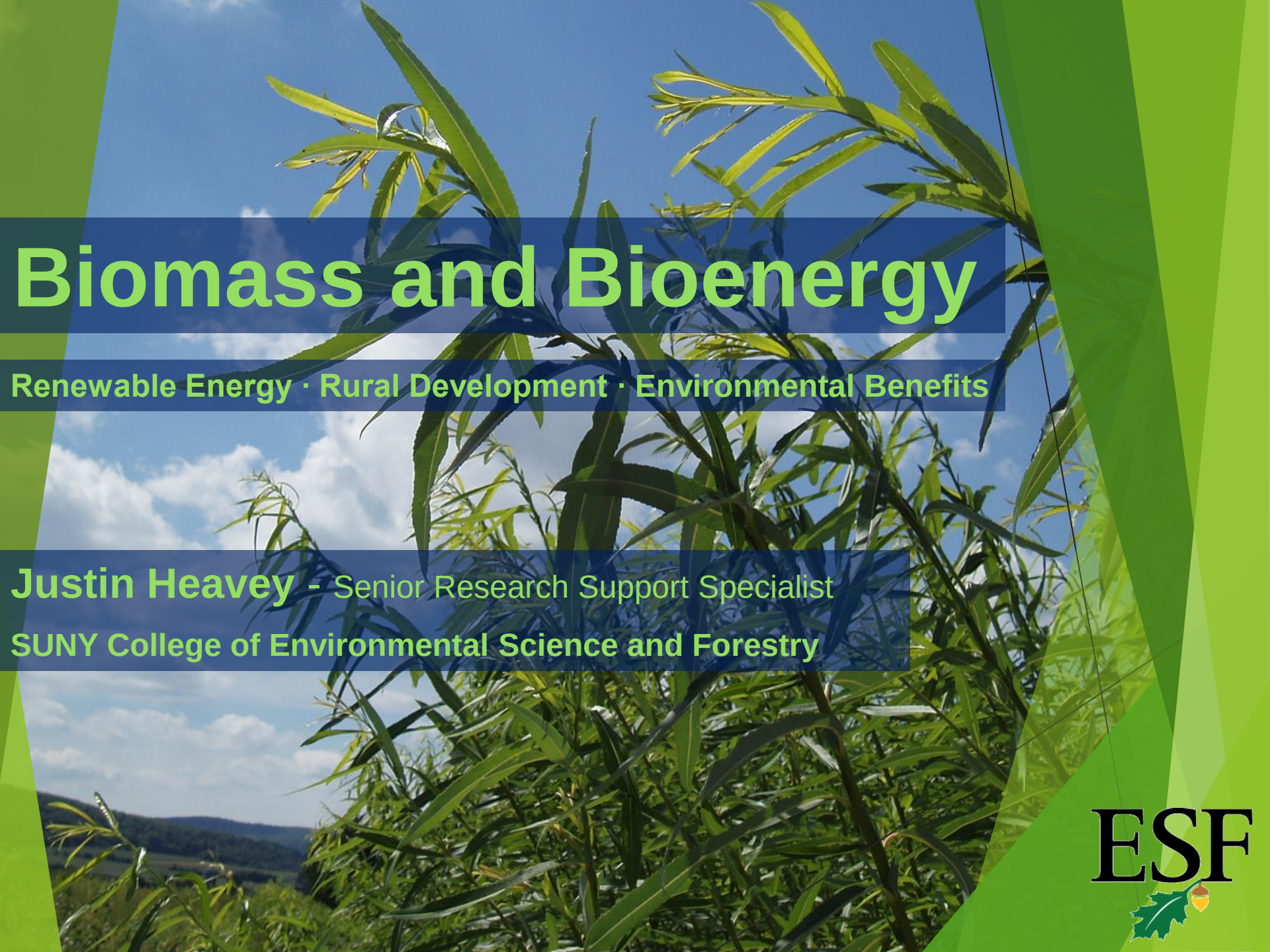


Biomass and Bioenergy

Renewable Energy · Rural Development · Environmental Benefits

Justin Heavey - Senior Research Support Specialist

SUNY College of Environmental Science and Forestry

ESF

My Background

Education

- B.S. Environmental Studies (Renewable Energy)
- M.S. Natural Resources Management

Experience

- 2008-2011
  - Office of Sustainability at SUNY-ESF *(Analyst)*
- 2011-2013
  - Research Foundation of SUNY *(Research Assistant)*
- 2013-2015
  - Willow Project Research Group *(Research Support Specialist)*
  - NEWBio Project *(Extension Staff)*
  - Office of Sustainability at SUNY-ESF (Fellow)
  - Instructor – Environmental and Energy Auditing

Overview

1. Biomass & Bioenergy
2. The Willow Project at SUNY-ESF
3. Willow Production and Management
4. Environmental & Other Benefits

