Woody Energy Crops

Dr. Raymond O. Miller
Sustainable Forestry Conference
15 April 1010
Florence, Wisconsin

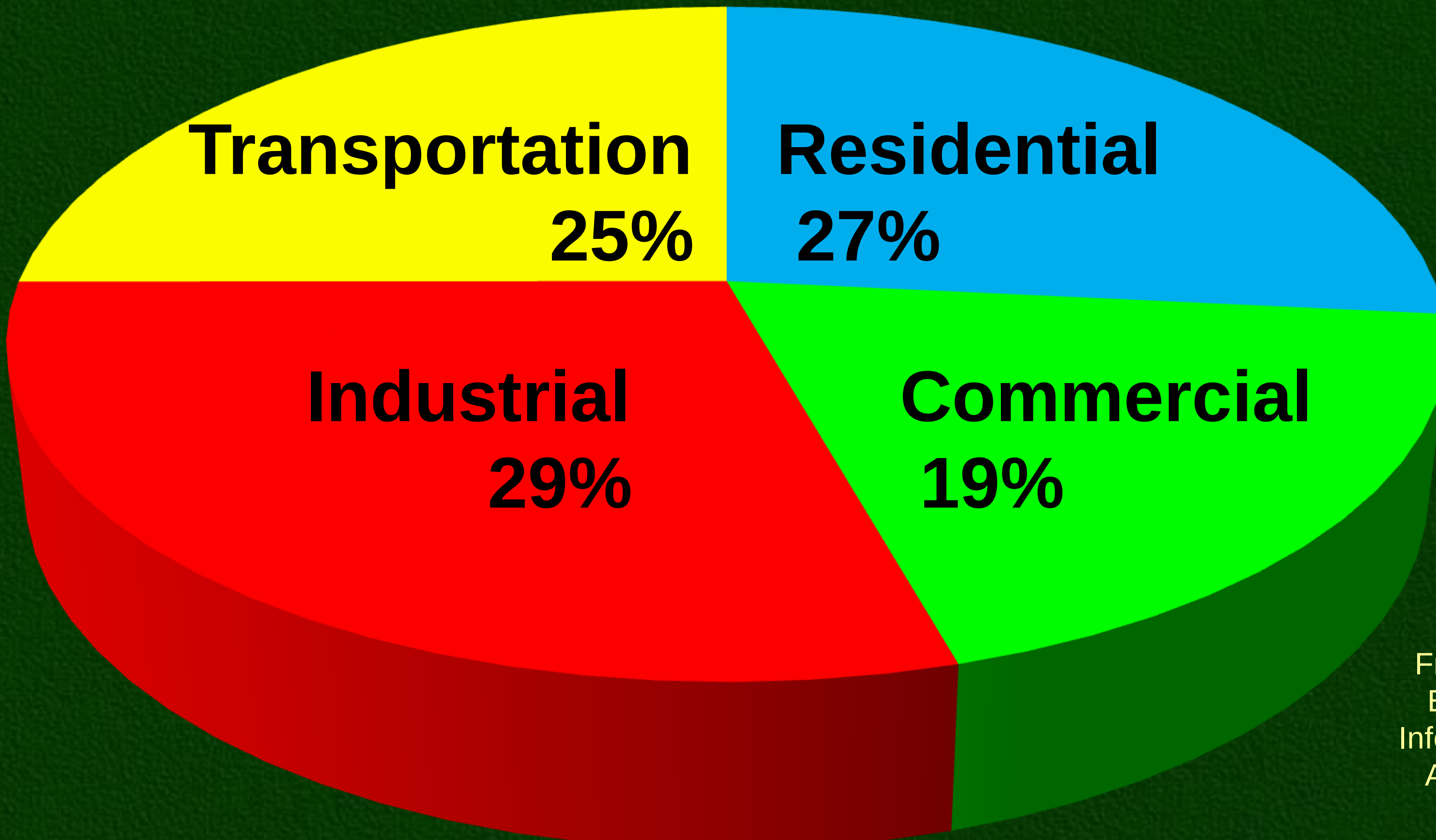
The Outline

- Energy 101 (context)
- Silviculture 101 (basic biology)
- Productivity projections (reality)
- Production systems (nuts & bolts)
- Current research (the future)

How much energy do we use?

- 3.2 Quadrillion btus (3×10^{15} btus), MI
  1.9 Quadrillion btus (2×10^{15} btus), WI
- Run a house furnace for 3.4 million yrs
- Nine trillion 100 watt bulbs for a year
  - *That's 6 bulbs every square foot*
  - *Or, about a million bulbs for each person*
- 600 billion miles in a 25 mpg car.
  - *That's about 80 rounds trip to Pluto*

