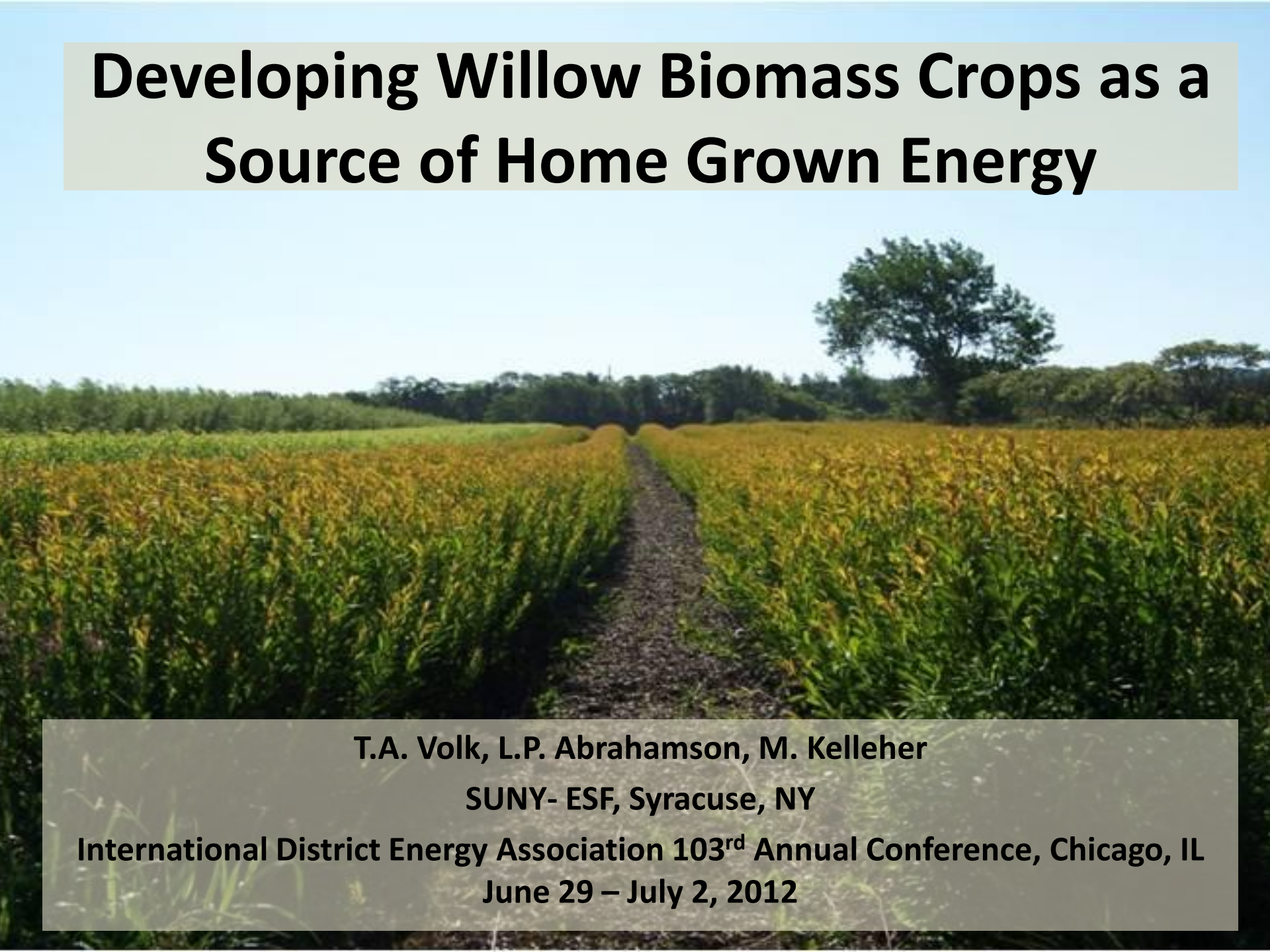
Developing Willow Biomass Crops as a Source of Home Grown Energy



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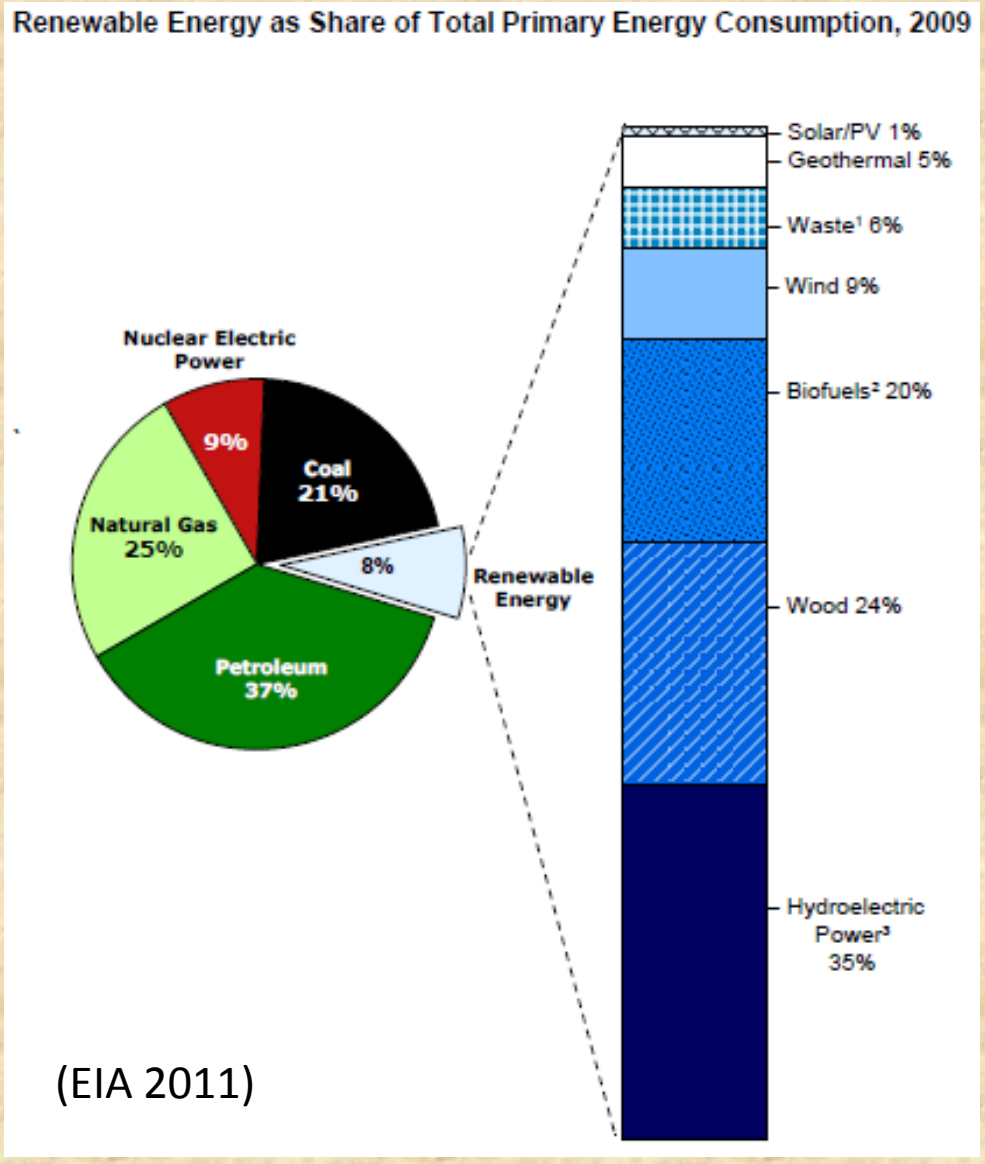
SUNY- ESF, Syracuse, NY