Biomass and Bioenergy

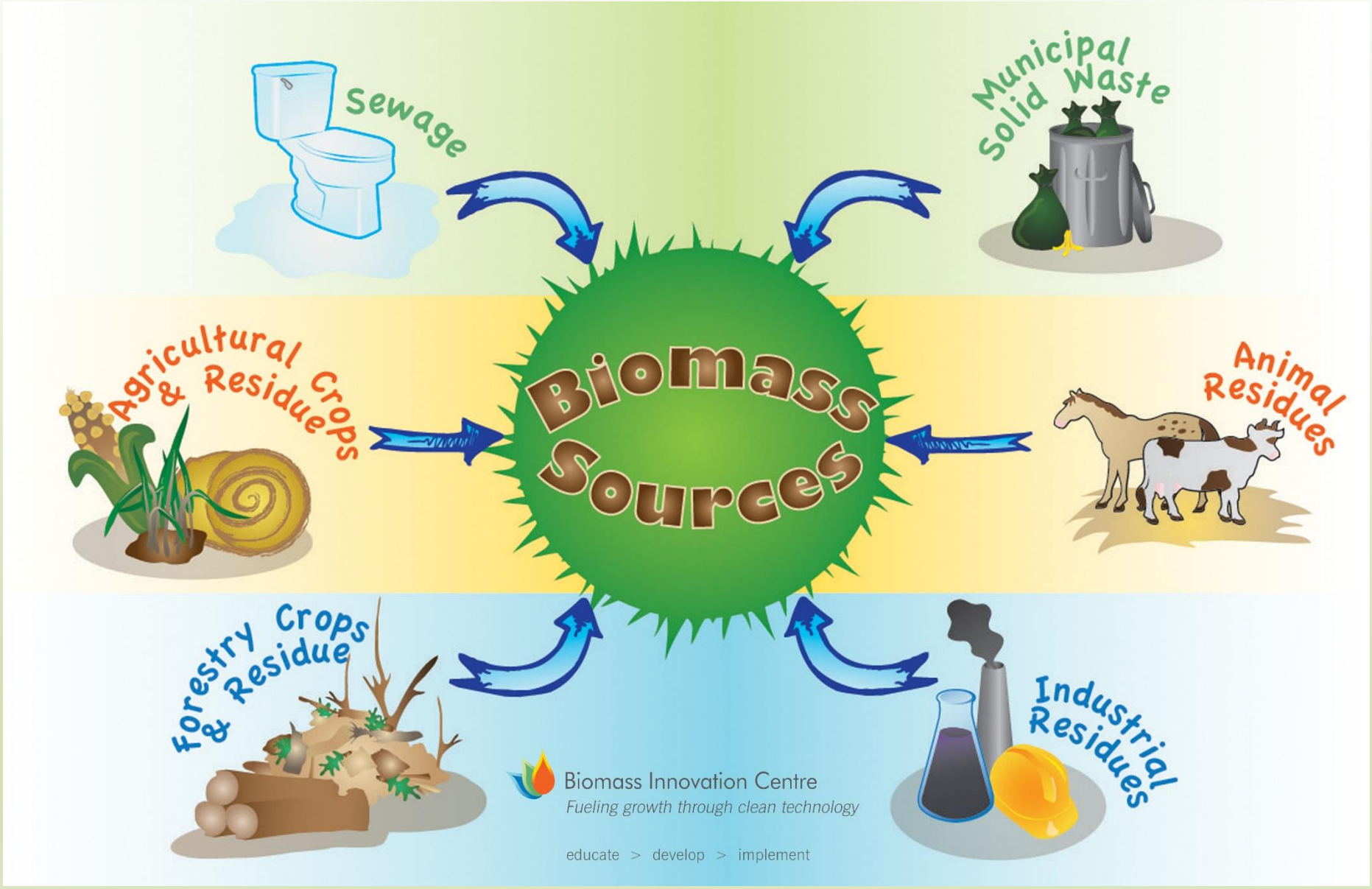
Bioenergy

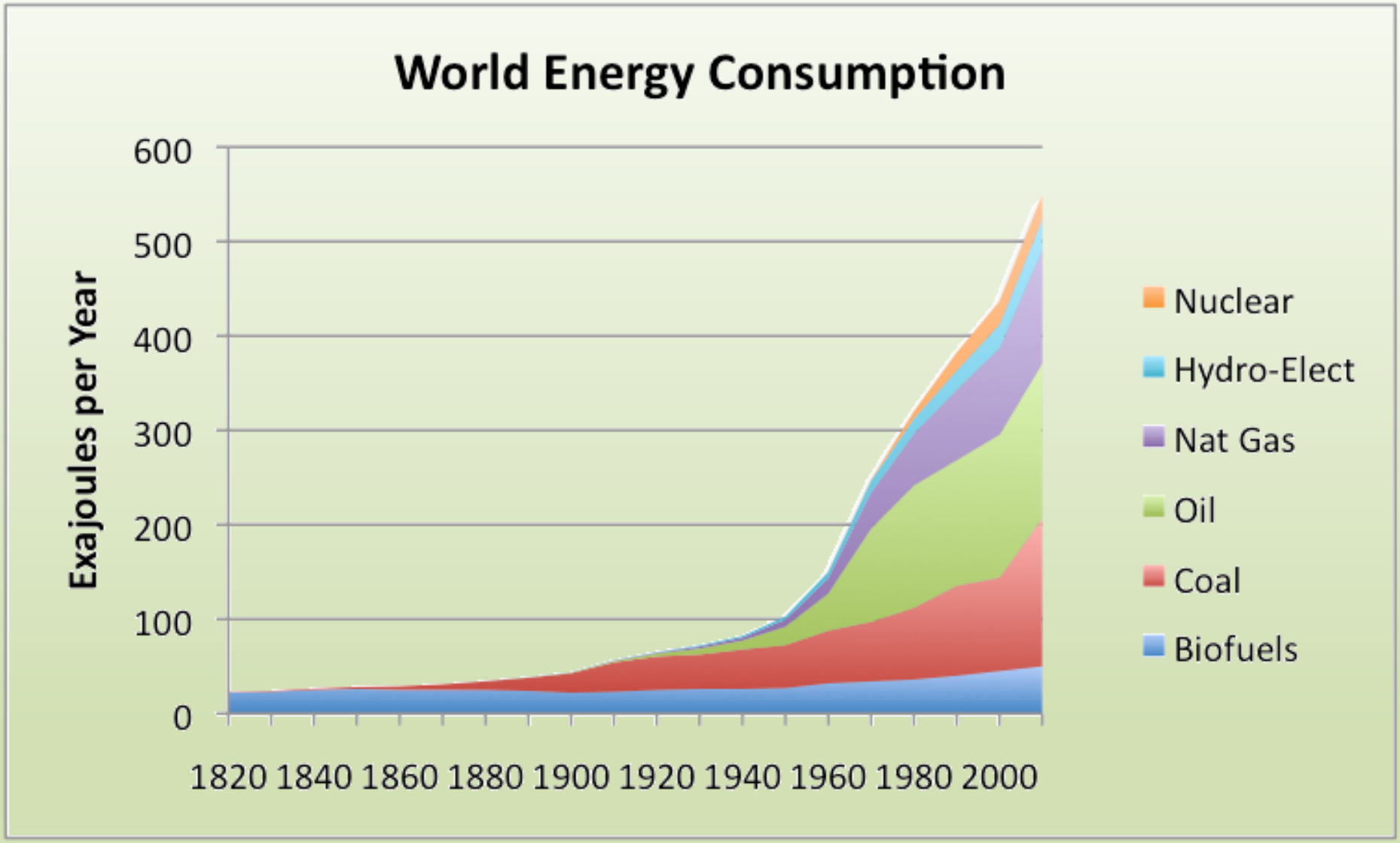
Energy from the sun stored in plants (biomass)

- **Agricultural Crops**
  - Corn, soybeans, sunflower

- **Herbaceous Crops**
  - Switchgrass, *Miscanthus,* ag residues

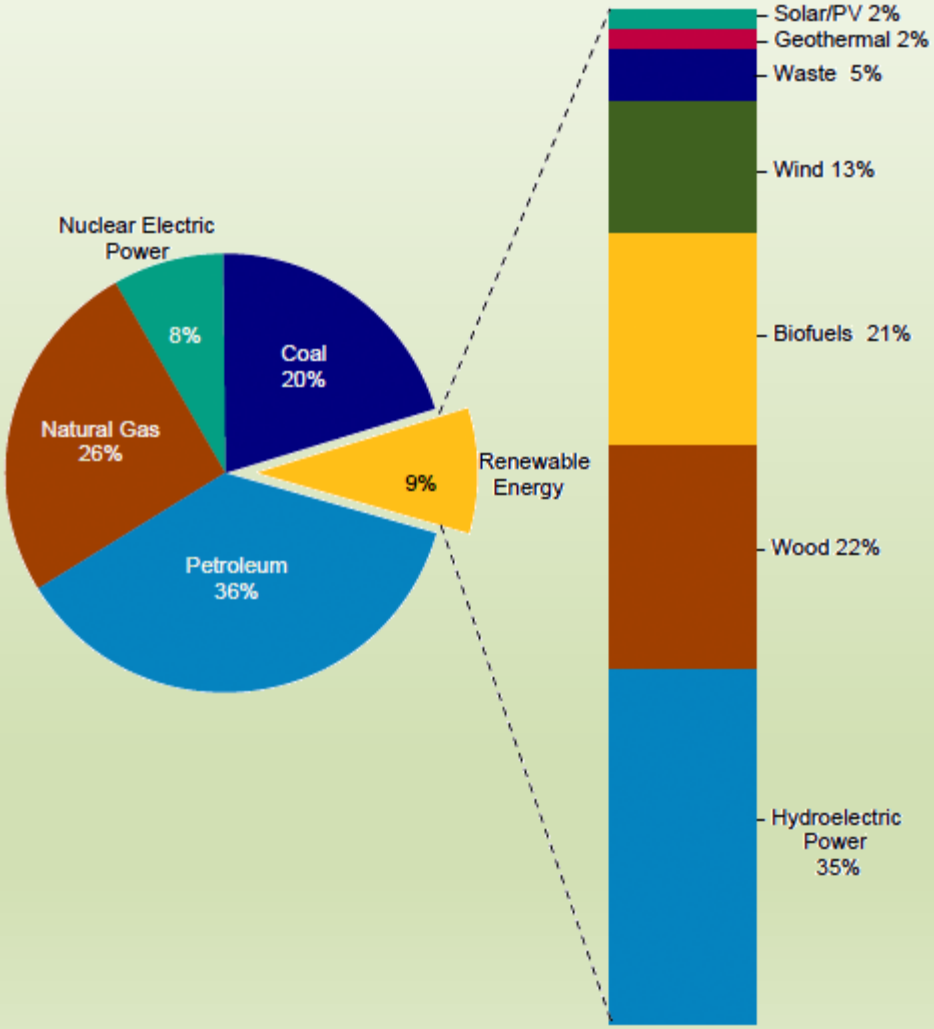
- **Woody Biomass**
  - Fire wood, forest residues
  - Short rotation woody crops…
    - Poplar, southern pine, shrub willow


Sewage
Municipal Solid Waste
Agricultural Crops & Residues
Biomass Sources
Animal Residues
Forestry Crops & Residue
Industrial Residues
Biomass Innovation Centre
Fueling growth through clean technology
educate > develop > implement


World Energy Consumption
Exajoules per Year
600
500
400
300
200
100
0
1820 1840 1860 1880 1900 1920 1940 1960 1980 2000
Nuclear
Hydro-Elect
Nat Gas
Oil
Coal
Biofuels

(EIA, 2011)

