Economics of Forest Biomass and Bioenergy

Janaki R. R. Alavalapati

Professor of Resource Economics and Policy
Director, CFEOR (Conserved Forest Ecosystems: Outreach and Research)
School of Forest Resources and Conservation
University of Florida, Gainesville, Florida

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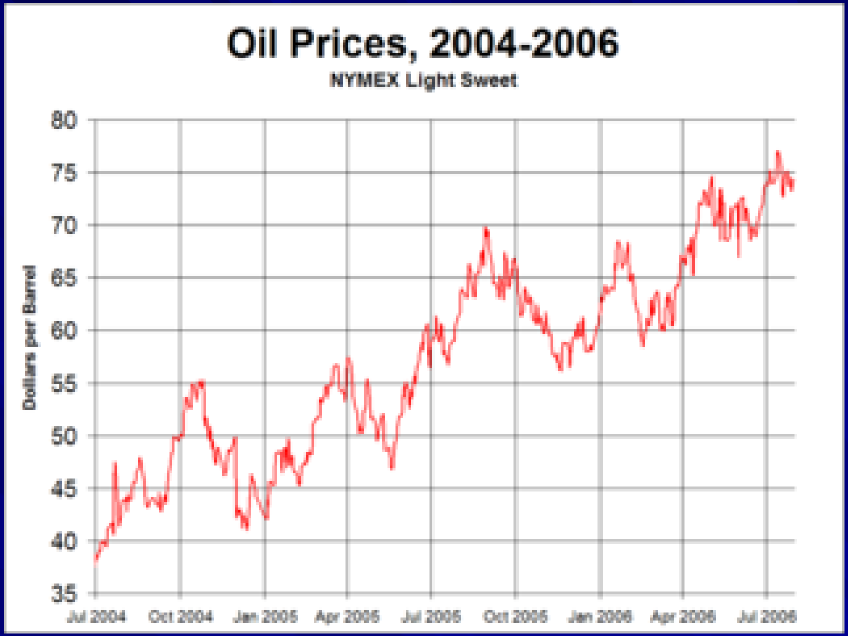
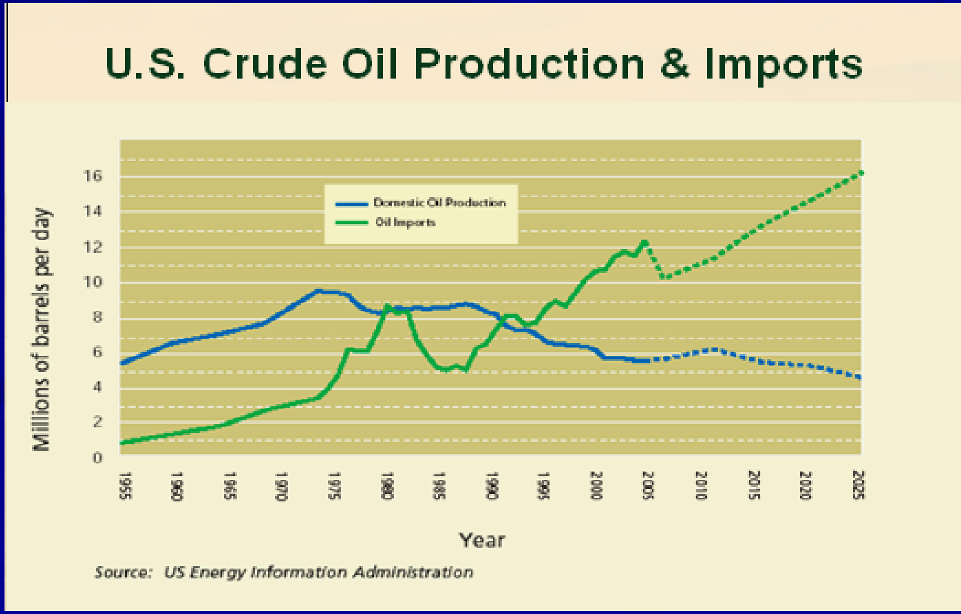
Overview of the presentation

- Introduction
  - Rationale for bioenergy
- Policy environment of bioenergy
- Selected forest bioenergy research of the Forest Policy and Economics Network (FORPEN)
  - Is adoption or pledge to adopt renewable portfolio standards (RPS) random?
  - Economics of using slash pine forest biomass for bioenergy
  - Determining optimum incentives to improve the health of forests and to promote bioenergy
- Challenges and opportunities for bioenergy

Introduction – Rationale for bioenergy

- US consumes 200 billion gallons of fuel per year
  - 140 billions of gasoline
  - 60 billions of diesel
- Price of crude oil is increasing
- Demand for energy is increasing
- Domestic production of oil is decreasing
- Oil imports are on the rise
- Concern for high dependency on foreign oil is escalating

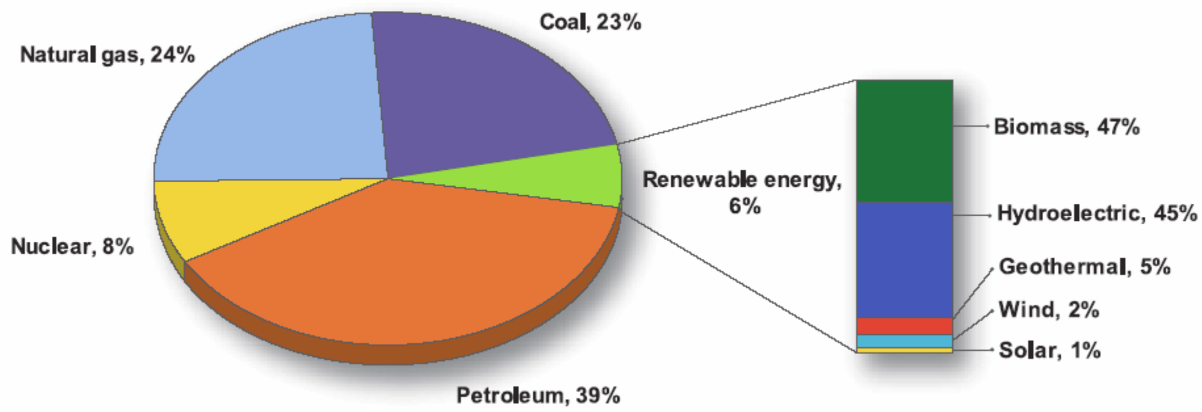




1 gallon = ~3.8 liters

Introduction – Rationale for bioenergy

- Renewable energy accounts for ~6% of total US energy consumption
- Biomass energy accounts for ~3% of total US energy consumption



Biomass Consumption	Million dry tons/year
Forest products industry	
Wood residues	44
Pulping liquors	52
Urban wood and food & other process residues	35
Fuelwood (residential/commercial & electric utilities)	35
Biofuels	18
Bioproducts	6
Total	**190**

- Forestlands and agricultural lands contribute 190 million dry tons of biomass - 3% of America's current energy consumption.