International District Energy Association 103rd Annual Conference, Chicago, IL
June 29 – July 2, 2012

Outline

- Role of woody biomass in current and future energy use in the United States
- Willow biomass crops
  - Production system
  - Environmental benefits
  - Economics and approaches for improvements
- SUNY ESF woody biomass CHP system

Role of Woody Biomass



(EIA 2011)

- Renewables contribute about 8% of the U.S. primary energy supply
- Biomass – wood and biofuels – is the largest source of renewable energy in the U.S.
- Wood is the second largest source of renewable energy in the U.S. after hydro
- Wood supplies about 2% of U.S. energy needs

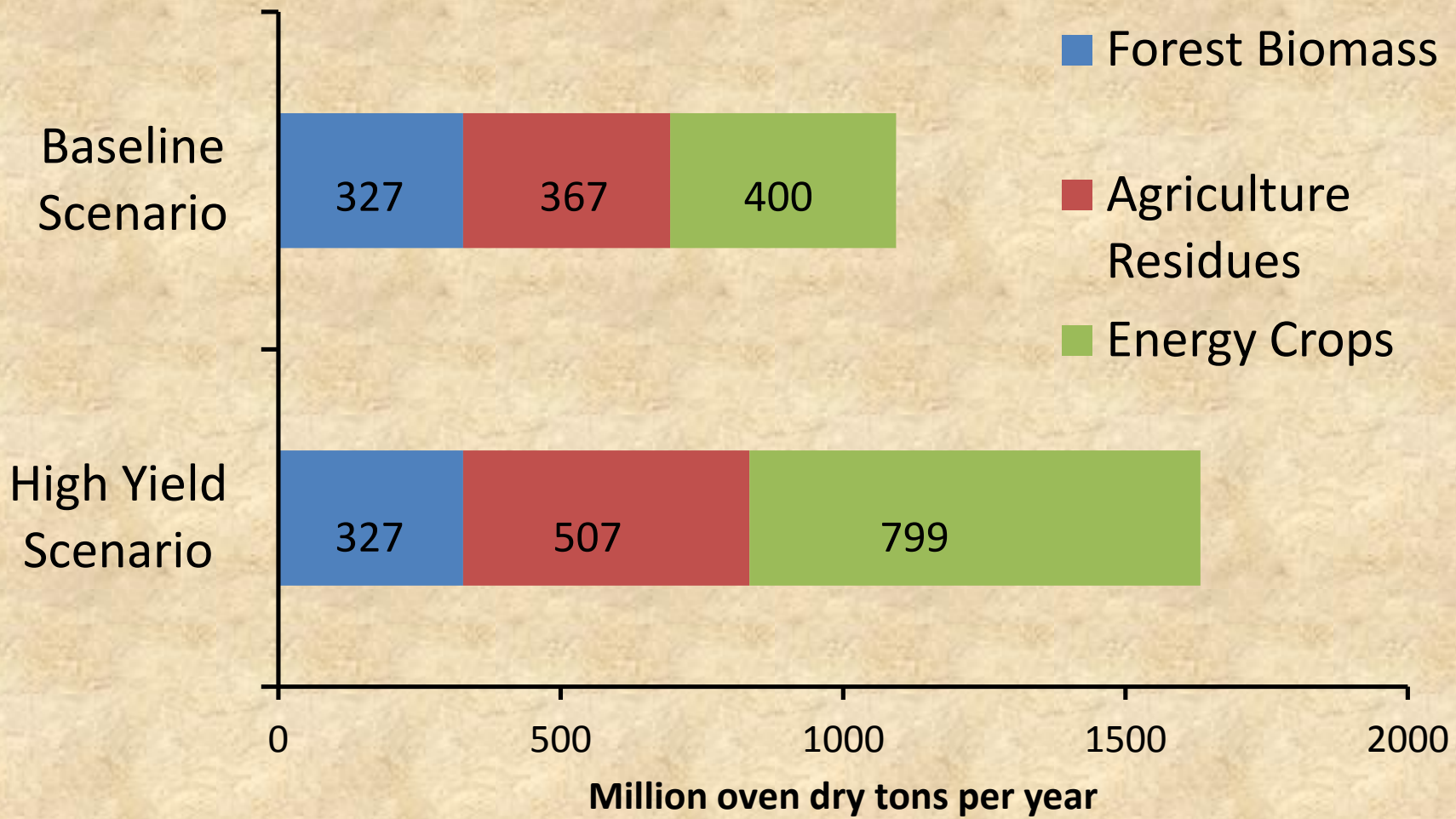
Woody Biomass Resources

- Variety of sources ranging from forest biomass to harvesting and manufacturing residues to short rotation woody crops (SRWC)
- Multiple sources can be harvested at different times of the year and mixed
  - Limits need for long term storage of feedstocks
  - Consistent year round supply can be maintained
  - Handling and transportation systems developed and in place
  - Just-in-time harvest and delivery
- SRWC and forests are perennial systems with low annual inputs and high potential to generate a broad range of ecosystem services
- SRWC are likely to be part of an integrated supply, not the sole source of material
  - Key SRWC in northern US: shrub willow and hybrid poplar

Billion Ton Update

- Biomass supply assessment for the U.S.
- Driven by need to meet the renewable fuels standard of 36 billion gallons by 2022
- 21 of the 36 billion gallons will come from cellulosic sources
  - Will require over 1 Billion dry tons of biomass per year to reach this target

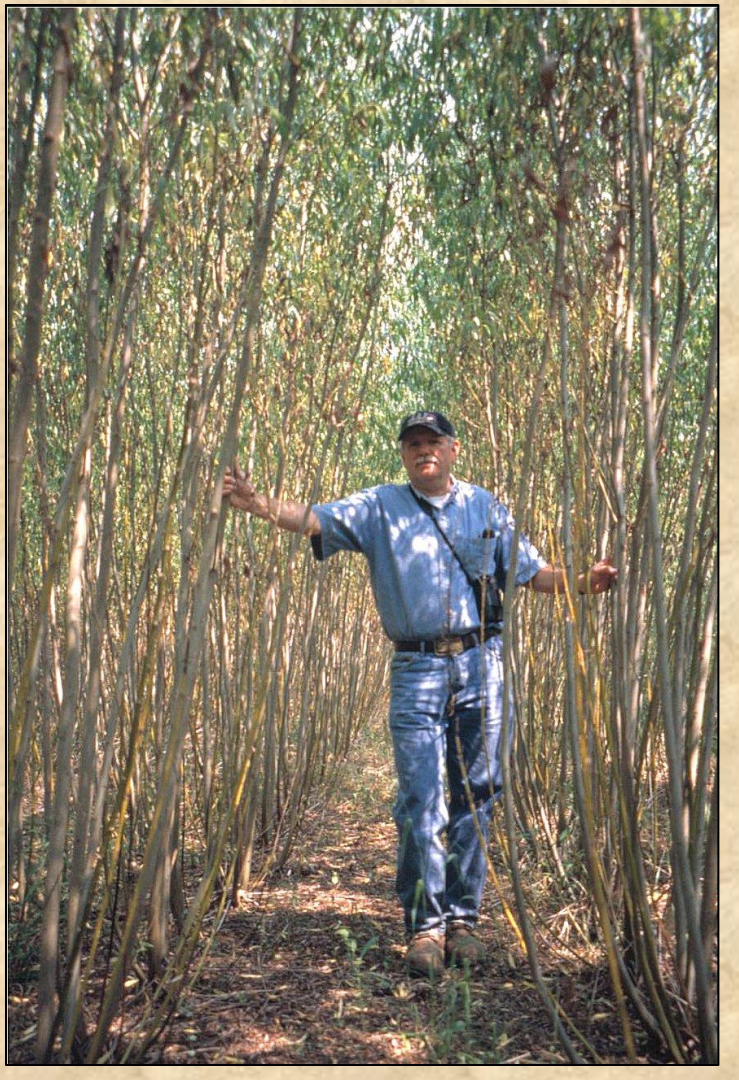
US Billion Ton Update



(USDOE 2011)