US Energy Use



Renewable Energy=

- 9% of total supply

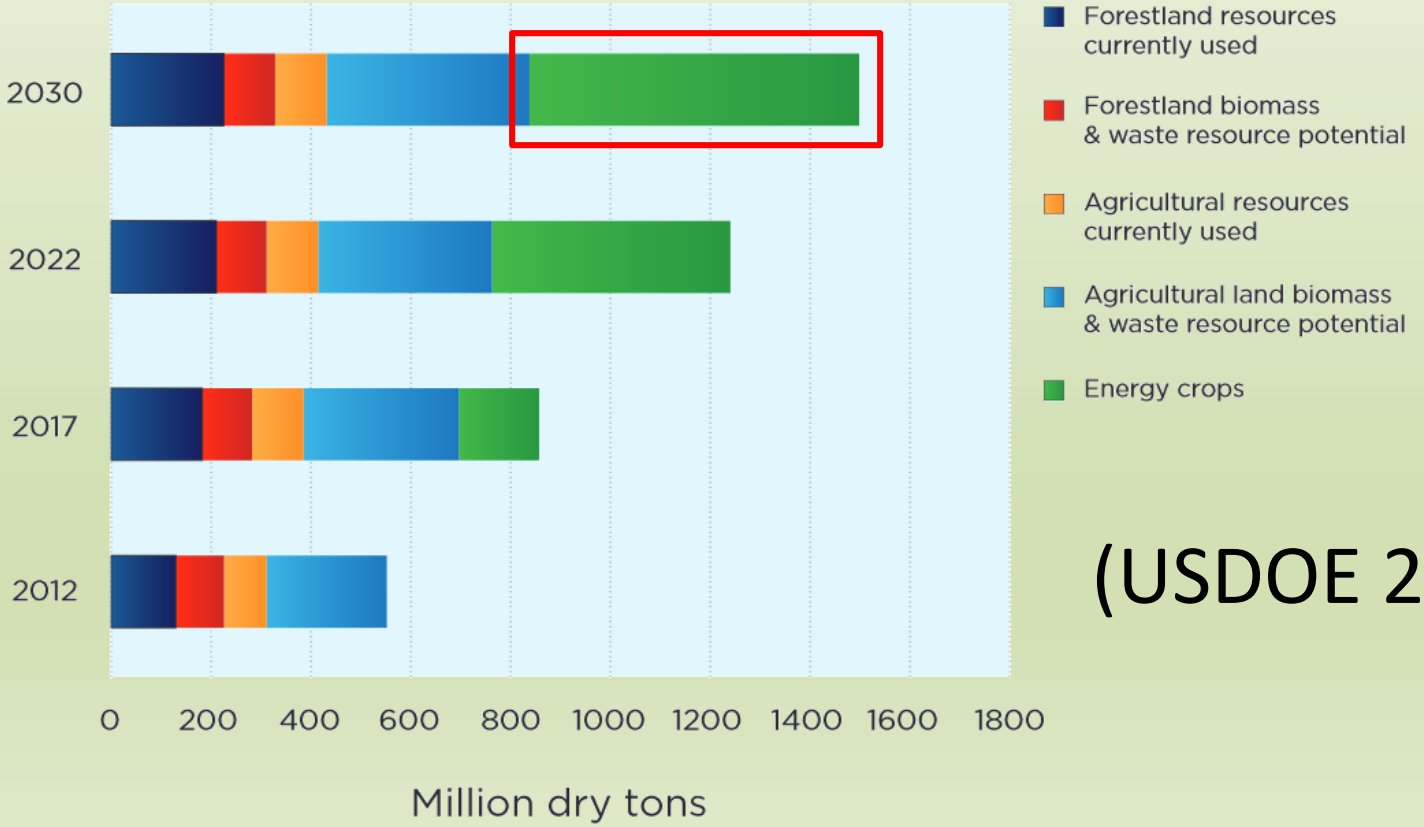
Biomass/Bioenergy =

- 43% of renewables
- Wood & Biofuels

(EIA, 2011)

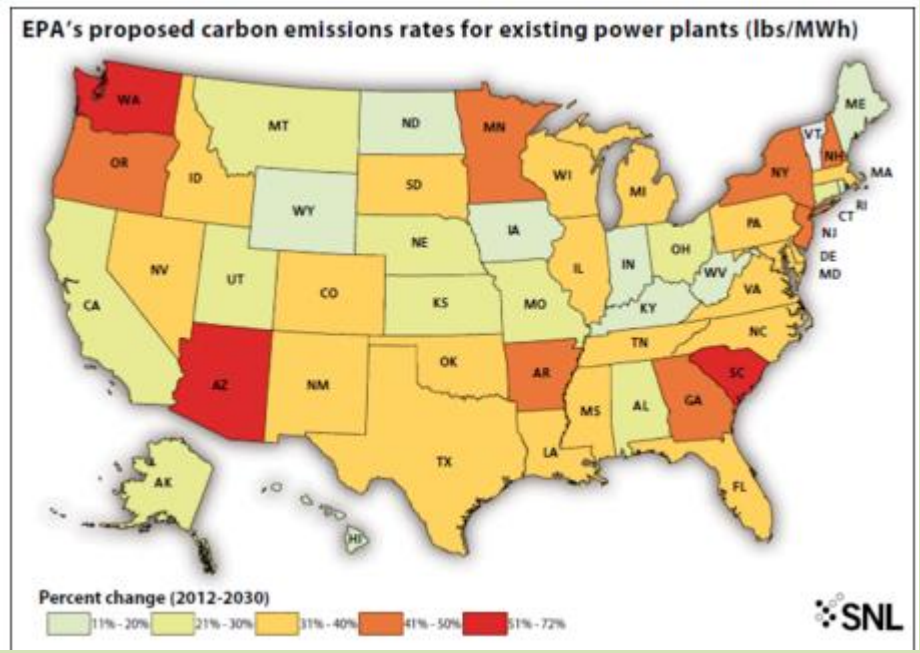
Projected Biomass Supply

- Potentially large increase over next 15 years
- Largest percentage from energy crops
- i.e. Shrub willow and others
- 600 Million tons/year (dry) from energy crops alone



(USDOE 2011)

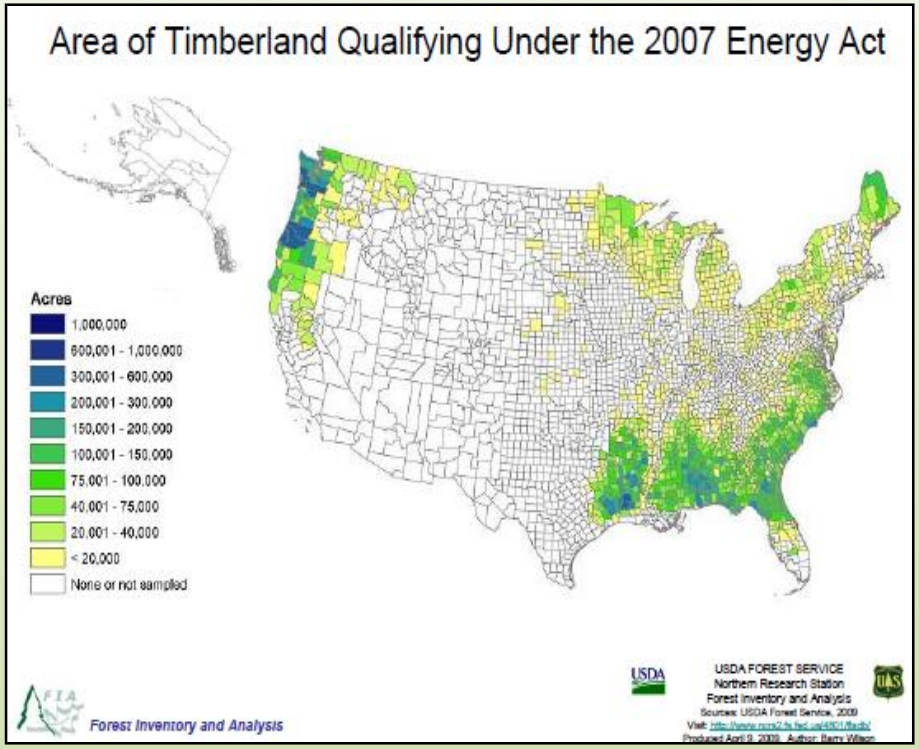
Policy Uncertainty

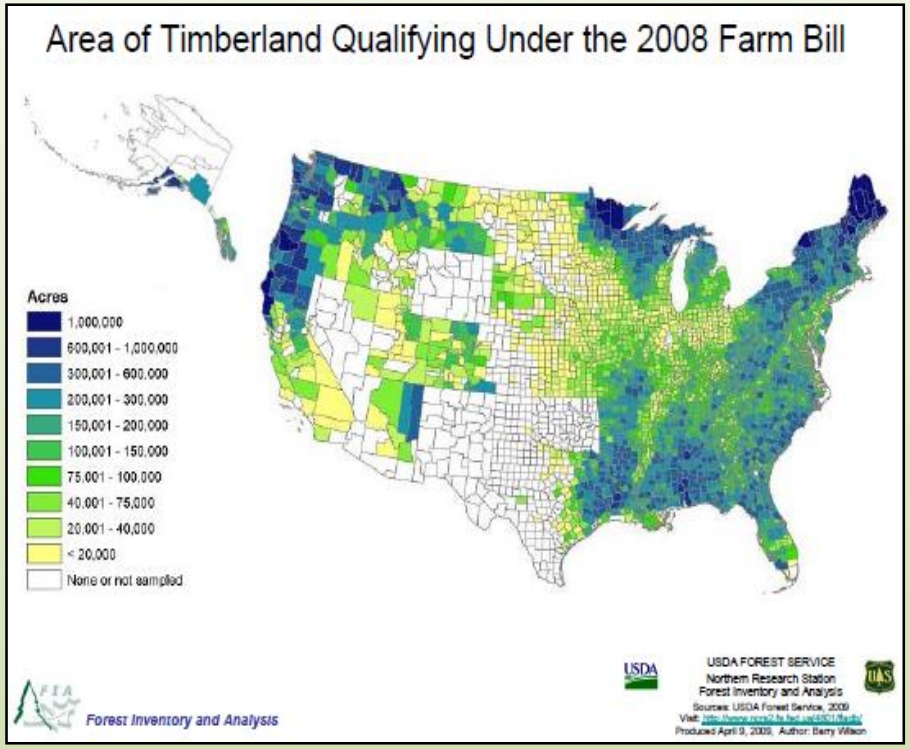


CO_2 reduction plans will be developed on a state by state basis.

- 31% of U.S. CO_2 emissions come from power plants
- Federal Clean Power Plan (Aug. 2015) reduces CO_2 power plant emissions by 32% (2005 base) by 2030
- May generate new interest in biomass, but the US EPA has not defined biomass or if it is C neutral, low C fuel or something else.

