Willow Bioenergy Crops

Environmental Benefits and Extension Services for Sustainable Supply Chains

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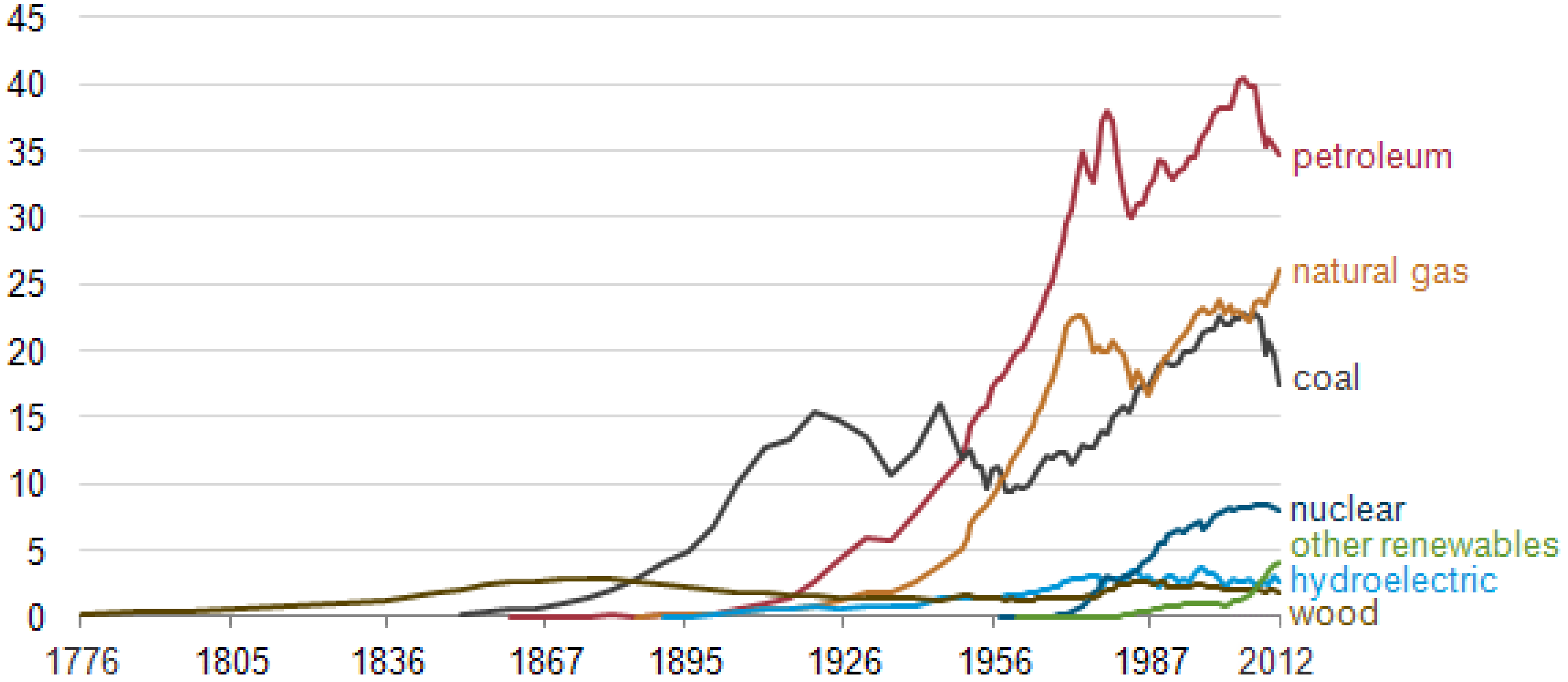
Overview