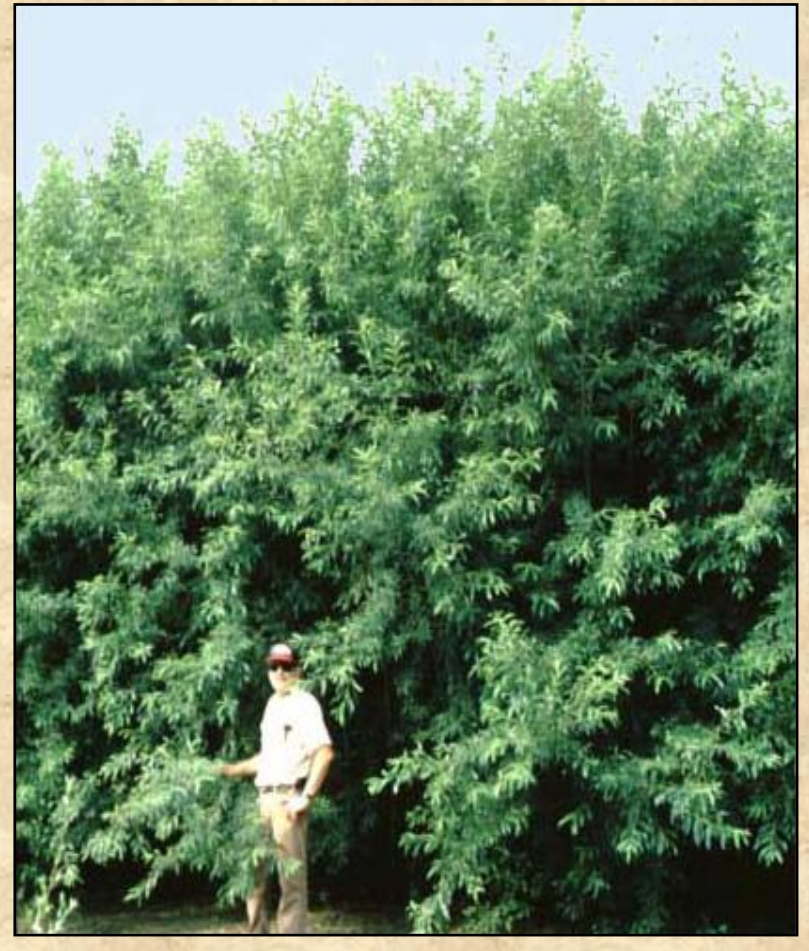
Willow Biomass Crops

- Over 350 species of willow in the world
- Wide range of genetic variability
  - Shrub willows are the main focus (>175 species)
- Pioneer species adapted to marginal conditions
- Coppicing ability
  - One planting, up to seven harvests
- Rapid growth and canopy closure



Three year old willow biomass crops.

Willow Biomass Crops

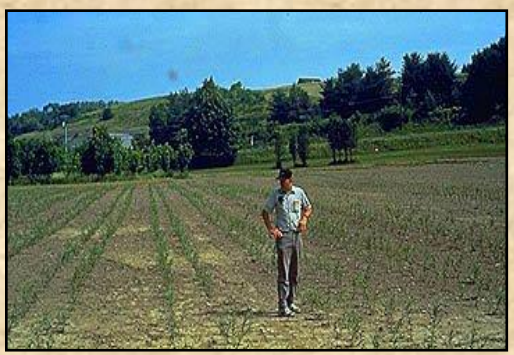


Three-year old willow in Tully, NY

- High biomass production potential
  - Yields of fertilized and irrigated unimproved clones up to 27 odt ha^{-1} yr^{-1} (Adegbidi et al. 2003)
- Easily established with unrooted cuttings
- Limited insect and pest problems
- Over 40,000 acres of commercial plantings in Europe
- Over 1,000 acres planted in U.S. with additional expansion underway
  - Over 25 yield trials in U.S. and Canada

Willow Biomass Production Cycle

Planting

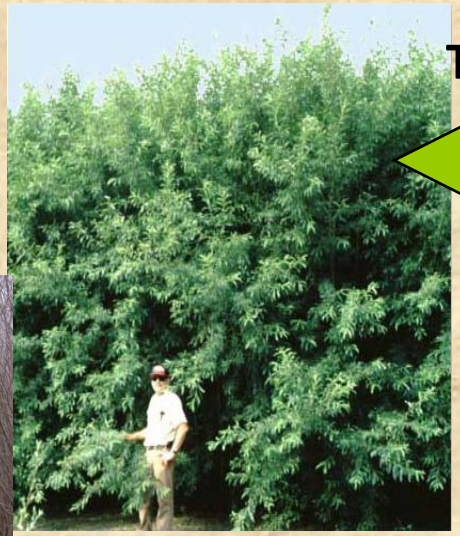


First year growth

Coppice

Early spring after coppicing

One-year old after coppice



Three-year old after coppice

Harvesting

Commercial Planting Stock Production

Shrub willows in nursery beds at Double A Vineyards, Fredonia, NY (www.doubleawillow.com).

- Double A Willow, Fredonia NY
  - More than 100 acres of willow nursery beds planted with varieties from SUNY ESF breeding and selection program since 2005
    - Includes several improved clones that have been awarded patents
  - Projected production of 30 million cuttings

Planting Equipment

Two styles of European planters being used in NY – the Step Planter and the Egedal.

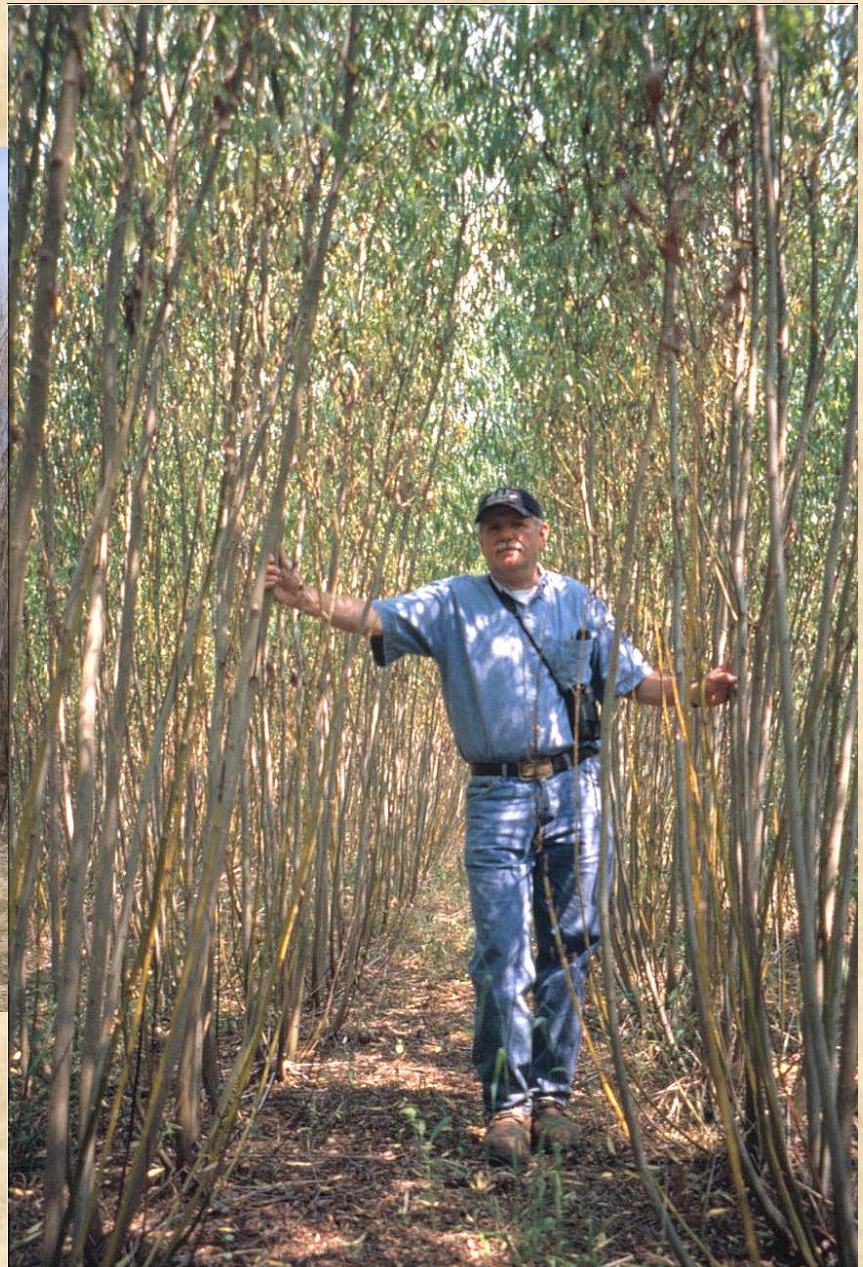
- Two different commercial willow planters in NY
- Step planter introduced to US in 1999 by SUNY – ESF
  - Under license for production in NY
- Egedal planter introduced to the US in 2008 by Dennis Rak from DoubleAWillow
- Planting rates around 2 acres per hour