Impact of Biomass Definitions





- Amount of timberland that could be included as acceptable biomass is up to 70% lower in the EISA 2007 definition compared to the Farm Bill

SUNY-ESF Willow Project

Research on shrub willow since 1986

- ✓ Breeding
- ✓ Yield trials
- ✓ Economic analysis
- ✓ Harvesting & Logistics
- ✓ Sustainability
- ✓ Multiple uses & benefits

Commercialization of shrub willow for biomass energy and alternative applications

Funding and Collaborators

U.S. DEPARTMENT OF ENERGY

Double A Willow

ESF

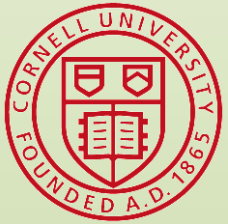
nyserda
Energy. Innovation. Solutions.

celtic energy farm

NEWBio

U.S. Department of Transportation

Cato Analytics, LLC



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

ReEnergy HOLDINGS LLC

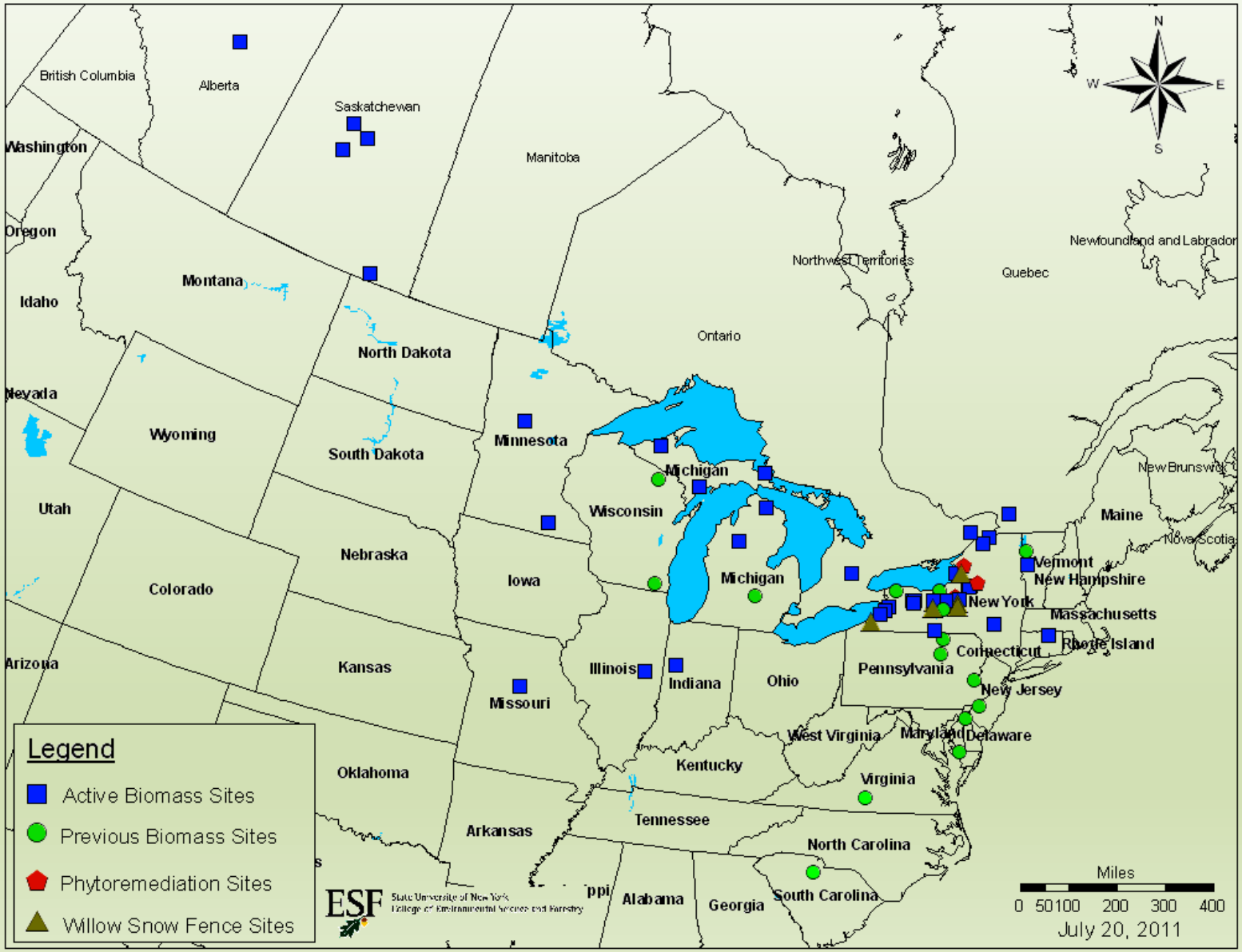
PENNSTATE 1855

NEW HOLLAND AGRICULTURE

GREENWOOD RESOURCES

...and many others

Willow Research Trials



Willow Genus (*Salix* spp.)

Shrub willow

Salix purpurea, Salix miyabeana, Salix sachlinensis, Salix viminalis, Salix eriocephala, Salix caprea…

…and many cultivars of these species

Not tree willows!

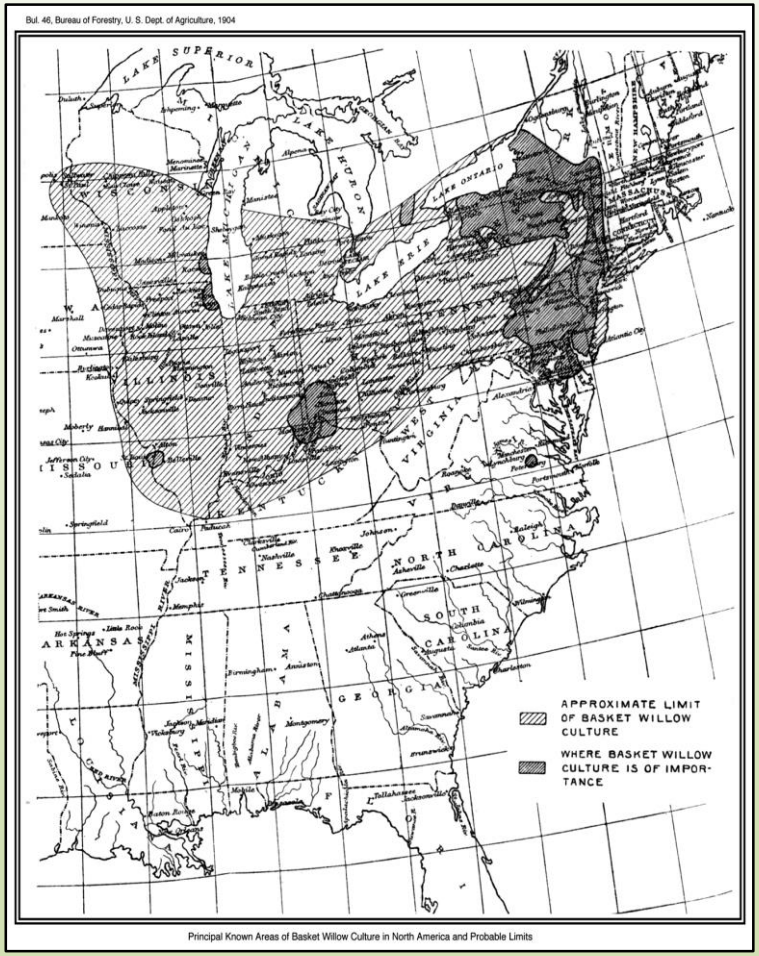
(Salix babylonica)

Ecology of Shrub Willow

- Occurs naturally around rivers, wetlands and other fresh water ecosystems

- Wide geographic range including most of New York, US and Canada
- Hundreds of species world wide - *Salix spp.*
- Pioneer species adapted to wide range of conditions

Regional History



Hubbard, W. 1904.

- Onondaga County was the center of the U.S. willow basket industry in the early 1900s

- ESF initiated willow biomass research in 1986

Shrub Willow

- ✓ 5 dry tons/acre/year
- ✓ Adaptable to various sites
- ✓ Clonal Propagation
- ✓ Rapid Growth Rates
- ✓ Coppice Ability
- ✓ Limited pests & diseases

Forestry

- Woody plants
- Hardwood biomass
- Perennial species
- Multi-year harvest cycle

Shrub Willow

Bioenergy Crops

Agriculture

- Agricultural lands
- Agricultural machinery
- Cultivation practices
- Intensive crop management

Site Preparation

Planting

Coppice (cut-back)

