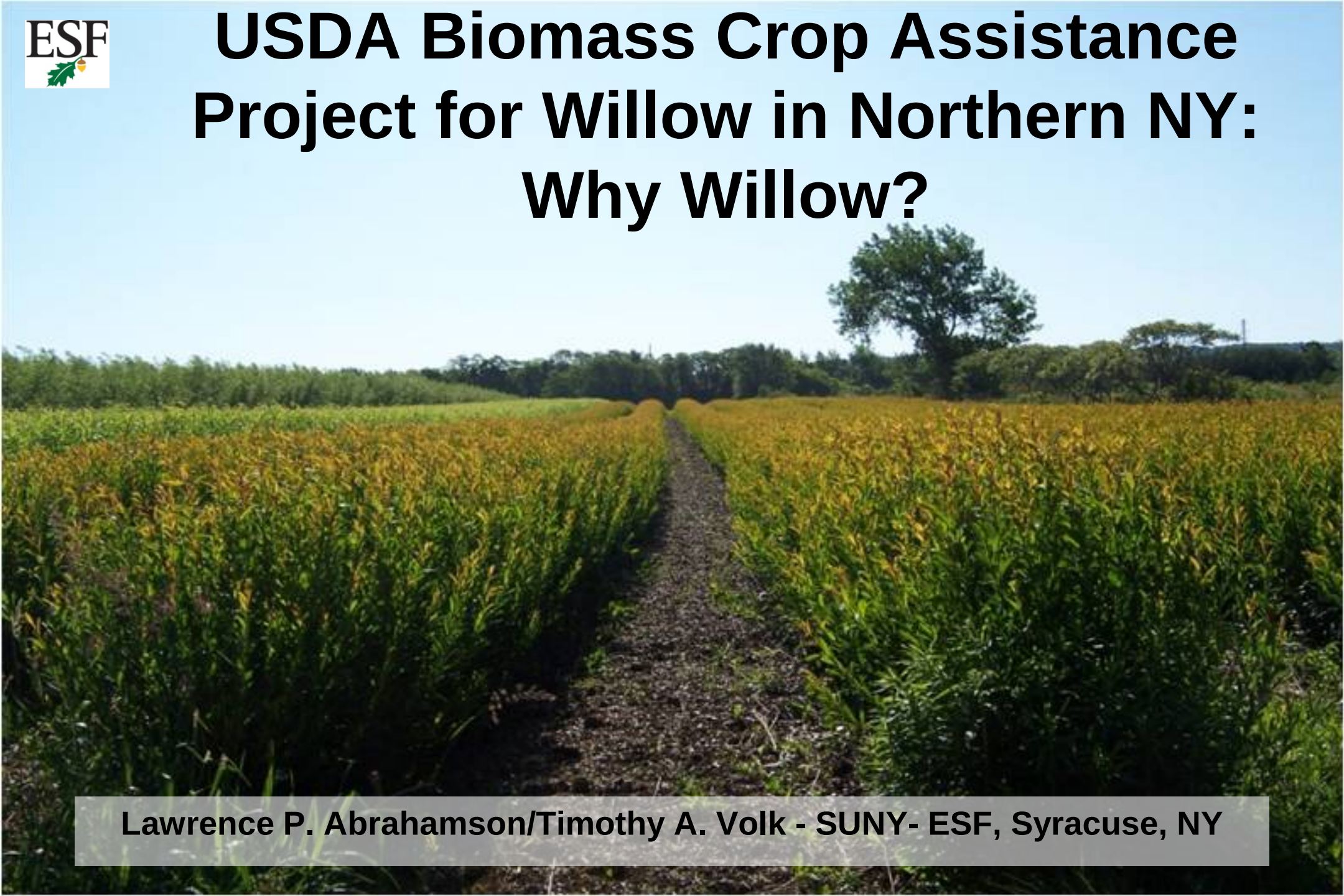
USDA Biomass Crop Assistance Project for Willow in Northern NY: Why Willow?

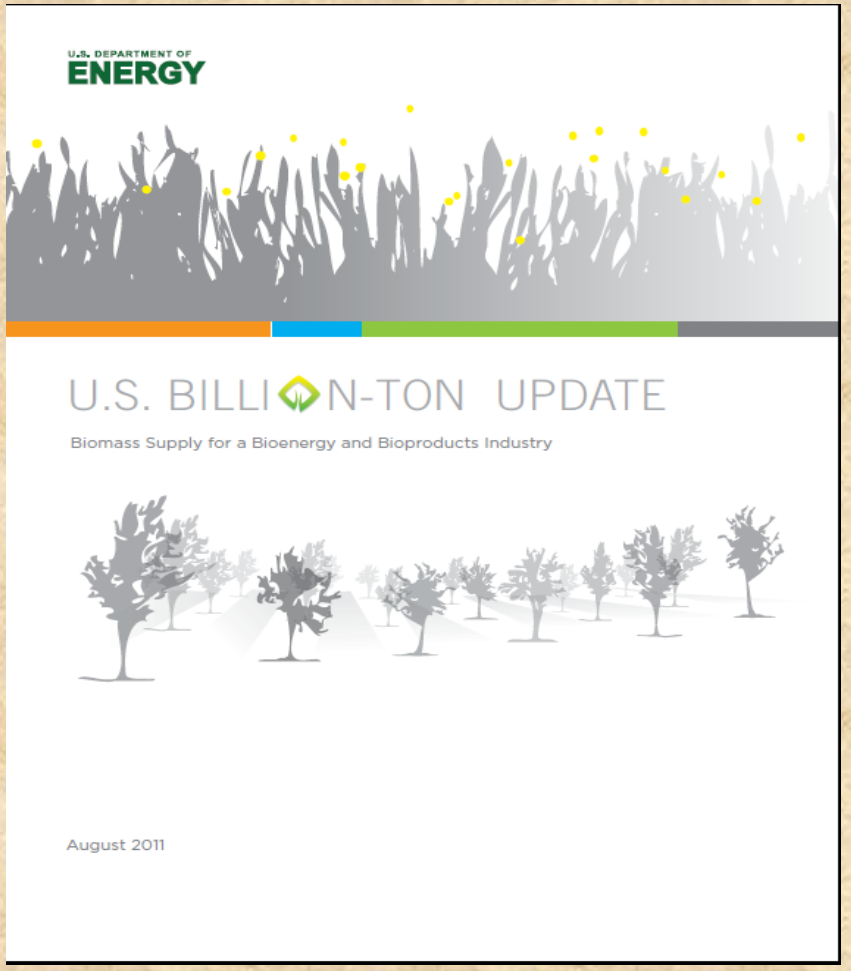


Lawrence P. Abrahamson/Timothy A. Volk - SUNY- ESF, Syracuse, NY

Overview

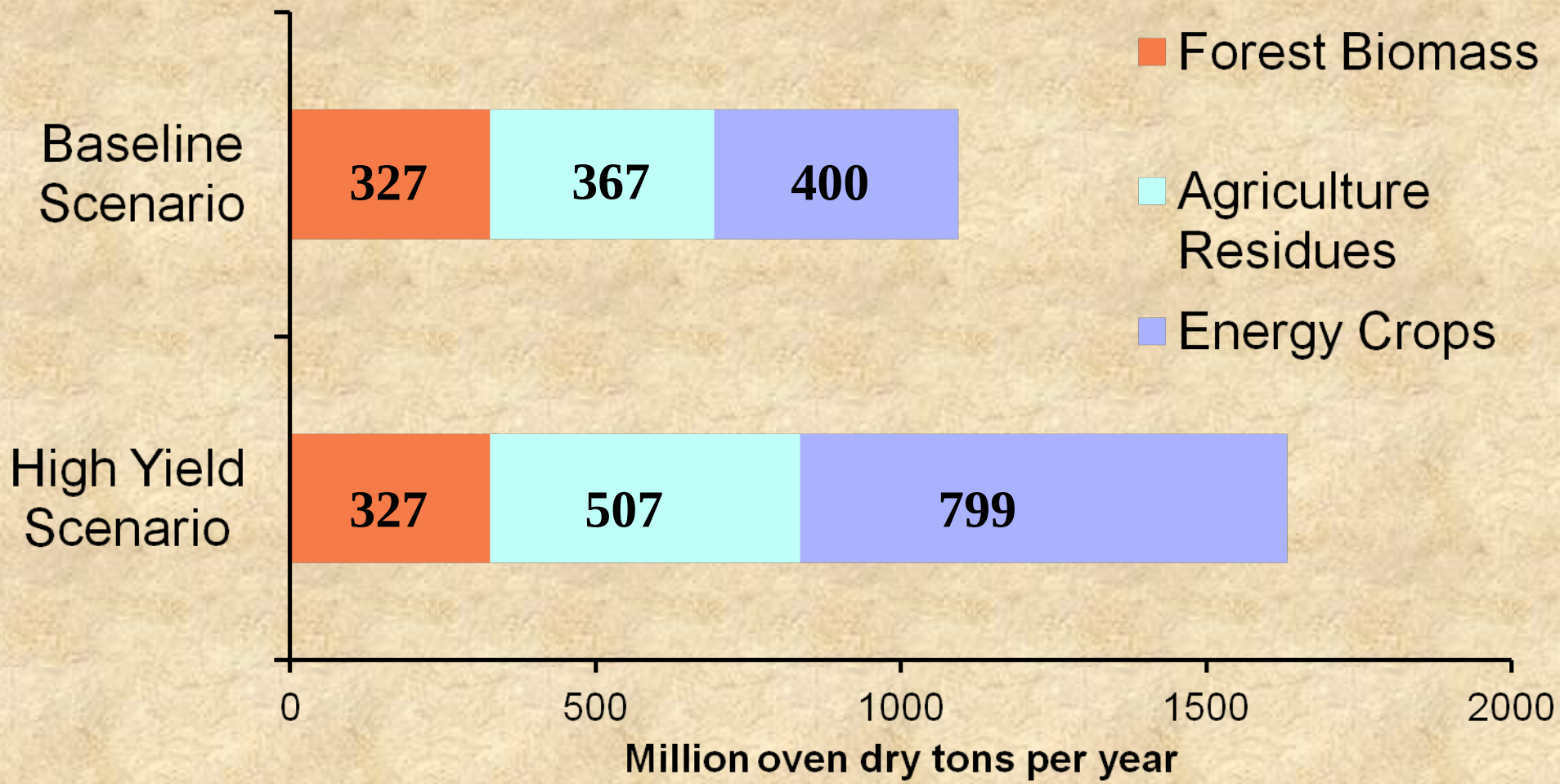
- Background on perennial energy crops
- Willow Production System
- Economics and impact of BCAP
- Environmental Benefits