Late May

Late June

Late August

Three Year Old Willow Biomass Crops

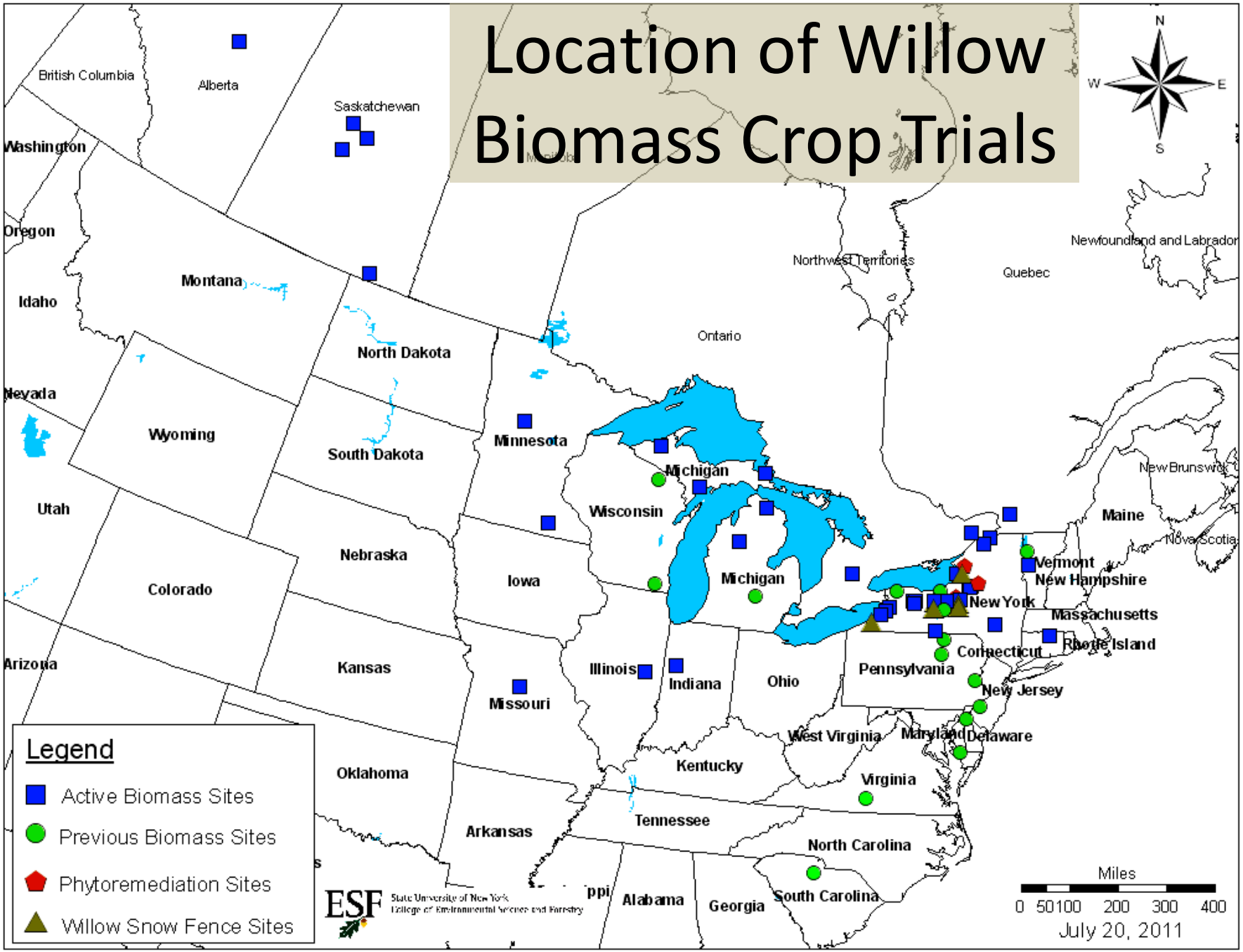


Harvester Development

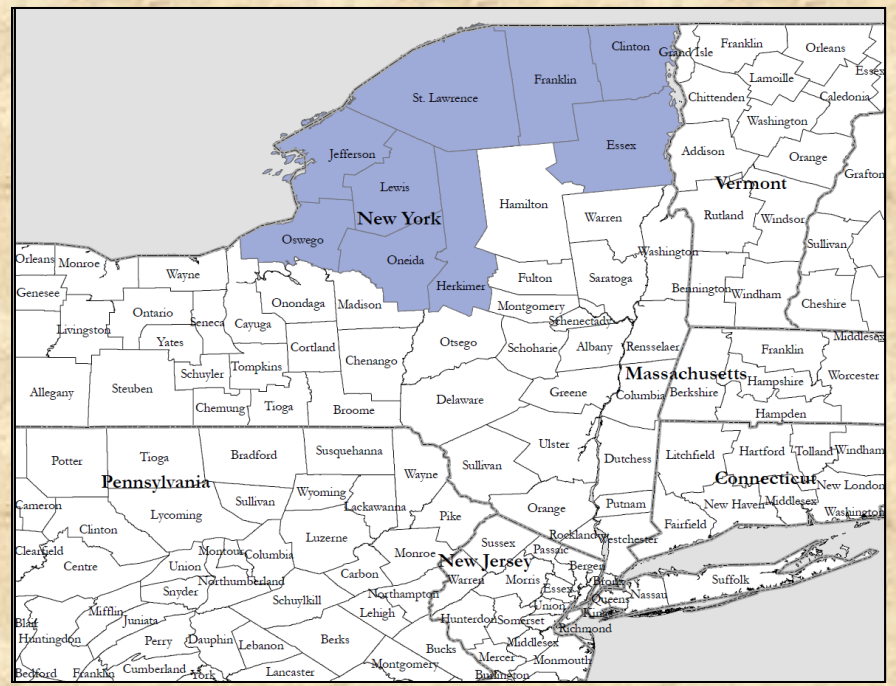
Harvesting three year old willow with a NH 130FB header designed for short rotation woody crops & NH FR9060 forage harvester