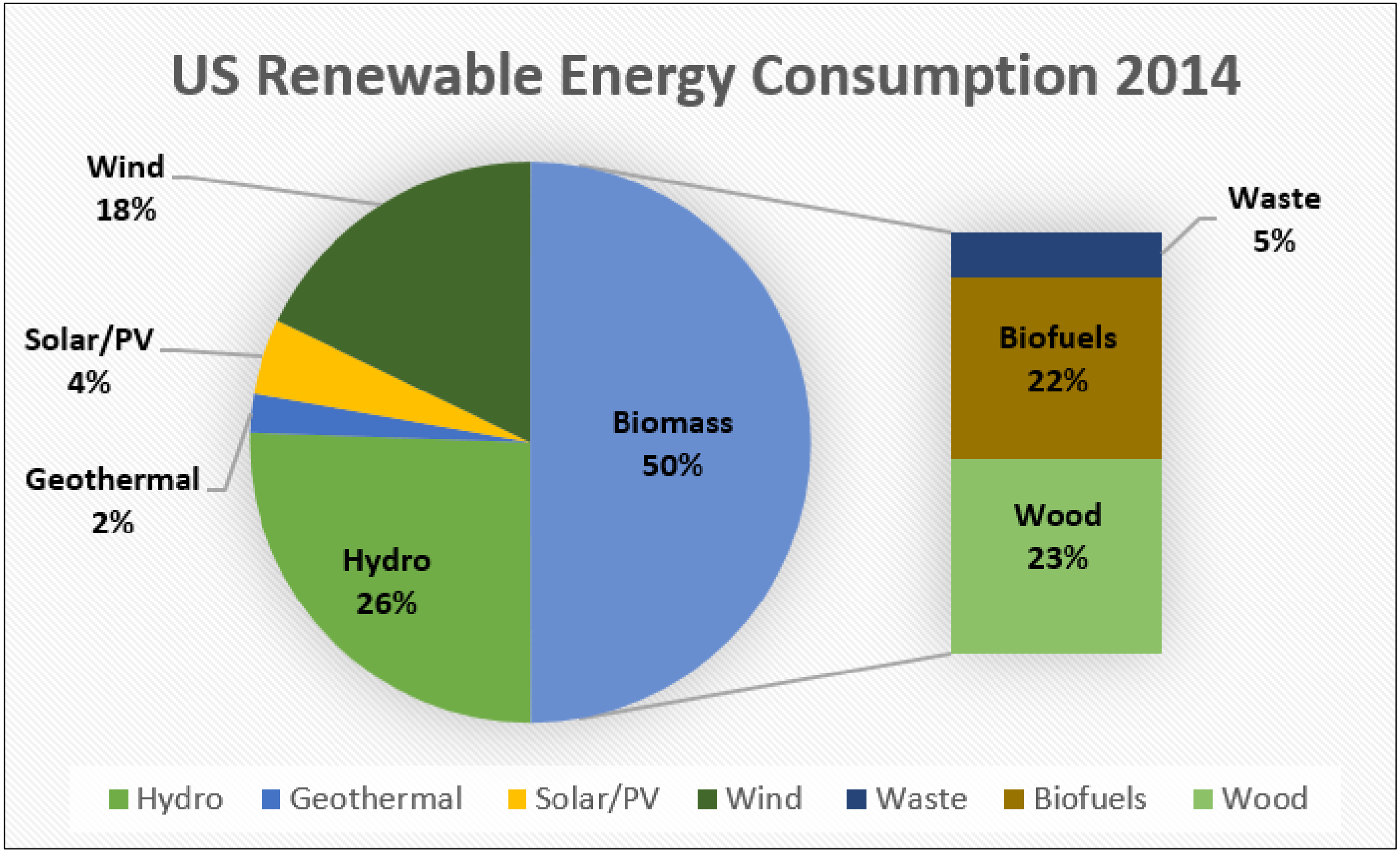
1. Biomass and Bioenergy
2. Shrub Willow
3. Environmental and Other Benefits
4. Barriers and Extension Services

History of energy consumption in the United States (1776-2012)

quadrillion Btu



Source: U.S. Energy Information Administration, AER Energy Perspectives and MER.



Source: U.S. Energy Information Administration, Monthly Energy Review, February 2016

Sources of Bioenergy

- Energy from the sun stored in plants
- Agricultural or forest bi-products
- Dedicated energy crops

Short Rotation Willow Crops (*Salix* spp.)

Shrub willow

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

…and hybrid cultivars of these species

Not tree willow!