Billion Ton Update



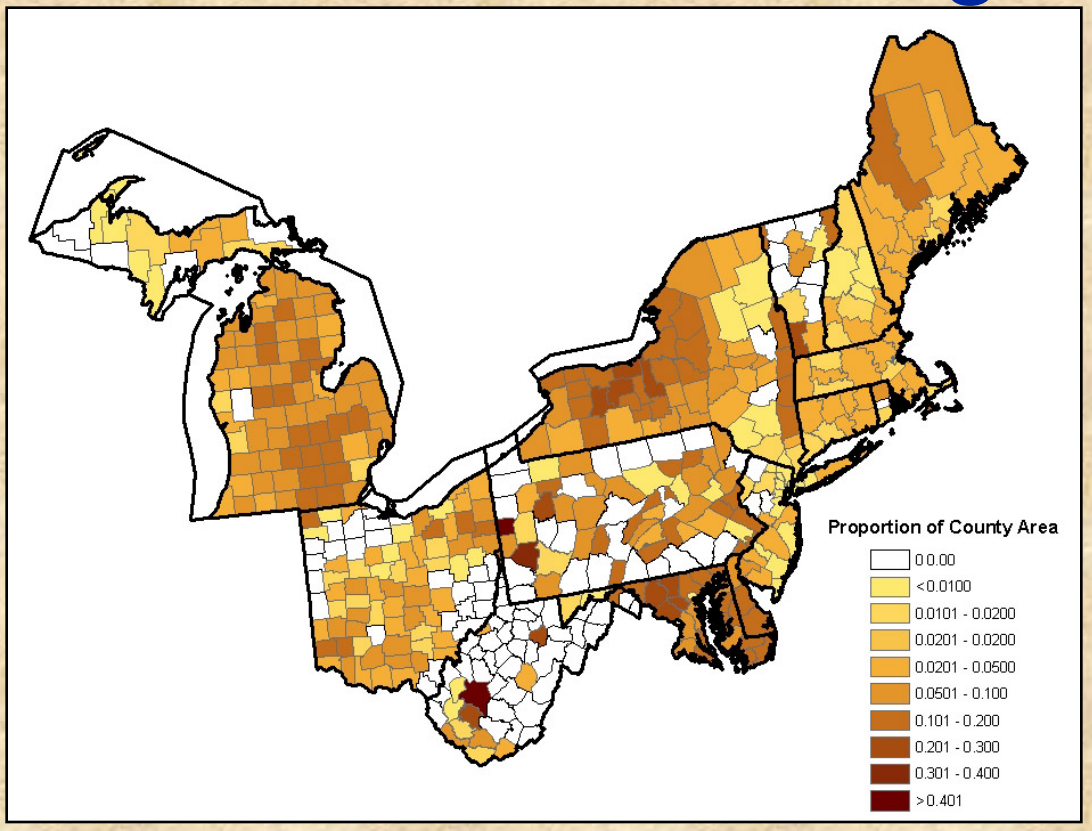
- Biomass supply assessment for the U.S.
- Driven by need to meet the renewable fuels standard of 36 billion gallons by 2022
  - 15 billion gallons from corn to ethanol
  - 21 billion gallons from other plant sources (cellulosic ethanol)
- The 21 billion gallons will require over 1 billion dry tons of biomass per year to reach this target

US Billion Ton Update



(USDOE 2011)

NY Renewable Fuels Roadmap: Potential Agricultural Land



Proportion of land in each county that is potentially available for perennial energy crops

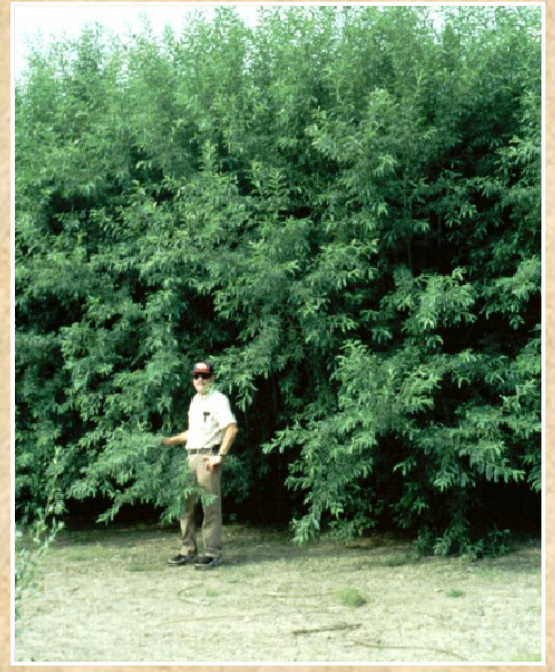
- Assessment of available land for perennial energy crops completed as part of NY Renewable Fuels Roadmap.
- Not all suitable land is available for perennial feedstocks
  - A large amount of hay and pasture land is needed for livestock production
- **About 1 – 1.7 million acres in NY could be available for perennial energy crops**

(Woodbury et al. 2010)

Woody Biomass Feedstocks

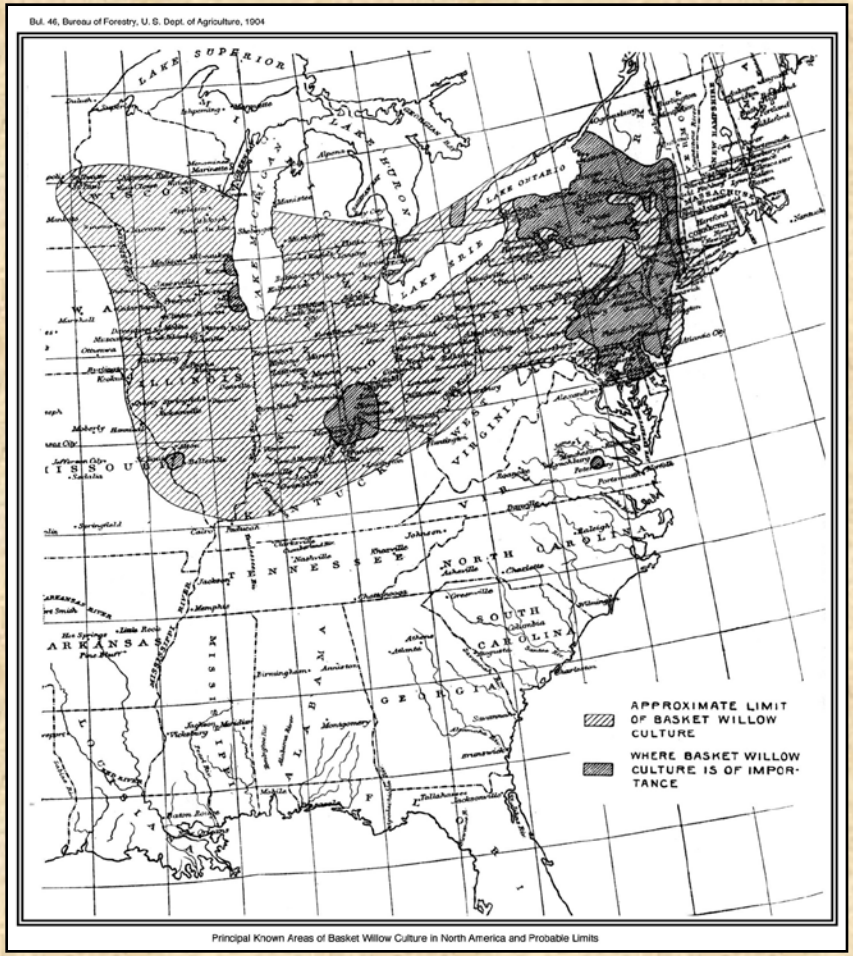
Large quantities of wood residues from primary and secondary wood product manufacturers are available

Low value wood from forests can be harvested sustainably



Willow biomass crops can be grown on under utilized open land

Willow - Regional Background



Hubbard, W. 1904.

