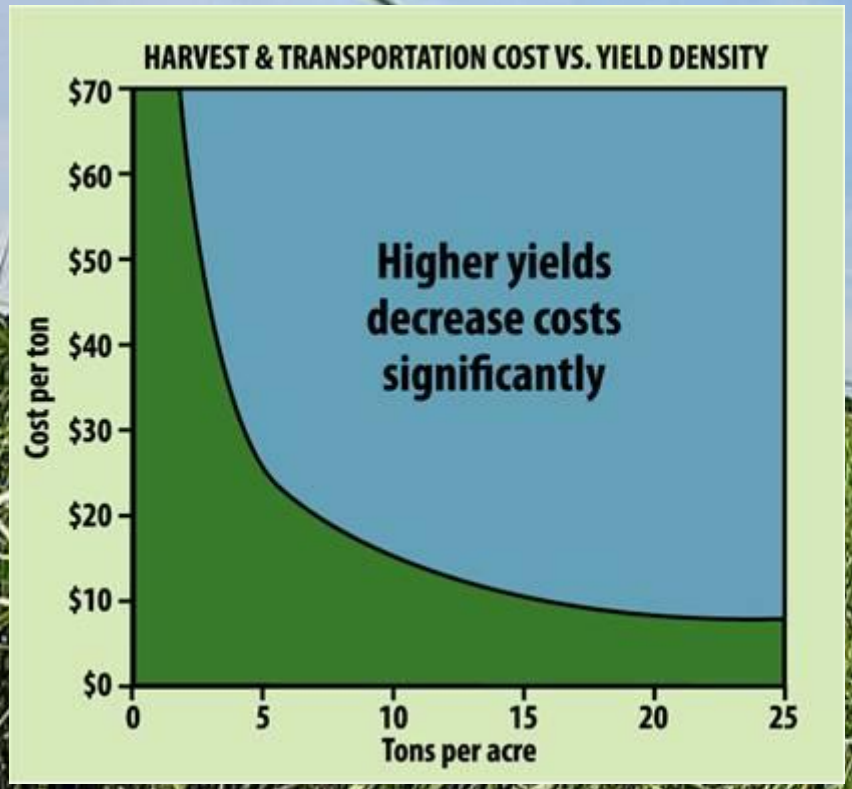
Effects of improvements in yield

Figure 5.20 Year 2030 energy crop production under baseline and 2% to 4% annual growth in energy crop yield



Biomass Yield Matters





* graphic not to scale

Increased yields enable:

- Land savings—more for other uses
- More sustainable production chains
- Faster profitability
- Savings in energy inputs
- Fewer farmers to convince
- Better crop rotation strategies
- Less infrastructure (roads)
- Better year round supply
- Ability to use cheaper land

Improving Yields by Breeding

Ceres Energy Crops

Switchgrass

- Wide Adaptation
- Low Input
- Perennial
- Seed Establishment

High Biomass Sorghum

- Yield
- Adaptation
- Production System
- Low Water Usage

Miscanthus & Energycane

- Yield
- Low Input
- Perennial

Sweet Sorghum

- High Free Sugar & Biomass yields
- Low Input
- Uses Existing Refining Systems

Improving yields by plant breeding and agronomy

Nitrogen Use Efficiency Transgenes

ARPA-E 2009 Awardee

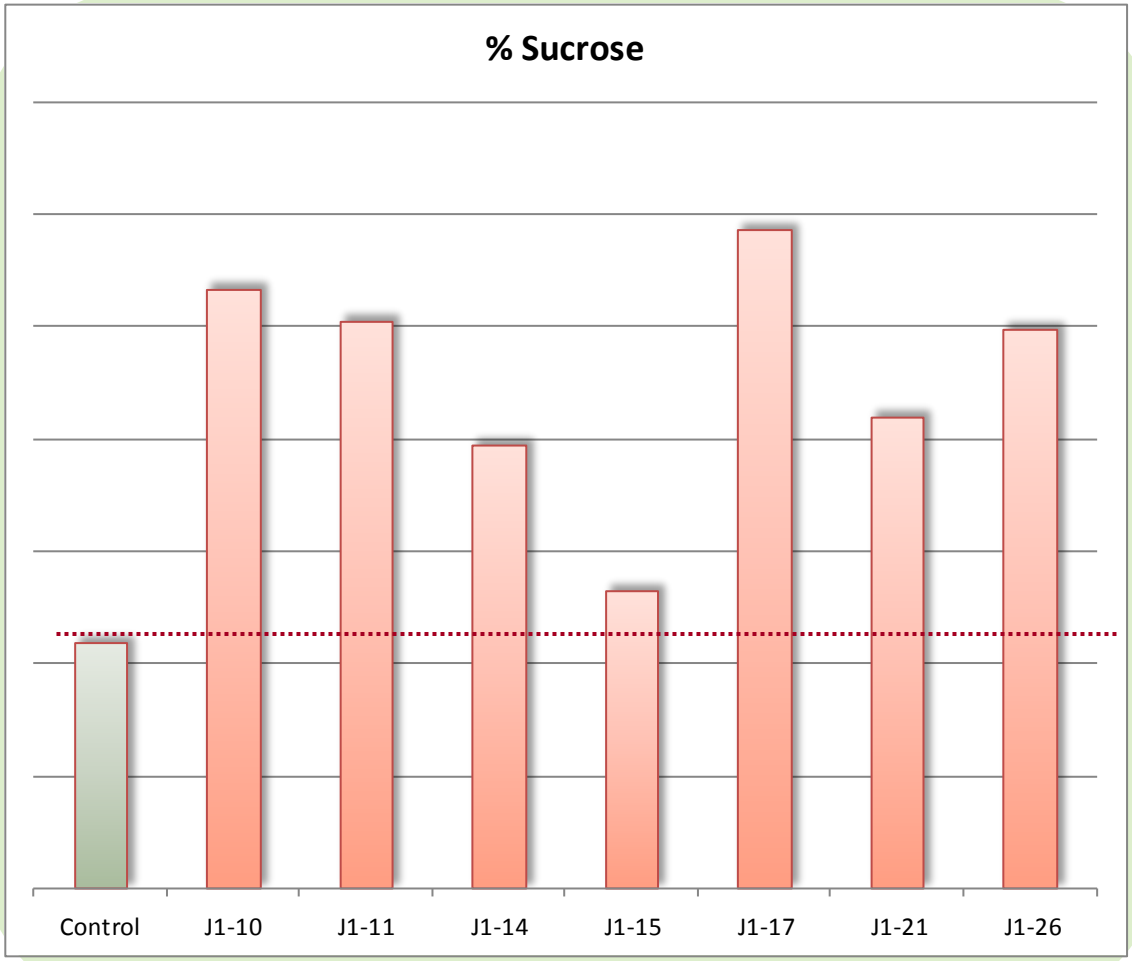
Water Use Efficiency Transgenes

Salt-Tolerance Transgenes

Decaying Roots

Healthy Roots

Soluble Sugar Increase Transgenes



- J1 enhances sucrose accumulation in multiple species

Driving feedstock production up and costs down……..

C4 Grasses
Marker-Assisted Breeding

Low Fertilizer
Drought Tolerance
Salt Tolerance

Improved Conversion

High Yields ~20 Tons/ Acre

Marginal "low rent" land

Reduced refining costs

Low capital costs

What determines how much biofuel we can make?

- How many production chains are profitable and sustainable
- Government policies, oil prices, national and international legislation
- Making lignocellulosic conversion to biofuels profitable
- Feedstock production costs

Yield improvements in existing and new bioenergy crops are happening and will open up new opportunities to grow more biofuels

ceres

END