Weeping willow
(Salix babylonica)

The Willow Project

Crop research and development…

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

Commercialization of shrub willow

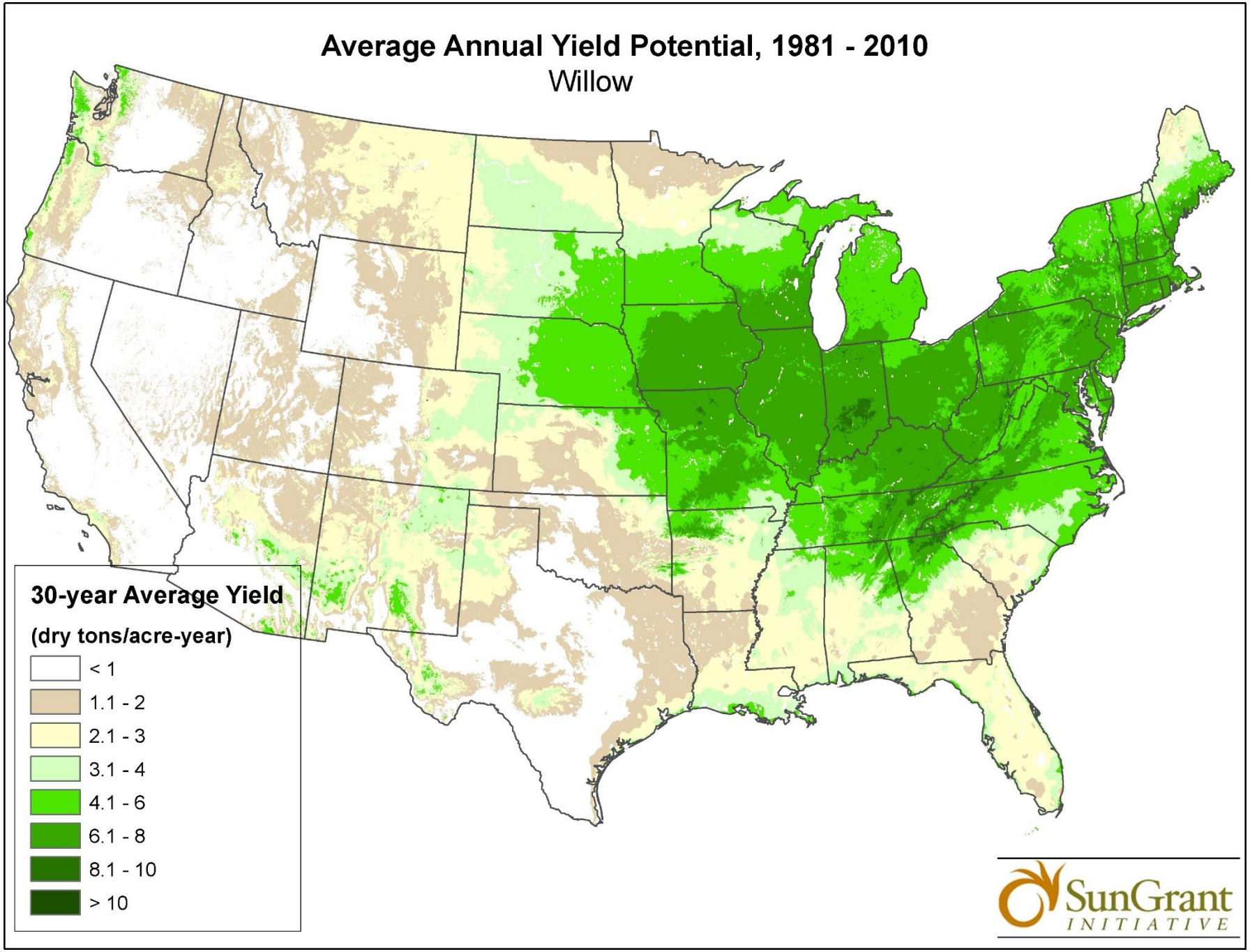
for biomass energy and alternative applications

Shrub Willow

- Fast growing hardwood
- 25 tons of biomass (wet) per acre
- Adaptable to a range of conditions
- Regrows from cut stems
- Broad genetic base for breeding