- Developing dormant season, single pass cut and chip harvesting system based on New Holland (NH) forage harvester with support from DOE and NYSERDA
- Increasing rotation from 3 to 4 years improves IRR from 5.5 to 8.8%
- Latest trials indicate that this system is effective and can harvest stems up to 12.5 cm (5 inches) in diameter

Location of Willow Biomass Crop Trials



Willow Biomass Crop Expansion



The BCAP region for willow biomass crops covers a nine county region in central and northern NY

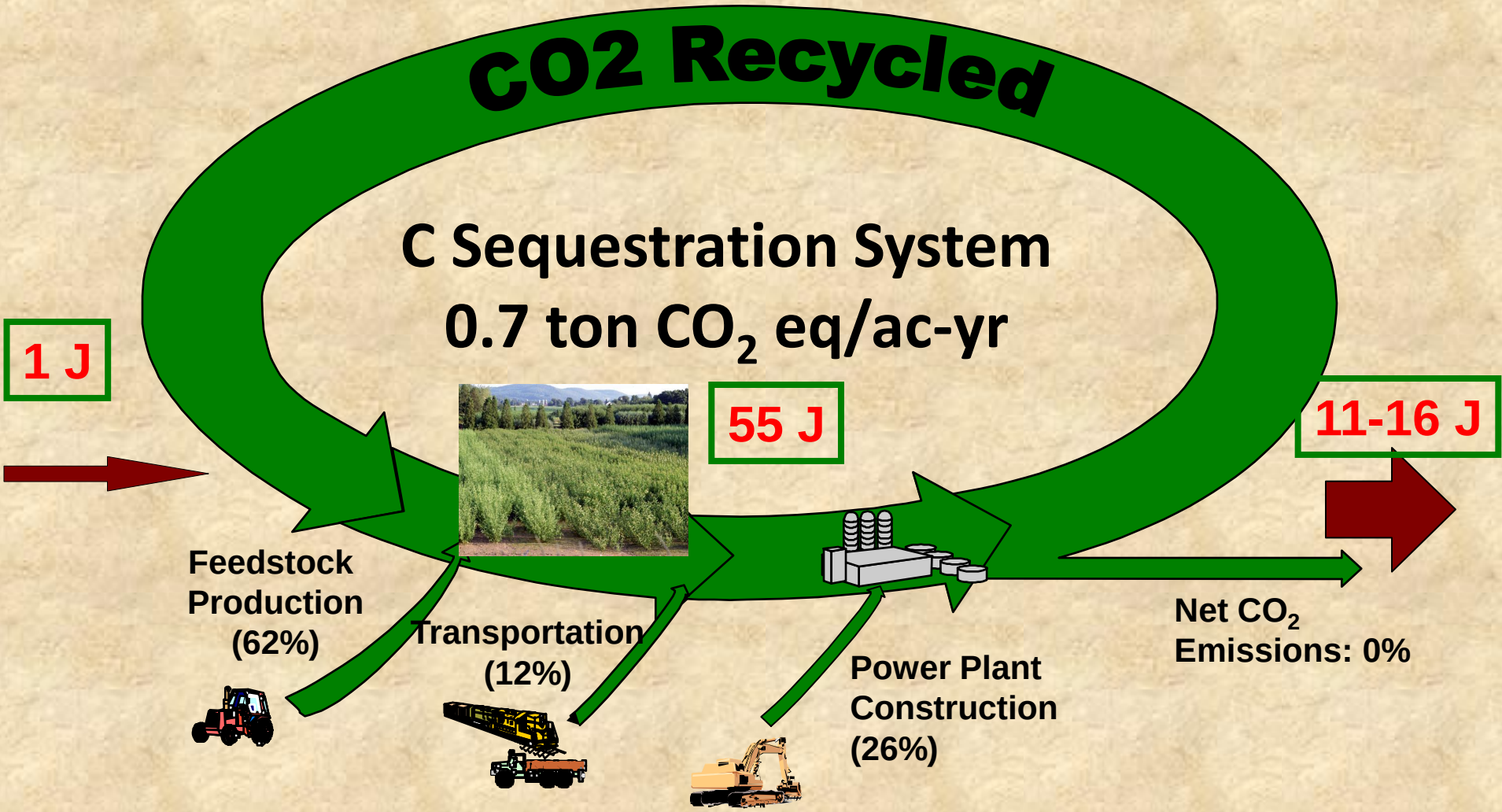
- USDA announced a biomass crop assistance project (BCAP) for shrub willow in a nine county region in central and northern NY
- ReEnergy has committed to purchasing all the biomass grown and using it for power and heat production in one of its three facilities in the region

Willow Biomass Crop Expansion

Planting willow biomass crops on marginal farmland in upstate NY

- Provides support to farmers for establishment of up to 3,500 acres of willow
- $4.3 million to support growers who establish and maintain the crop
  - Annual rental payment set by USDA based on soil characteristics
  - Up to 75% of establishment costs covered by USDA

Carbon Cycle and Net Energy Balance



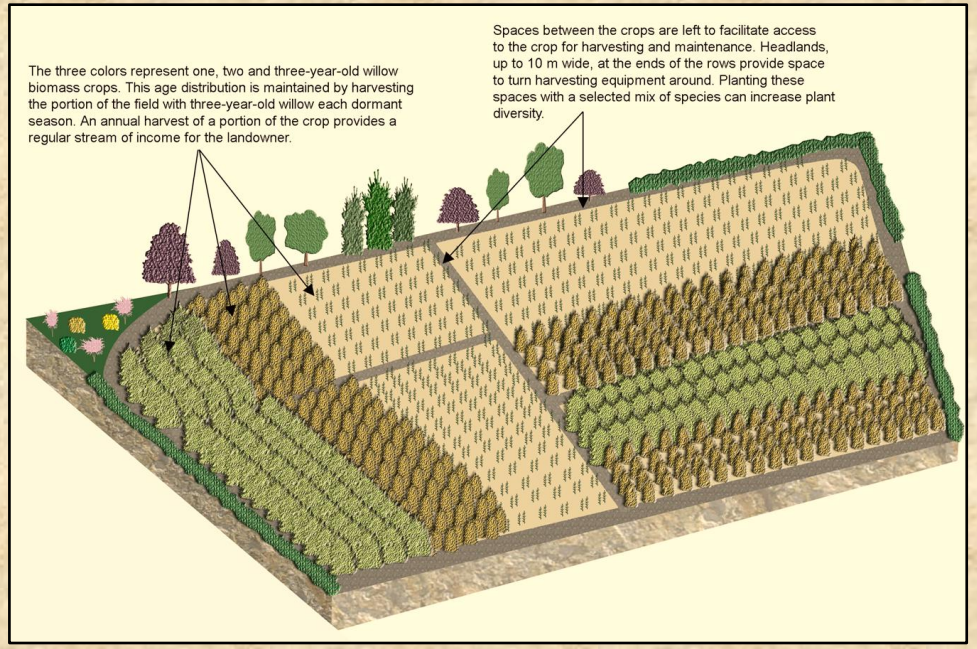
(Mann and Spath 1997, Heller et al. 2003, Pacaldo et al. 2011)

Bird Diversity in Willow

Andre Dhondt – Laboratory of Ornithology
Cornell University
Peter Wrege – Cornell University

Cornell Lab of Ornithology

Wildlife and Biodiversity Benefits



Different growth stages of willow biomass crops create diversity across the landscape

- Bird diversity in willow crops as high as natural shrub land and eastern deciduous forests (Dhondt et al. 2004, 2007)
- Mixtures of species and ages create structural and functional diversity across the landscape
- Harvest occurs during the dormant season

