Requirements of Feasible Biofuel

- Time frame: 2012, 2017?
- Doesn’t compete with food supply
  - Non-food crop, non-food component of food crop, MSW
  - Marginal land or existing degraded crop land
- Has neutral or positive environmental impact
  - Less GHG emissions relative to petroleum-based jet fuel
  - Maintains soil and water quality, protects wildlife and biodiversity
- Cost-reasonable, vs cost-competitive
  - Incorporates security value of domestic fuel source and increasing costs and insecurity of imported oil
- Meets 50% of airforce jet fuel needs
  - 1.2 bg/y (of 2.4 bg/y total) airforce; 13 bg/y total domestic commercial aviation longer-term
  - 14 Mt biomass, 1.4Mha = 3.5Mac; 150 Mt/15Mha/37Mac

Feedstock Supply Session 1: Carbon and greenhouse gas emissions (biofuel C intensity)

PANELISTS

- **David Bransby**, Energy Crops Research, Auburn University
- **Michael Wang**, Argonne National Laboratory
- **Kurt Thelen**, Crop and Soil Science, Michigan State Univ.

QUESTIONS

- *What crops (here and after including forest crops) are best for production of biofuels for aviation in terms of production capacity?*
- *Which crops have greatest potential for low cost production (cost per MJ of bioenergy produced)?*
- *What are the comparative carbon and greenhouse gas implications of the potential biofuel feedstock crops?*
- *What are the carbon or greenhouse issues for biofuel production and use**?***

Feedstock Supply Session 2: Sustainability, input requirements, etc.

PANELISTS

- **Joseph Burton**, Research Leader ARS/USDA
- **Burt English**, Professor and Research Coordinator, Agricultural Economics, University of Tennessee Knoxville
- **Ilhami Yildiz**, Professor, Energy for Sustainable Society, California Polytechnic

QUESTIONS

- *How do we define sustainability?*
- *Which crops can be produced in a sustainable manner with regard to inputs---soil, water, greenhouse gas emissions and wildlife diversity?*
- *What are the land use implications of aviation biofuel from the most promising biofuel crops (in the US and Globally)?*
- *Assuming domestic US production of biofuels for aviation, is there greater potential for oilseeds, fermentation based biofuels from starch, sugar, and or cellulosic crops?*

Feedstock Supply Session 3: Food vs. fuels issues

PANELISTS

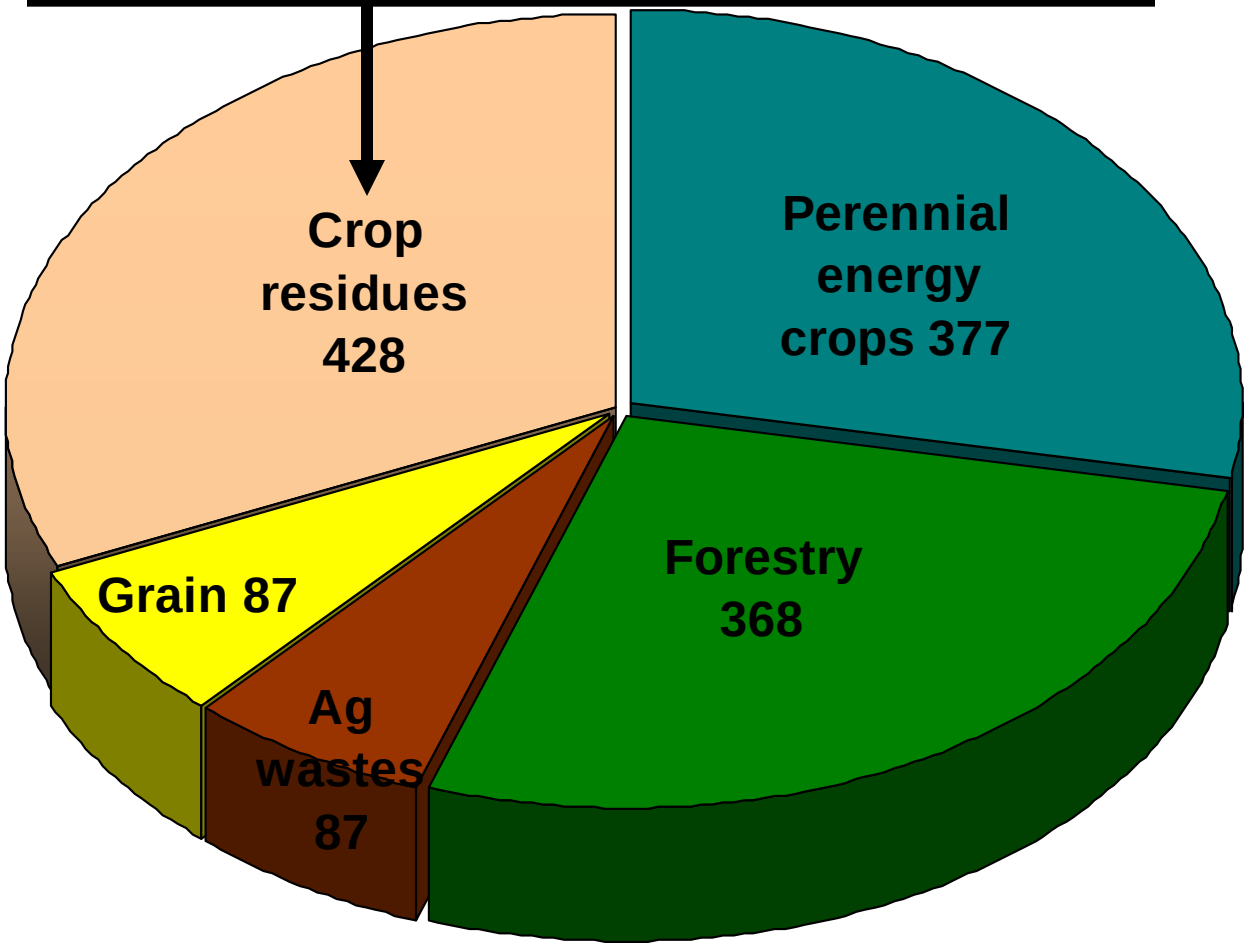
- **Michael Bomford,** Research Scientist, Kentucky State University
- **Sharon Shoemaker,** Executive Director of the California Institute of Food and Agricultural Research, University of California, Davis
- **Goro Uehara,** Professor of Soil Science, Department of Tropical Plant and Soil Sciences, University of Hawaii

