The Forest Resource at the Burley-Demerritt/Dudley-Bartlett Farm

Analysis as a Potential Source of Renewable Energy And Bedding Material For the Organic Dairy Research Farm

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Sustaining the Organic Dairy Research Farm

- Major impediments: Imports
  - Energy
  - Bedding
  - Grain
- Forest resource could provide two of these

- Additional Concerns
  - Environmental Footprint and Impact
  - Financial Viability – Diversified Income Required
Energy Demand

Total Electricity Use and Distribution

<table>
<thead>
<tr>
<th></th>
<th>Pig barn</th>
<th>Milking Process</th>
<th>Lights/ Pump</th>
<th>Elec. Heat</th>
<th>Residence</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>%</td>
<td>Kwh</td>
<td>$</td>
<td>%</td>
<td>Kwh</td>
<td>$</td>
</tr>
<tr>
<td></td>
<td>0.410</td>
<td>46879</td>
<td>$7,032</td>
<td>0.169</td>
<td>19317</td>
<td>$2,898</td>
</tr>
<tr>
<td></td>
<td>0.124</td>
<td>14135</td>
<td>$2,120</td>
<td>0.255</td>
<td>29134</td>
<td>$4,370</td>
</tr>
<tr>
<td></td>
<td>0.042</td>
<td>4800</td>
<td>$720</td>
<td>100%</td>
<td>114,266</td>
<td>$17,140</td>
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</tbody>
</table>

50-65% chilling?

Total Energy Use

<table>
<thead>
<tr>
<th></th>
<th>Electricity</th>
<th>Oil</th>
<th>Gasoline</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>kWh</td>
<td>kWh</td>
<td>gal</td>
</tr>
<tr>
<td>Heat</td>
<td>76,013</td>
<td></td>
<td>810</td>
</tr>
<tr>
<td>Process</td>
<td>38,253</td>
<td></td>
<td>400</td>
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</tbody>
</table>

Assumes build-out of house as office and education center
Bedding Requirement

- 135 “Cords”
  - ~ 5 semi tractor-trailer loads

- $50-$70 per “Cord”
  - Availability very limited

- Estimated weight per “cord”?
The Forest Resource

160 acres of woodlands
  - UNH campus Master plan

Classic Old-Field
New England Woodland
  - White Pine
  - Red Maple
  - Black Birch
  - Red Oak
  - Hemlock
Measuring Biomass and Productivity

- Random Plot locations
- 23 plots
- 7m radius plots
- Diameter - All stems >5cm
- Radial increment – 50 stems
  - Randomly selected
  - Weighted to larger trees
- Leaf Productivity – 19 plots
Results:
Species and Diameter Distribution

Classic old field composition with selected large stems of Hemlock and Red Oak
Converting Diameter to Biomass

- Generalized Allometric Equations
  - Different equations relate to different wood densities

\[ Y = a \times DBH^b \]
Biomass by Species and Size Class
Biomass Production - Wood

Biomass production per tree is:
Biomass at current diameter minus Biomass at diameter five years ago
These relationships give five year growth as a function of diameter:
Total wood NPP = 4.2 (+/- 0.4) Mg/ha.yr
Biomass Production - Foliage

<table>
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<th></th>
<th>g/basket</th>
<th>g/m²</th>
<th>t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>64.5</td>
<td>317.1</td>
<td>3.17</td>
</tr>
<tr>
<td>S.D.</td>
<td>18.3</td>
<td>89.9</td>
<td>0.90</td>
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<tr>
<td>SEM</td>
<td>4.2</td>
<td>20.6</td>
<td>0.21</td>
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<table>
<thead>
<tr>
<th>% of Total</th>
<th>Birch</th>
<th>RM</th>
<th>SM</th>
<th>RO</th>
<th>WO</th>
<th>WP</th>
<th>Hem</th>
<th>Other</th>
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</thead>
<tbody>
<tr>
<td>% of Total</td>
<td>10%</td>
<td>27%</td>
<td>2%</td>
<td>22%</td>
<td>1%</td>
<td>29%</td>
<td>3%</td>
<td>5%</td>
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</tbody>
</table>

![Bar graph showing biomass production per species: White Pine, Red Oak, Red Maple, Hemlock, All Others.]}
Comparison With Other Stands

Both foliar and wood production are in range with other old field stands in New England and the Lake States

Sustainable Energy Yield

4.2 Mg wood
ha.yr  ×  13 MBTU
Mg wood  ×  100 ha
Farm  =  5400 MBTU
Farm.yr

Energy Requirements

<table>
<thead>
<tr>
<th>Energy</th>
<th>Requirement</th>
<th>MBTU</th>
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</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>114,266 Kwh</td>
<td>389</td>
</tr>
<tr>
<td>Heating Oil</td>
<td>810 gallons</td>
<td>112</td>
</tr>
<tr>
<td>Gasoline</td>
<td>400 gallons</td>
<td>50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>551</strong></td>
</tr>
</tbody>
</table>

Assume 50% efficiency in conversion to energy:
Required Harvest: ~ 20% of Annual Wood NPP
Acres to Harvest per Year

Assumptions:
- Mean biomass: 165 Mg/ha
- Mean Energy Content: 2145 MBTU/ha
- 50% efficiency in energy conversion and use

Calculation:
- Available Energy: 1027 MBTU/ha
- Farm Energy Demand: 551 MBTU/yr

Required Harvest: 0.55 ha (~1.2 acres) per year
Sustainable Bedding Yield

**Assumptions:**
- 4.2 Mg wood /ha.yr = 420 Mg/farm.yr
- Standard cord = 1 Mg wood
- Density of shavings = ½ density of whole, stacked wood

**Calculation:**
- Bedding yield = 840 “cords”/yr
- Farm Demand = 135 “cords”/yr

**Required Harvest:** ~ 16% of Annual Wood NPP
Acres to Harvest per Year

• Assumptions:
  • Mean biomass: 165 Mg/ha
  • 1 Mg = 1 standard cord
  • 1 standard cord = 2 “cord” of shavings

• Calculation:
  • 330 shaving “cords” per ha
  • Farm Demand = 135 “cords” of shavings

• Required Harvest = ~0.4 hectare (~0.9 acres) per year
Total Demand for Energy and Bedding

Maximum Use Scenario

- Energy: 1.2 acres/year
- Bedding: 0.9 acres/year
- Total: 2.1 acres/year
- Total Forest Land: 160 acres

- Sustainable Rotation Length:
  \[ \frac{160 \text{ acres}}{2.1 \text{ acres/year}} = \approx 75 \text{ years} \]
Energy Yield from Bedding/Manure Mixture

- Jerose and Diamond Hill Farm

- Estimates for Burley-DeMerritt:
  - 50 Jerseys
  - 5.6 tons manure/day
  - 90 day compost period
  - 194,000 BTU per hour
  - 1,700 MBTU per year
    - As low-grade heat

- Total farm demand
  - 551 MBTU
Alternate Use Scenarios

1. Cogeneration of Electricity and Heat
   - Efficiency: 80%
   - Yield: 4320 MBTU/yr

2. Composting of Shavings/Manure
Alternate Use Scenarios

- Thinnings for Bedding and Compost
- Harvest of Select Trees for Solids and Veneer
Conclusions

- There is ample forest production on the farm to meet annual demands for both energy and bedding.

- Integrated system including:
  - Thinning for bedding
  - Compost for energy and CO₂
  - Greenhouse operation using heat and CO₂
  - Final woodland harvest for solids and veneers