Source: EIA, 2004a & b

Figure 2: Summary of biomass resource consumption

Introduction – Rationale for bioenergy

- Over 1.3 billion dry tones of biomass per year is available to displace 30% of U.S. fossil fuel consumption (Perlack et al. 2005)

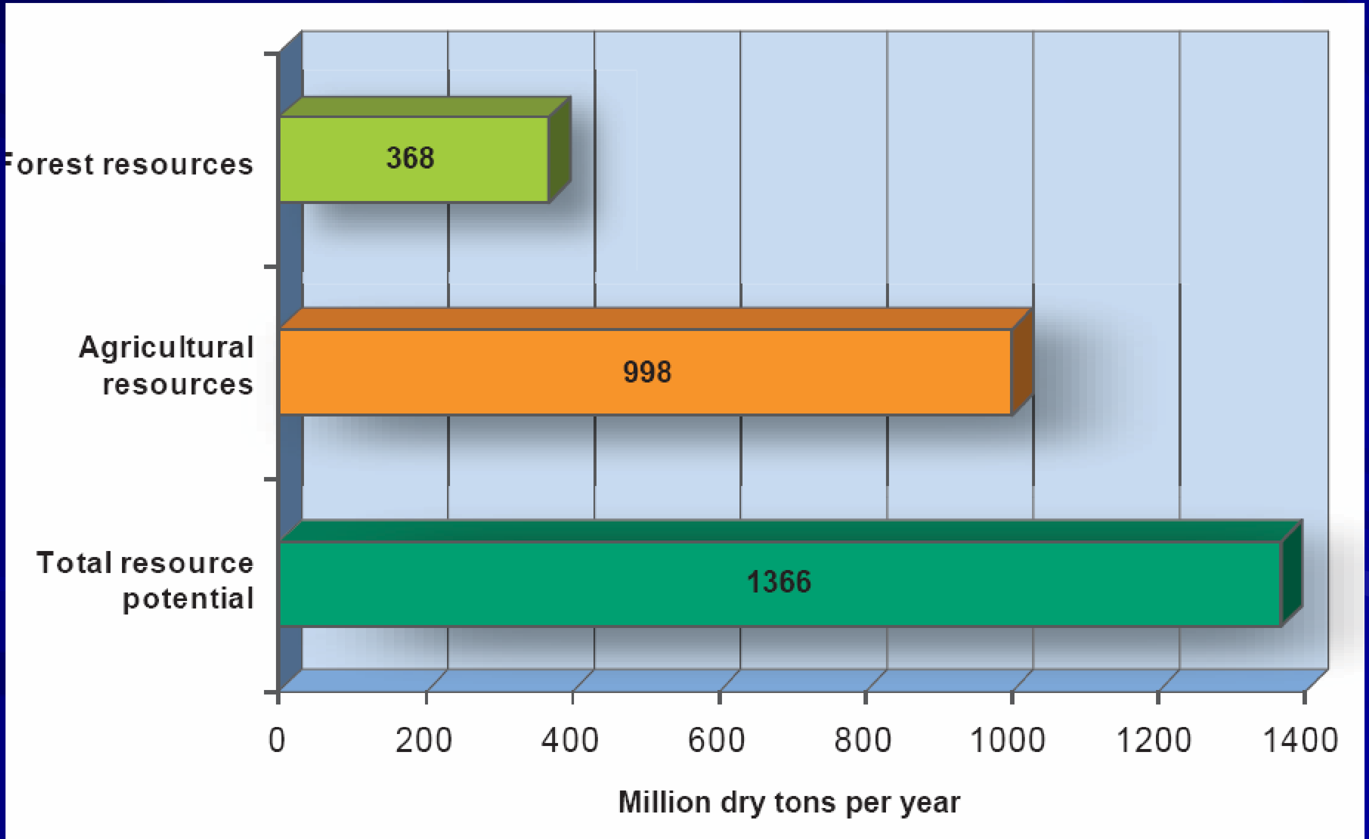
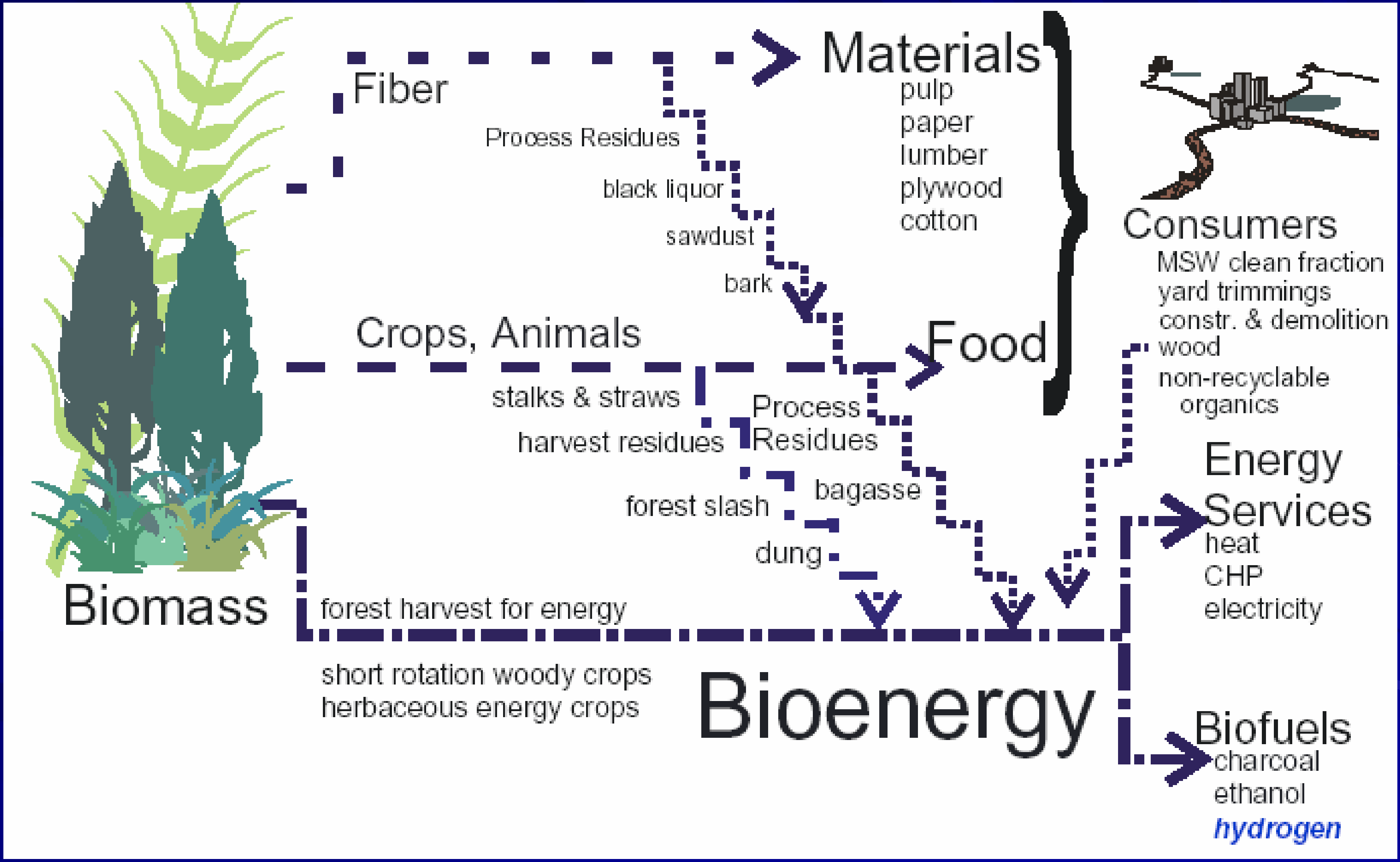


