“The Final Step: Harvesting Hybrid Poplar for Renewable Bioenergy Feedstock”

Rich Shuren,¹ Brian Stanton,¹ Rick Stonex,¹ Jesus Espioniza,¹ and Tim Volk²

¹/ GreenWood Resources
²/ The State University of New York, College of Environmental Science and Forestry
The goal of AHB is to:
- prepare the Pacific Northwest for a sustainable biofuels industry
- produce 100% infrastructure compatible biofuels
- use hybrid poplar as the feedstock for conversion
- mitigate technology risks along the entire supply chain

GreenWood Resources was selected as the Feedstock Team leader, and charged with demonstrating the viability, yields and harvesting systems for delivering poplar feedstock to the bio-refinery.
The AHB project was led by the University of Washington

Feedstock team partners included:
- New Holland Agriculture
- University of California, Davis
- University of Idaho
- Washington State University, Extension
- Oregon State University
- Rocky Mountain Wildlife Institute
Demonstration Farm Locations

Jefferson, Oregon
- Planted 2012
- 85 acres
- 11 clonal varieties

Hayden, Idaho
- Planted in 2012
- 65 acres
- 7 clonal varieties

Pilchuck, Washington
- Planted in 2013
- 98 acres
- 10 clonal varieties

Clarksburg, California
- Planted in 2013
- 50 acres
- 9 clonal varieties
Establishment and Crop Care

Prepared and maintained with conventional agricultural equipment

Planted in large mono-clonal blocks of 5 to 8 acres

Monitored monthly for pest and disease control

Inventoried annually for growth and yield

Harvested 2 years after planting and 3 years from coppice regeneration

Jefferson, Oregon – age 2 from planting

Photo courtesy Mike Halbleib, Oregon State University
Sites Harvested in 2017

Jefferson, Oregon
Harvested Feb. – April, 2017

Hayden, Idaho
Harvested July, 2017

One additional site in Pilchuck, Washington will be cut in early 2018. The Clarksburg, California site will be harvested by the landowner at his discretion.

Work conducted by GWR and Syracuse University, New York, Environmental Sciences and Forestry (SUNY/ESF)
## Timetable for Demonstration Farms

<table>
<thead>
<tr>
<th>Site</th>
<th>Planted</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; Harvest</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; Harvest</th>
<th>Restoration</th>
</tr>
</thead>
</table>

The AHB Biofuels project concludes August 31, 2018
### Yields and Size Distribution – Age Three Coppice Stands

<table>
<thead>
<tr>
<th>Site</th>
<th>Average DBH ¹ (mm)</th>
<th>Best DBH ¹ (mm)</th>
<th>Average Stem Count per Stool</th>
<th>Best Stem Count per Stool</th>
<th>Average Yield (BDMT/ha) ²</th>
<th>Best Yield (BDMT/ha) ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jefferson, Oregon</td>
<td>60</td>
<td>61</td>
<td>2.5</td>
<td>3.0</td>
<td>39.9</td>
<td>54.2</td>
</tr>
<tr>
<td>Hayden, Idaho</td>
<td>58</td>
<td>59</td>
<td>2.6</td>
<td>2.7</td>
<td>35.6</td>
<td>47.0</td>
</tr>
</tbody>
</table>

¹/ Breast height diameter of the largest sprout per stool  
²/ Bone dry metric tons per hectare
Harvesting and transportation costs can be 50% or more of total production costs and are the top source of GHG emissions.

For systems with short harvest cycles (diameters <15 cm) a single pass cut and chip harvester is the most widely used type of equipment.
Harvesting Hybrid Poplar

Header designed to fit New Holland FR9000 and Forage Cruiser series of forage harvesters
New Holland FB 130 Header

Sugar Cane Harvesting Technology

2 fast rotating knives (cut stems)
2 slow rotation feeding towers (center stems)
1 paddle roll (lift stems)
2 grab/feed rollers (pull and feed stems)
Hydrostatic drive (in cab speed setting)
New Holland 130 FB Coppice Header

FR
NEW FR, TOP CHOP QUALITY WAYS

FEATURES
ULTIMATE CAPACITY
New Holland knows that throughout its history, forage harvesters have been a key component in the success of their operations. For this reason, they have developed the 130 FB Coppice Header to meet the needs of today's farmer. It is designed to harvest up to 100 bales per hour, ensuring that you can keep up with the demand for quality forage.

SUPERIOR HARVEST QUALITY
The 130 FB Coppice Header is equipped with a powerful 300 HP engine, allowing it to efficiently harvest even the most challenging crops. Its design ensures consistent and high-quality forage, making it the perfect choice for farmers who need to produce top-quality forage consistently.

LOWER OPERATING COSTS
Lower operating costs mean higher profits. The 130 FB Coppice Header is designed to be efficient and cost-effective, allowing you to maximize your profits and reduce your overall operating costs.

ABSOLUTE DRIVING PLEASURE
The 130 FB Coppice Header is designed for comfortable and efficient operation. It features a spacious and comfortable cab, allowing you to enjoy a pleasant driving experience while you work.

OVERVIEW | DETAIL | MODELS | TECHNICAL INFORMATION

COPPICE HEADERS

BIOMASS HARVESTING
The 130 FB Coppice Header has been designed with biomass harvest in mind. It is ideal for harvesting straw, wheat, and corn stover, ensuring optimal performance and efficiency in biomass harvesting.