Average Annual Yield Potential, 1981 - 2010

Willow



Mechanized Planting

Unrooted Stem Cuttings

Five to Ten Feet per Year

Harvest Every Three Years

Seven Harvests from One Planting

Renewable Biomass Feedstock

Multiple Conversion Pathway and BioProducts

Environmental and Rural Development Benefits

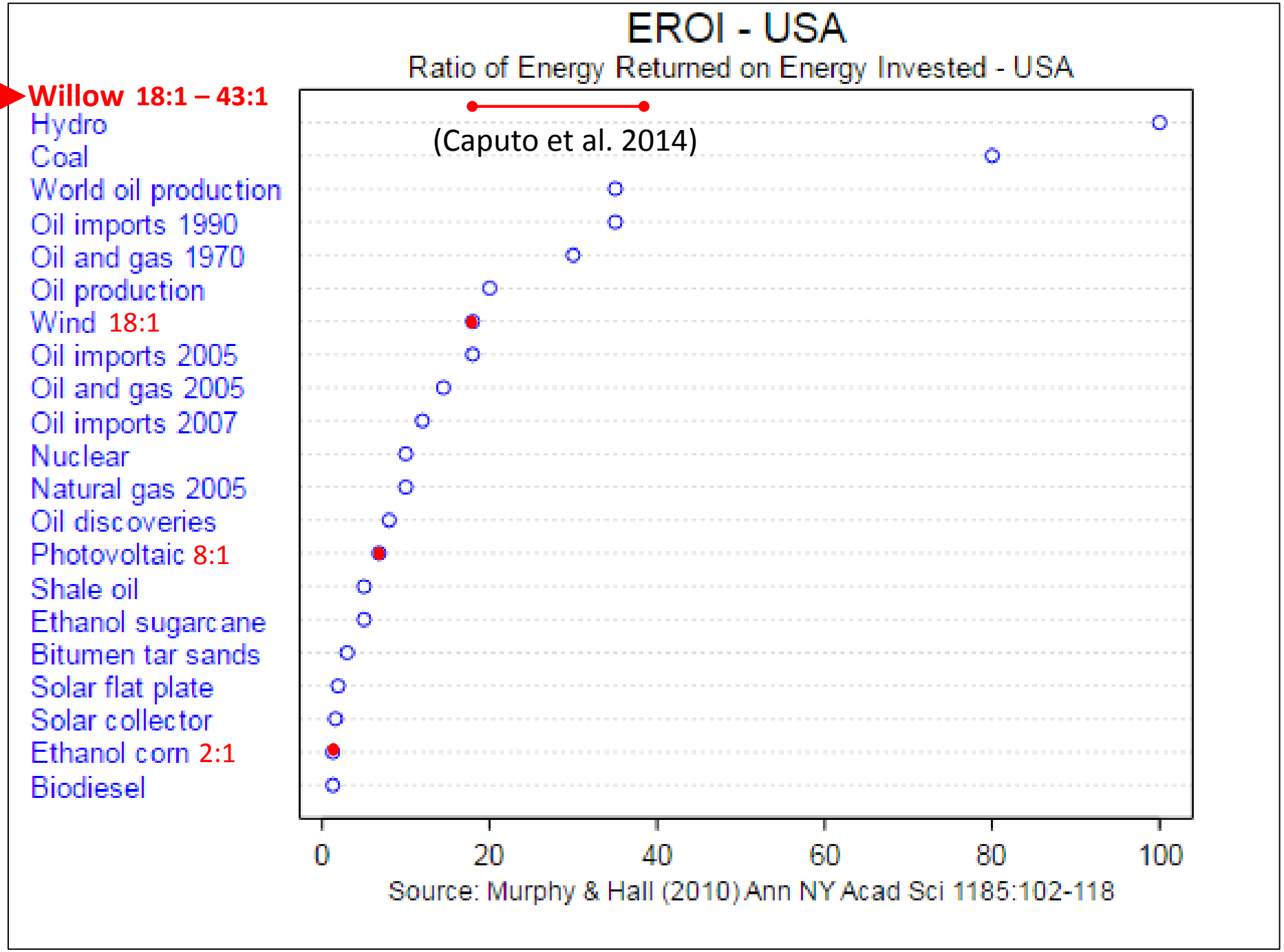
Is “renewable” enough?

Lifecycle Analysis

- Production through end use
- Carbon neutral 22-year lifecycle (Caputo et al. 2014)
- CO_2 sequestered above- and belowground
- Offsets 100% of emissions (or more)
- Energy production with net-zero emissions

Net-energy Ratio

It takes energy to make energy!