Figure 1: Annual biomass resource potential from forest and agricultural resources

Introduction – Rationale for bioenergy

- It is renewable and thought to be environmentally benign and socially desirable
- Energy input per unit of ethanol is lower than the energy output (0.78 million Btu of fossil fuel is needed for 1 million Btu of ethanol delivered) --Wang 2007; Hill et al. 2006; Farrell et al. 2006
- On a per-gallon basis, corn and cellulosic ethanol could reduce GHG emissions by 18-28% and 87% respectively (Wang 2007)
- New markets, economic stimulation, and additional employment opportunities (Gordon 2006) in:
  - Growing & collecting
  - Processing and shipping
  - Value added activities

Mapping the biomass to bioenergy



With grateful acknowledgements to Bob Shleser

Policy environment of bioenergy

- Selected energy related policies
  - Tax credit of $0.51 per gallon for ethanol until 2010
  - The American Jobs Creation Act of 2004
    - A tax credit of $1.00 per gallon of biodiesel from oil crops and animal fats
    - $0.50 per gallon tax credit for production from recycled fats and oils
  - The Energy Policy Act 2005
    - Renewable fuel standard (RFS): 4 billion gallons in 2006 and 7.5 billion gallons by 2012
    - Cellulosic Biomass Program: A gallon of ethanol produced from crop residues and tree crops can be counted as 2.5 gallons to satisfy the RFS