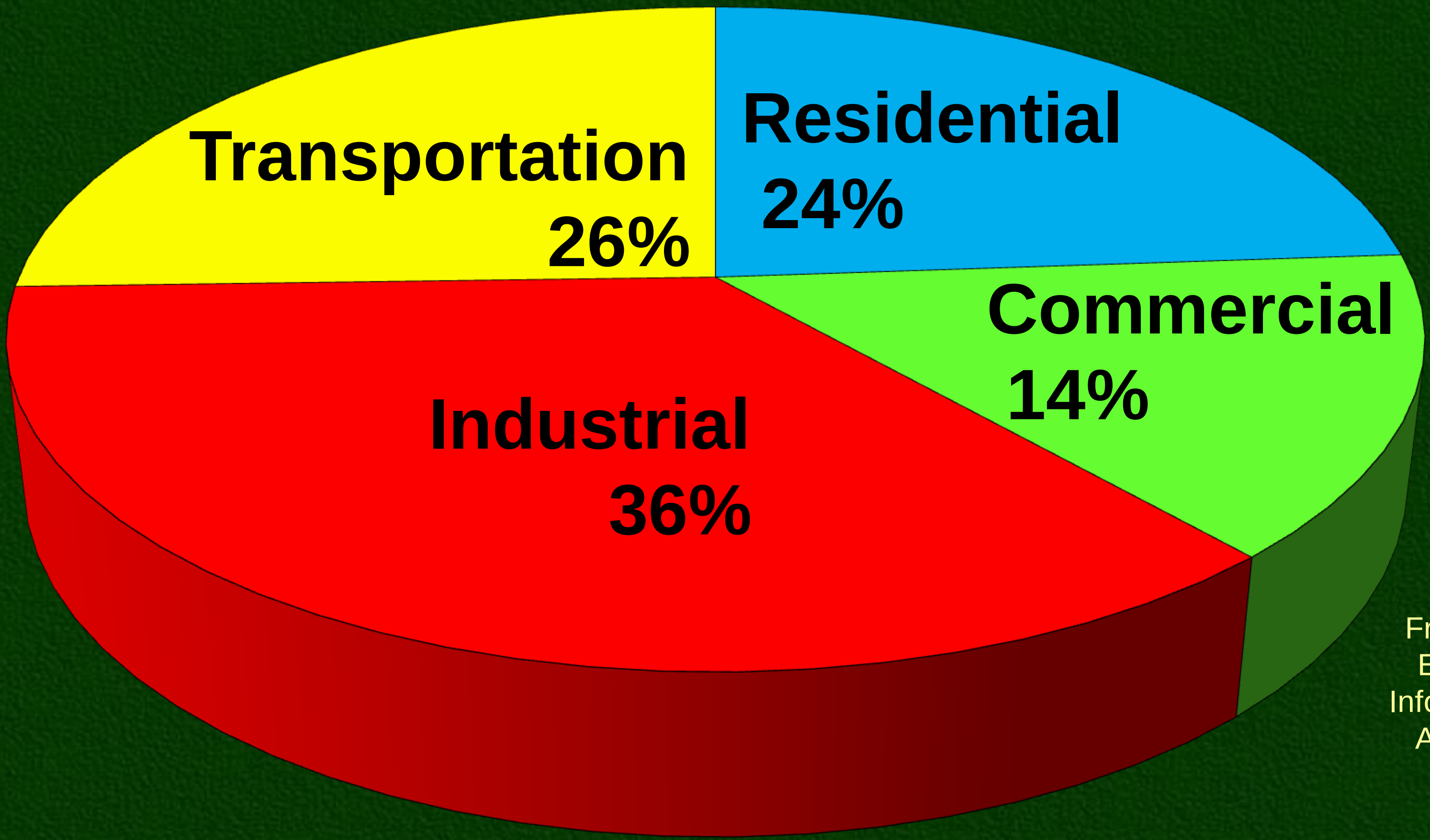
Energy use in Michigan



From US Energy Information Agency

Total annual energy consumption = 3.2 Quadrillion BTUs
(lignocellulosic feedstocks could provide up to 21% of this)