Wildlife Habitat and Biodiversity

Birds and small mammals

- (Campbel et al. 2012)

Bees and other pollinators

- (Tumminello and Volk 2016)

Beneficial soil organisms

- (Minor et al. 2004)

Deer, turkeys and other game…

Low Environmental Impact

Natural weed control (Heavey & Volk 2014)

- Limits the need for herbicides

Disease and pest resistance (Abrahamson et al. 2010)

- Limits the need for pesticides

Low fertilizer requirement (Quaye et al. 2014)

- Relative to annual crops

Perennial cover and root system

- Mitigates soil erosion (Kloster, 2014)
- Limits runoff protecting water quality (Bressler, 2016)

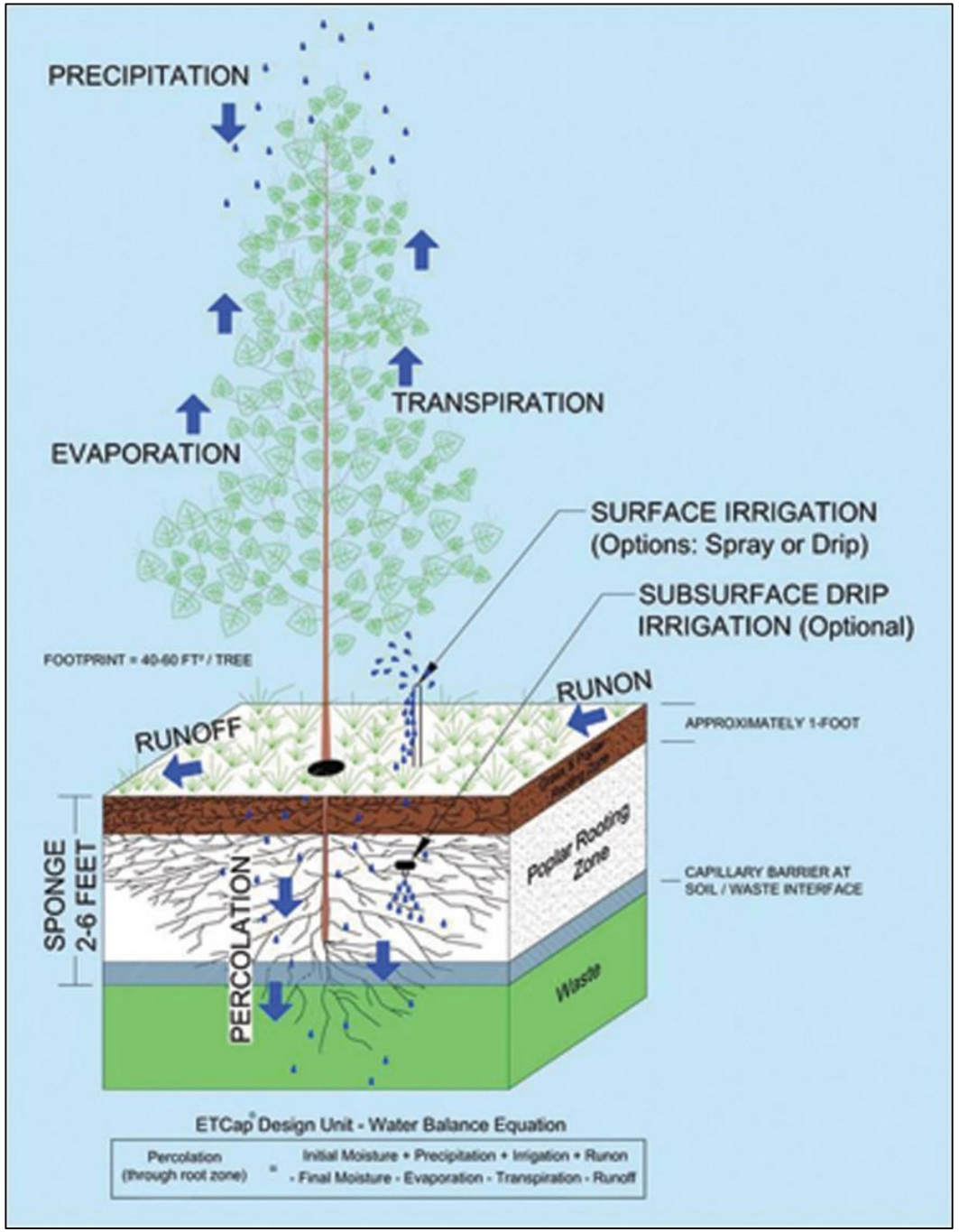
Bioremediation

Plants do work of machines and industry

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

Same traits as bioenergy…

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



Vegetative Cap of a Former Industrial Site

Alternative to Geomembrane Cap

- Same function
- 1/10th the energy, GHG, and cost
- Stops chloride salts from entering local watershed