One Crop Establishment

Three Years Growth

Minor Maintenance

7 Crop Cycles

Harvest Biomass

Seven Harvests

Rapid Regrowth

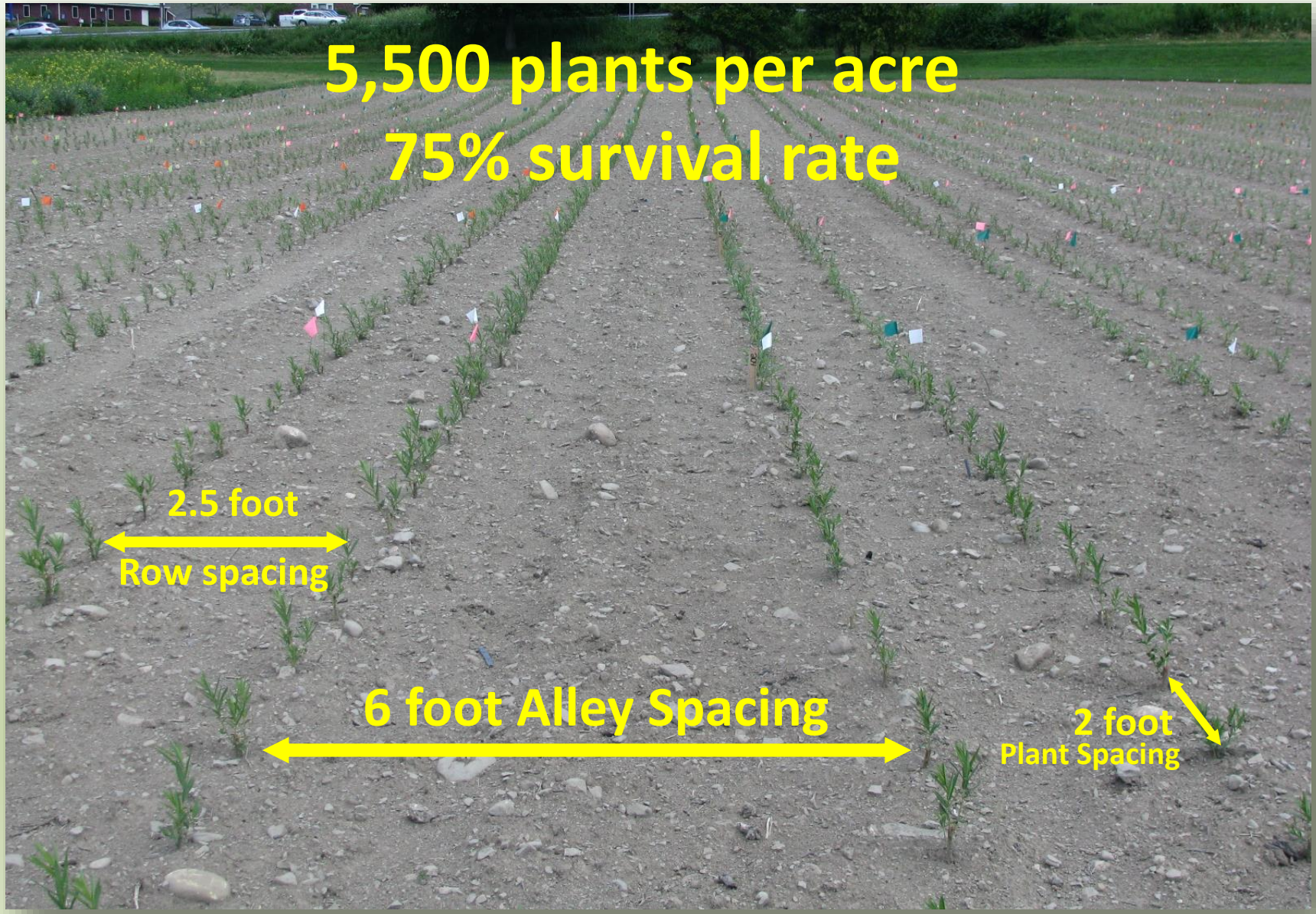
15 dry tons/acre each harvest

Mechanized Planting

Unrooted Stem Cuttings

Just Planted

Double-Row Pattern



Few Weeks After Planting

End of First Growing Season

Coppice

Mid-Summer

Five to ten feet per year

Five to Ten Feet per Year

Large Woody Stems

1 to 2 inch diameter

Mechanized Harvesting

Cut Stools

The Following Spring

Repeat seven times

Biomass Energy Feedstock

Forest Residues/Slash

- Logging byproduct
- Harvest and thinning
- Tree tops and branches
- Non-Merchantable logs
- Woody biomass feedstock

Management Options

Management Options

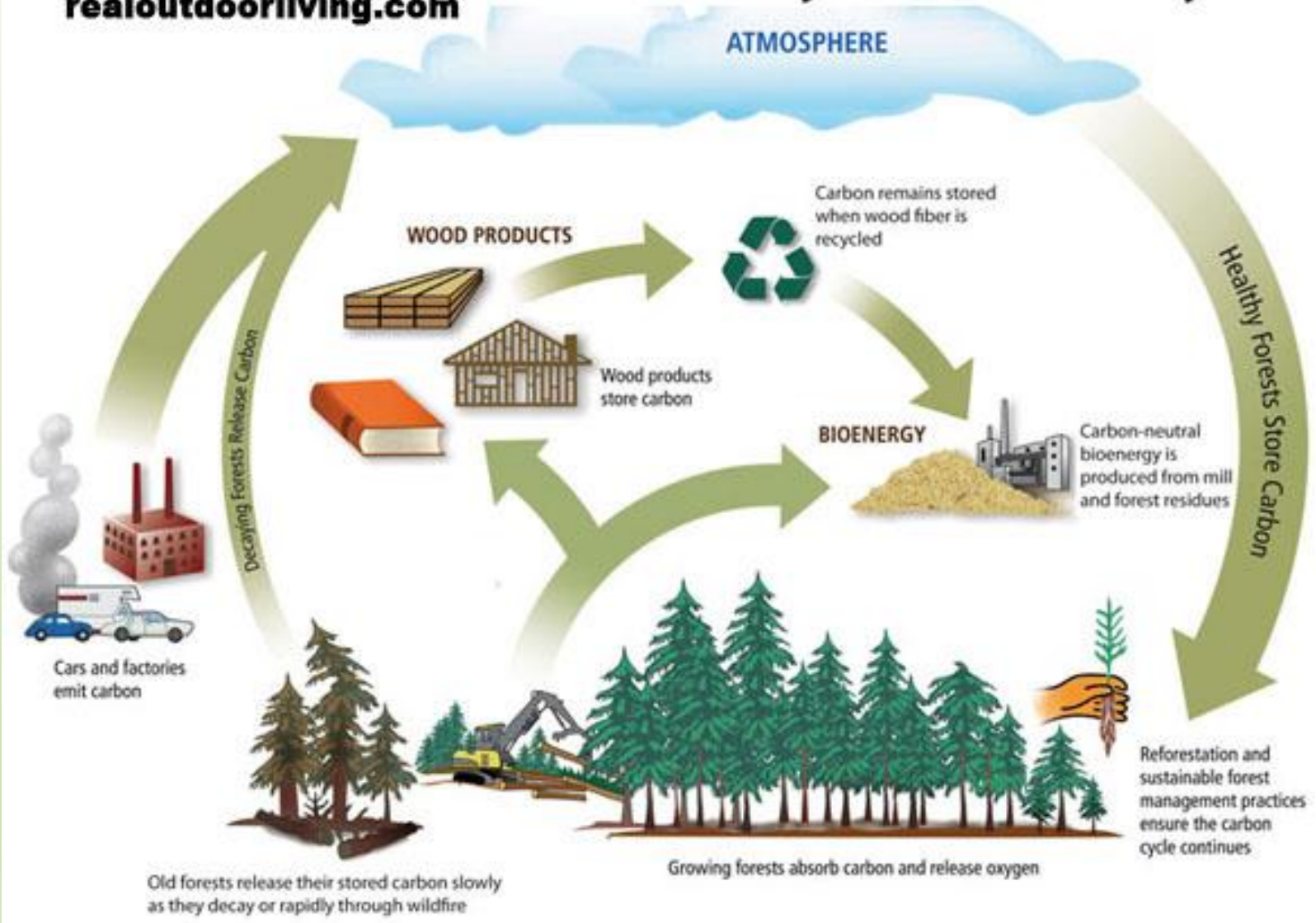
Management Options

Management Options

Management Options

Sustainable Forestry Carbon Cycle

realoutdoorliving.com

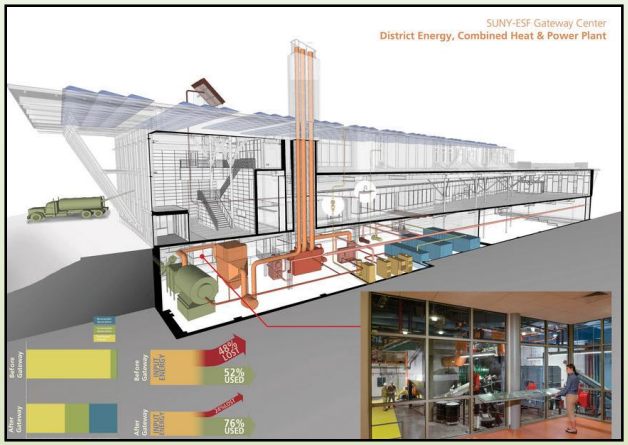


Multiple Pathways

Biopower

Thermal

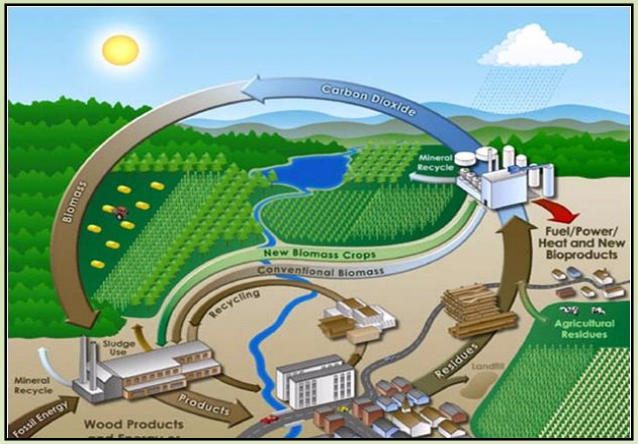
Combined Heat & Power



Co-firing

Gasification

Biorefinery



Multiple Products

State of the Willow Industry

- **60 - 80 thousand acres in Europe** (AEBIOM, 2011)
  - Development since 1970's
  - Higher fuel and biomass prices
  - More renewable energy mandates and incentives