Energy use in Wisconsin

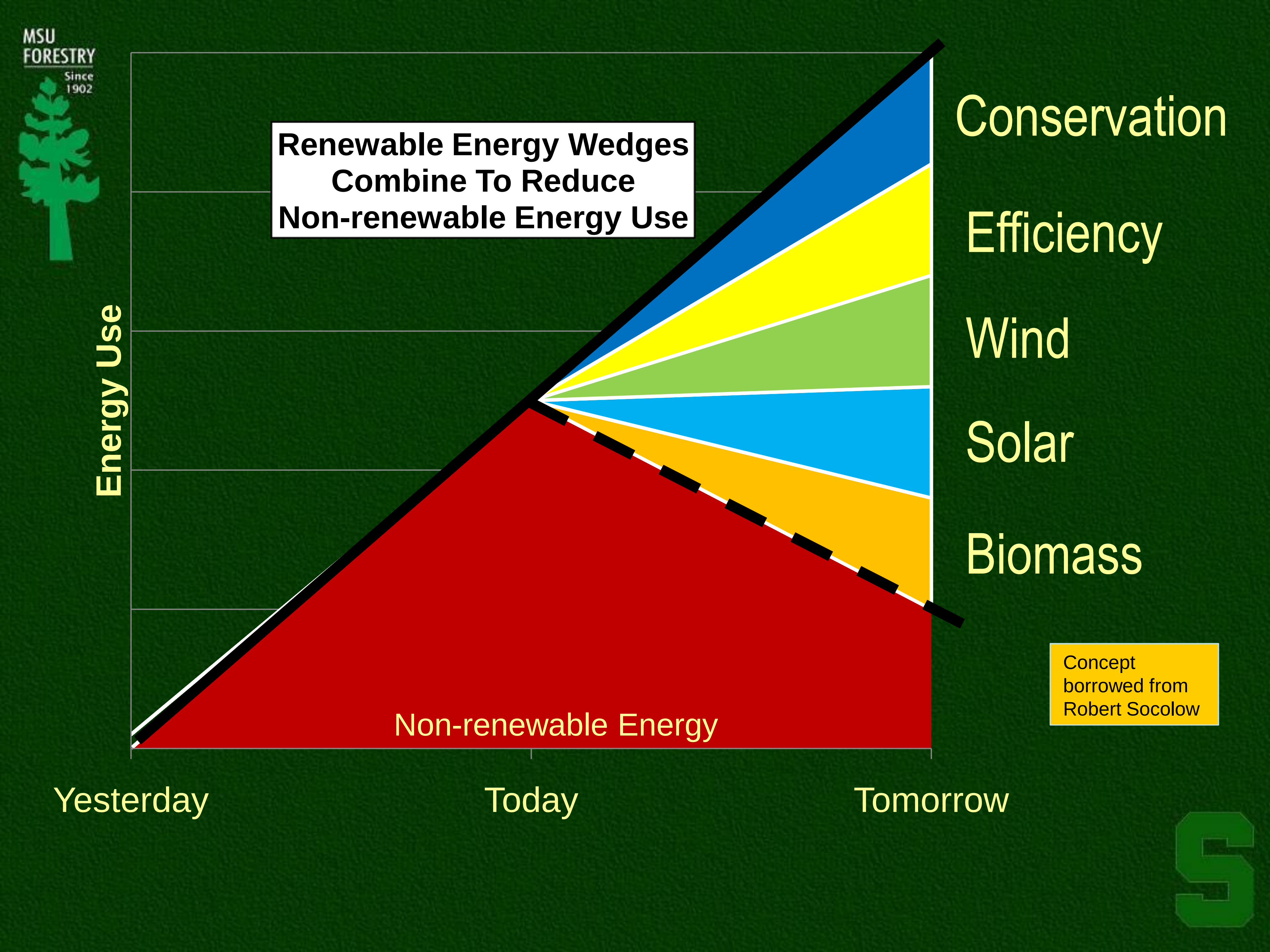


From US Energy Information Agency

Total annual energy consumption = 1.9 Quadrillion BTUs

Drivers for Renewables

- Rising fossil fuel prices (*irregular but trending upward*)
- Concerns of CO_2 emissions
- Cost of NO_x and Mercury emission reductions
- Desire to build new industry
- Renewable fuel/energy mandates
- Policy driving cost shares & incentives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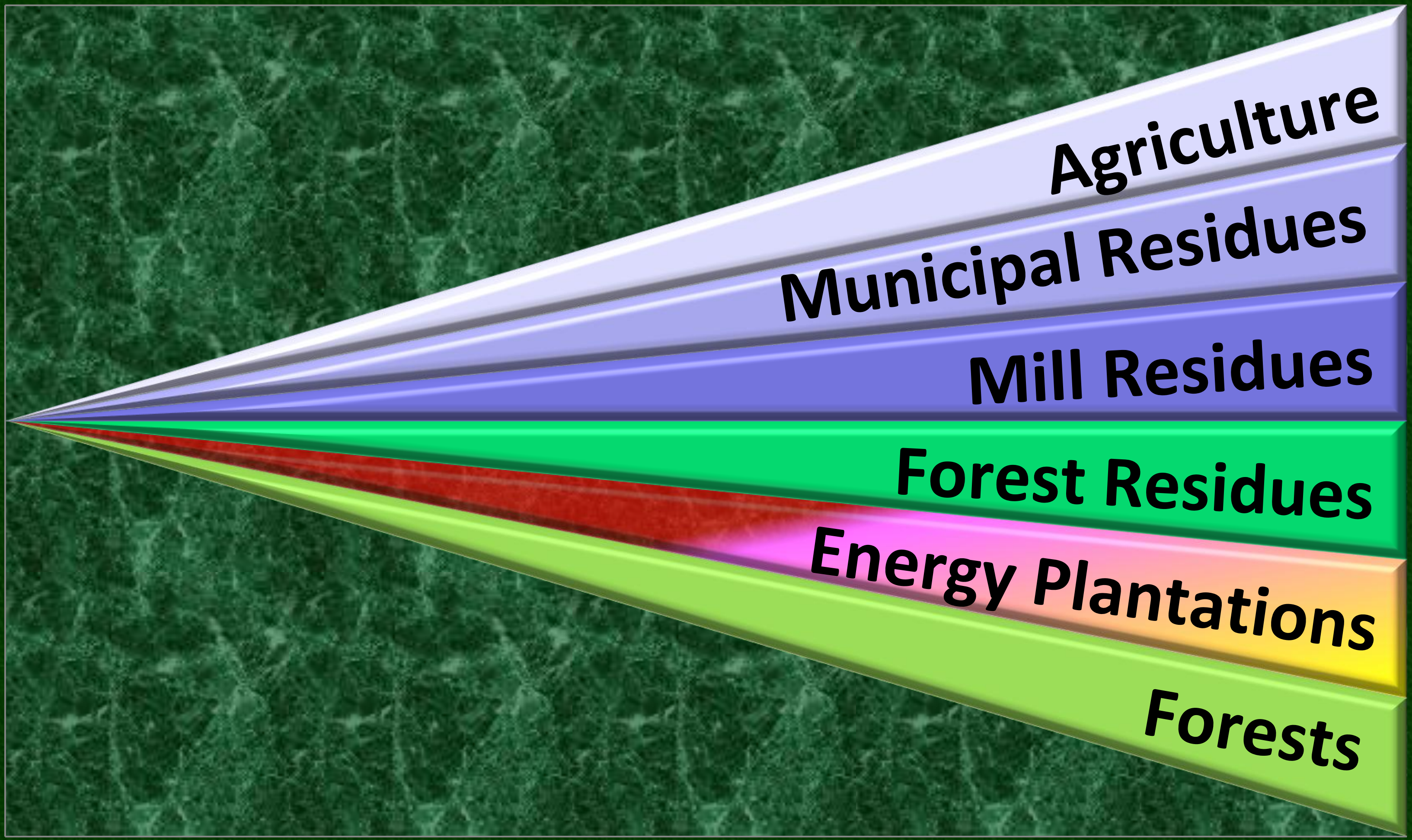
Renewable Energy Wedges Combine To Reduce Non-renewable Energy Use
Energy Use
Conservation
Efficiency
Wind
Solar
Biomass
Non-renewable Energy
Concept borrowed from Robert Socolow
Yesterday
Today
Tomorrow