- More willows produced in Onondaga County than any other location in the U.S.
- Willow biomass research begins at SUNY-ESF in 1986
- Longest running and largest program in North America

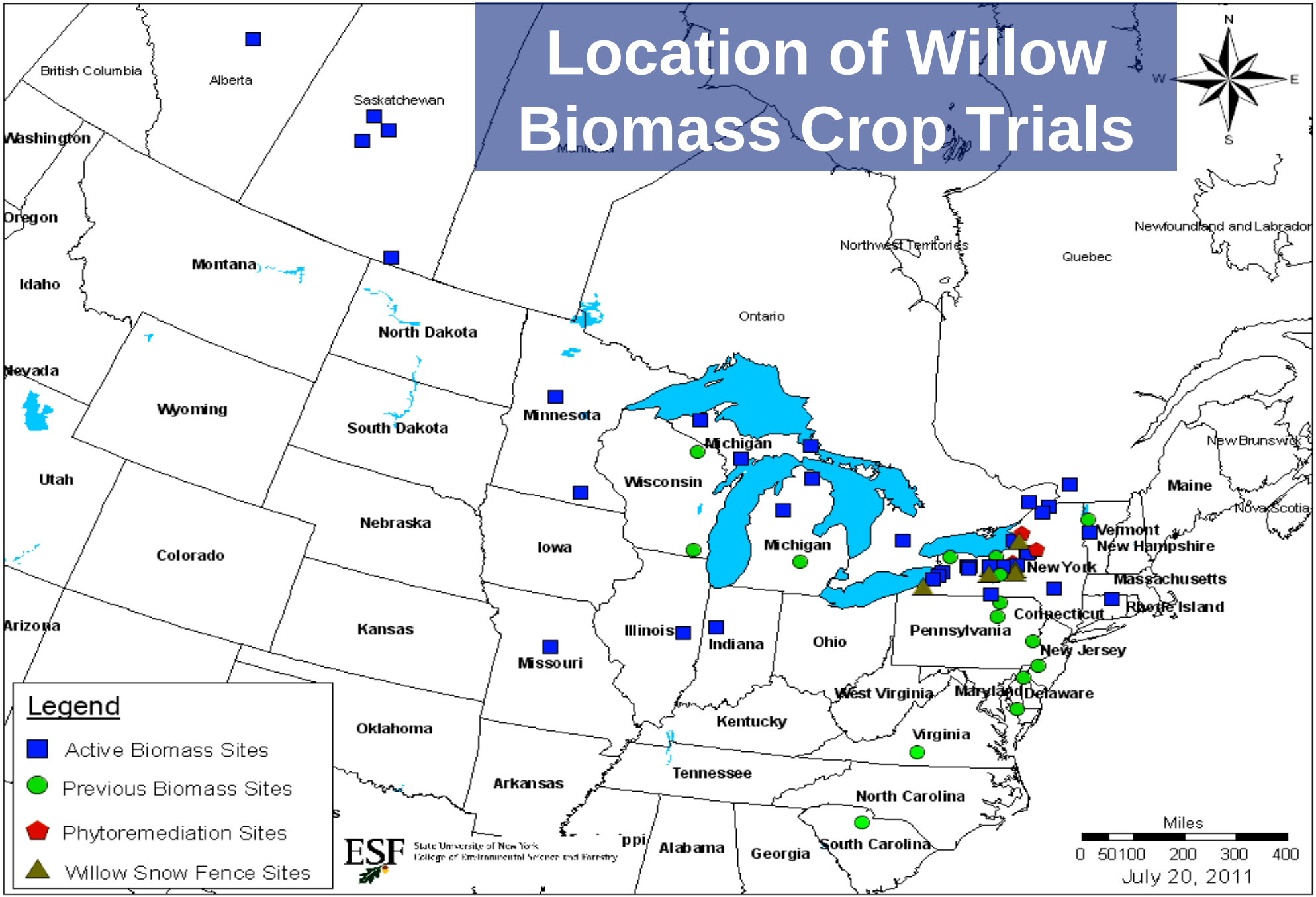
Willow Energy Crops

4-month old coppice willow at Tully, NY

- In the NE US and Canada **willow** is the predominant SRWC
- Greater yields than any other woody species in the region
  - 5 odt/A/yr presently
    - » 30+% future increase/new varieties
- Produced on under utilized farmland
- Plant cuttings (sticks)
- Coppice harvest (resprouts from base)
- Can be grown and harvested as a sustainable, renewable biomass crop
- Similar BTU/energy qualities to northern hardwoods (Energy in a dry ton of willow = dry ton of other hardwoods)

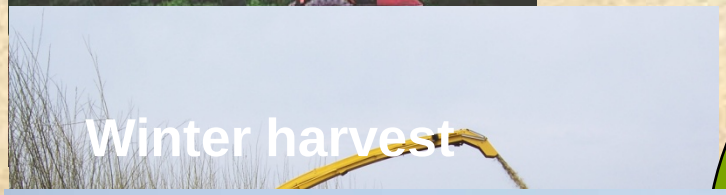
Current Status

- Over 50,000 acres of commercial plantings in Sweden
- 10,000 acres in UK, Poland, Denmark
- Over 1,000 acres planted in U.S. already with more planned in other states
  - Over 35 yield trials in U.S. and Canada


Location of Willow Biomass Crop Trials
N
W
E
S
British Columbia
Alberta
Saskatchewan
Washington
Oregon
Montana
Idaho
North Dakota
Nevada
Wyoming
South Dakota
Minnesota
Utah
Nebraska
Colorado
Iowa
Kansas
Missouri
Arizona
Oklahoma
Arkansas
Illinois
Indiana
Ohio
Michigan
Wisconsin
Kentucky
Tennessee
Mississippi
Alabama
Georgia
West Virginia
Virginia
North Carolina
South Carolina
Pennsylvania
New York
Maryland
Delaware
New Jersey
Connecticut
Rhode Island
Massachusetts
Vermont
New Hampshire
Maine
New Brunswick
Nova Scotia
Newfoundland and Labrador
Quebec
Ontario
Northwest Territories
Legend
Active Biomass Sites
Previous Biomass Sites
Phytoremediation Sites
Willow Snow Fence Sites
ESF
State University of New York
College of Environmental Science and Forestry
Miles
0 50100 200 300 400
July 20, 2011

Willow Biomass Production Cycle

Site preparation



Winter harvest

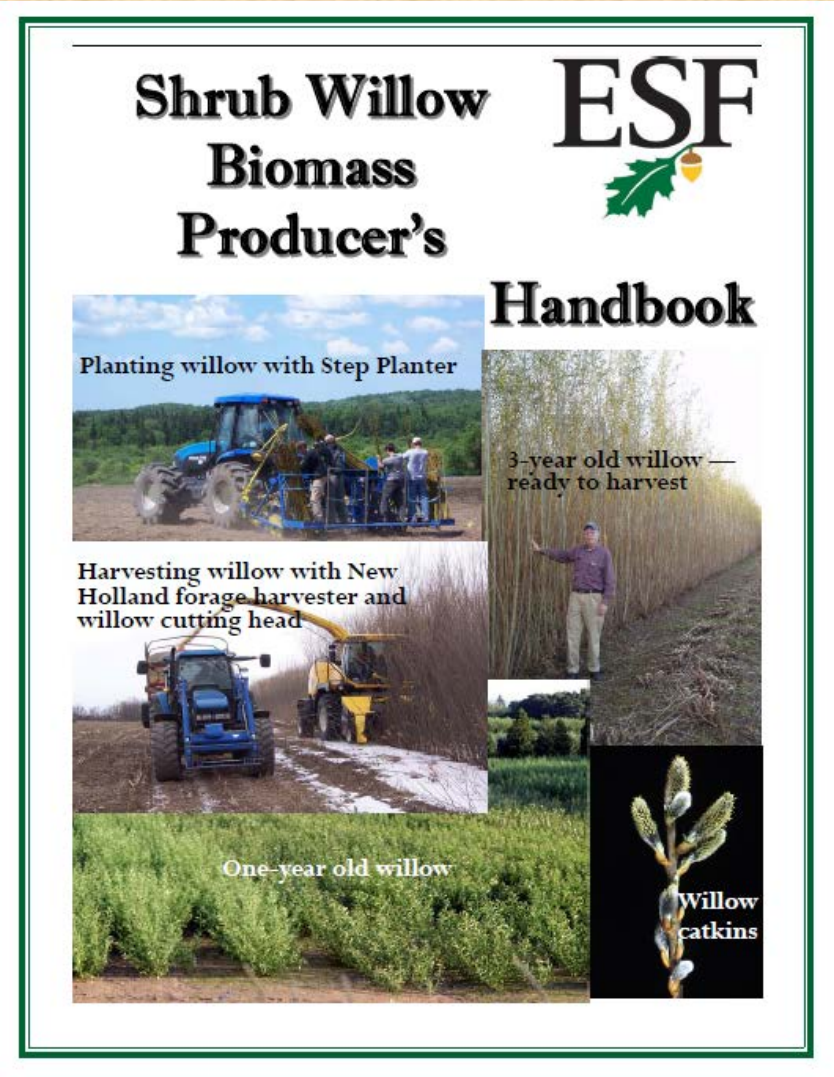
Three years old after coppice

One year old after coppice

At least 7 harvests

Regrowth after coppice

Recommended Practices



- Current set of recommended practices are available in Shrub Willow Biomass Producer's Handbook
- Available at www.esf.edu/willow

Factors Influencing Site Selection

- Proximity to market
- Field sizes and surrounding land use
- Proximity to other fields of willow
- Field access at different times of the year
- Soil type