Willow Cash Flow Model

Welcome to EcoWillow v1.6

An Economic Analysis Tool for Willow Short-Rotation Coppice for Wood Chip Production

ESF State University of New York
College of Environmental Science and Forestry

Photo: Thomas Buchholz

Photo: Timothy Volk

Photo: Timothy Volk

Photo: Lawrence Smart

Project Name	
Location	
Acres (min. 20)	60

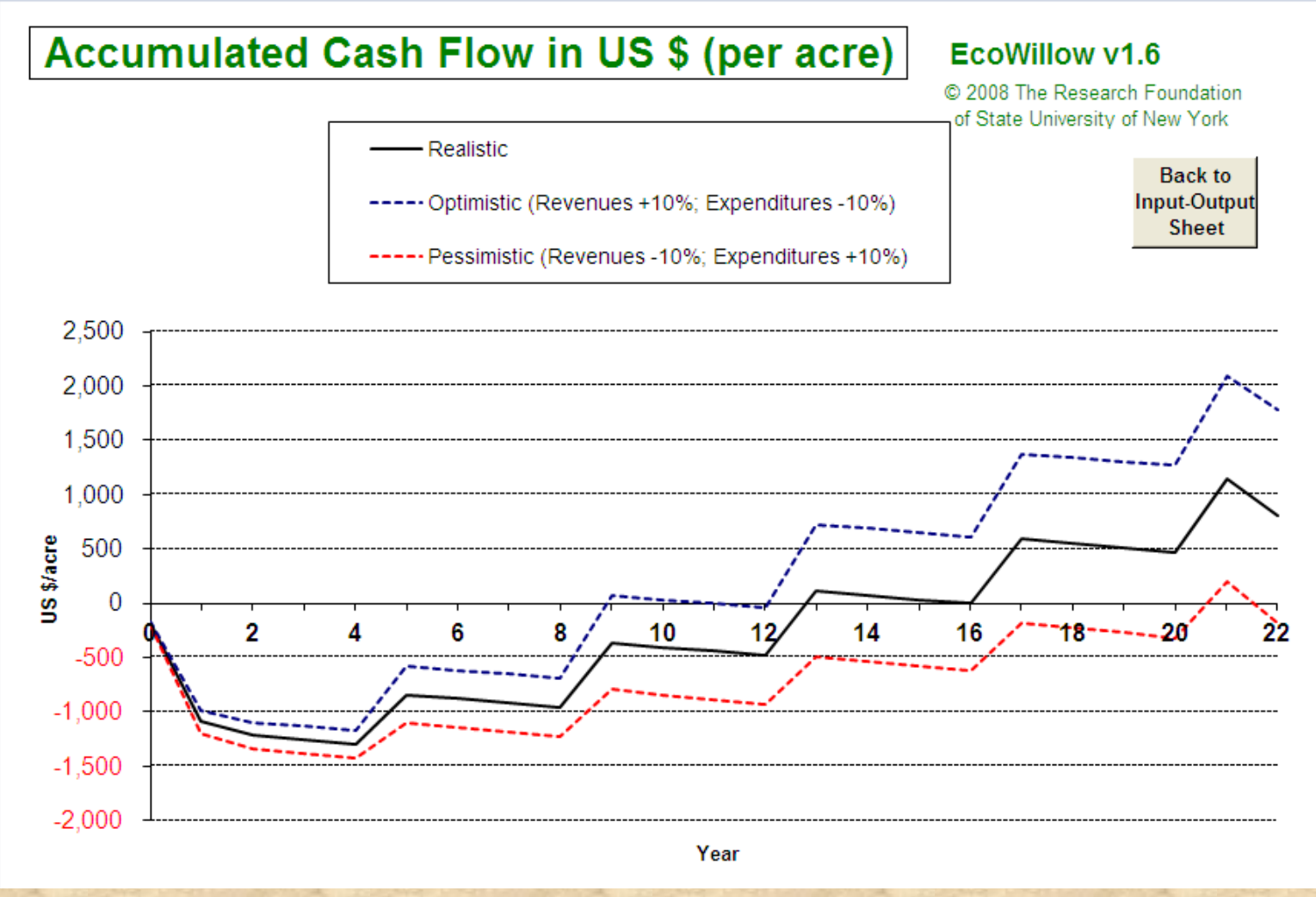
Begin

Tutorial

We acknowledge support of NYSERDA, USDA CSREES, and the State of New York, Dept. of Agriculture and Markets

(Available for download from http://www.esf.edu/willow/download.asp/)

