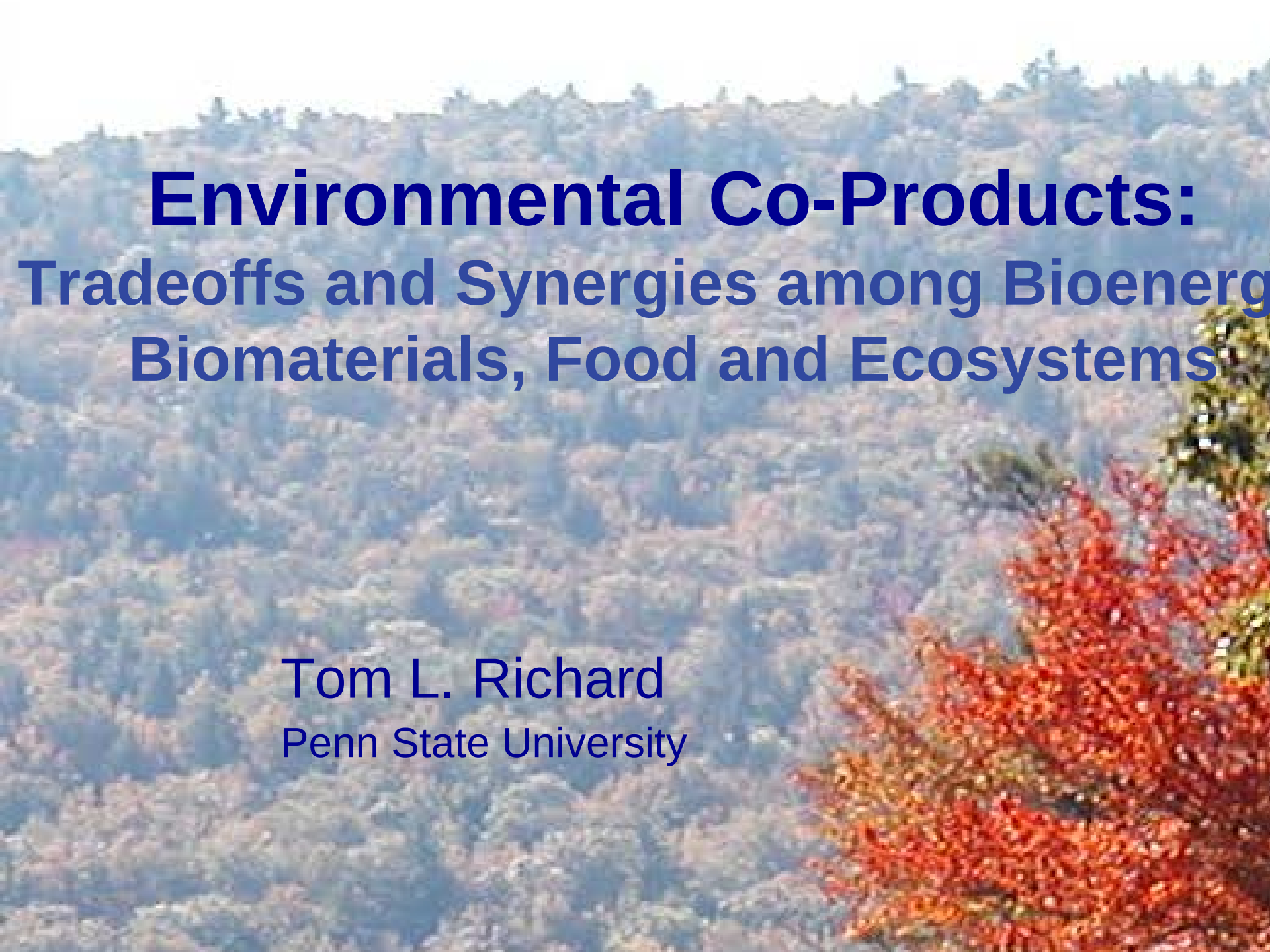

Environmental Co-Products:
Tradeoffs and Synergies among Bioenerg
Biomaterials, Food and Ecosystems