Soil/Land Use Characteristics

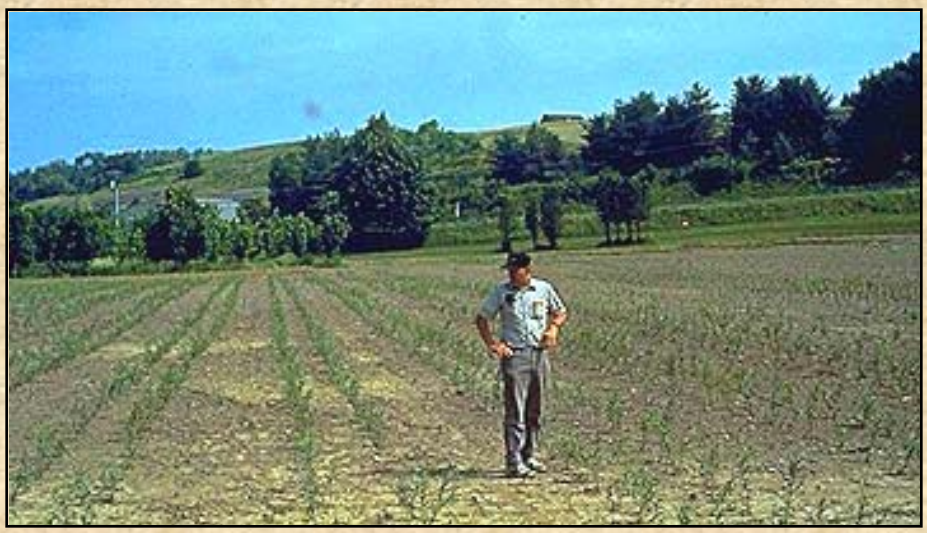
Palmyra gravelly silt loam in Tully, NY

- Soil characteristics
  - Wide range of textures
    - » Not sands or heavy clays
  - Poorly to well drained
  - pH 5.0 – 8.0
  - Rooting depth > 15”
- Currently open land
  - Idle, brush, pasture, cropped

Willow Establishment and Management

- For interested landowners who do not want to plant and manage the crop
  - There are companies willing to lease land and manage the establishment and planting of the crop
  - DoubleAWillow
  - Celtic Energy Farms for land in Jefferson county
  - Other potential organizations

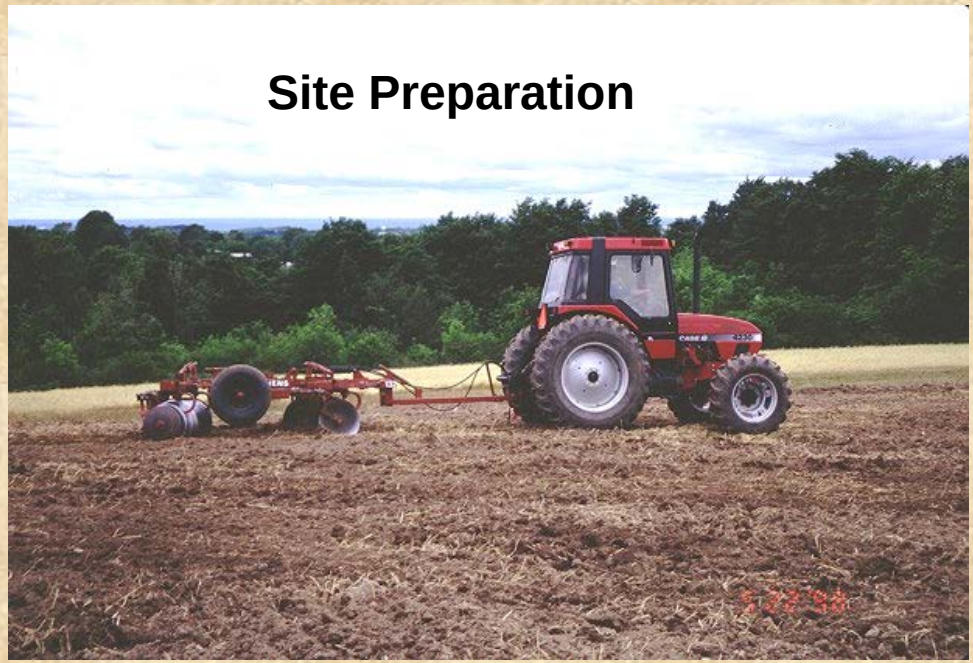
SRWC Establishment



Willow growth six weeks after planting when fall tillage site preparation was used.

- Establishment phase is critical for economic and biological success
- Establishment costs are 20 - 25% of total cost of production over the 22 year life span of the crop
- Low production during establishment has a negative impact on yields in the first, and in many cases subsequent, rotations

Site Preparation for a Field in Permanent Cover



➢Essential step in the process in order to get willow crop established and ensure long term productivity of the system

➢Make use of a combination of chemical and mechanical treatments

- Fall prior to planting
  - Mow
  - Spray contact herbicide
  - Plow and disk or zone cultivation
  - Cover crops if needed
- Spring
  - Cultivate or spray with contact herbicide
  - Plant
  - Spray preemergence herbicide

DOUBLE A VINEYARDS, Inc. AND DOUBLE A WILLOW

10277 Christy Road
Fredonia, New York 14063
716.672.8493
Fax 716.679.3442
websites: www.doubleavineyards.com
www.doubleawillow.com

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 150 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 Material

- Willow is planted using 6 – 8 inch sections of dormant one year old stems
- Willow varieties for biomass production have been selected from years of testing of thousands of individuals
- Four or more diversity groups should be planted in each field
- Lists of recommended varieties are available at DoubleAWillow.com and in the Shrub Willow Biomass Producer's Handbook

Planting Stock Supply

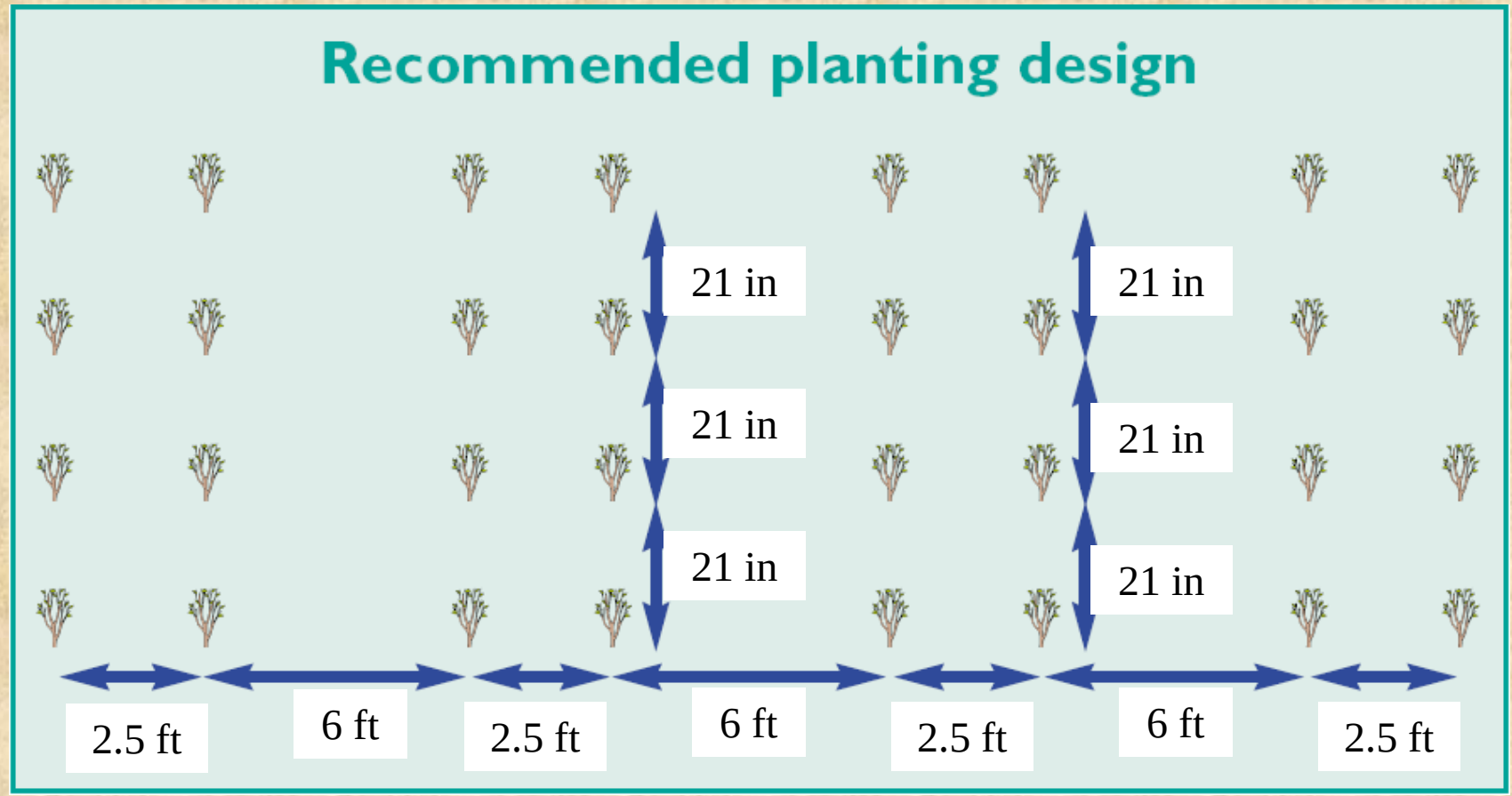
- Commercial scale quantities of willow varieties selected for biomass production are available from DoubleAWillow
  - Harvested stems are kept dormant in cold storage from harvest until planting in the spring
  - Orders need to be made in the late fall to ensure that material is available for spring planting
  - Will require a deposit of about 1/3 of the cost at the time of the order
  - Purchasers will need to sign a growers agreement (available at www.doubleawillow.com)