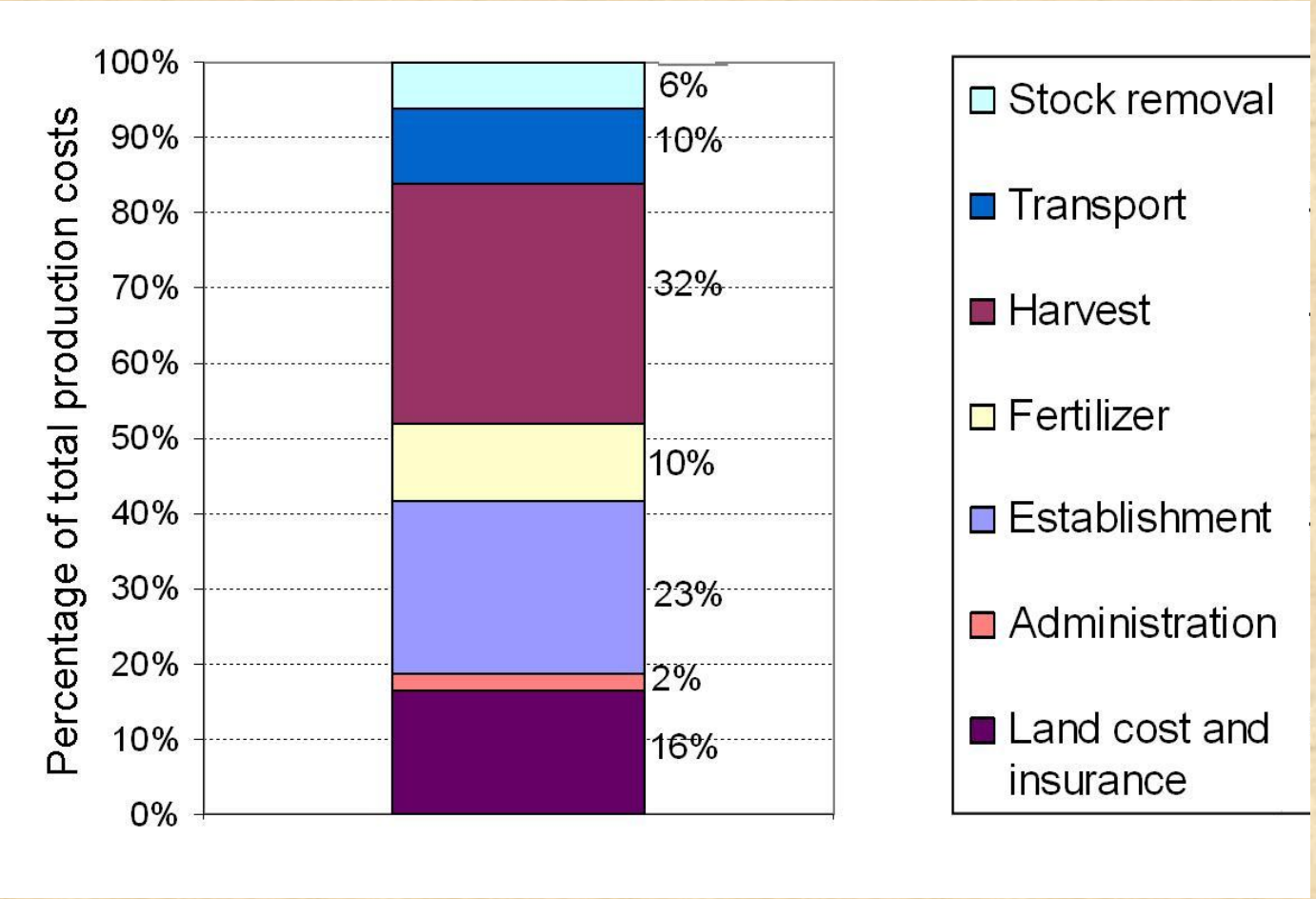
Economics of Willow – Base Case



IRR: 5%

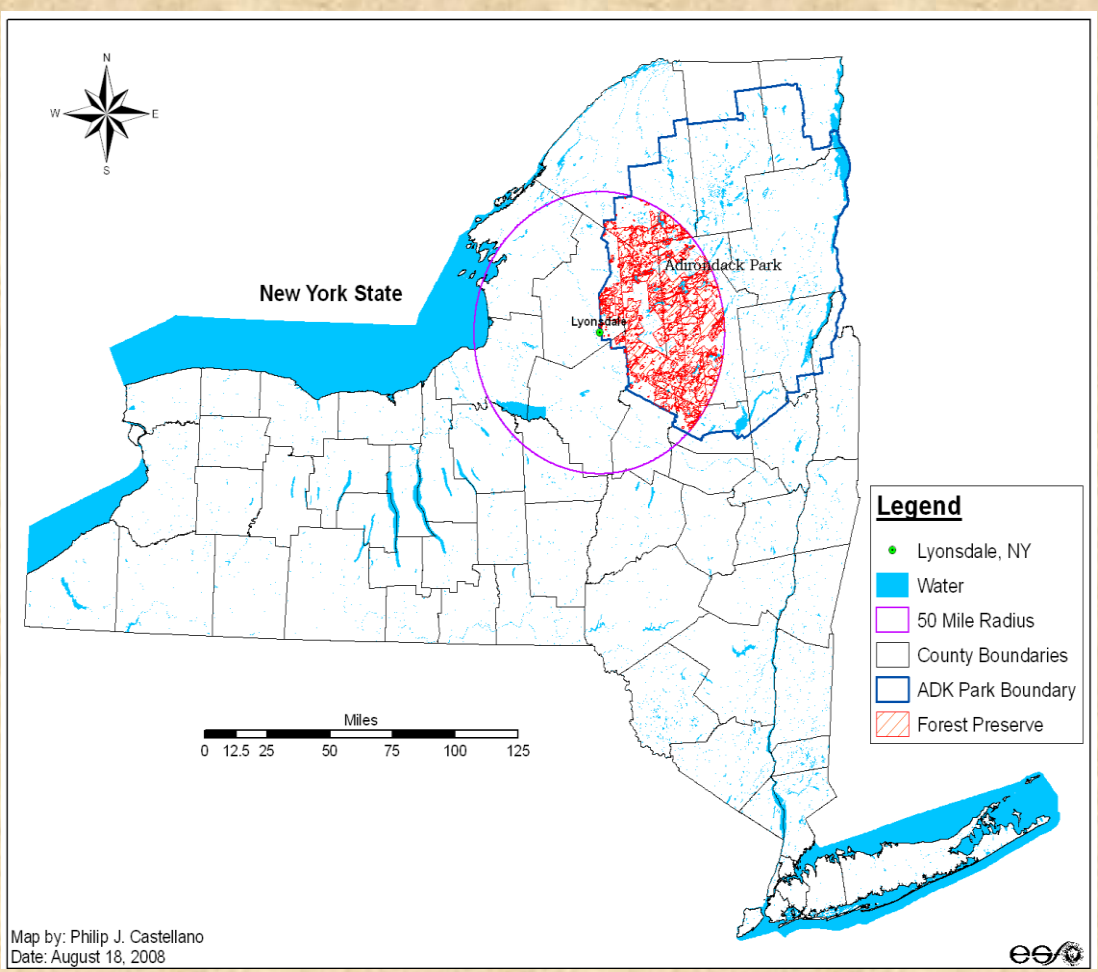
(Buchholz and Volk, 2011)

Willow Production Cost Structure



Source: Buchholz and Volk 2011

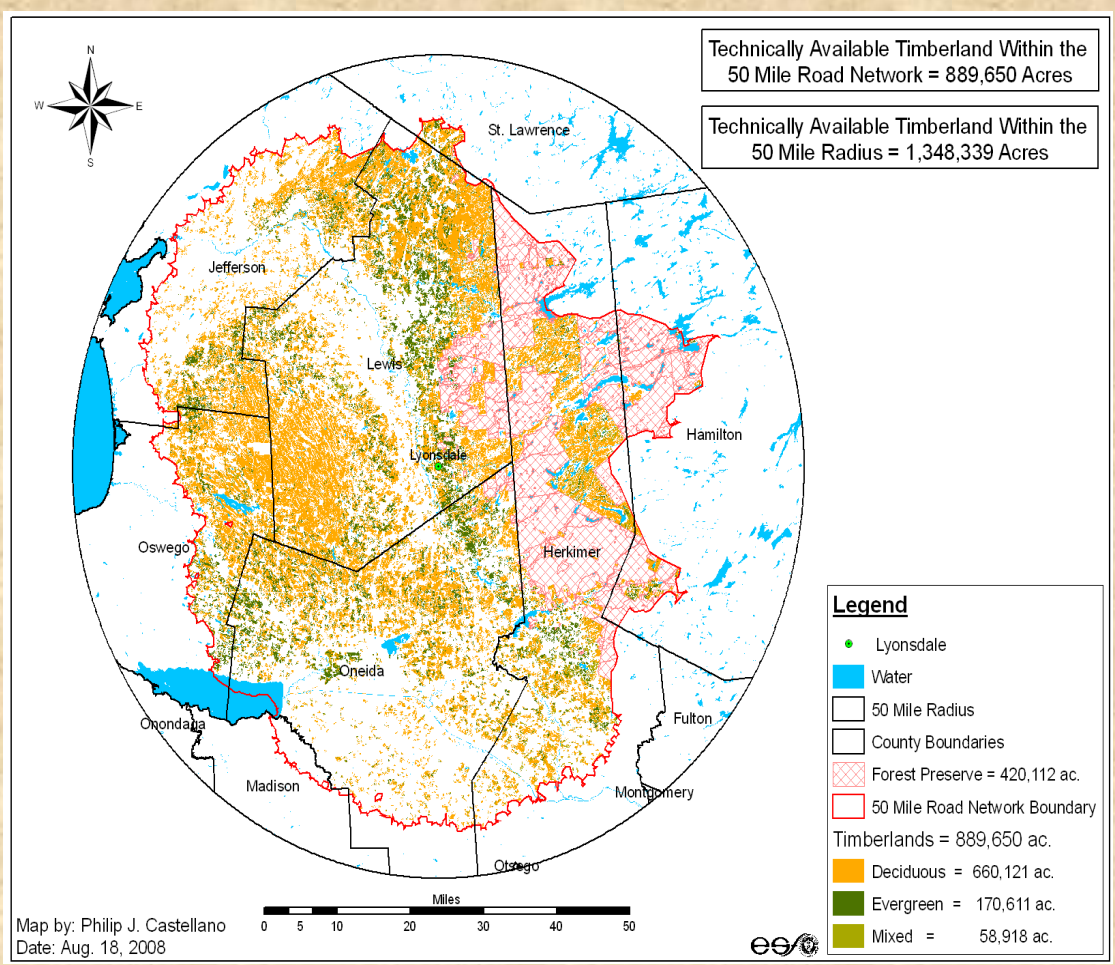
Technically Available Woody Biomass Supply