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Environmental Co-Products

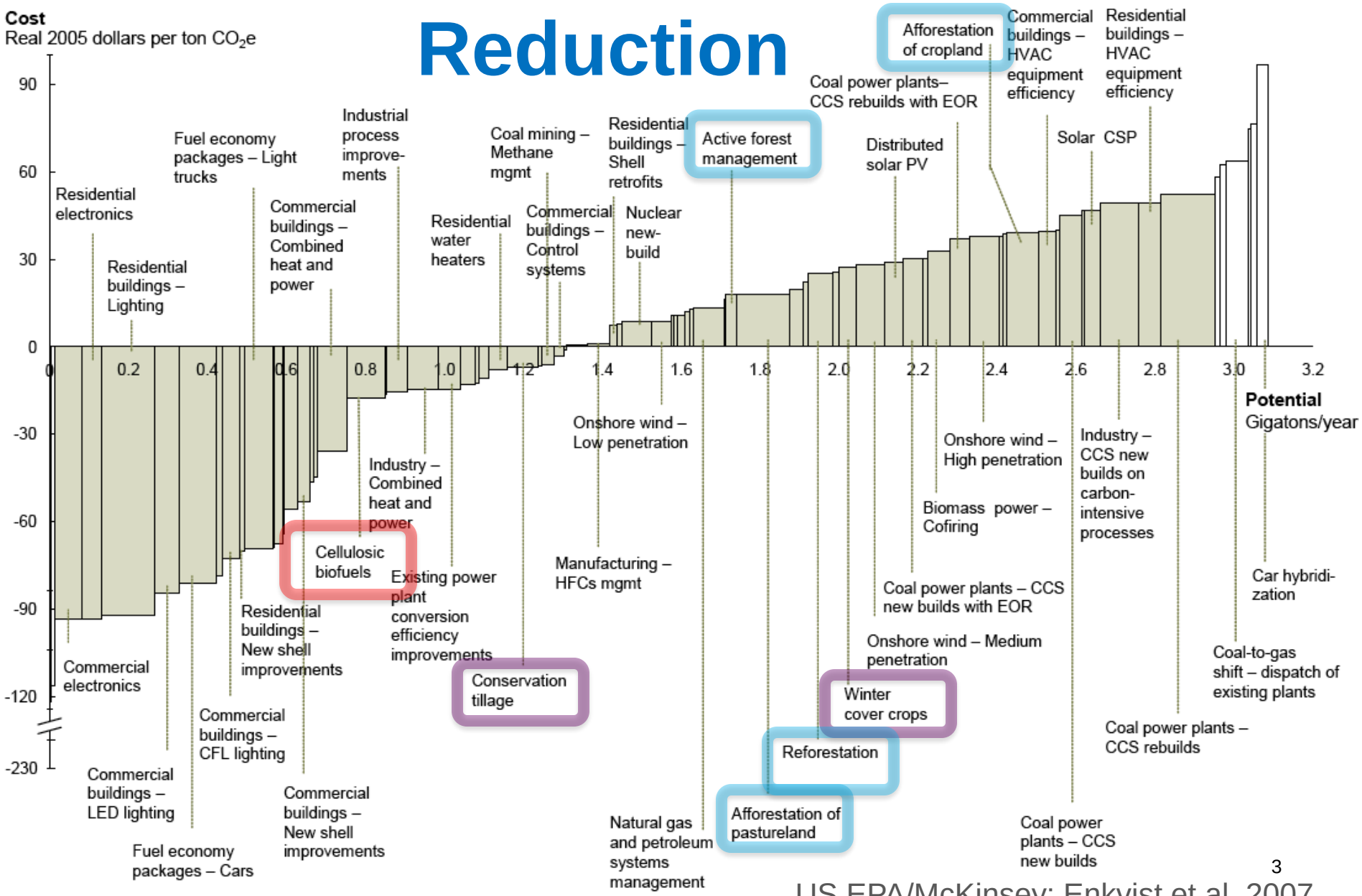
Carbon

- *Net CO_2 emissions from fuel production and use*
- *Credit for co-products*
- *Net change in soil carbon*
- *Net change in geologic carbon*
- *Indirect effects – land use change*

Water Quality

- *Nitrogen (N) – drinking water, algal growth, eutrophication*
- *Phosphorus (P) – algal growth, hypoxia*
- *Sediment – carries P, compromises fish, fills dams*

Marginal Costs of Carbon Reduction



US EPA/McKinsey; Enkvist et al. 2007

Carbon Benefits from Biomass?