- **Commercial production in US**
  - Less incentives, lower biomass prices
  - Previous (unsuccessful) efforts
  - Now 1200 acres established in northern NY
  - Dedicated end user, 11 year contracts
  - USDA BCAP
  - SUNY-ESF, Cornell University, NEWBio

Willow in Northern NY

-About 1200 acres in the ground

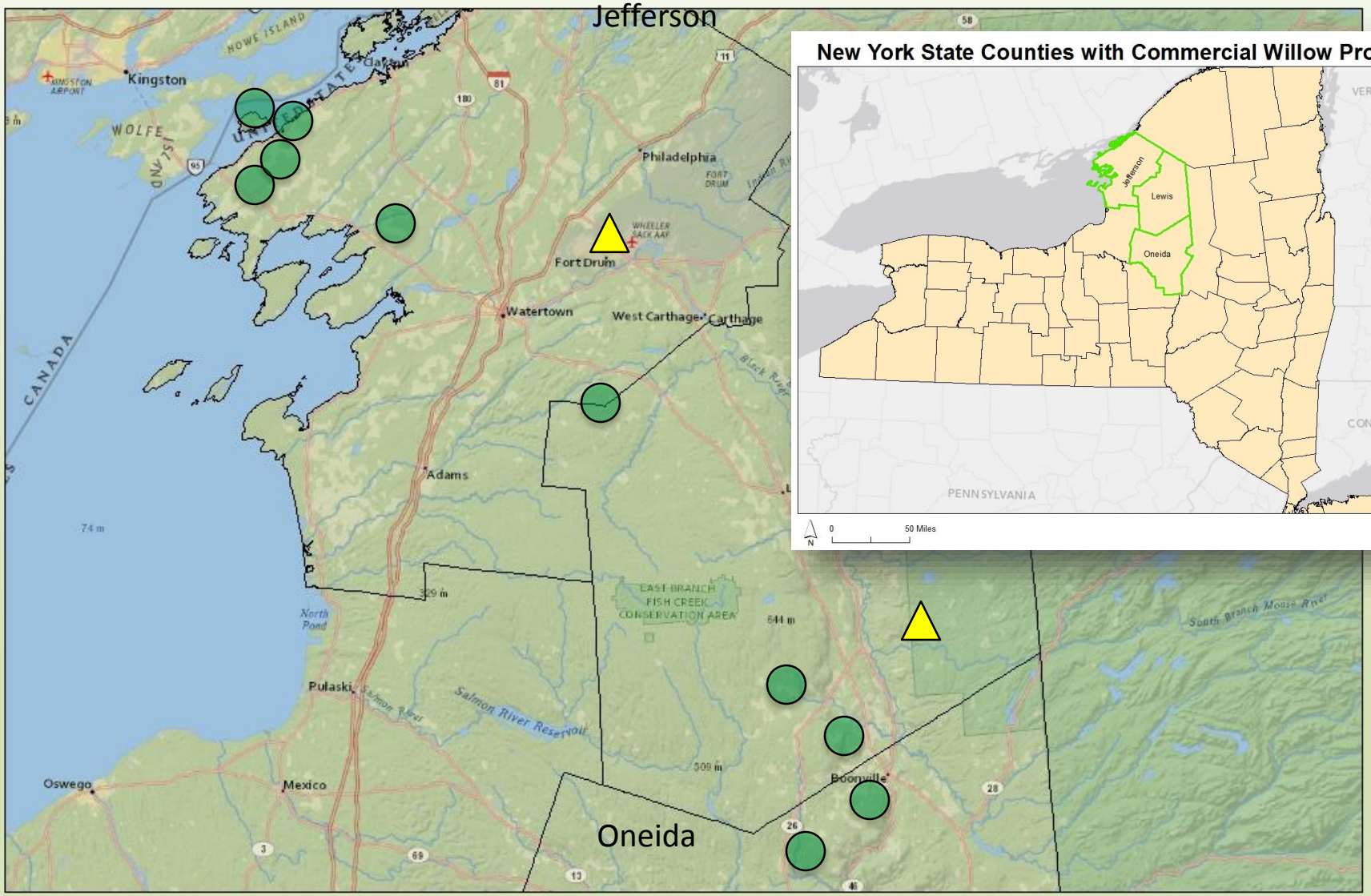
-Harvesting about 100 - 200 acres per year

-Delivered to ReEnergy biopower facilities

-Mixed with forest residues

-Renewable electricity

Northern New York Willow Biomass Production and Biopower



Biomass Crop Assistance Program

Catalyze commercial adoption & innovation…

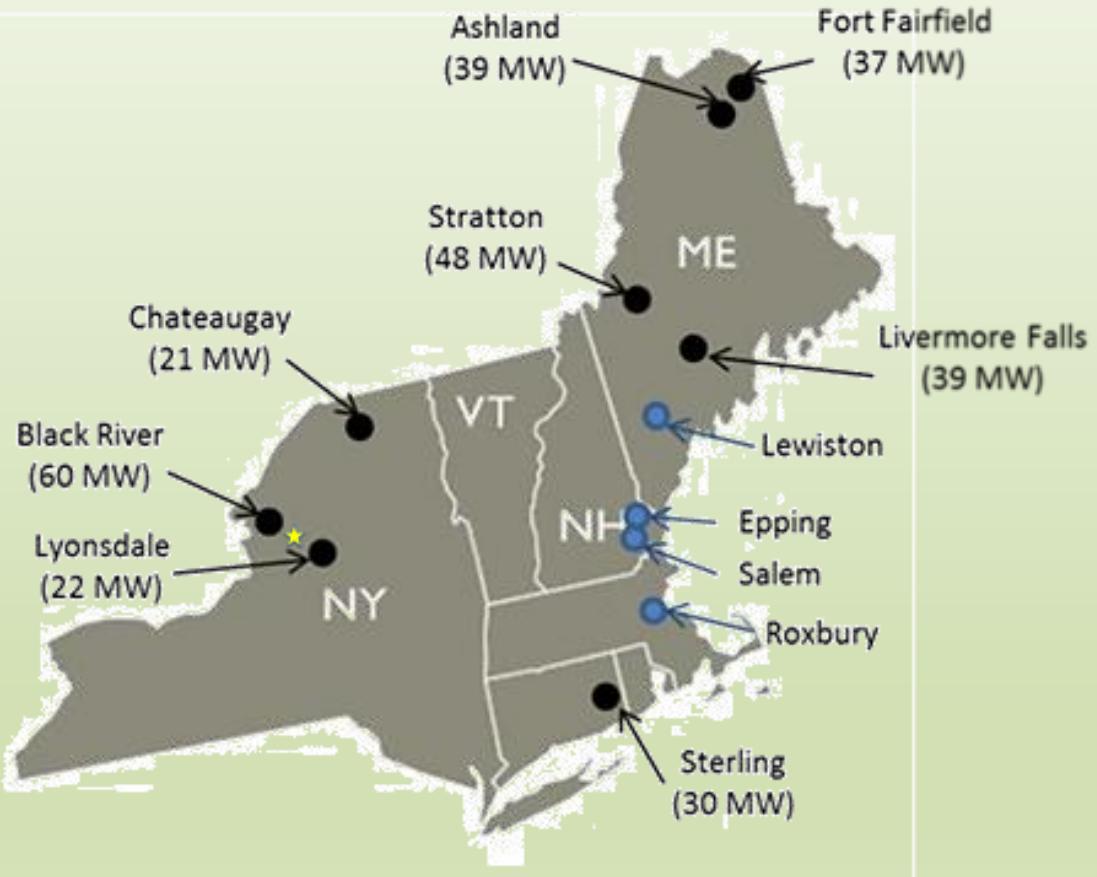
- ✓ Partial establishment grants
- ✓ Land rental payments
- ✓ Purchasing contracts

Lasting funding opportunity was 2013

- ✓ Possible future funding
- ✓ Included in current farm bill
- ✓ Successful production and end use in Northern NY
- ✓ Project Sponsor – ReEnergy Holdings LLC

ReEnergy Holdings

- ~300 MWs of renewable energy generation
- ~ 300 employees; 5 states



- Renewable Energy Facility
- Recycling Facility
- Headquartered in Latham, NY

ReEnergy Holdings in New York

- 80 employees
- 103 MW of installed capacity, or 738,000 MWh – enough to serve 96,000 homes
- $24 million in annual fuel purchases
- Support more than 300 indirect jobs, most in the forest

ReEnergy Facilities in NYS

- ReEnergy Black River: 60 MW
- ReEnergy Lyonsdale: 22 MW
- ReEnergy Chateaugay: 21 MW

ReEnergy Biopower

- Large demand for woody feedstocks
- Primarily forest residues
- Recent contract with Fort Drum Army Base
- 100% renewable electricity for next 20 years

Fuel Supply Program

- **End-market for BCAP Shrub Willow**

- **Equipment Leasing Program**
  - ReEnergy launched a program allowing loggers to gain access to state-of-the-art equipment and secure long-term agreements to provide fuel to ReEnergy

- **SFI Certification**
  - First company solely devoted to electricity production to be certified by SFI
  - Commitment to use best management practices and protect forest health


NSF

Certificate of Registration

ReEnergy Black River

Sustainable Forestry Initiative (SFI)®: [2010 – 2014]

Commercial Willow Feedstock

- Over 5,900 tons of willow delivered to Lyonsdale and Black River facilities 2013-2015
- Willow found to be suitable fuel in terms of moisture and ash content, now incorporated directly with other feedstocks upon delivery.
- Current willow plantings are planned to be harvested about 350-400 acres per year.
- This will produce roughly 8,000-9,000 green tons of feedstock annually

Willow Chip Quality

Monitoring commercial willow chip quality since 2012…

(Eisenbies et al. 2014, Conable et al. 2014, Heavey et al. 2015)

Quality characteristics that meet or exceed end user specifications with low variability

Suitable for mixing with forest residue chips for biopower

Specifically….