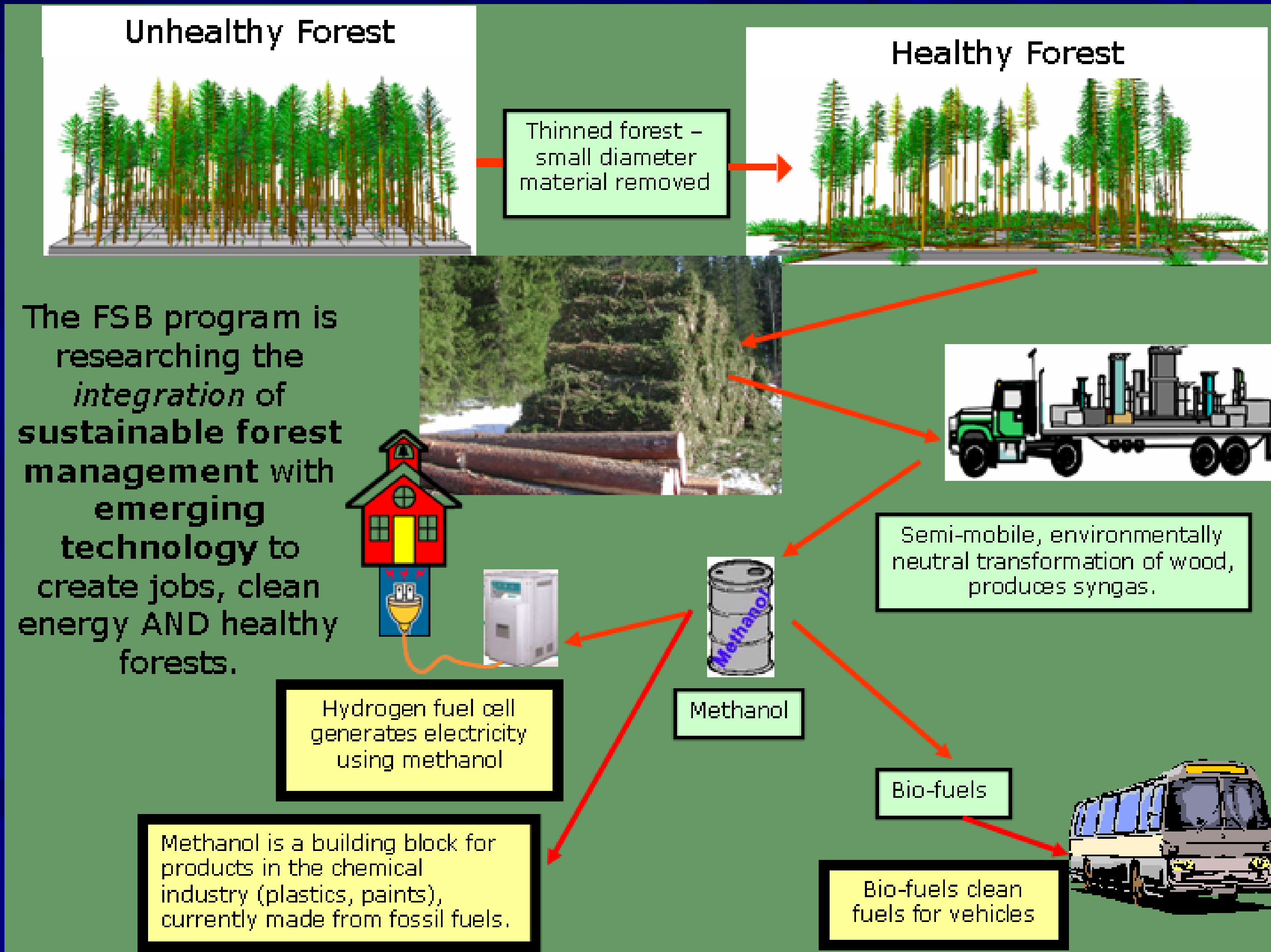
Policy environment of bioenergy

- Selected environmental policies
  - EPA phased out lead with ethanol as an octane enhancer
  - Clean Air Act
    - Oxygenate methyl tertiary butyl ether (MTBE) is being phased out and replaced with ethanol
    - Payments to carbon credits??
- Selected agricultural policies
    - USDA 2000 Appropriations Act: Authorized biomass harvest on CRP lands
    - Commodity Credit Corporation (CCC) Bioenergy Program 2000: Alleviate crop surpluses and stimulate production of biofuels

Policy environment of bioenergy

- Selected agricultural policies (continued)
  - Farm Security and Rural Investment Act of 2002
    - Federal Biobased Products Preferred Procurement Program (FB4P): Requires federal agencies to procure biobased products
- USDA Forest Policy
  - Healthy Forest Restoration Act
    - Develop innovative opportunities for small diameter wood and improve the health of forests
    - Authorize funds to establish small-scale business enterprises to make use of biomass and small-diameter material

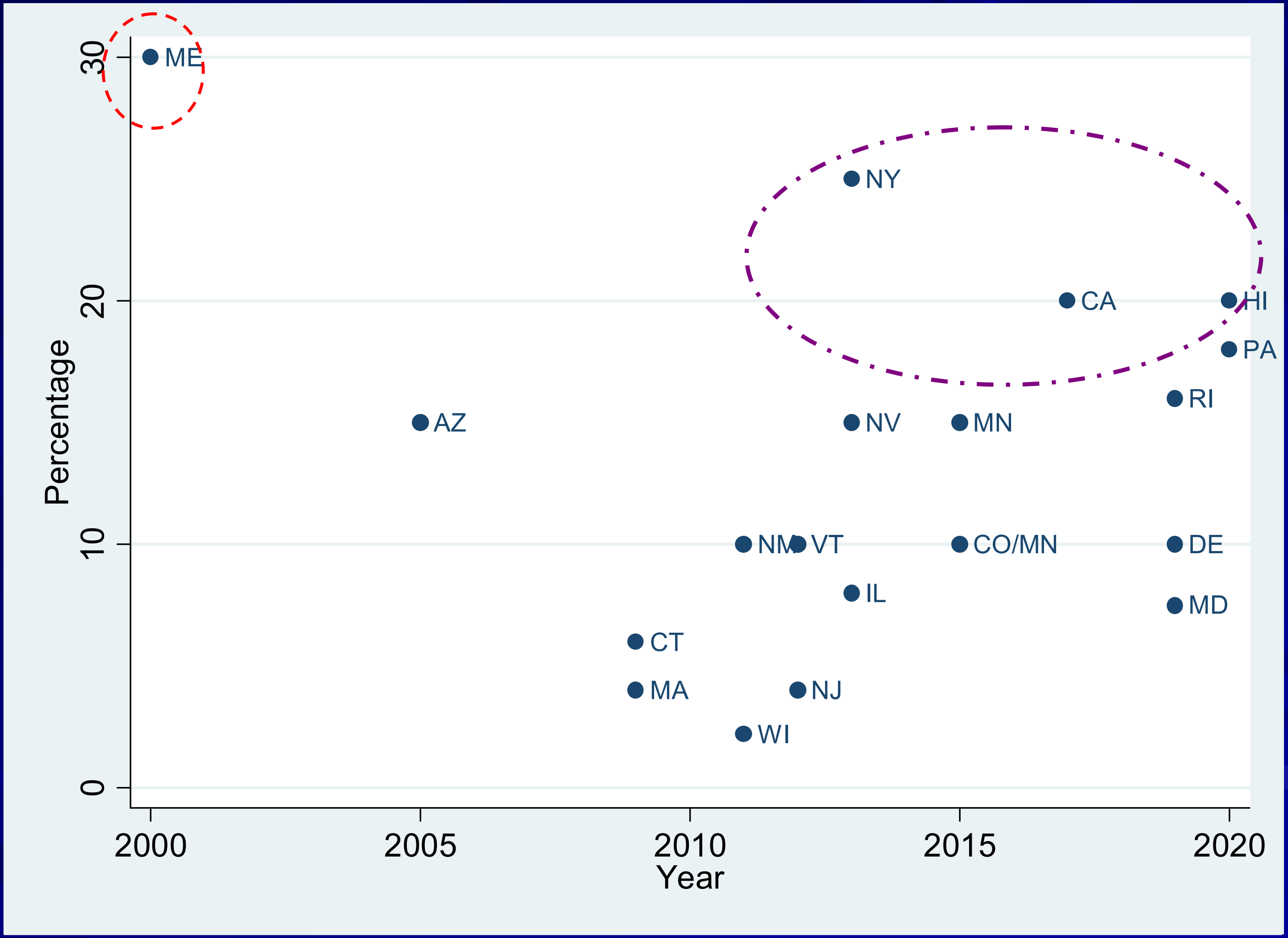
Intent of Healthy Forest Initiative 2003



Forest biomass and bioenergy research

- Renewable portfolio standards (RPS) creates a cap-and-trade system for renewable energy credits
- As of September 2005, RPS have been adopted or pledged to adopt in 21 states and the District of Columbia
- *Is adoption or pledge to adopt RPS random?*
- *If RPS are an innovation, what are the factors influencing their adoption?*

Renewable Portfolio Standards by state in the USA (2005)



As of September 2005, RPS were adopted or pledged to adopt in 21 states and the District of Columbia.