1) ***Wastes and residues***

   Go to CO2 anyway; no “carbon debt”

2) ***Energy crops on agricultural land***

   Synergies with water quality, some carbon benefit

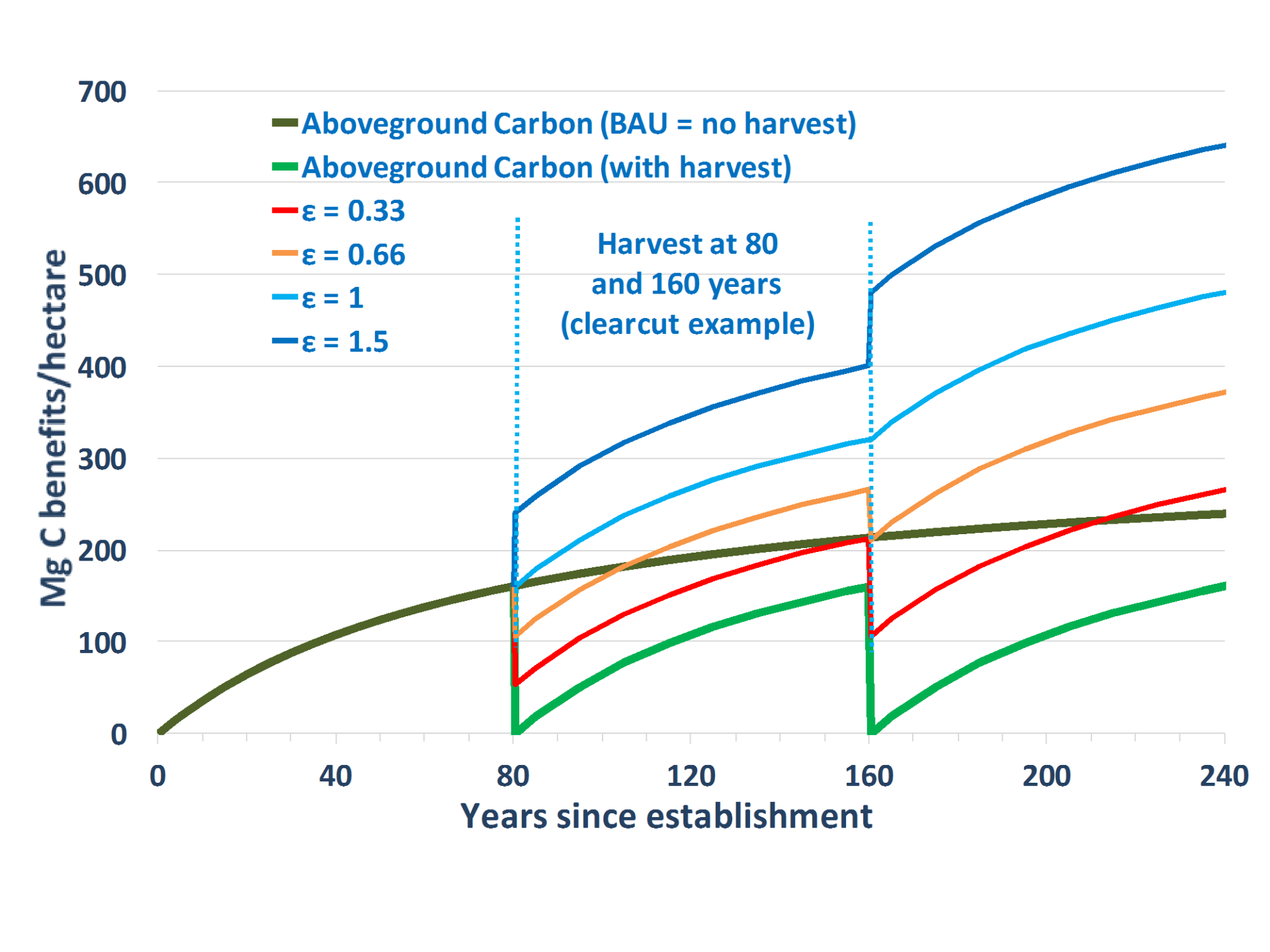
3) ***Energy from forests***

   Residues mostly to CO2 anyway;