The Biomass Wedge



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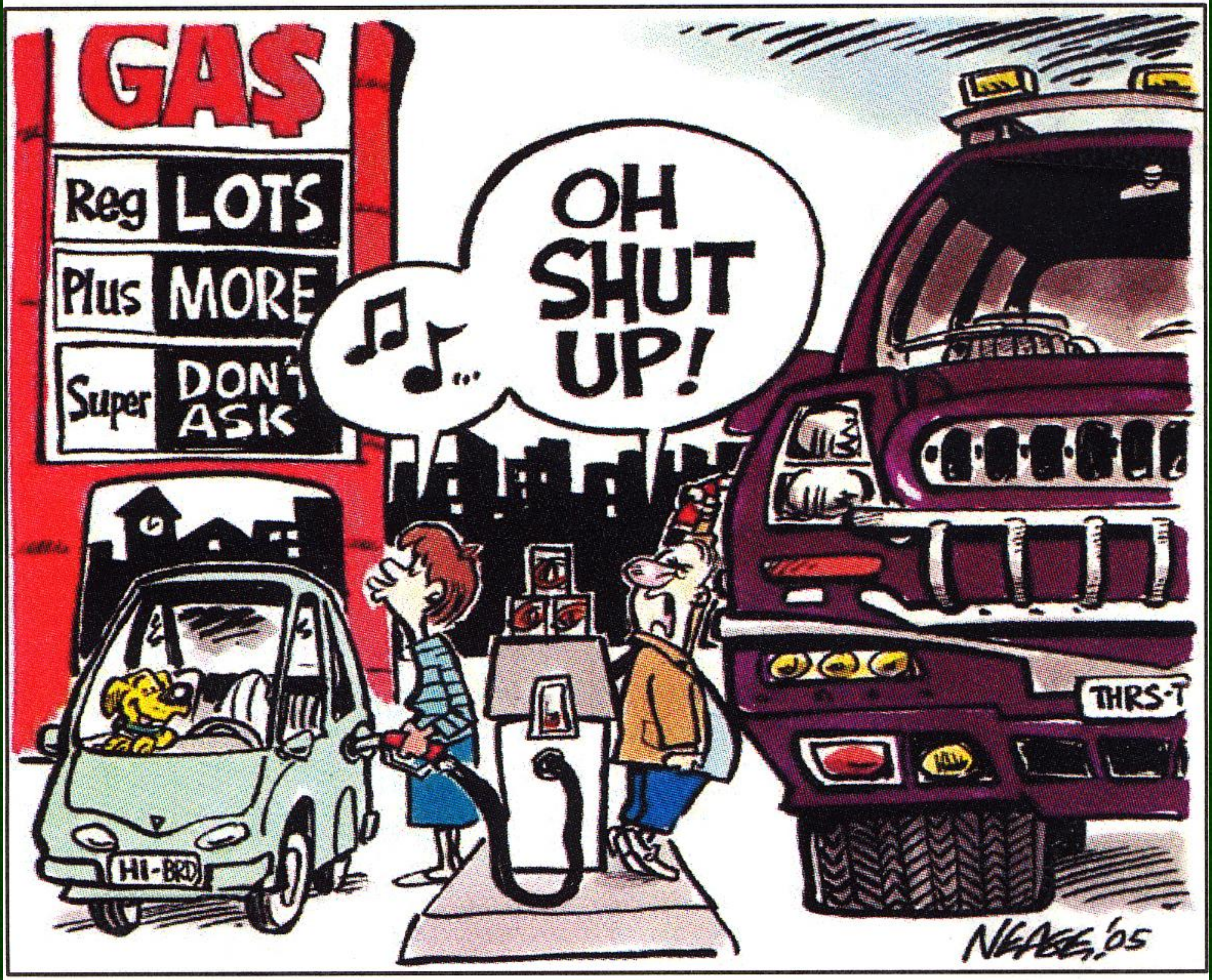