Biomass Energy Production

- Same as mineral soils

Environmental Benefits

- As mentioned

Planned recreation opportunities

- Hiking trails, bird watching, nature education

Rural Development

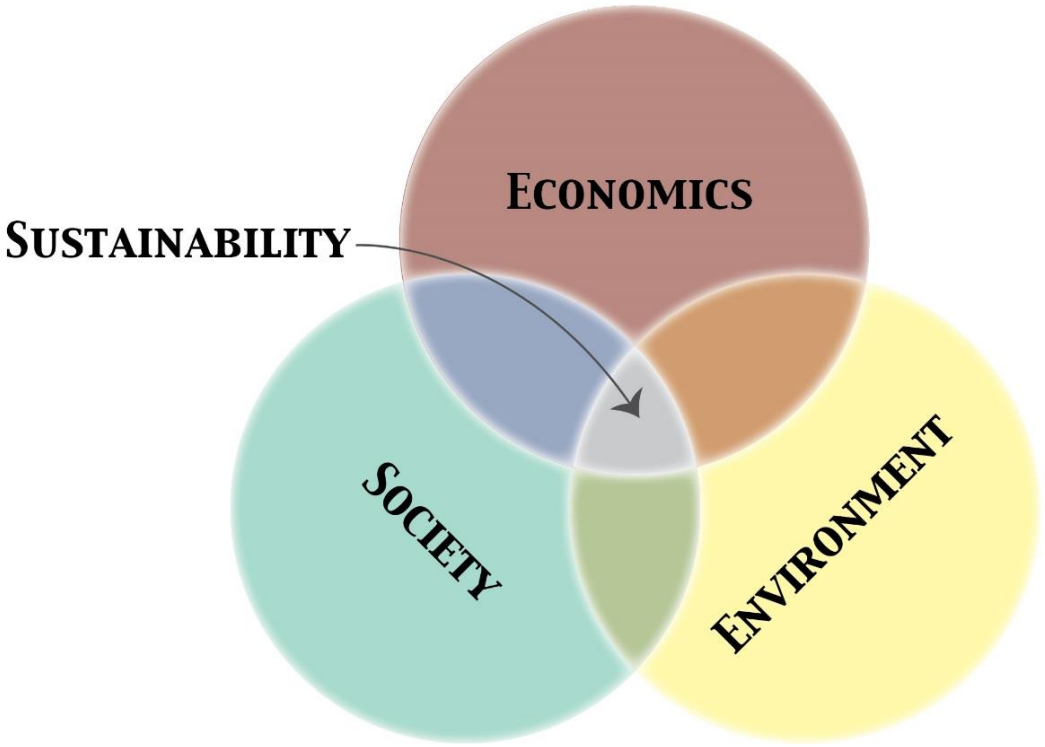
10,000 Acres of Bioenergy Crops

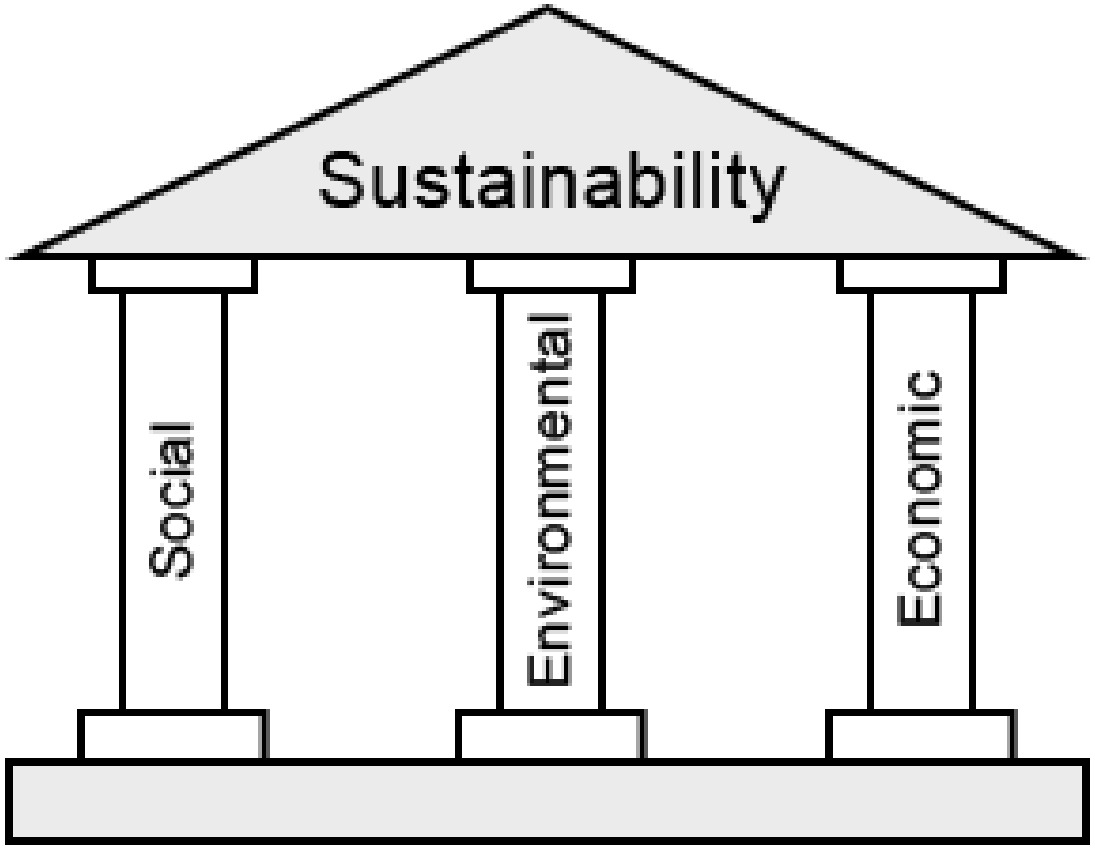
- 40-50 direct full time jobs (NYSERDA 2010)

Marginal Lands

- 1 million acres of idle land in NYS
- Often poorly drained
- Not compete with other land uses
- Productive use for untapped resource

Multifunctional Systems





Barriers and Extension Services

State of the Industry

70,000 acres in Europe (AEBIOM 2011)

- Higher fuel and biomass prices
- More renewable energy mandates and incentives

New York State

- USDA Biomass Crop Assistance Program
- 1,150 acres producing about 8,000 tons of biomass annually
- USDA NIFA and NYSERDA sponsored extension programs

Barriers to Commercialization

- High upfront costs, multiple-year payback
- Limited knowledge of crop management
- Access to specialized machinery
- Perceptions of feedstock quality

- Awareness among potential producers and supporting stakeholders

If initial deployment of willow is not successful, subsequent deployment can be delayed by years.

(McCormick and Kåberger 2007, Helby et al. 2006)