   Near term trade-offs with carbon storage in trees

Carbon Utilization Efficiencies (ε) (Biomass vs Fossil)

$\varepsilon = \frac{MJ/CO_2e\ Biomass}{MJ/CO_2e\ Fossil}$	Natural Gas	Coal	Oil
Thermal	0.64		0.92
Electric	0.33	0.69	
Combined Heat and Power	0.66		0.97
Current Cellulosic Ethanol			0.50
Mature EtOH, FT liquids, Electricity			0.60
Mature EtOH, FT liquids, Elec. w/ CCS			1.00

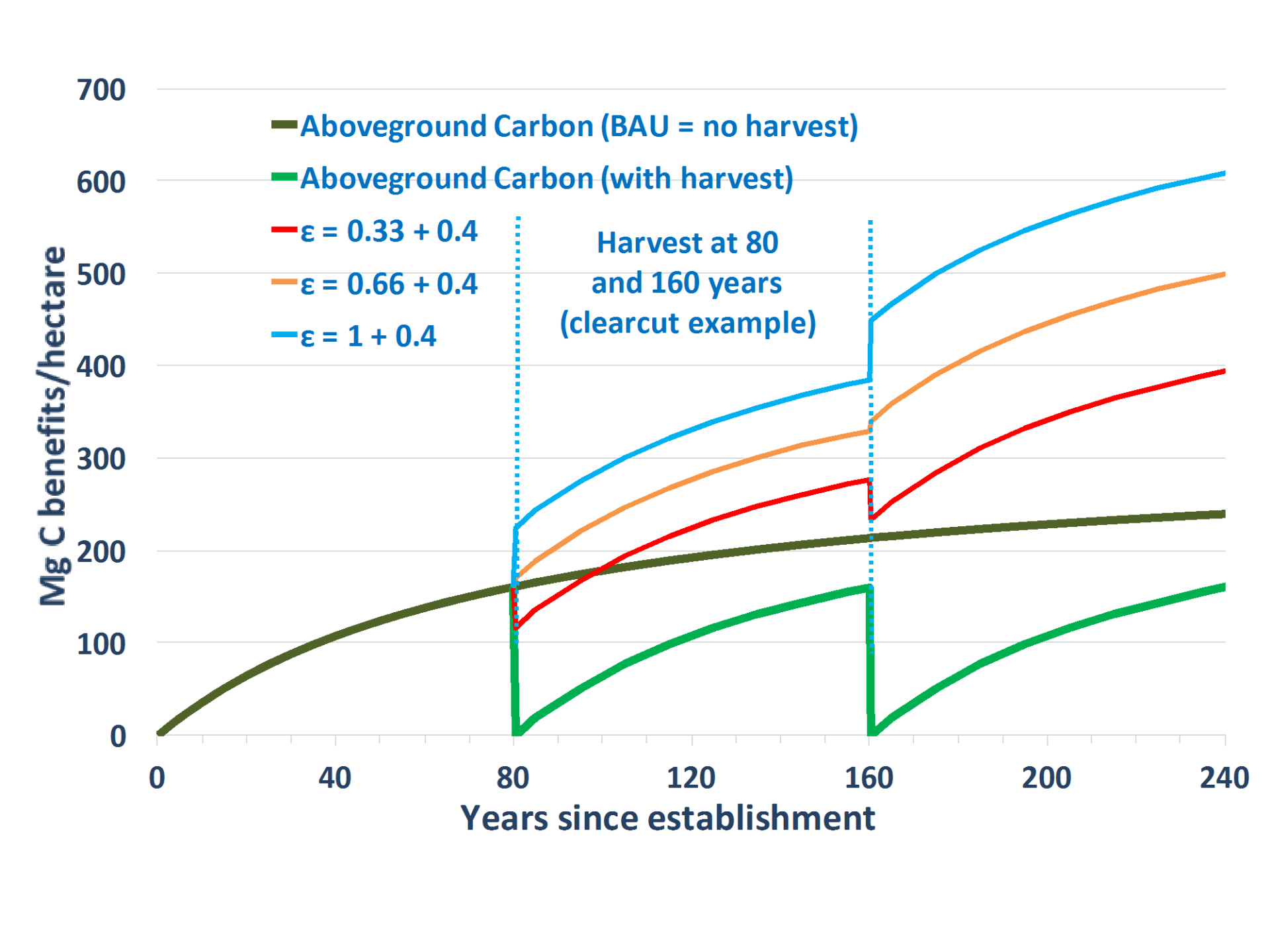

700
600
500
400
300
200
100
0
Mg C benefits/hectare
Aboveground Carbon (BAU = no harvest)
Aboveground Carbon (with harvest)
ε = 0.33
ε = 0.66
ε = 1
ε = 1.5
Harvest at 80
and 160 years
(clearcut example)
0
40
80
120
160
200
240
Years since establishment

Carbon Utilization Benefits (Materials)

	Emission Reductions (vs. Concrete and Steel)
Walls	**1.2 – 1.8 kg CO_2e-C /kg wood C**