The Supply Chain

FEED-STOCK

Residues

Unused Stuff

Energy Crops

HAND-LING

Raw or Green

Dried

Com-pressed

Modified

PRO-CESSING

Com-bustion

Thermo-chemical

Biochem-ical

PRODUCT

Power

Heat

Transpor-tation

Chemicals

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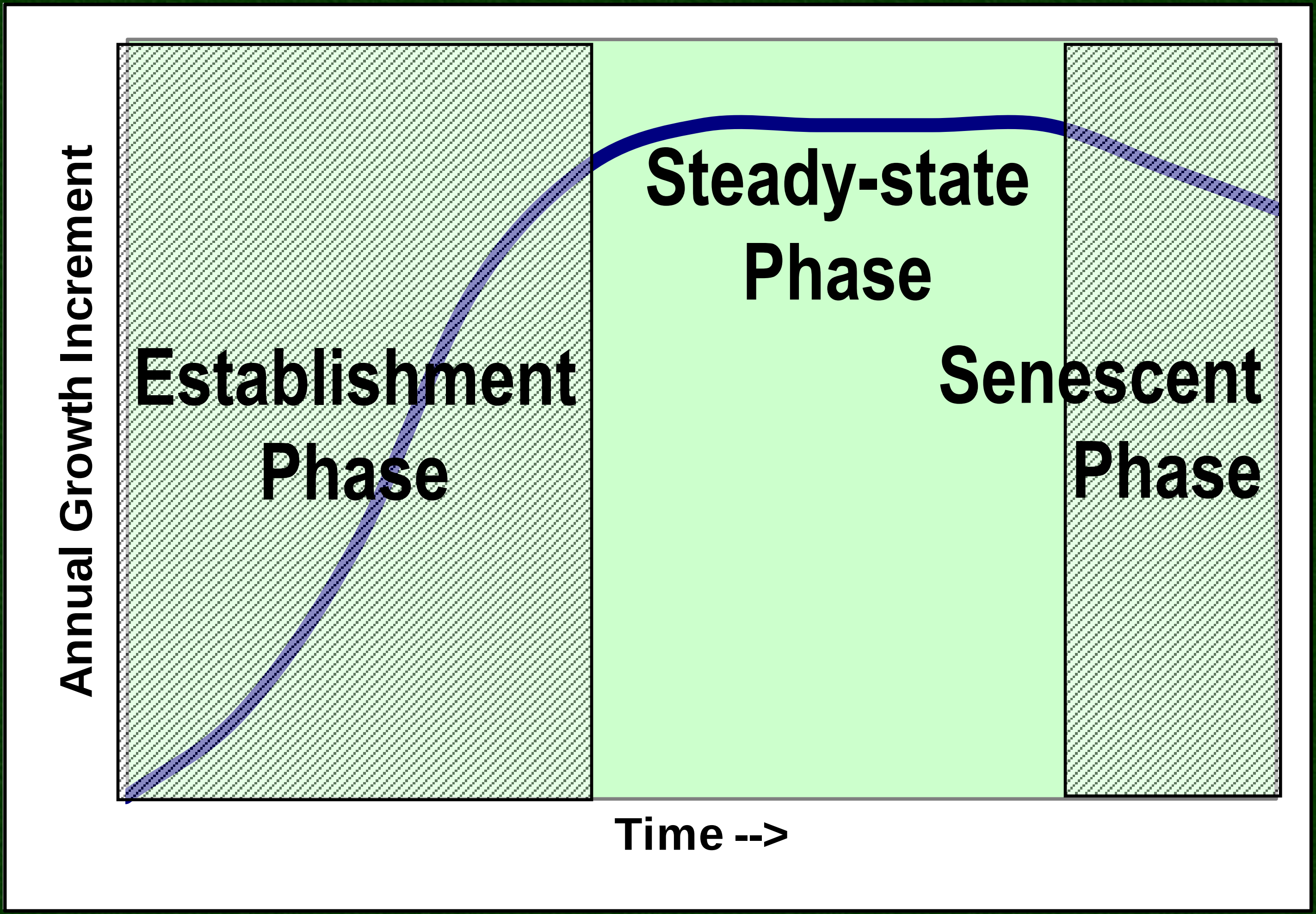
Nature's Solar Collectors

- Plant Efficiency depends on
  - *Leaf area*
  - *Crown architecture*
  - *Photosynthesis/metabolic balance*
  - *Partitioning of carbohydrates by the plant*
- Productivity depends on the arrangement of plant communities (Stands)

Stand Development

- Carrying capacity = ability of a site to produce fiber
- Stocking = measure of site occupancy
- Productivity = f(# plants x plant size)
- Plant size determines
  - *Product eligibility*
  - *Equipment design & efficiency*
  - *Feedstock composition*

Stand Development



Class Dismissed

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Global Wood Production in Plantations, 2005

- 30% of earth's surface is forest
- 7% of forests are plantations
- 66% of industrial wood production comes from plantations!
- 66% of wood comes from 7% of forests

Why Plantations?