Model specification and variables

- Dependent variable - a binary variable

  Y=1, Adoption or pledged to adopt RPS

  Y=0, Otherwise
- Independent variables
  - Socio-economic factors
    - Gross State Product (GSP)
    - Growth rate of population (GRP)
    - Education: % of population (25 years and over) with a bachelor's degree or more
  - Political factor
    - Political party dominancy (PPD): If the total number of Republicans in the Senate and the House is greater than Democrats, a value of 1 is assigned and 0 otherwise.
  - Environmental factors
    - Natural resources expenditure (NRE)
    - Share of coal in electricity generation (Coal)

$$\ln[P_i / 1 - P_i] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki}$$

Logistic regression results

Variable	Coefficient	Robust SE	Elasticity at means
GSP	0.0065*	0.0037	0.8221
GRP	20.9745*	12.1464	0.4694
EDUCATION	0.1424**	0.0601	2.2079
PPD	-2.6060**	0.9075	-0.9043
NRE	-0.0031*	0.0018	-0.5989
COAL	0.0096	0.0110	0.2785
Constant	-4.2492**	1.94	-2.4574
Pseudo R^2	0.3351		
Correct prediction	82.00%		
LR test	22.98		

Coefficients significant at ** *p*<0.05, **p*<0.10

Source: Huang, Alavalapati, Carter, and Langholtz (2007)

Forest biomass and bioenergy research

- *Economics of utilizing slash pine forest biomass for electricity or ethanol in Florida*
- Florida consumes 8 billion gallons of fuel each year (99% is imported)
- With 18 million people, per capita consumption is ~440 gallons
- Florida Energy Act of 2006
  - $30 million dollar, 4 year plan for energy diversification
- HB 7123 (most recent State bill) designed to jumpstart renewable energy investment and development in the State
  - Designates creation of a $20 million dollar cellulosic ethanol demonstration plant

- Sugar cane to ethanol (401,000 ac)
- Citrus to cellulosic ethanol (748,555 ac)
- Peanuts and soybeans to biodiesel (171,000 ac)
- Corn to ethanol (65,000 ac)
- Mined lands for SRWC (200,000 ac)
- Forests ~(16,000,000 ac)

Economics of using forest biomass for bioenergy

- Currently slash pine plantations in Florida are not thinned
  - Forest stands are highly prone to catastrophic wildfires
  - Lack of vigor – susceptible for pest attacks (Southern Pine Beetle)
- Thinning not only improves the health of forest but also provides biomass for bioenergy
- Additional market for biomass feedstock may improve profitability of slash pine forestry

Economics of using forest biomass for bioenergy

- The Black and Scholes-Faustmann (BSF) approach is used to value a forest stand
- C= S*N(d1)-X*exp(-rt)*N(d2)
- C is the value of the option, S is the stock price, and X is the current exercise cost; r is risk free interest
- d1= {Ln[(S)/X] + σ2 t/2} / [σ √t]; d2= d1 – σ √t
- N(d1) and N(d2) are the standard normal cumulative distribution function

Economics of using forest biomass for bioenergy

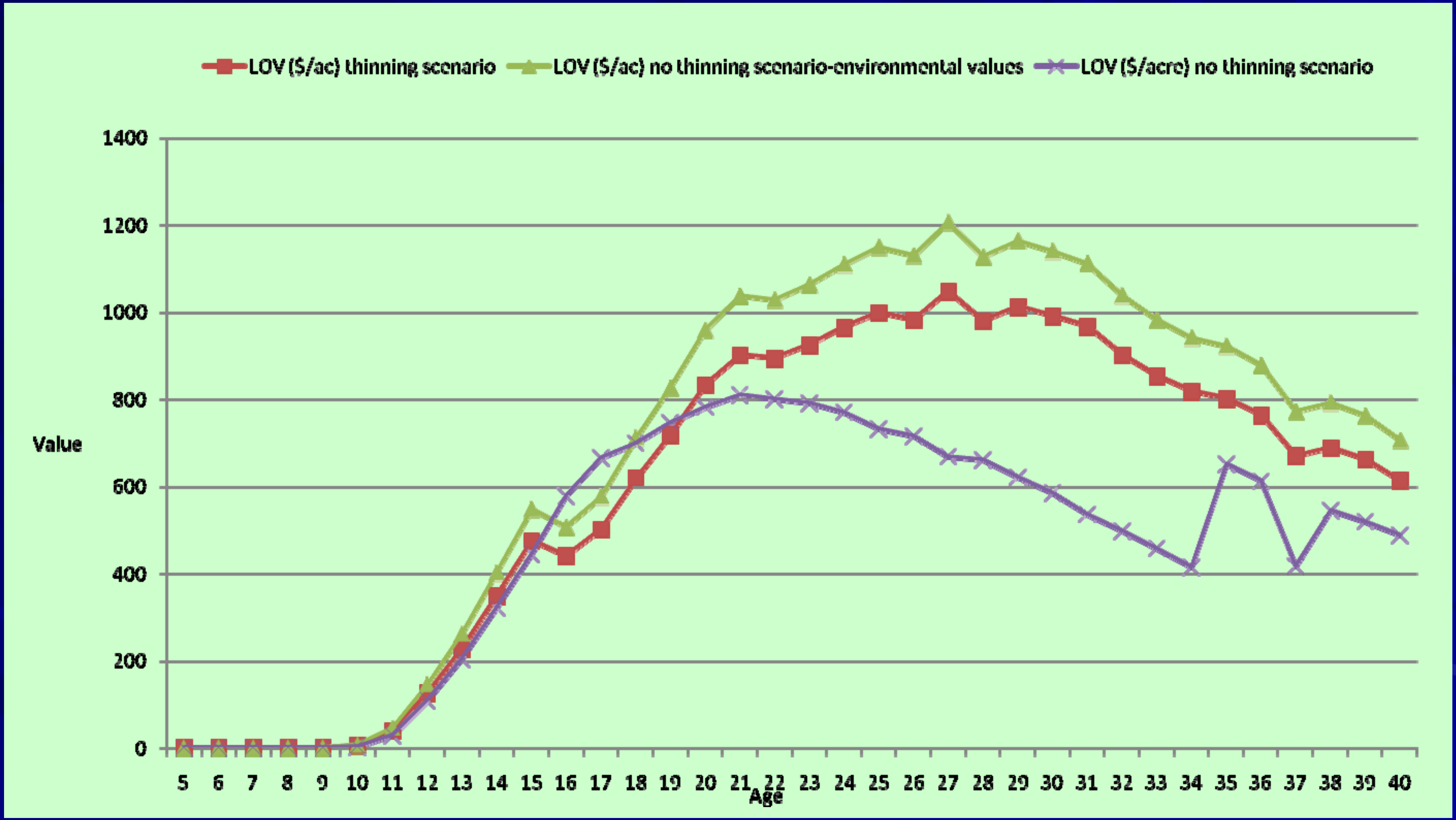
- Under the assumption of perpetual forestry the Black and Scholes formula takes the following structure
- F(t)= V(t)*{(S*N(d1)-X*exp(-rt)*N(d2)}
  - F(t) is the value of the forest
- LOV= F(t)*(1-exp(-pt))
- S is the stumpage price; X is the forest management cost; p is the discount rate
- Environmental benefits in terms of reduction of wildfire hazard and pest attack are incorporated
- LOV is the Land Option Value (similar interpretation of the Land Expectation Value)