Flooring	**2.4 – 6 kg CO_2e-C /kg wood C**

20% of a 160 Mg C/ha harvest to materials, with an emission reduction multiplier of 2 kg/kg, is equivalent to increasing the efficiency by **0.4**

Oliver et al. 2014


700
600
500
400
300
200
100
0
Mg C benefits/hectare
Aboveground Carbon (BAU = no harvest)
Aboveground Carbon (with harvest)
ε = 0.33 + 0.4
ε = 0.66 + 0.4
ε = 1 + 0.4
Harvest at 80
and 160 years
(clearcut example)
0
40
80
120
160
200
240
Years since establishment

Water Benefits from Biomass?

1) ***Wastes and residues***

Reduced impact from waste disposal (biosolids, manures, industrial organic wastes)

2) ***Energy crops on agricultural land***

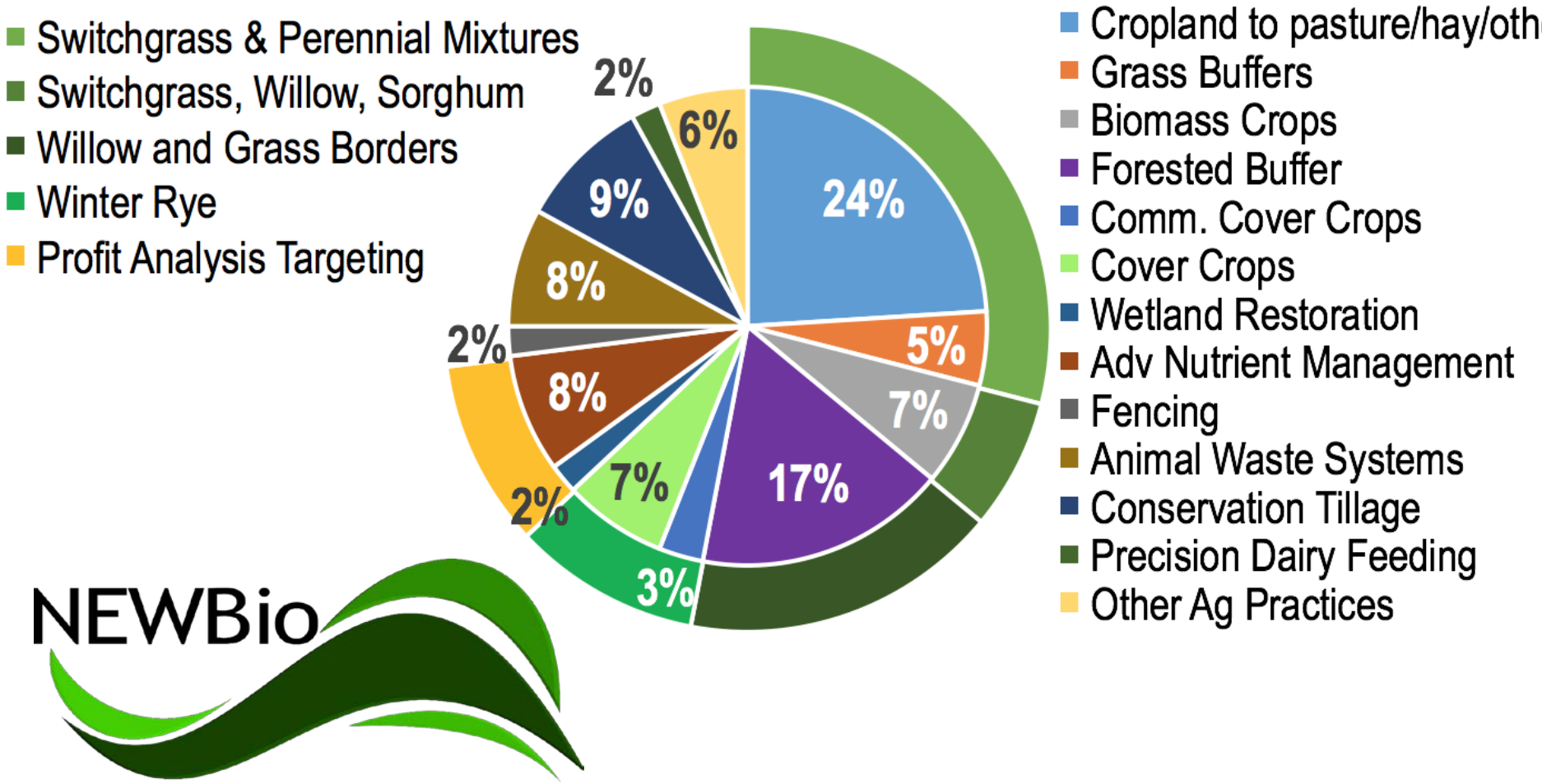
Strong synergies with water quality, some annual and especially perennial energy crops