Moisture: 43% ± 2%

Ash: 3% ± 0.5%

Energy: 8200-8300 btu/lb

EcoWillow Model

- Cash flow model
- Willow biomass crops
- All phases of production
- User-friendly & customizable
- Recently updated using..
  - Commercial operations
  - Latest research studies
  - Example production scenarios

Download at:
www.esf.edu/willow

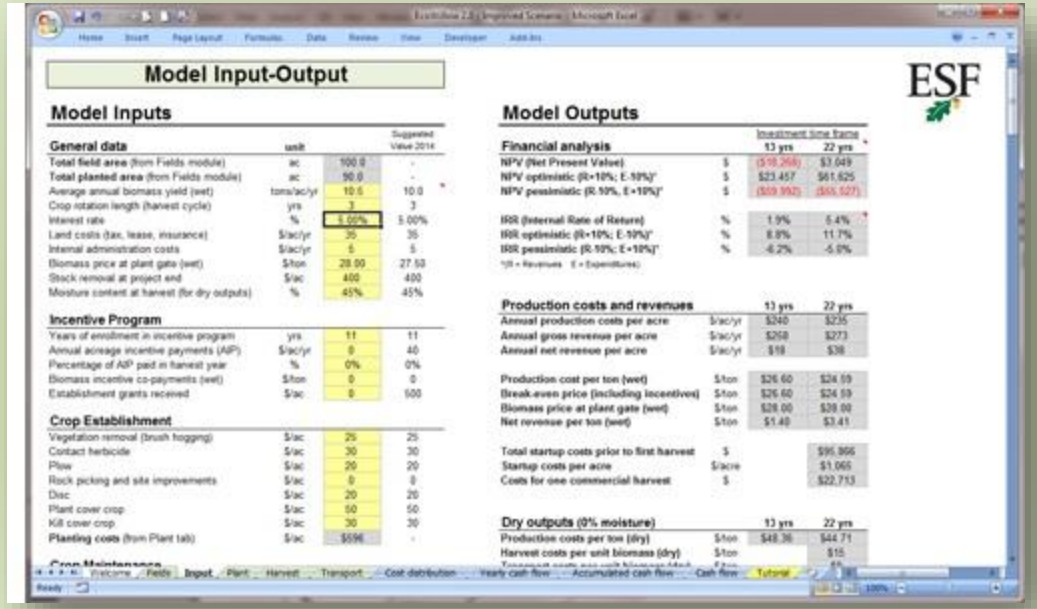
Economics of Production

Base Case Scenario 2014

- Conservative estimates of profitability
- 22-year life cycle of the planting including tear-out
- Does not include best BCAP incentives or best practice targets

Model Outputs

- Break-even scenario
- Payback is entire life cycle of project



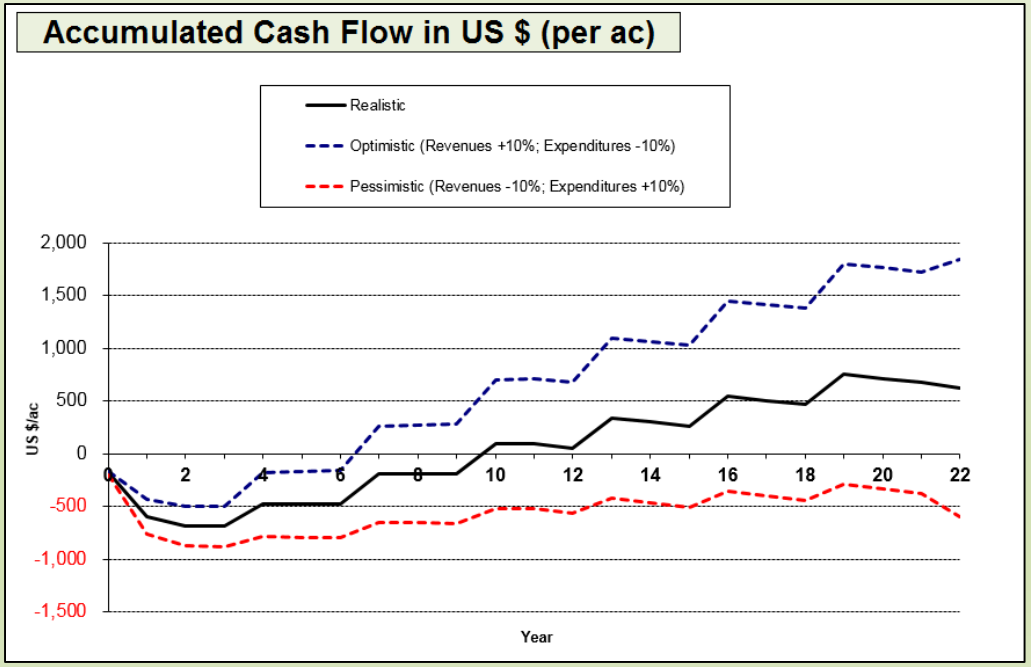
Economics of Production

Base Case Scenario + BCAP Incentives

- 2014 base case assumptions and 2015 BCAP funding

Model Outputs

- Positive NPV
- IRR 10%
- Payback…
  - 10 years after planting
  - Third Harvest
- All-in costs about $25/ton



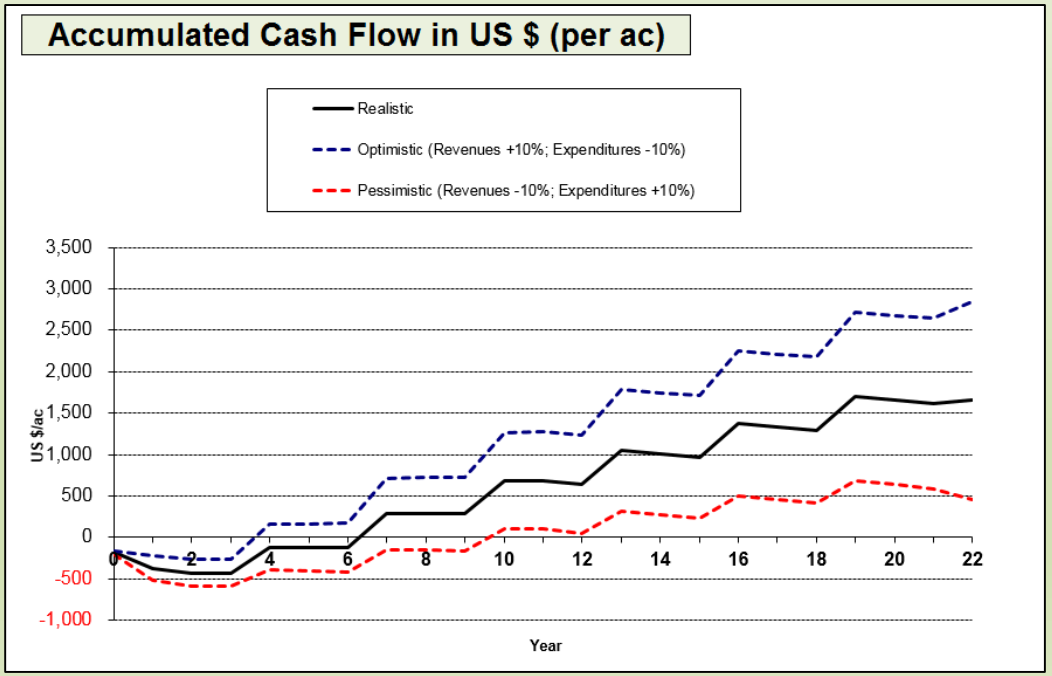
Economics of Production

Improved Base Case + BCAP Incentives

- Adds current BCAP incentives and best practice targets to base case

Model Outputs

- Positive NPV
- IRR 20%
- Payback
  - 7 years after planting
  - Second harvest
- All-in costs about $20/ton



Environmental Benefits

…is renewable enough?