Economics of using forest biomass for bioenergy

S1 (Sawtimber)	$43.2 ton/acre
S2 (Chip and Saw)	$25.75 ton/acre
S3 (Pulpwood)	$7.48 ton/acre
S4 (Forest biomass for bioenergy)	$7 ton/acre
$\sigma 1$ (Sawtimber)	0.1007
$\sigma 2$ (Chip and Saw)	0.1004
$\sigma 3$ (Pulpwood)	0.11
$\sigma 4$ (Forest biomass for bioenergy)	0.14
r	0.03
p	0.05

Parameters used in the model

Economics of using forest biomass for bioenergy



Slash pine forestland option under different scenario

Economics of using forest biomass for bioenergy

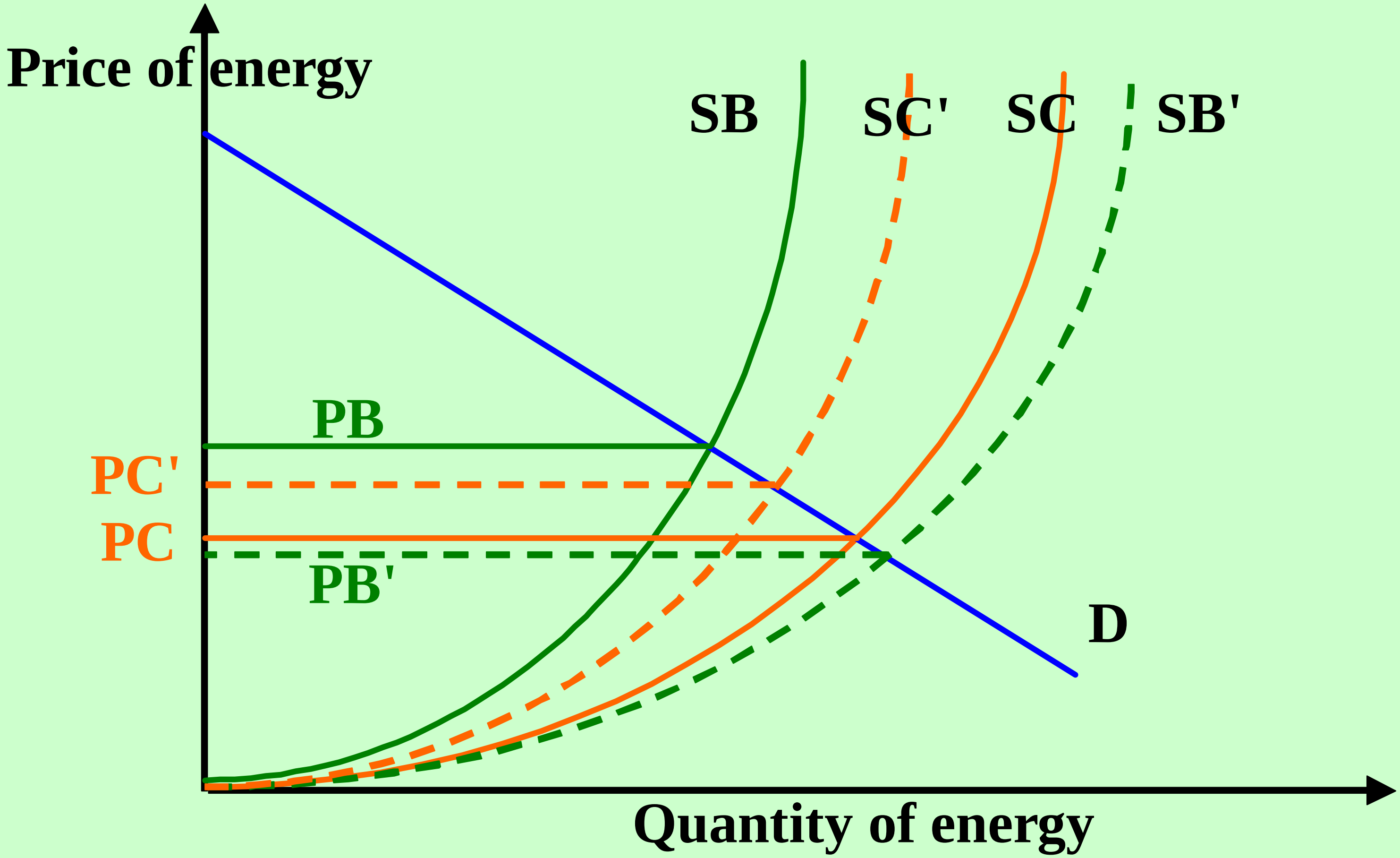
- The LOV under "no thinning" scenario is $810.42/acre with an optimal rotation age of 21 years
- The LOV under "thinning with environmental benefits scenario" is $1206.86/acre with an optimal rotation age of 27 years
- Bioenergy option is shown to improve the value of forestland by ~49%