- Higher productivity
  - *Smaller landbase*
  - *Less hauling*
  - *Shorter rotations*
- Better control over feedstock characteristics
- Better control over production system
- Less public resistance
- More opportunities for subsidies and credits

Energy Plantation Potential

- **MI & WI Timberland**

  ~0.5 dry tons·acre^{-1} ·year^{-1}

- **Pulpwood plantations**

  1.7 dry tons·acre^{-1} ·year^{-1}

- **Energy plantations**

  4 dry tons·acre^{-1} ·year^{-1}

  (~8 times the yield of Timberlands)

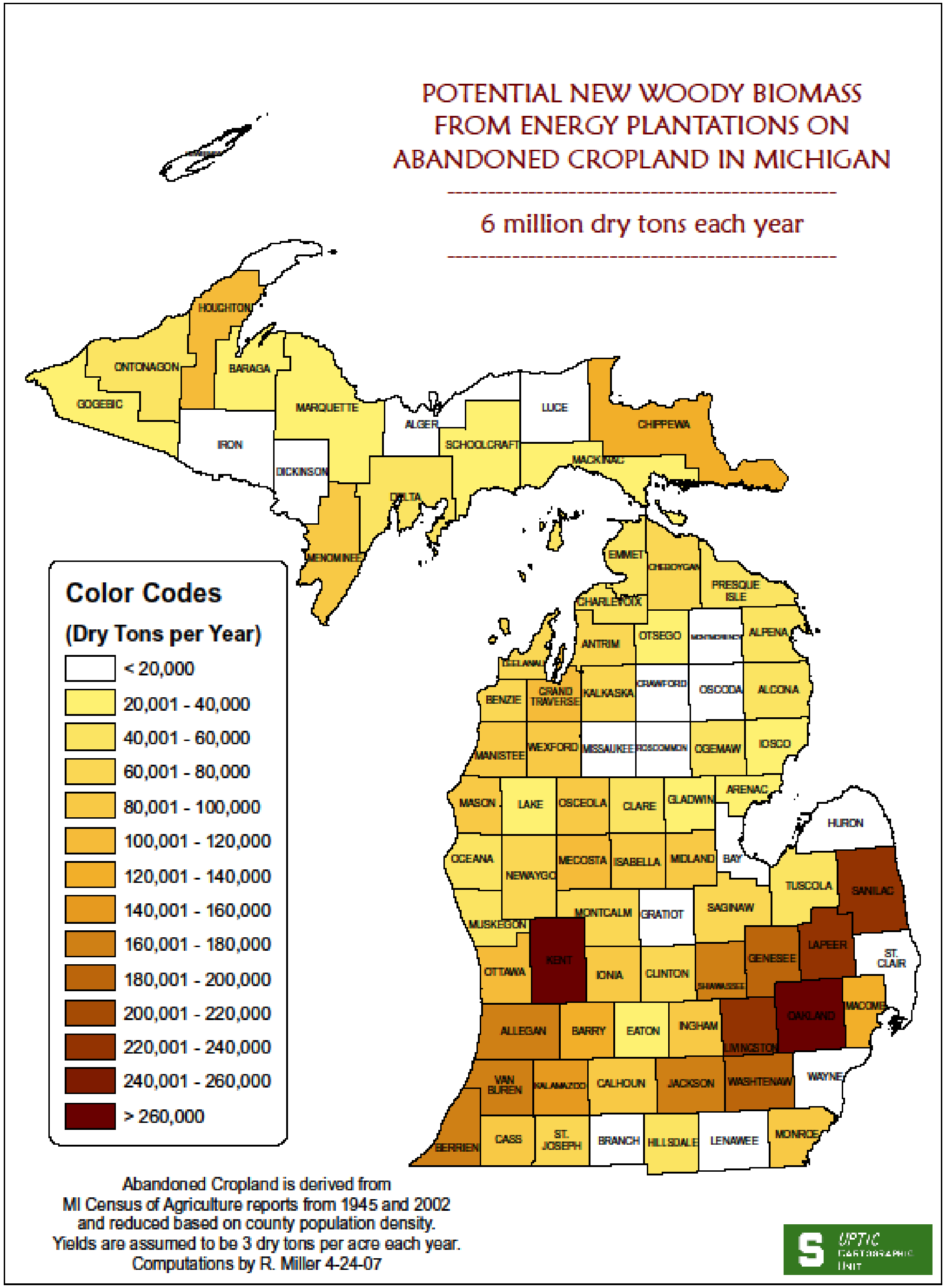
40 million g/yr ethanol plant

- Needs about 500,000 dry tons per year
- From 1 million acres of "Timberland"
- Or, 125,000 acres of "Energy Plantations" (200,000+ acres 'available' in the UP)
- Haul radius for Energy Plantations is ~1/3 that of Timberland if they are 8 times as productive per acre.
- Production costs are higher, but transportation costs are lower.
- Is there an economist in the house?