3) ***Energy from forests***

Most benefits already baked into models

Harvest benefits water only if systems are overloaded with P or contaminants.

Mapping Biomass to Water Quality



NEWBio

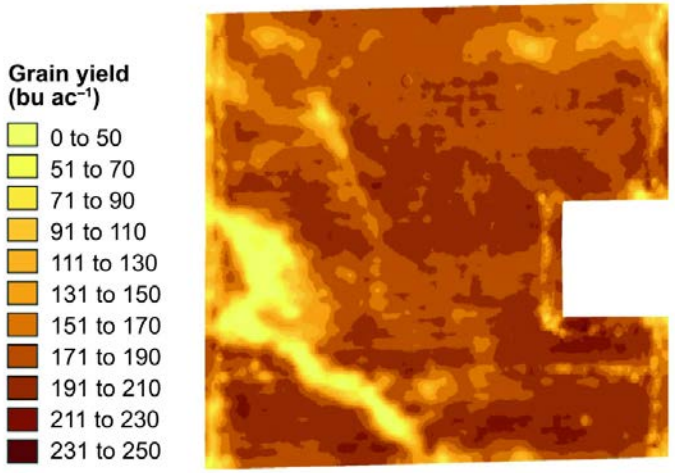
NEWBio is supported by AFRI Competitive Grant No. 2012-68005-19703 from the USDA National Institute of Food and Agriculture.
NEWBio's mission is to lay the foundation for a sustainable bioenergy future for the Northeastern United States. Our objectives are to design, implement, analyze and evaluate robust, scalable, and sustainable value chains for the biomass industry, with the ultimate goal the eventual development of lignocellulosic biomass suitable for advanced transportation fuels in our region.

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

Yeoman Farmer meets The Internet of Things: Sub field economic analysis

* Since the dawn of agriculture, farmers have managed the landscape as fields. These fields were once small, but now are large. And they are far from uniform.

- Farmers have traditionally assessed profitability on the basis of a whole field. Precision agricultural tools allow much higher resolution. That knowledge now allows sub-field profit management.



* Key question: To what extent do economically marginal regions of fields overlap with environmentally sensitive parts of the landscape?

The Costs of Uncertainty