QUESTIONS

- *What are the food versus fuel issues for biofuels?*
- *Are production and processing possibilities and implications for food/fuel location specific?*
- *What government policies could accelerate biofuels production?*
- *What can the Air Force contribute to the development technology, organization and policy that would accelerate biofuels development?*

2005 US-DOE Biomass Feedstock Supply: “Billion Ton Study”

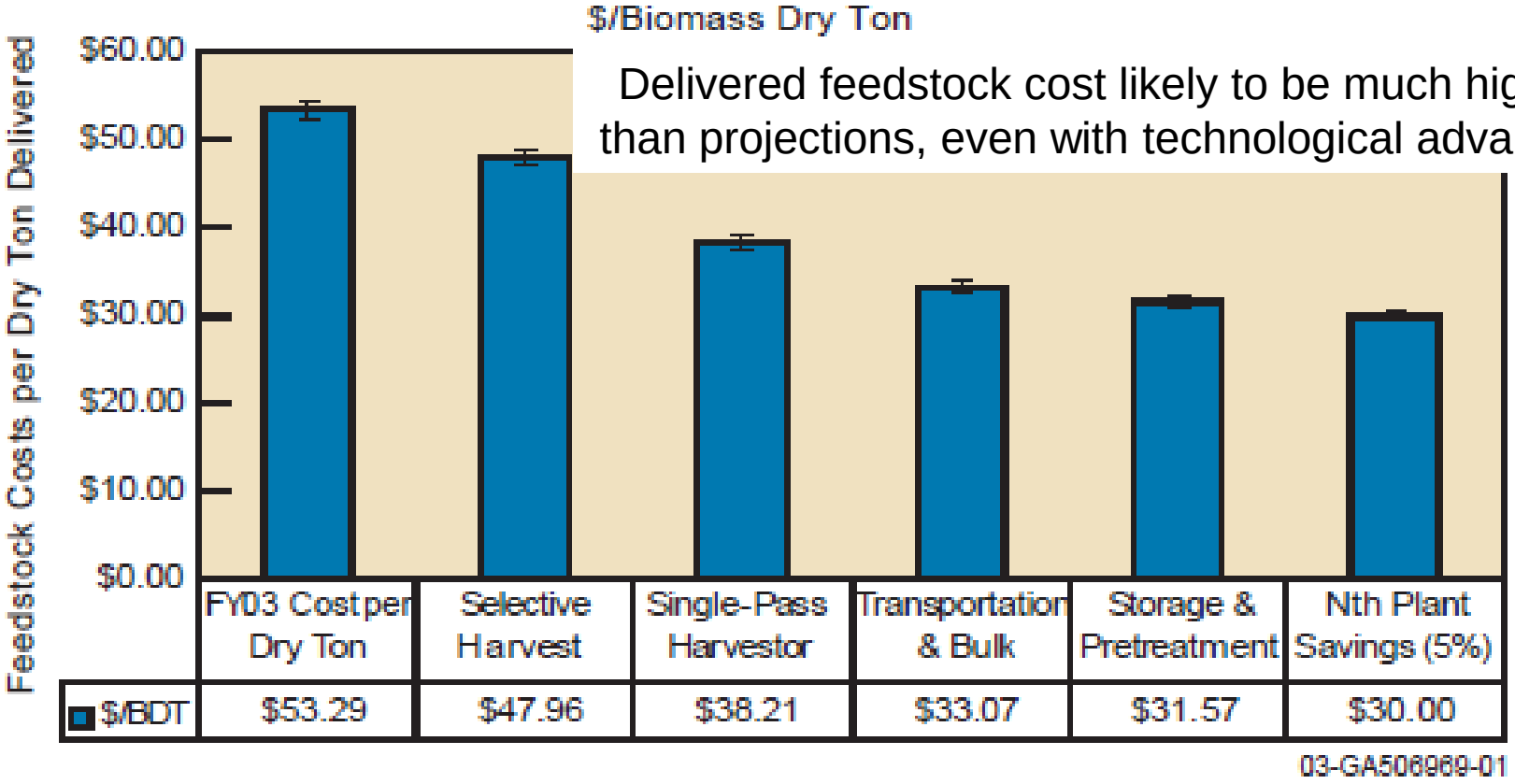
Bomford: crop residue estimate overestimated, sustainability concerns about soil C