Willow Varieties

Willow Species Characteristics	Diversity Group
SV1 (*Salix dasyclados*)	1
SX61 (*Salix sachalinensis*)	2
S365 (*Salix discolor)*	3
SX64 (*Salix miyabeana*)	5
SX67 (*Salix miyabeana*)	5
Fish Creek (*Salix purpurea)*	6A
Onondaga (S. *koriyanagi* X *S. purpurea*)	6B
Allegany (S. *koriyanagi* X *S. purpurea*)	6B
Sherburne (*S. sacchalinensis X S. miyabeana)*	7
Canastota (*S. sacchalinensis X S. miyabeana)*	7
Tully Champion (*S. viminalis X S. miyabeana)*	8
Owasco (*S. viminalis X S. miyabeana)*	8
Otisco (*S. viminalis X S. miyabeana)*	8
Fabius (*S. viminalis X S. miyabeana)*	8
Truxton (*S. viminalis X S. miyabeana)*	8
Oneida (*S. purpurea X S. miyabeana)*	9
Millbrook (*S. purpurea X S. miyabeana)*	9
Preble (*S. viminalis* X (*S. sachalinensis* X *S. miyabeana*)	10

- Recommended varieties based on years of testing and screening of thousands of individuals
- Plant four or more varieties from different diversity groups in large fields
- List is available from handbook and at nursery website

Field Layout



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 US by NY company
- Egedal planter introduced to the US in 2008 by Dennis Rak from DoubleAWillow
- Planting rates ~ 2 ac/hr

Herbicides

- Willow susceptible to most broadleaf contact herbicides
- Can spray over top of willow with grass specific herbicides
- A range of preemergence herbicides has been tested

Control of Competing Vegetation that first year is ESSENTIAL!!

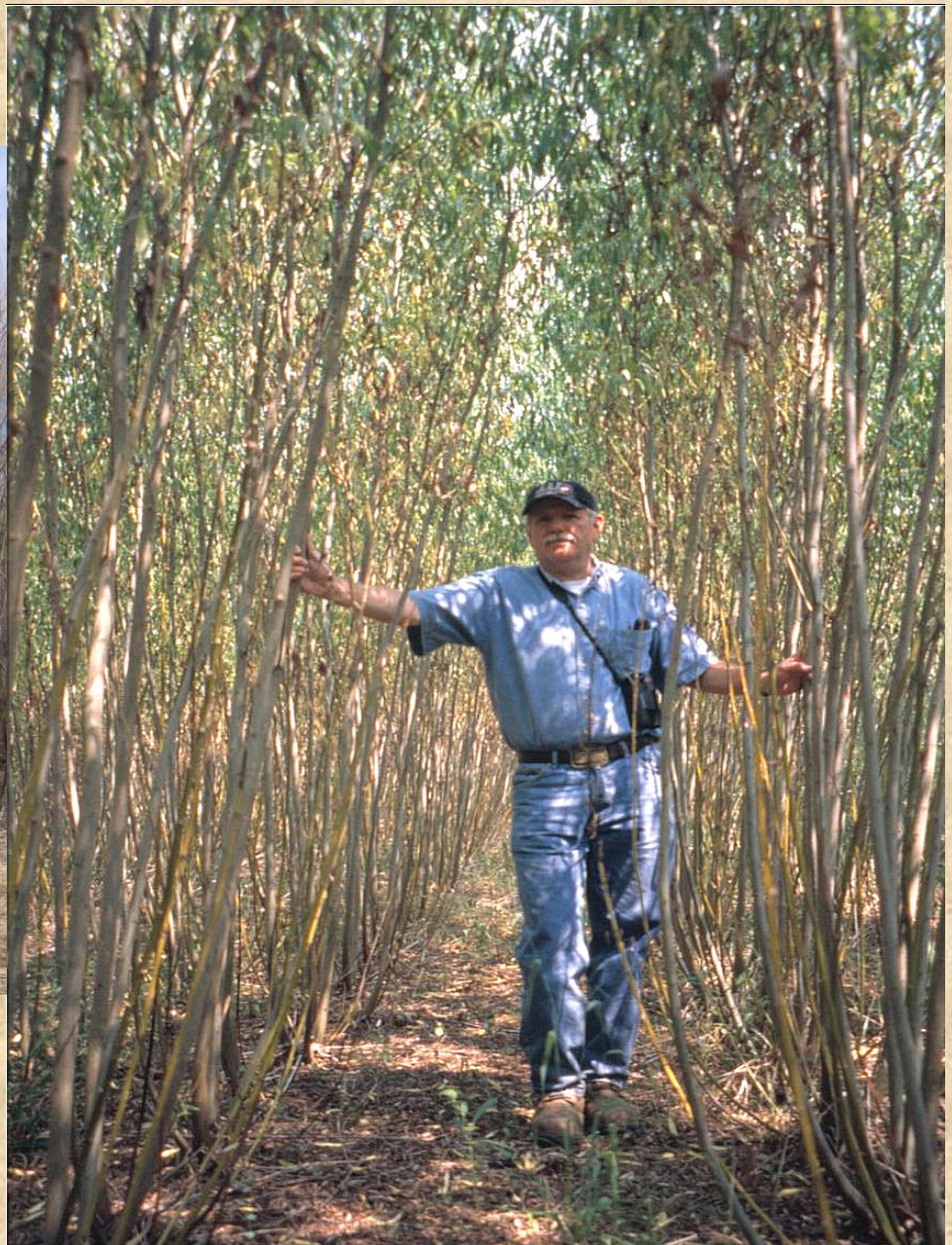
Severely reduce yield over the live of the crop or lose the crop outright due to competition for light.

Coppicing SRWC

Sickle bar mower used to coppice one year old SRWC

- Coppicing during the dormant season after the first year of growth has been the standard recommendation for SRWC in Europe and North America (Danfors et al. 1998, Abrahamson et al. 2002).

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

- Harvesting occurs during the dormant season to ensure vigorous regrowth
- Developing dormant season, single pass cut and chip harvesting system based on New Holland (NH) forage harvester with support from DOE and NYSERDA

Chip Collection Systems

Covered /Uncovered over-the-road trailers (30-36 tons of chips)

Self-unloading forage wagons

Forage blower

Moving Harvested Chips

Forage dump wagon

Large forage dump wagon

Open top over-the-road trailer (25-30 tons of chips)

Nutrient Management

Studying the effect of applications of composted chicken manure on willow biomass crops.

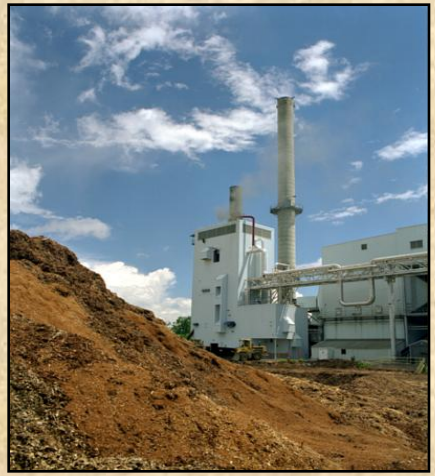
- N applied once every three years following harvest (100 lbs N/Acre)
- Organic amendments
  - yields with composted chicken manure and biosolids similar to those using 100 lbs N/A/3-years
- Most recent trials indicate that N addition has no impact on yield in the first rotation