Reasonable Yield Reports

Taxa	Mean Annual Increment	Test Location
European alder	**4.6 dry tons·acre^{-1}·year^{-1}**	**Indiana**
Cottonwood	**4.2 dry tons·acre^{-1}·year^{-1}**	**Mississippi**
Yellow birch	**3.7 dry tons·acre^{-1}·year^{-1}**	**Michigan**
Silver maple	**3.3 dry tons·acre^{-1}·year^{-1}**	**Kansas**
Poplar hybrid	**6.6 dry tons·acre^{-1}·year^{-1}**	**Brit. Columbia**
NM6 poplar	**3.8 dry tons·acre^{-1}·year^{-1}**	**Escanaba, MI**
Willow	**2.5 dry tons·acre^{-1}·year^{-1}**	**Escanaba, MI**

Cannell & Smith (1980)
predict a working maximum to be 3.1 – 6.2 dry tons·acre^{-1}·year^{-1}



Landbase

- 800,000 acres in the UP & northern LP
- 486 Mw electricity
- 192 M gal etOH

(Making a bunch of assumptions)

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Alteration of Existing Systems

- Capture feedstocks - native forests
  - *Under /over dimension materials (residues)*
  - *Undesirable species*
  - *Mortality*
  - *Ladder fuel reduction treatments*
  - *Unique habitat management systems*

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Natural Forest Materials

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Residues

(SRIC) Energy Plantations

- **Standard Density**
  - 500 to 1,000 stems per acre
  - 8 to 12-year rotations
  - Use existing equipment
  - Offers harvesting and product options
- **High Density**
  - 3,000+ stems per acre
  - 3- to 4-year rotations
  - Requires special equipment
  - Produces narrow range of feedstocks

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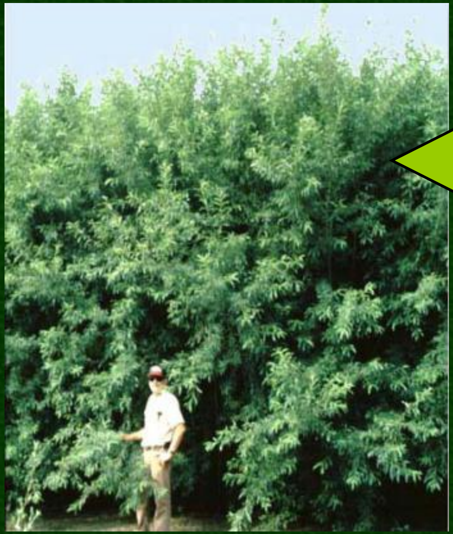
Poplar Production System

Willow Biomass Production Cycle

Site Preparation

Planting

Three-year old after coppice



One-year old after coppice

First year growth

Coppice

Early spring after coppicing

Energy Plantation Phases

- Site Preparation
- Plantation Establishment
- Management / Maintenance
  - *Weed & Pest Control*
  - *Fertilization and/or Irrigation*
- Harvesting
- Transportation


SALIX
MASKINER AB
Step
SRC Planting


Energy Planter
Egedal
Energy Planter


CRL

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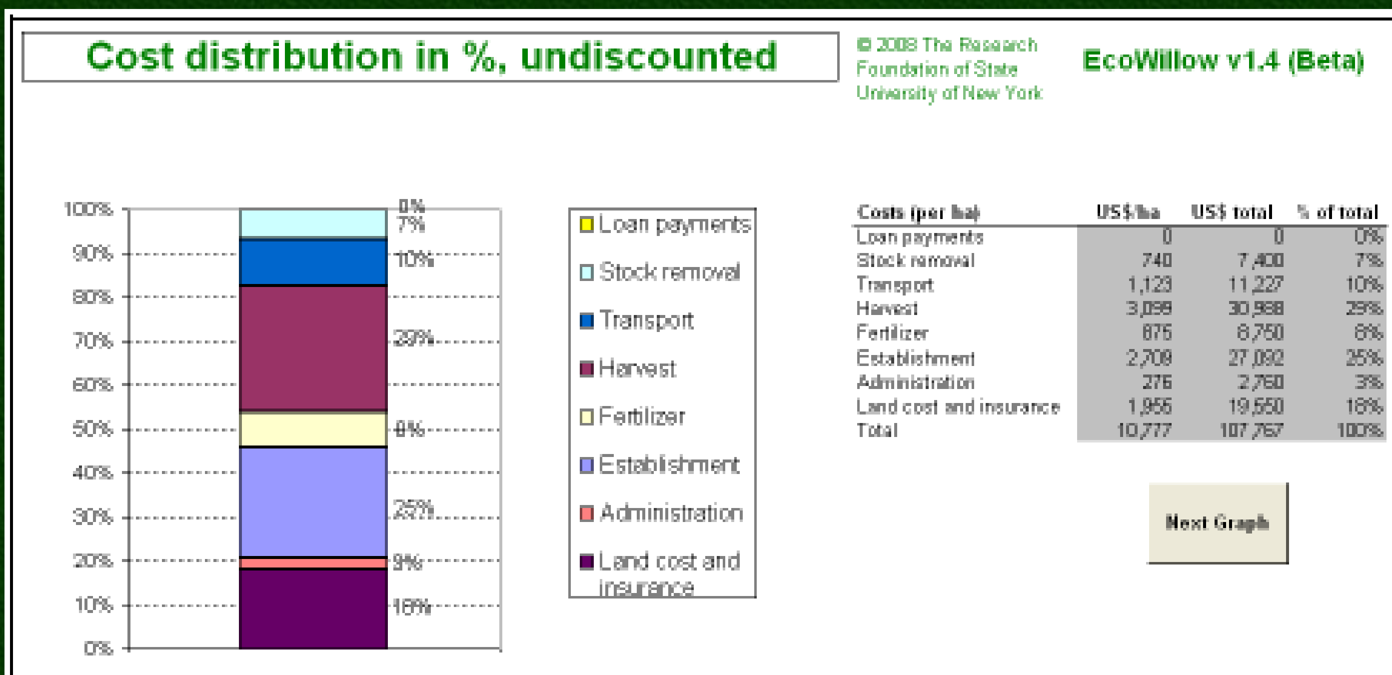
Gunville