Determining optimum incentives to improve the health of non-industrial private forests (NIPF) and to promote forest bioenergy in the U.S. south
(on-going research)

J.R.R. Alavalapati and W.H. Smith, G. Amacher, and S. Mehmood
Respectively, University of Florida, Virginia Polytechnic Institute and State University, and University of Arkansas

http://www.sfrc.ufl.edu/faculty/alavalapati/bioenergy/index.html

Environmental economics of bioenergy



D=demand for energy; SB= supply of bioenergy; SC=supply of conventional energy; P=price

Source: Alavalapati et al. 2006

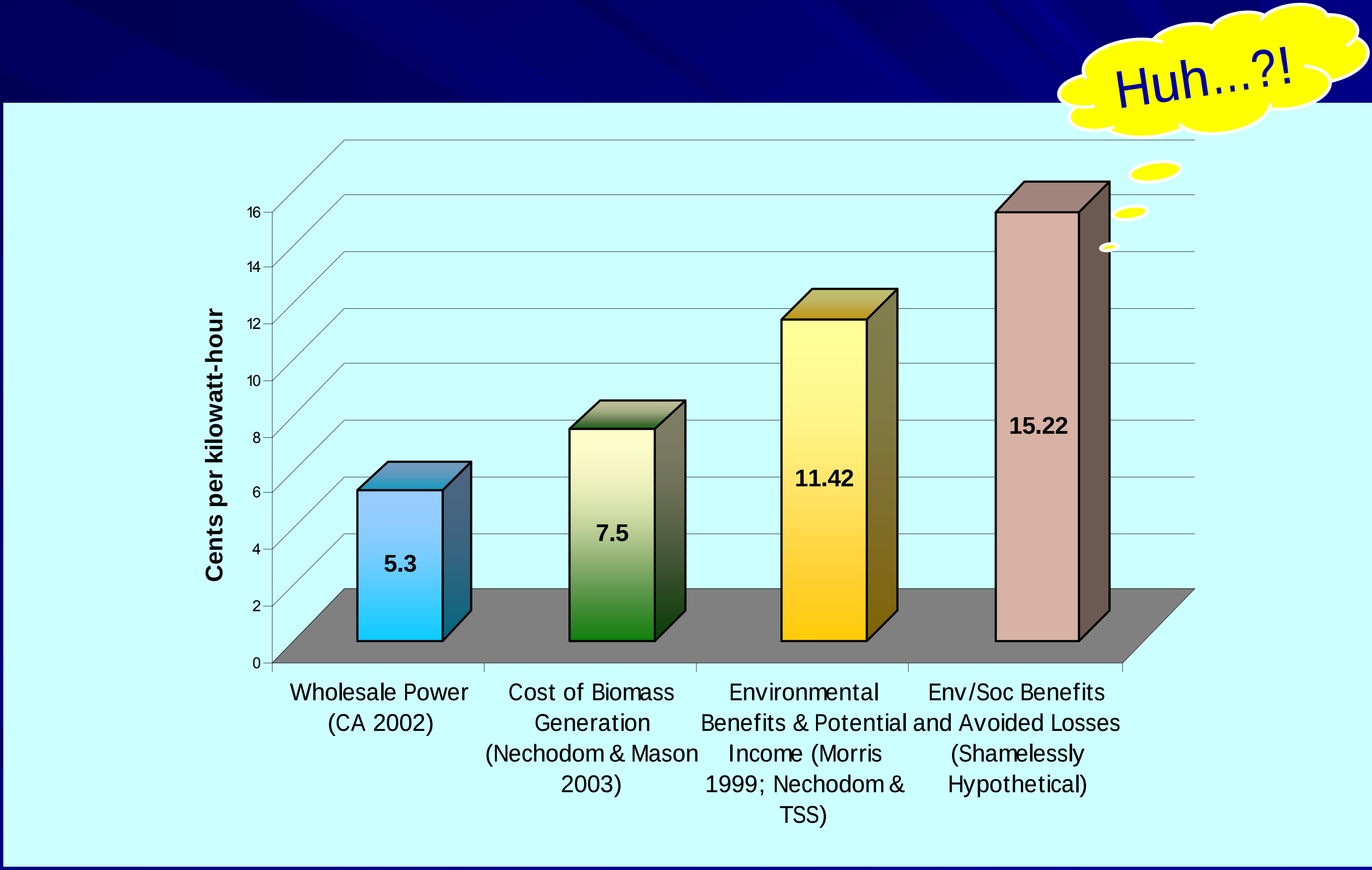
Task 1: Assess the preferences of NIPF landowners for policy incentives in Florida, Arkansas, and Virginia

- Data on the following is being collected through a survey
  - Willingness to participate in incentive programs to improve forest health
  - Willingness to participate in biomass cooperatives
- In addition, Forest Inventory and Analysis (FIA) data is being analyzed to explore the amount and nature of the available NIPF resources in the South.