Marginal and Idle Lands

Can be grown on lower quality soils

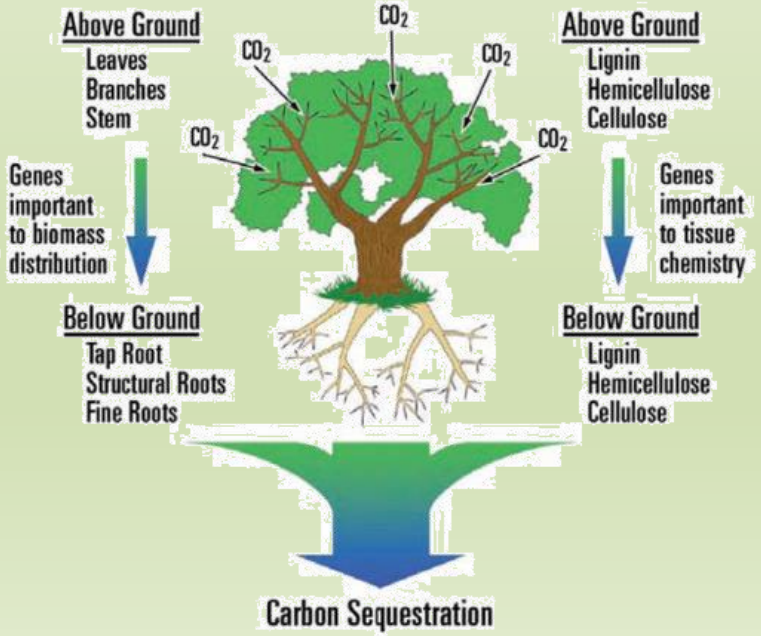
Idle land - Not profitable for ag in current markets

1 million acres in NYS - poorly drained, wet soils

- ✓ Tap underutilized resource
- ✓ Rural development
- ✓ Productive ecosystems
- ✓ Not compete with food/feed

Carbon Neutral Lifecycle

- ✓ Net-zero GHG emissions (Caputo et al. 2014)
- ✓ Does not contribute to climate change
- ✓ CO_2 sequestered above- and belowground
- ✓ Offsets +100% of emissions
- ✓ All phases of lifecycle
  - Power plant construction



Energy Return on Investment

It Takes Energy to Make Energy!

Willow Energy Return

- Between 15:1 and 45:1

(Caputo et al. 2014)

Other Renewable Sources

- Wind ~20:1
- Solar PV ~10:1
- Corn Ethanol ~2:1 or less

Wildlife

- ✓ Willow increases habitat & biodiversity

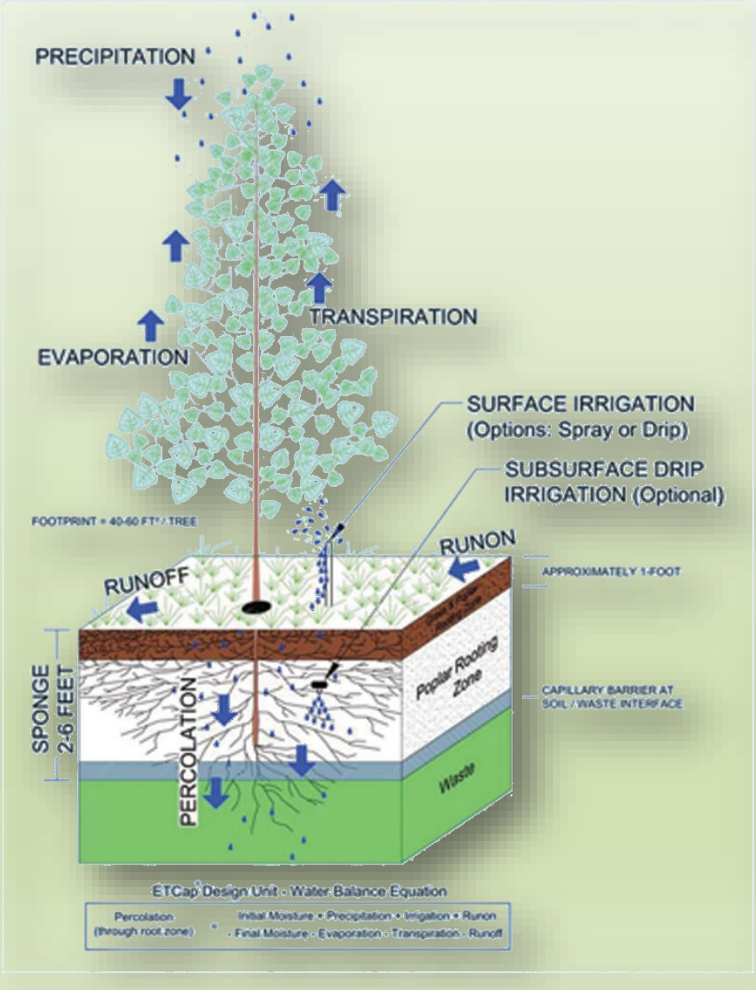
  (Campbel et al. 2012)

- ✓ Birds and small mammals
- ✓ Bees and pollinators
- ✓ Beneficial soil organisms
- ✓ Deer, turkeys, other game

Bioremediation

Plants do work of machines & industrial processes….

- ✓ Water filtration
- ✓ Soil remediation
- ✓ Landfill caps
- ✓ Pollution control



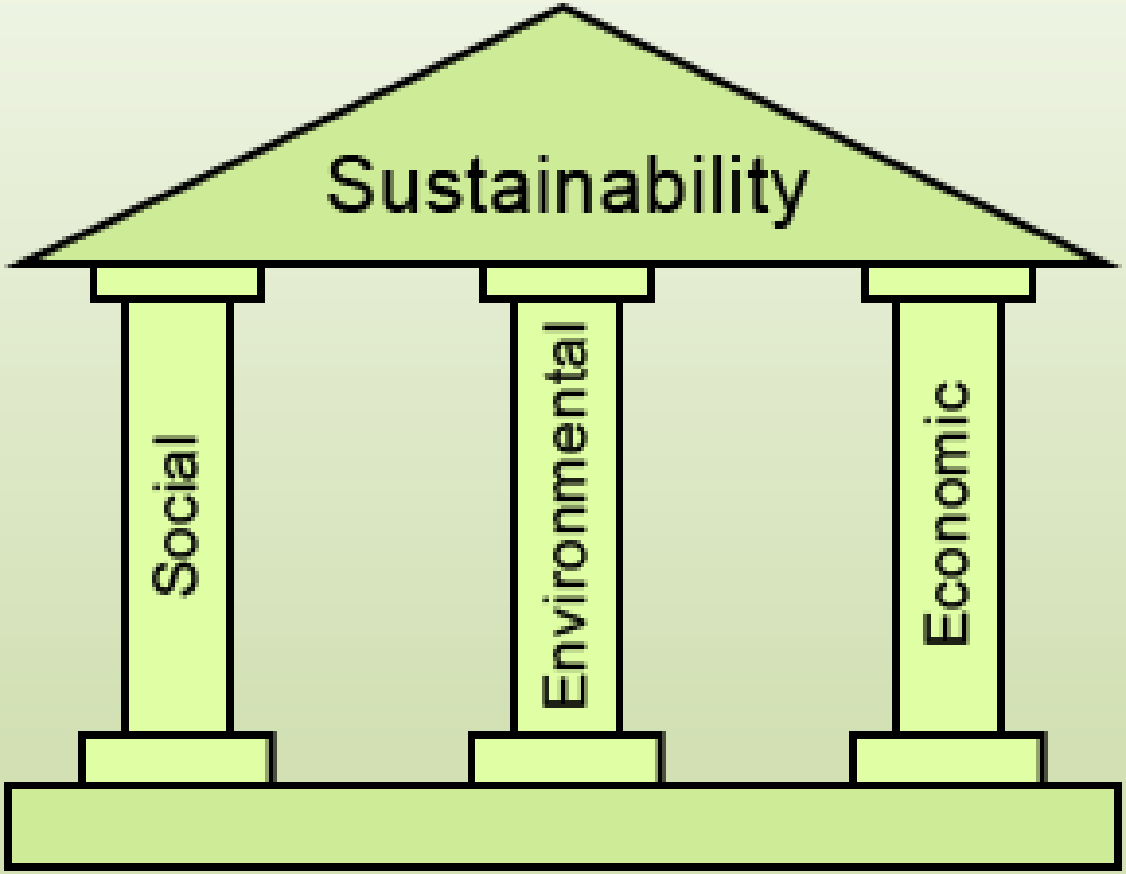
Same traits as bioenergy..

- ✓ High growth rate
- ✓ Coppice ability
- ✓ Fibrous root system
- ✓ Stress tolerances

Numerous Benefits

1. Alternative landfill cap - cheaper and more effective
2. Produces bioenergy from willow stems
3. Protects local watershed and ecosystems
4. Documented increase in wildlife and biodiversity
5. Recreation opportunities - nature trails, bird watching, etc

Willow systems can produce multiple-benefits…



For comprehensive sustainability

Other Environmental Benefits

Low Impact…

- **Natural weed control** (Heavey & Volk 2014)
  - limits the need for herbicides once crop is established
- **Disease and pest resistance** (Abrahamson et al. 2010)
  - limits the need for pesticides
- **Low nutrient requirement, high nutrient cycling**
  - limits need for fertilizers (energy/GHG/cost intensive)
  - (Quaye et al. 2014, Hang et al. 2014)
- **Perennial cover and root system** (Kloster, 2014)
  - Limits soil erosion and nutrient loading dramatically compared to annual crops

Jobs and Rural Development

Previous estimates (NYSERDA 2010, Proakis et al. 1999)…

10,000 acres of bioenery crops…

- ~40 - 50 direct jobs
- ~20 - 30 indirect/induced jobs
  - Biomass production, transport and end-use

Other Multifunctional Systems

Living Snow Fences

Stream Bank Stabilization

Municipal/Organic Wastes

Landscape/Ornamental

Careers in Bioenergy

- Researcher
- Educator
- Extension
- Producer
- End User
- Entrepreneur
- Manager
- Technician
- Policy Maker

Summary

- ✓ Bioenergy is an important source of renewable energy
- ✓ Shrub willow is an ideal biomass feedstock
- ✓ Economics can be favorable
- ✓ More than just energy
- ✓ Rural development and careers
- ✓ Environmental benefits

Thank You!

Justin Heavey

ESF Willow Project

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