Biomass Feedstock Production
Short Rotation Woody Crops

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Challenges and opportunities in producing crops appropriate for biomass-based energy systems

Sustaining Benefits from Working Farms, Ranches and Forests
Feedstock Supply – Agricultural and Forest Biomass
Integrated Biobased Products and Bioenergy Approach
A challenging management environment
Integrated Biobased Products And Bioenergy - A Systems Approach

- Research & Development
- Synthesis
- Development of
  - options
  - strategies
  - systems
  - practices
- Deployment

For sustainable goods, services, & values
The Biomass Feedstock Opportunity & Potential

**Feedstock**
- Forest Residues
- Hazardous Fuel Treatments
- Short Rotation Woody Crops
- Wood Waste
- Conventional Forestry
- Mill Wastes & Residues

**Conversion**
- Manufacturing
- Co-firing
- Combustion
- Gasification
- Hydrolysis
- Digestion
- Pyrolysis
- Extraction
- Separation

**Uses**

**Fuels:**
- Ethanol
- Other Liquid Fuels
- Hydrogen

**Electricity and Heat**

**Biobased Products**
- Composites
- Specialty Products
- New Products
- Chemicals
- Traditional Products
Timberland in the U.S.

- Over 207 million hectares of timberland in the U.S.
- Over 25 billion tons of standing biomass
- Variation in ownership patterns, policies and attitudes determine access to forest resources
U.S. annual forest growth is 1.7 times greater than annual removals.

- Varies from 1.2 in the south central to 3.3 in the pacific northwest.
- Also varies by forest type and species.
- With technical, regulatory and social constraints an estimated 369 million odt of woody biomass is available each year (Perlack et al. 2005).

*(Smith et al. 2009)*
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
Leading Short-Rotation Woody Crops Systems

Southern Pine
- Loblolly

Hardwoods
- Poplar,
- Eucalyptus,
- Sycamore,
- Sweetgum

Coppice
- Willow
Selected Sources of Woody Biomass

Spectrum of systems and associated gradients in silvicultural inputs and effects on soil productivity (Volk, et al after Burger, 2002).
Current POLYSYS Poplar/Pine/Willow Yields

Annual Yield (dry tons/acre)

0.0  5.0
3.5  5.5
4.0  6.0
4.5  5.1

(Stokes 2010)
Expected production for selected woody crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Low</th>
<th>Avg</th>
<th>High</th>
</tr>
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<tbody>
<tr>
<td>Loblolly Pine</td>
<td>9</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Hybrid Poplars</td>
<td>6</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Willows</td>
<td>10</td>
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</tr>
<tr>
<td>Eucalyptus</td>
<td>18</td>
<td>22</td>
<td>25</td>
</tr>
</tbody>
</table>

(dry Mg/hectare-yr)

Coleman and Kline, 2010
Volk, et al, 2010
Loblolly Pine (*Pinus taeda*)

- Main species on over 12 million ha
- Makes up over one-half of the standing pine volume
- Yields (odt/ha)
  - Current: 9 - 11
  - Near future: 13 - 18
  - Distant future: 20+
Impact on Growth

Average Annual Growth

- Natural Stands 1950s
- First Plantations 1970s
- Current Plantations 1990s
- Future Plantations

Oven dry tons/ha

0 5 10 15 20 25 30 35 40

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Eucalyptus

• More than 700 species of *Eucalyptus* world wide
  – 20 species widely planted in over 100 countries

• Some of the fastest growing trees in the world

• Advantages
  – rapid growth rate
  – resistance to disease and insects
  – desirable wood properties
  – coppicing ability

• Limitation
  – Cold hardiness

(ArborGen)
Eucalyptus

- *Eucalyptus benthamii* (Eben) and *Eucalyptus macarthurii* (Emac) are fast growing with sufficient frost tolerance for most of the Gulf and Atlantic Coastal Plains in the southern US.
- Planted for both pulp and bioenergy
Hybrid Poplar - Genus *Populus*

- 29 species from the northern hemisphere
- Aspens, cottonwoods, poplars

**Habitat**

- Warm to cold temperate climates
- Adapted to wetlands and uplands

**Fastest growing tree in the temperate zone**

- Acceleration phase of stand development can occur within three years of establishment

*Harvesting hybrid poplar plantation in the Pacific Northwest*
*Brian Stanton 2010*
Hybrid Poplar Production

- Current acreage planted at about 750 – 1,500 plants ha\(^{-1}\)
- Weed control for first 2-3 years
- Fertilizer applications in early and mid rotation
- Harvested using forestry equipment on 10 -12 year rotations

Hybrid poplar several weeks after planting

(Bill Berguson 2010)
Willow Biomass Crops

- Over 350 species of willow in the world
- 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 Production Cycle

- **Site Preparation**
- **Planting**
- **Coppice**
- **Harvesting**

- Three-year old after coppice
- One-year old after coppice

First year growth

Early spring after coppicing
The Future for Woody Biomass

• Most SRWC are in their infancy in terms of development and deployment...

• Potential for increasing multiple benefits from SRWC systems including biodiversity, soil and water quality...

• Integrating SRWC into the landscape will enhance these benefits and create opportunities for ecosystem restoration, agricultural preservation, outdoor recreation...
  – Nutrient buffers
  – Marginal and under utilized areas
  – Strip cropping systems
  – Timber belts, windbreaks, living snow fences
The Future for Woody Biomass

- **Improve the economics**
  - Increasing yield through genomics, breeding and selection
    - A 50% increase in yield will increase the IRR by 260%
  - Refining site-variety relationships and recommendations
  - Optimizing harvesting systems to lower costs
  - Improving and optimize crop management - weed control, nutrient management, density, rotation length...
  - Producing multiple products...

![Woody Crops Cost Breakdown](image-url)
Forest Landowners Future - two market strategies

1) grow “traditional market species” (having a wide variety of uses) or

2) “grow specialty species” (specific properties for specific markets) where performance premiums could accrue.

- Supplementary markets in traditional forest products sectors provide landowners with flexibility.
- Leveraging existing forest industry infrastructure provides additional cost savings.
- Landowners will ultimately benefit if markets develop.
...to sustain the health, diversity, and productivity of the nation’s forests and grasslands to meet the needs of present and future generations...

...dedicated to providing and developing scientific and technical knowledge aimed at improving our capability to protect, manage, and use forests and rangelands...

Thank You