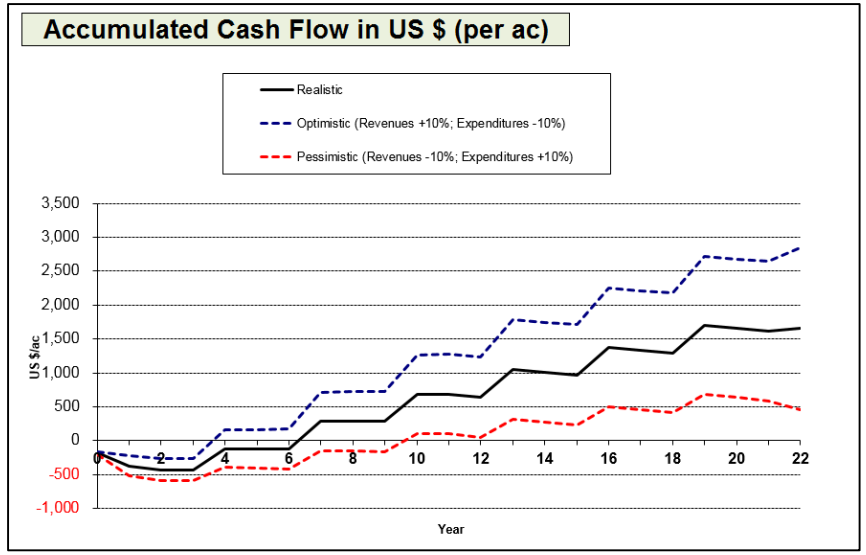
Economics of Production

EcoWillow 2.0

- Cashflow model
- Demonstrate costs and returns
- User-friendly
- Customizable

Model Scenario Outputs (best case)

- IRR 20%
- Payback 7 years after planting (2nd Harvest)
- USDA BCAP
- Meet best practice target



Equipment Access Program

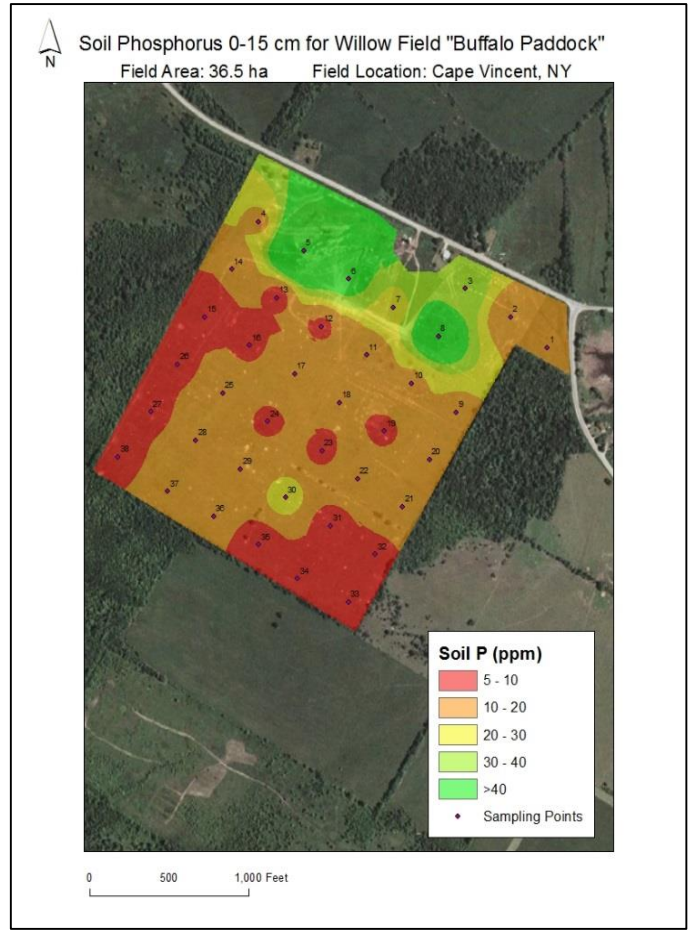
- Reduced rental rate
- Technical and logistical assistance

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

NEWBio

Crop Management

- Crop scouting
- Soil sampling
- GIS analyses
- Supply chain logistics
- Support research on commercial acreage



Feedstock Quality

Perception that willow “doesn’t burn … has low BTUs ... high moisture and ash”

Feedstock sampling throughout supply chain since 2012

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

Meets end-user specs with low variability

- Moisture: 43% ± 2%
- Ash: 3% ± 0.5%
- Energy: 8200-8300 btu/lb (dry)

6,000 tons utilized in the past three years

Outreach and Education

- Extension publications
- Webinars and Social Media
- Field Tours and Equipment Demos
- K-12 Engagement
- Meeting Current and Potential Producers In the Field

Summary

- Biomass an important renewable energy source
- Shrub willow is one of many biomass feedstocks
- More than just renewable energy…
  - Environmental and other benefits
  - Multifunctional sustainable systems
- Extension services are critical to success!

Thank You!

www.esf.edu/willow

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