Conversion Technologies

Combined Heat and/or Power

Biorefinery

Co-firing



Gasification

Small Scale Heat

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

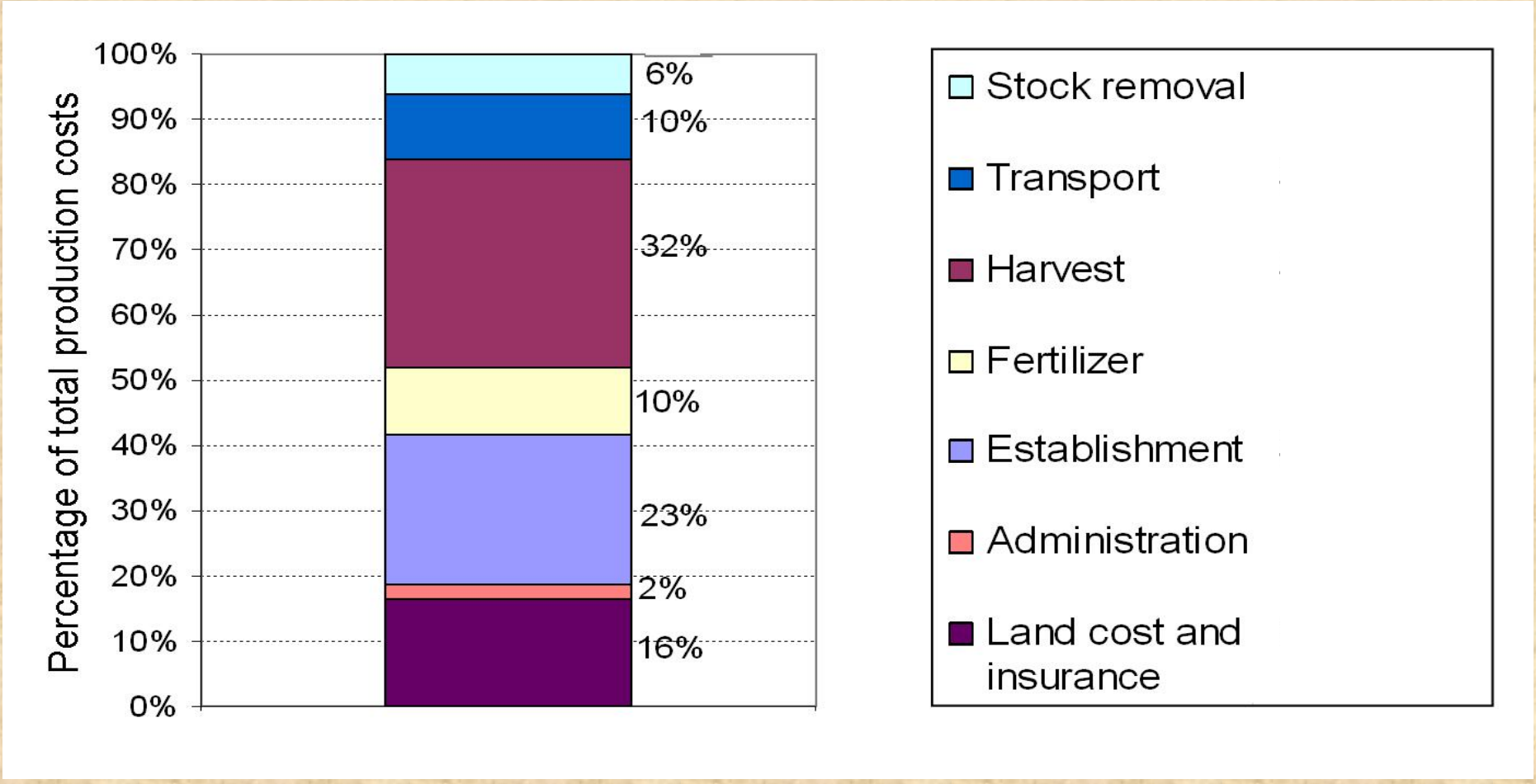
We acknowledge support of NYSERDA, USDA CSREES, and the State of New York, Dept. of Agriculture and Markets

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

Willow Biomass - Economics

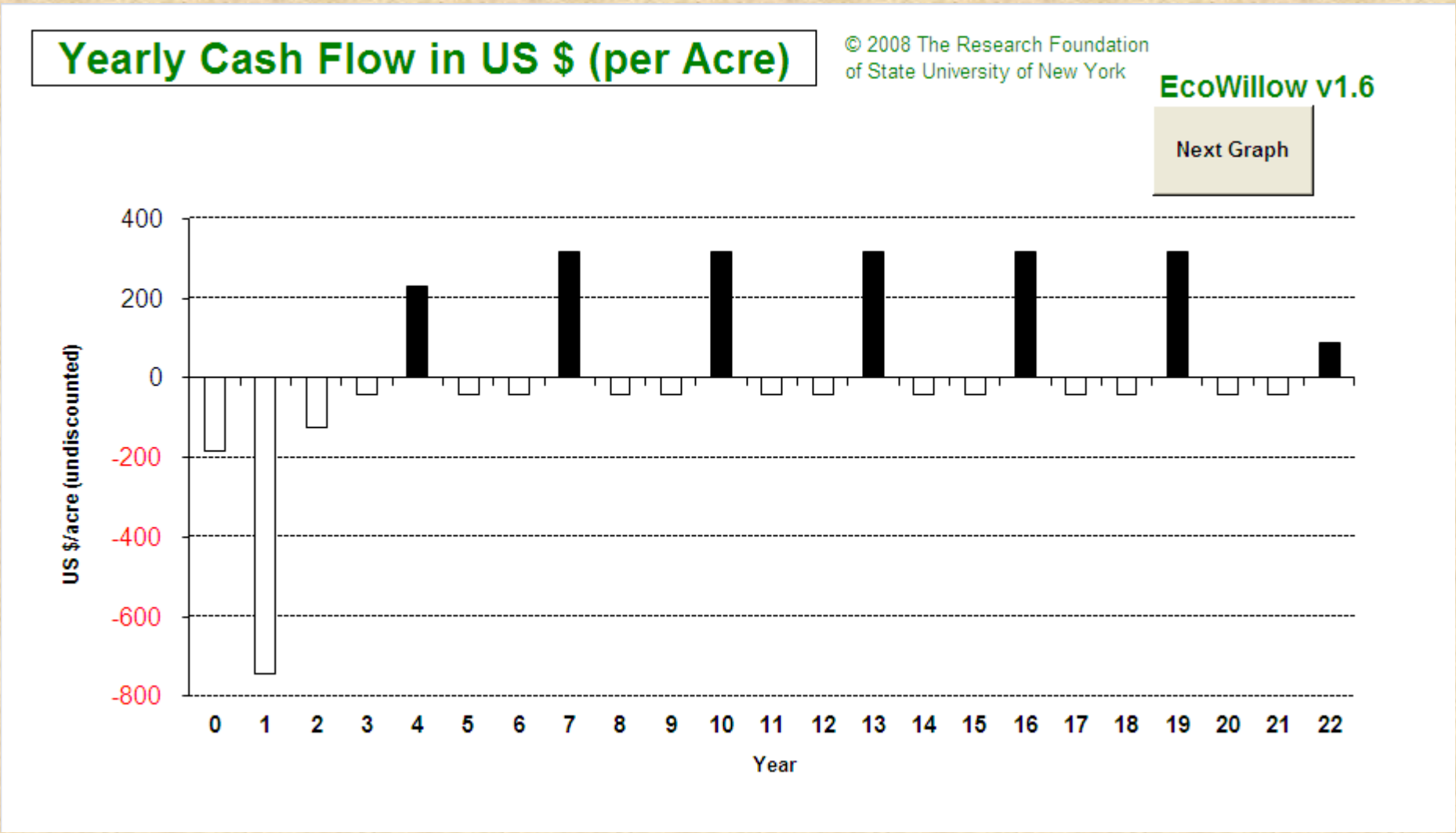
- Cash flow model for willow biomass crop production and delivery to end user
- Allows for input parameters to be set by each user
- Includes all components of willow crop production from site preparation to delivery of biomass to end user
  - Land costs
  - 100 acre land area
  - Site preparation
  - Planting, maintenance and harvesting
  - 3 year harvesting cycle
  - 25 mile delivery of willow biomass
  - Multiple harvests over 22 years with yield of 5 dry tons/acre-year
  - Removal of willow at end of crop's functional lifespan
  - Assumes a $27.50/green ton price at the plant gate

Willow Production Cost Structure



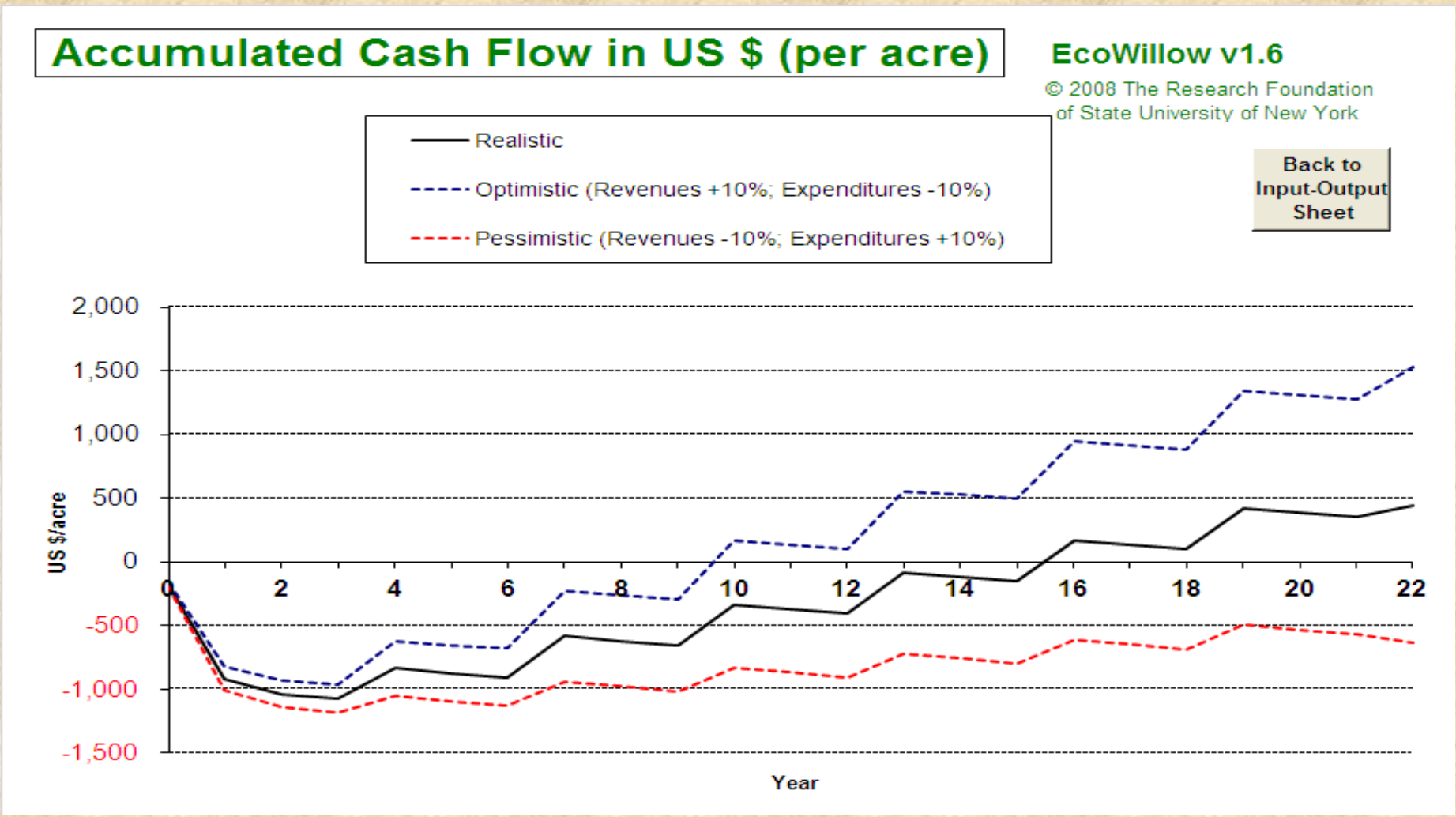
(Source: Buchholz and Volk 2011)