Task 2: Assess public preferences/support for bioenergy and forest sustainability

- A household survey is being developed to elicit data on public preferences for sustainable woody biomass production and bioenergy
  - Focus groups, pre-testing, and mail survey
  - Random selection of households from FL, VA, and AK
- Develop a MNL model to analyze household data
- Estimate public willingness to pay for societal benefits (improve health of forests, reduce foreign oil dependency, air quality) associated with forest bioenergy
- Integrate willingness to pay estimates into regional impact analysis of policies

Costs & benefits per kilowatt-hour electricity production



Task 3: Assess the impacts of policy incentives on land use decisions

- A model describing landowner decisions, guided by Task 1, is being developed

- Land use response functions will be developed showing how the profitability depends on bioenergy policy instruments

- Integrate land use response function into regional impact analysis (Task 4)

Landowner decision-making model

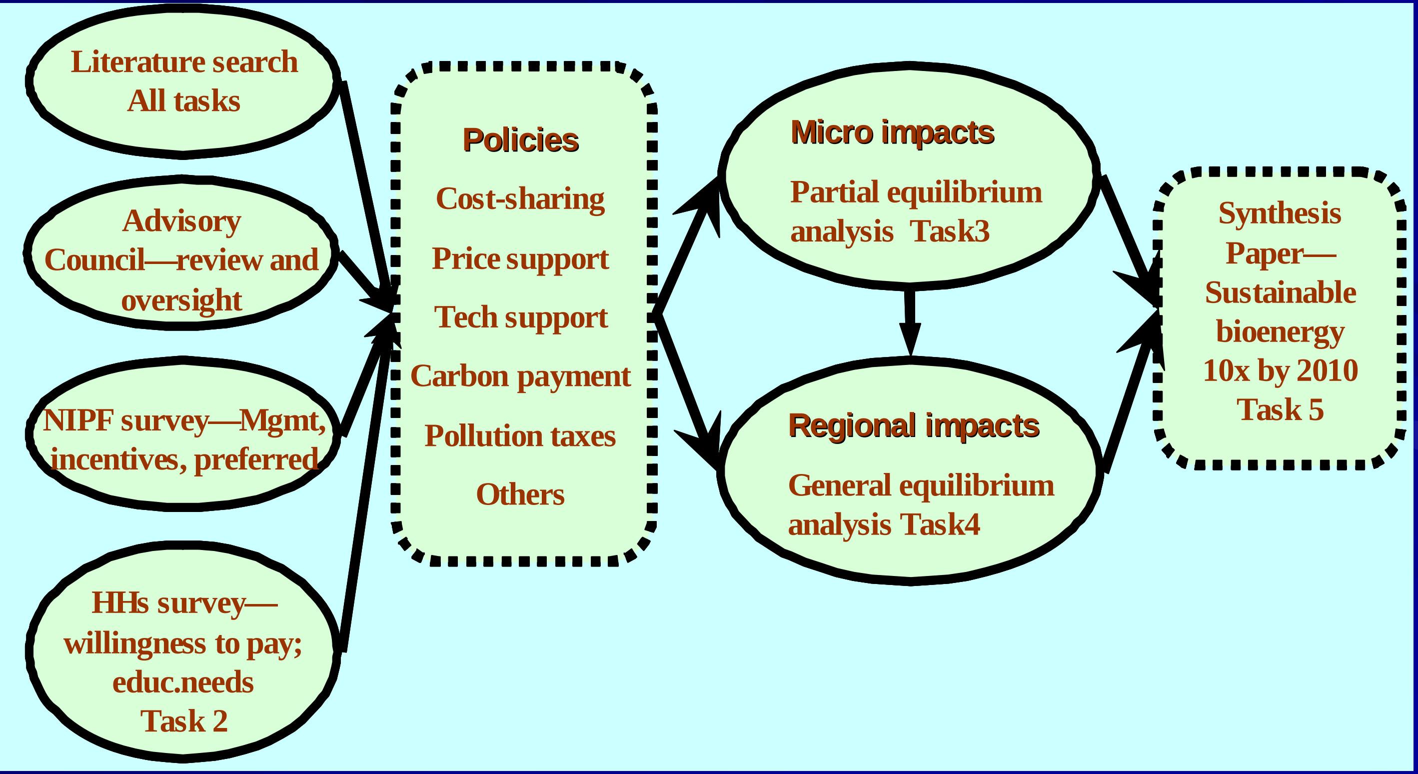
- Dynamic approach
  - Landowner cares about timber and non-timber uses of forests
- Solve for optimal forest management decisions on land used for bioenergy production
- Embed decision model into an optimal land allocation problem comparing bioenergy production to best alternative (non-bioenergy) uses of land
- Risks to bioenergy production will be included
- Analyze five types of instruments: tax incentives, land use or set aside payments, tree planting cost sharing, and cooperatives among adjacent landowners in forming biomass sheds

Task 4: Assessing regional impacts of biomass production and use for bioenergy Approach

- A computable general equilibrium model is being developed for the southeastern USA
  - Model will be simulated to assess the following policy shocks
    - Cost sharing
    - Price support
    - Technical support
    - Carbon payments
    - Pollution taxes
  - Both economy-wide and distributional impacts of above policies will be estimated

Task 5: Developing a Synthesis Paper on Bioenergy and Sustainability of NIPF

- Draw information from
  - Extensive but coordinated review of literature
  - Results from tasks 1-4
- Assess the current situation and predict the future of NIPF sustainability



Challenges to bioenergy

- Controversy about energy yield ratios
  - Ethanol from corn requires 29% more fossil energy than the ethanol fuel produced, biodiesel from soybeans, 27% (Pimental et al. 2005)
  - More recent studies, however, claim net positive energy yields. +25% ethanol, +93% biodiesel, (Hill et al. 2006 among others)
- Market competitiveness
  - Cost of ethanol production using sugarcane ~$2.40 and using sugar beet ~$2.35 (USDA 2006); Competitive only under existing high prices of crude oil
  - Cellulosic ethanol is even less competitive

Challenges to bioenergy

- External costs of fossil fuels and benefits of bioenergy are not reflected in market prices
  - Cost of dependency on foreign oil
  - Benefit of reduction of green house gas emissions through bioenergy
- Incentive programs to support bioenergy must meet the "green box" criteria of WTO
  - Programs must be publicly funded, not involve transfers from consumers, and not have the effect of price support to producers
- Potential competition between food and energy security (Brown 2005)
- Limited information is available on long-term impacts (socio-cultural and environmental) of bioenergy production at regional/national level

THANKS!

Questions?