80 km radius woody supply shed around Lyonsdale, NY (Castellano and Volk 2008)

- Determine amount of technically available woody biomass from forests and willow biomass crops available in 80 km radius around Lyonsdale, NY

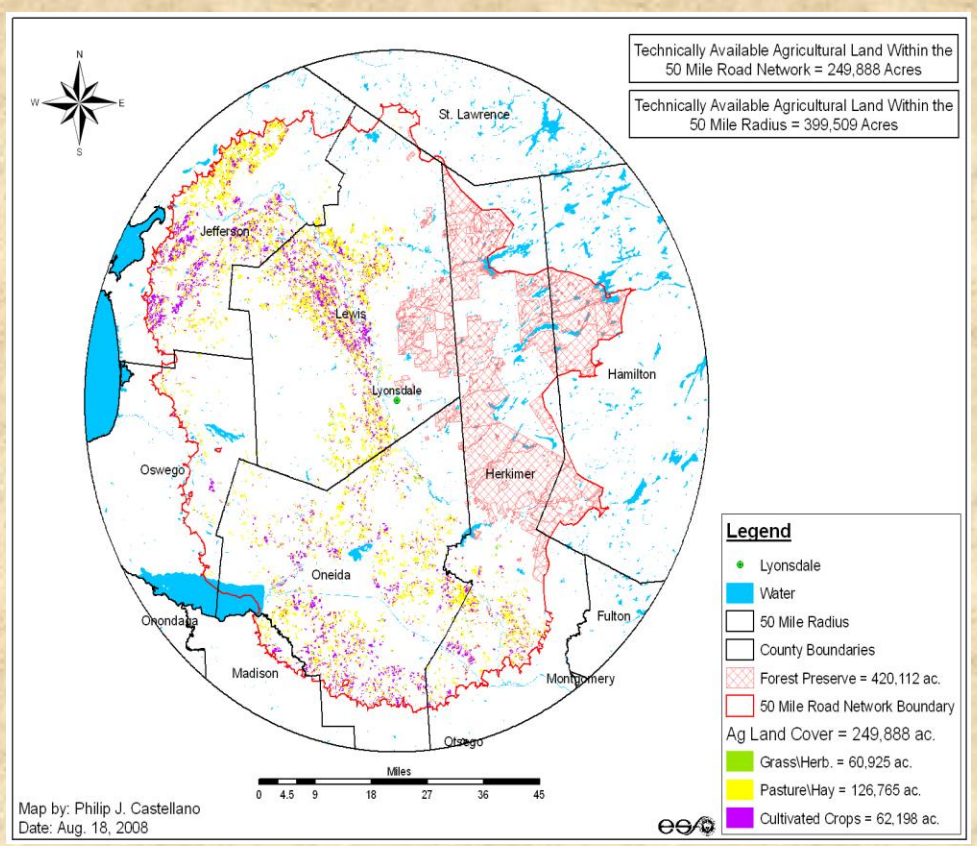
Technically Available Woody Biomass from Forests



- Over 1.5 million acres of forest cover
- Remove forest land:
  - preserves
  - excessive slope
  - small parcels
  - classified wetland
- ~ 900,000 acres of timberland
- Potential production of 422,000 odt per year

Timberland within the 50 mile road network around Lyonsdale, NY (Castellano and Volk 2008)

Technically Available Woody Biomass from Agricultural Land



Agricultural land in a 50 mile radius around Lyonsdale, NY (Castellano and Volk 2008)

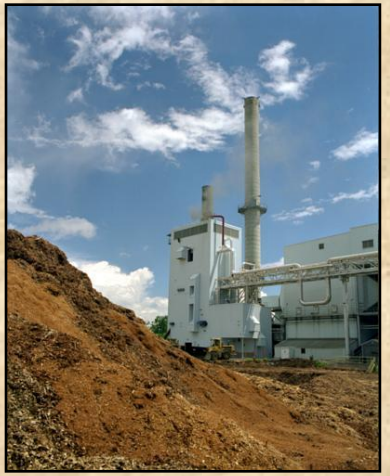
- 517,000 acres of agricultural land
- Remove land:
  - not classified for agriculture
  - excessive slopes
  - wetlands
  - small parcels
- Leaves ~ 250,000 acres
- On 10% of this land could produce 112,000 odt/yr
- Willow biomass crops grown on a land area that is 2.8% of the timberland area could produce 22% of the total biomass

Market Developments

Combined Heat and Power

Biorefinery

Co-firing



Gasification

Thermal Applications

Gateway building – CHP System

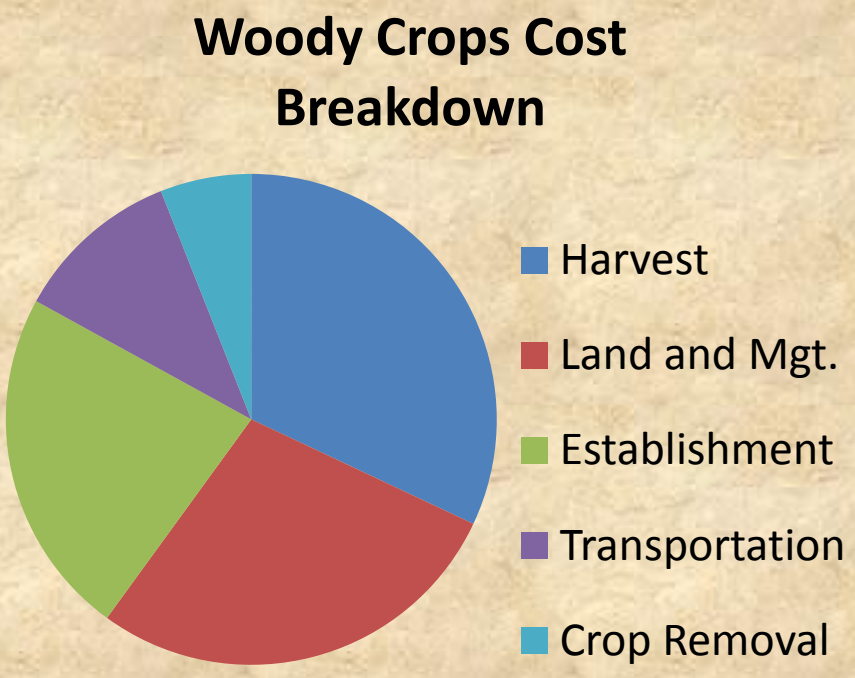
New "zero net energy" showcase building for campus. Design includes biomass combined heat and power, PV, green roof, passive solar and rain gardens.

Combined Heat and Power System

- CHP System is a 25% improvement to overall energy efficiency
  - Provides 65% of campus thermal needs and 20% of campus electrical needs.
- Offset 54,000 MMBTU Fossil Fuels Annually
  - 18,000 MMBTU from efficiency improvements
  - 36,000 MMBTU from fuel switching improvement
- System is projected to save ESF $450,000 annually, and provides a $1.5 million NPV over 15 years
- System will be visible to the public and student with color coded components to enhance educational opportunities

The Future for SRWC

- SRWC are in their infancy in terms of development and deployment
- Combine SRWC with other woody biomass sources to provide consistent flow of feedstock
- Potential for large portion of supply from small land area due to high yields
- Need to improve the economics of SRWC
  - Increase yield, optimize production systems, reduce establishment and harvesting costs



Distribution of costs for willow biomass crops over five 4-year rotations (Buchholz and Volk 2010)

Acknowledgements

- Honeywell International
- NYS Energy Research and Development Authority (NYSERDA)
- NYS Dept. Agriculture and Markets
- NYSTAR
- USDA CSREES
- US Dept. of Interior
- US DOE

Questions