Economics of Willow – Base Case



(Buchholz and Volk, 2011)

Economics of Willow – Base Case



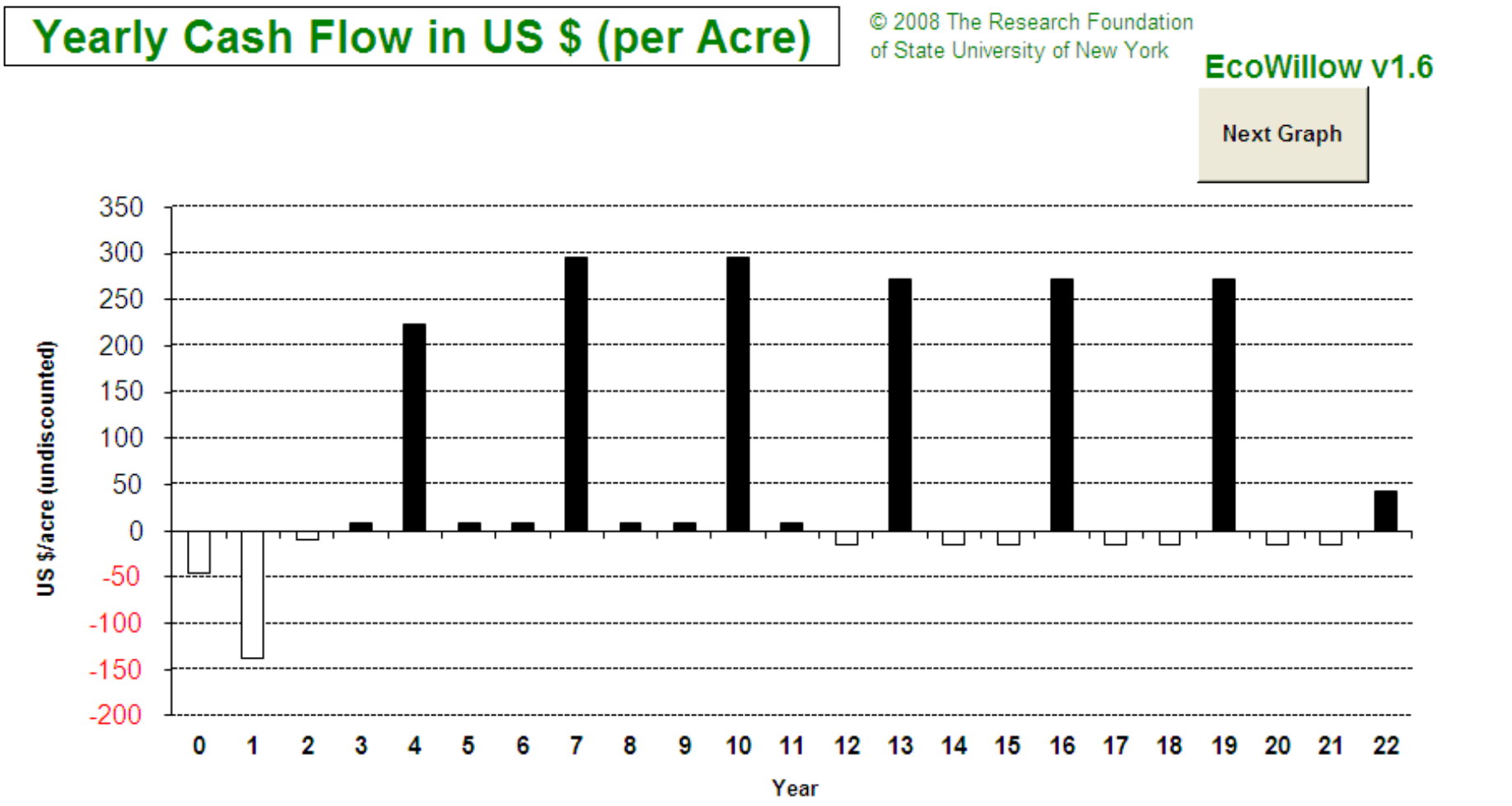
	13 Years	22 Years
Internal Rate of Return (%)	-1.0	3.3

(Buchholz and Volk, 2011)

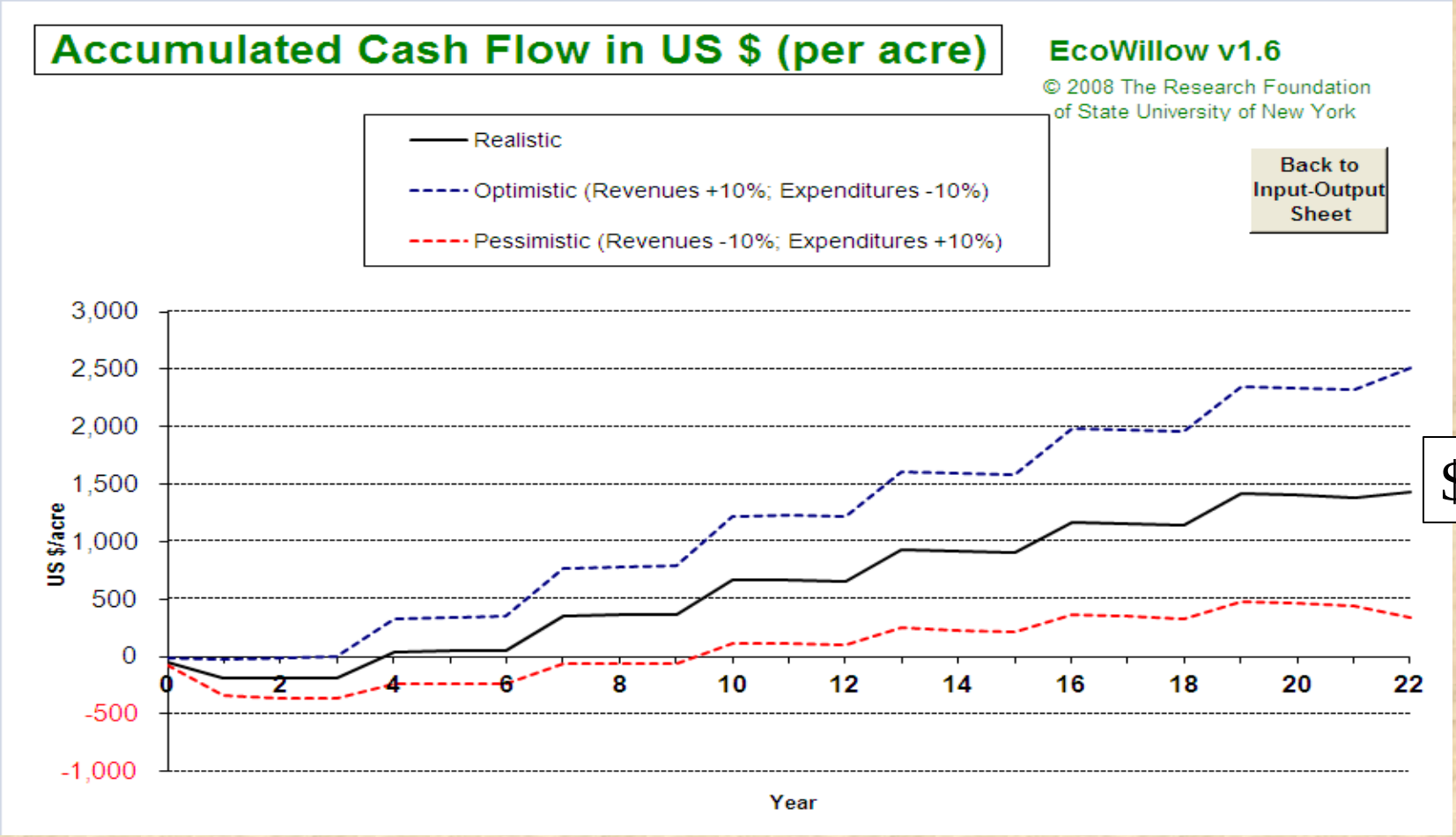
Economics of Willow – BCAP

- Establishment cost share grant of $741/acre
  - 75% of total costs up to a maximum cost share payment of $741/acre
- Annual rental payment based on soil type plus a 25% incentive
  - Used $35/acre
  - Reduced in year of harvest (one out of three years there will be no payment)