Estimated biomass (million tons/year) contribution by 2030

Perlack et al., 2005; http://bioenergy.ornl.gov

Figure 1.6 shows how the research and technology development outlined in this roadmap lays out a viable path for reducing this cost to the target $30/dry ton delivered.



Delivered feedstock cost likely to be much higher than projections, even with technological advances

Figure 1.6. Research and technology development pathway towards achieving feedstock price target. **Source: Biomass feedstock supply roadmap, US-DOE, Nov 2003.**

Feedstock supply and performance characteristics by 2012

Region	Feedstock	Biomass Quantity	Food v Fuel	GHG	Water, quantity	Water, quality	Soil-C
South	forestry	+++	0	+++	0	?	?
	switchgrass	++	--	?++	0	?++	?+
	rapeseed*	+	?	?	0	?	?
Midwest	waste cooking oil-animal fat	+	0	++	0	0	0
	switchgrass	+	--	?	0	?++	?+
	corn stover	+++	0	---	0	--	---
	soybean	++	--	---	0	---	---
Northeast	MSW	++	0	0	0	0	0
	woody crops	++	0	++	0	0	?0
West	dead timber	+++	0	++	0	0	0
	wheat straw	++	0	--	0	0	----
	rice straw--CA	+	0	0	0	0	0
	MSW	++	0	++	0	0	0
	Camelina	+	--	?	0	0	?--
Alaska, Hawaii	dead timber-AK	++	0	++	0	0	0

*Insert into existing cropping systems without loss of yield in those systems (rotations with wheat, substitution for cotton, others?)

Note: for "ready to go" biofuel crops (both perennial and annual), criteria include seed availability in commercial quantities and established agronomic best management practices. Economics and logistics not considered.

Feedstock supply and performance characteristics by 2017.

Region	Feedstock	Quantity	Food v fuel	GHG	Water, quantity	Water, quality	Soil-C
South	forestry	+++	0	+++	0	?	?
	switchgrass	++++	--	?++	0	?+	?++
	rapeseed*	+	?	?	0	?	?
	sweet sorghum	+++	?	?	0	?	?
Midwest	waste cooking oil-animal fat	+	0	++	0	0	0
	switchgrass	++	--	?	0	?++	?+
	corn stover	+++	0	---	0	--	---
	soybean	++	---	?—	0	?	?
	sweet sorghum	++	--	--	0	--	?
Northeast	MSW	++	0	0	0	0	0
	woody crops	++	0	++	0	0	?0
West	dead timber	+++	0	++	0	0	0
	wheat straw	++	0	--	0	0	----
	rice straw	+	0	0	0	0	0
	MSW	++	0	++	0	0	0
	Camelina	+	--	?	0	0	?—
	Algae	+	0	?+	++	--	?+
Alaska, Hawaii	Dead timber-AK	++	0	++	0	0	0
	High yield grass	+	0	++	0	+	++

*Insert into existing cropping systems without loss of yield in those systems (rotations with wheat, substitution for cotton, other substitutions?)

Note: for "ready to go" biofuel crops (both perennial and annual), criteria include seed availability in commercial quantities and established agronomic best management practices. Economics and logistics not considered.

Feedstock supply: additional comments

- Timeline for commercial development of biofuels for jet fuel will be delayed unless Airforce cannot pay higher price for second generation biofuels.
- Kurt Thelen: what will it take to get growers to switch to new biofuel crops?
- One-third of country is covered by forest; excess supply of pine in the southeast.
- Dead timber from northward expansion of pine beetle is a considerable standing biomass resource; logistics of harvest is difficult where no existing logging infrastructure.
- Areas with high density of marginal and degraded land should be targets for dedicated perennial biomass crops
- Perform studies of biomass resources and potential supply in a 50-mile radius around all airbases.

Feedstock supply: additional comments

- A number of potential biofuel crops will need considerable investment in genetic improvement, which will require many years
  - Sweet sorghum, jatropa, etc.
- For all biofuel crops, an integrated approach is needed
  - Ecosystem impact broader than local environmental impact
  - Integrated biorefining and high value chemicals
- While ethanol can be upgraded to jet fuel, is this an efficient process? Answer has impact on viable options for biofuel crops and biorefining processes
- Municipal solid waste has infrastructure to utilize it in some areas, not in others. High tipping fee regions most promising.