FS17 – New Holland 130 FB Header
BY THOMAS • OCT 11, 2018 | DOWNLOAD: 1,526

3 Easy Steps:
1) Click “Download”
2) Download on our website
3) Get Free File Converter

New Holland 130FB Forage Harvester Header: Sale Price 25K€, 60 € daily maintenance costs, Working Width 2.0 meters, Operating Speed 8 km/h.
Variety of different collection vehicles used depending on local availability

Vehicles need to fit in row spacing and enter and exit fields without running over harvested plants and damaging tires
Harvesting Hybrid Poplar

The time to think about harvesting is before you plant. Fields will be harvested multiple times over the life of the crop

- headland space at end of rows for harvester and support vehicles
- spacing impacts yield and equipment access over multiple rotations
- nearby short term storage
Harvesting Data Collection

GPS units for time and monitoring information with custom dictionaries for delays or breakdowns.

Computer on forage harvester collects engine load, fuel consumption etc.

Loads of chips are weighed to provide information on standing biomass and throughput.
Sample Data from GPS Units
Effective material capacity (EMC) or harvester throughput (Mg/h – wet biomass) is key parameter.

EMC is strongly related to standing biomass.

Average throughput in these systems is 60 – 70 Mg/hr (wet biomass) when efficiency >80%.

Relationship between standing biomass and harvester throughput in hybrid poplar crops.
Harvesting Rates

When efficiency is high, increasing speed is not directly related to increased throughput.

In addition to standing biomass, factors such as spacing, stem diameter, tree height and ground conditions can impact operations.

Relationship between standing biomass and harvester throughput in hybrid poplar crops.
Harvesting Rates

- **Ground Limited**
- **Vegetation Limited**
- **Mechanically Limited?**

- Effective Material Capacity vs. Standing Biomass - Delivered

- Harvesting rates: 0.5 ha hr⁻¹, 1.0 ha hr⁻¹, 1.5 ha hr⁻¹, 2.0 ha hr⁻¹

Advanced Hardwood Biofuels Northwest
hardwoodbiofuels.org

United States Department of Agriculture
National Institute of Food and Agriculture
Fuel consumption increases with engine load as expected.

Crop specific fuel consumption decreases as standing biomass increases. For every increase of 10 Mg wet/ha, fuel consumption decreases by 0.11 L/Mg (3 – 5%).
Biomass Characteristics

Key chip characteristics (moisture, ash content, particle size distribution) are consistent and meet current end user needs.

Less variability in characteristics than herbaceous crops or agriculture residues.

Differences between leaf off and leaf on harvests.

Chips from leaf on (above) and leaf off harvests (right).
Harvesting Costs

Harvesting costs (material delivered to intermediate storage <10km) have dropped by about 1/3 in the past decade as equipment has improved and down time has decreased.

As harvester downtime decreased, costs associated with collection vehicles and other parts of the system also decreased.

Costs impacted by field layout, size of crop, type and number of collection equipment, haul distances, operator experience.
Harvesting Costs – Willow (NE)

Challenge to accurately estimate costs because of limited number of locations and field sizes where operational data has been collected.

Current estimates for harvester operations in willow biomass crops in the $28 – $34 Mg\(^{-1}\)\(_{\text{dry}}\) but some factors (e.g. using a large number of small collection wagons) put it into the low $40s Mg\(^{-1}\)\(_{\text{dry}}\).
**Harvesting Costs – Poplar (PNW)**

Delivered biomass price ($USD) per bone dry metric ton (BDMT) for two sites, under two land scenarios

<table>
<thead>
<tr>
<th>Biomass Price to achieve:</th>
<th>Jefferson</th>
<th></th>
<th>Hayden</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Land Lease</td>
<td>Land Purchase</td>
<td>Land Lease</td>
<td>Land Purchase</td>
</tr>
<tr>
<td>0% real IRR ¹</td>
<td>$ 94.01</td>
<td>$ 83.01</td>
<td>$ 107.95</td>
<td>$ 102.44</td>
</tr>
<tr>
<td>2% real IRR</td>
<td>$ 97.47</td>
<td>$ 94.35</td>
<td>$ 113.14</td>
<td>$ 112.72</td>
</tr>
<tr>
<td>4% real IRR</td>
<td>$ 101.35</td>
<td>$ 106.71</td>
<td>$ 118.94</td>
<td>$ 124.09</td>
</tr>
<tr>
<td>6% real IRR</td>
<td>$ 105.61</td>
<td>$ 120.12</td>
<td>$ 125.27</td>
<td>$ 136.48</td>
</tr>
<tr>
<td>8% real IRR</td>
<td>$ 110.26</td>
<td>$ 134.74</td>
<td>$ 132.20</td>
<td>$ 149.99</td>
</tr>
<tr>
<td>10% real IRR</td>
<td>$ 115.27</td>
<td>$ 150.49</td>
<td>$ 139.68</td>
<td>$ 162.74</td>
</tr>
</tbody>
</table>

¹/ Internal Rate of Return, including anticipated taxes
Harvesting System Improvements

62.5% reduction in biomass throughput
Harvesting System Improvements

Improve feeding on header for poplar, particularly tall material

Planting design, rotation length, and crop management need to be coordinated with harvesting system

Entire harvesting system needs to be coordinated to optimize the system
What’s Next?

Harvest the Pilchuck site in early 2018
- capture additional time and motion data
- provide bulk material for study and conversion research

Wrap up the Clarksburg site in early 2018
- site is reverting to the landowner “as is”
- owner will conduct harvest and restoration
- provide sample material for study and conversion research
Thank you! Questions?