Economics of Willow – BCAP



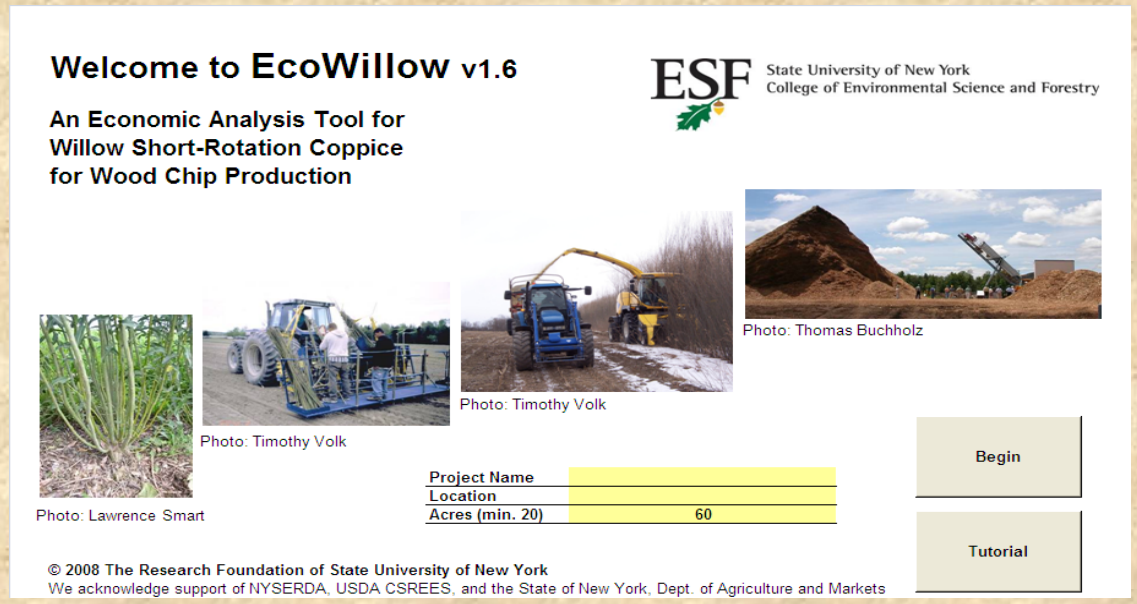
Economics of Willow – BCAP



$1,428/acre

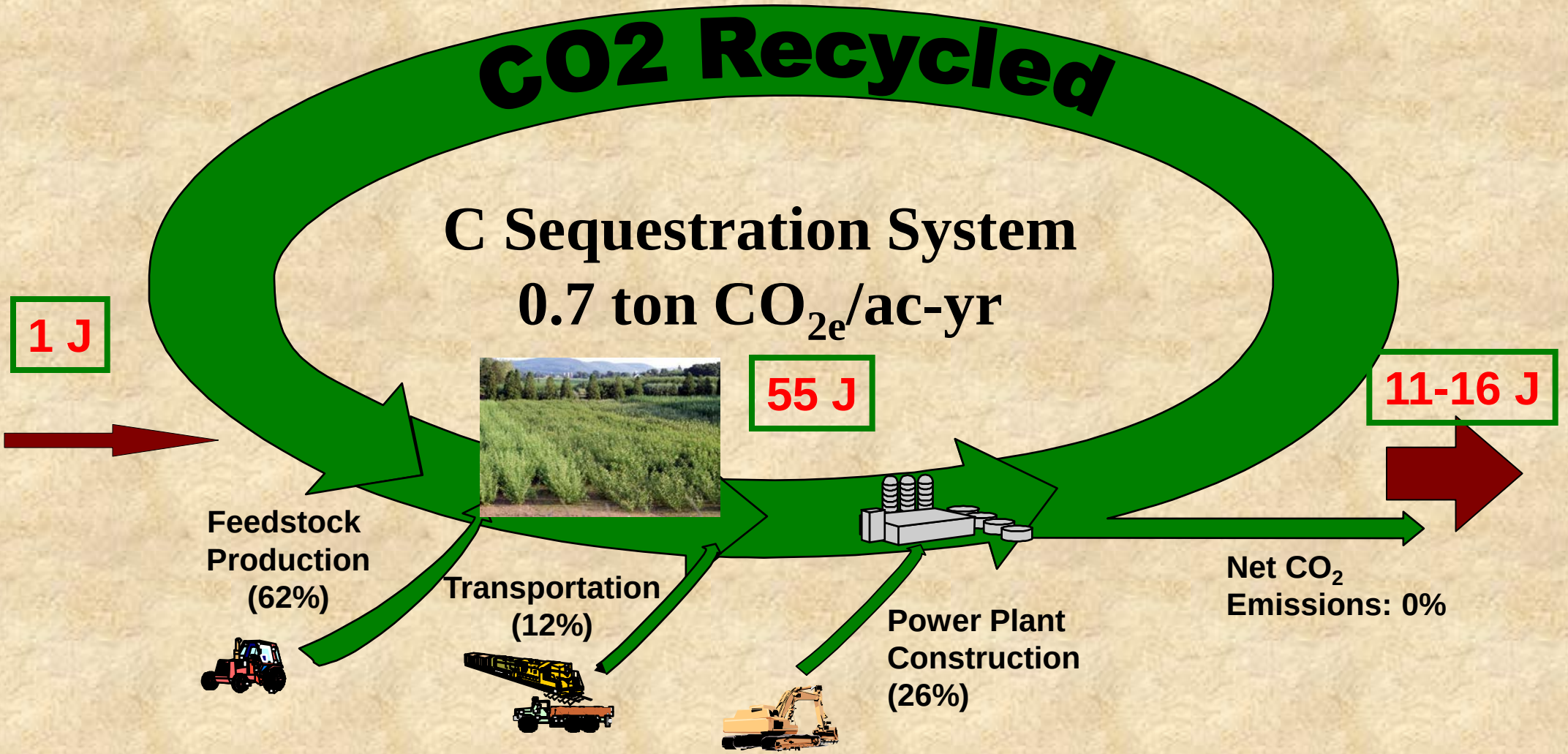
	13 Years	22 Years
Internal Rate of Return (%)	31.3	31.9
NPV (Net Present Value)(6% discount rate)	539	740

Willow Cash Flow Model



- Any of the input parameters can be changed and the model updates calculations
- Model is available from www.esf.edu
  - Fill in contact information so you can be notified about updates
  - Not used for any other purpose

Carbon Cycle and Net Energy Balance



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

GHG Reductions with BCAP

- Two ways the BCAP will reduce GHG emissions

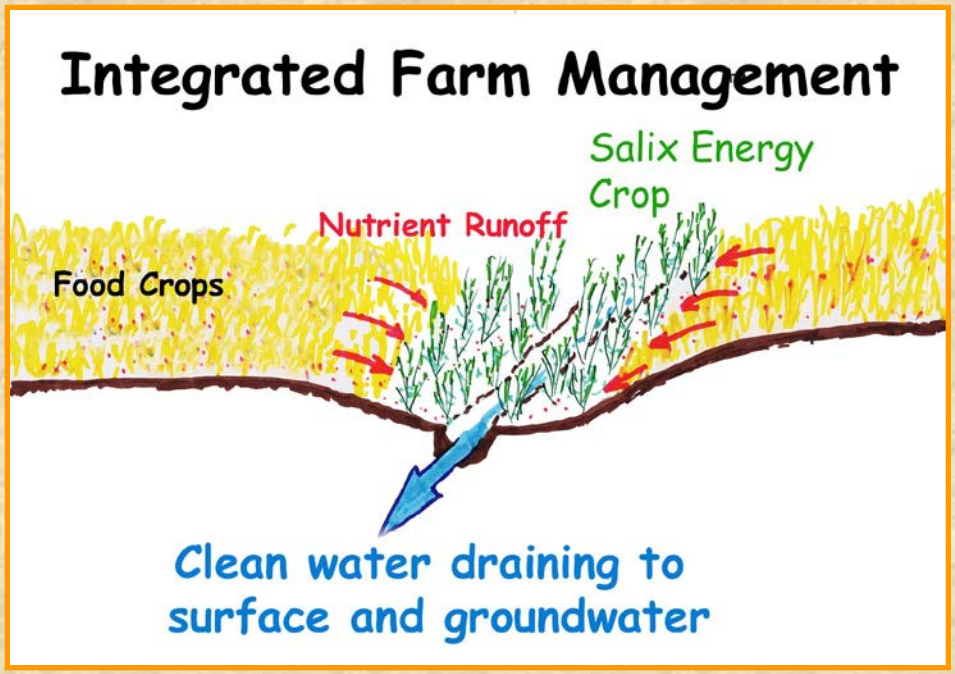
1. Willow system sequesters C at a rate of 0.78 tons CO_{2e} /acre each year
   - 3,500 acres over 10 years will sequester 27,300 tons CO_{2e}
2. Offset energy production using fossil fuels
   - 5,168 tons CO_2/yr
   - Offset over 7 years is 36,174 tons of CO_{2e}

Bird Diversity in SRWC

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

Cornell Lab of Ornithology

Opportunities for Multiple Benefits



Incorporating willow biomass crops into riparian buffers produces clean water and renewable energy (Courtesy of Salix Maskiner AB)

- Short rotation woody crops are **unique:**
  - produce environmental and rural development benefits in addition to bioenergy and/or bioproducts
    - » Riparian buffer strips
    - » Windbreaks and living snow fences
    - » Nutrient and waste management systems
    - » Brownfield restoration
    - » Phytoremediation

Additional Information

- For additional information about willow biomass crops and the BCAP project go to:

www.esf.edu/willow

Questions