Eco-Willow

Economic Analysis Tool

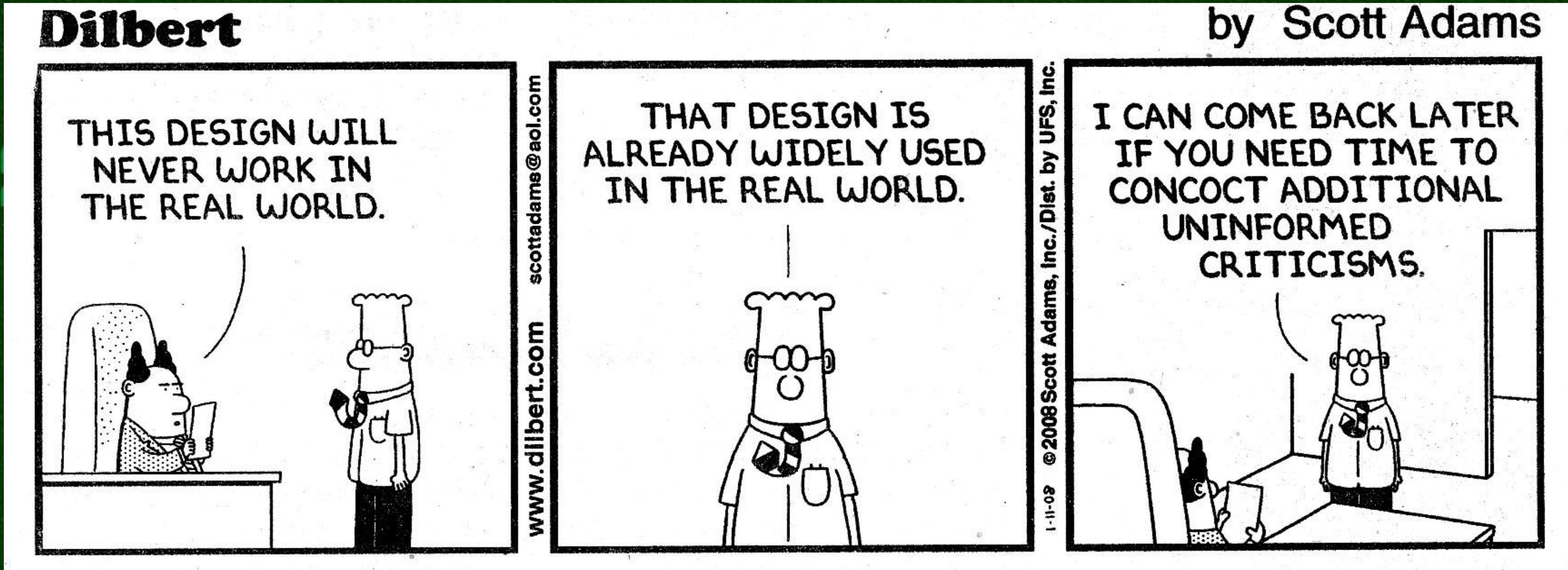
www.esf.edu/willow/download.htm



Costs (per ha)	US$/ha	US$ total	% of total
Loan payments	0	0	0%
Stock removal	740	7,400	7%
Transport	1,123	11,227	10%
Harvest	3,099	30,988	29%
Fertilizer	875	8,750	8%
Establishment	2,709	27,092	25%
Administration	276	2,760	3%
Land cost and insurance	1,955	19,550	18%
Total	10,777	107,767	100%

Energy Plantation Costs

- Land Costs (18%)
- Site Preparation (7%)
- Plantation Establishment (25%)
- Management / Maintenance (11%)
- Harvesting (29%)
- Transportation (10%)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Making It Work

- Triple Helix Partnerships (*Universities, Government, Industry*)
- Regional scientific networks
- Yield improvements
- Production system efficiencies
- Increased sustainability
- Education & outreach
- Better understanding of fundamentals

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