Willow rings for biomass production

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Background:
The poorly drained morainic landscape of the Canadian prairies is covered by thousands of small wetlands commonly referred to as sloughs or potholes (Photo 1). Historically, wetlands have been considered a waste of valuable land that could only be improved through drainage and elimination of the wetland. However, wetlands play an important ecological role for plant and wildlife diversity, hydrology, surface water storage, water quality.

The wetlands in the aspen parkland are generally surrounded by a ring of phreatophytic shrubs, particularly willows, in the zone between high and low water levels. Land settlement has resulted in deceased frequency of prairie fires and more controlled grazing which in turn has resulted in increased tree growth in the proximity of retained wetlands. Therefore even though the occurrence of wetlands has declined significantly over the years since settlement, the presence of woody biomass surrounding wetlands has likely increased.

We have considered that a more balanced coexistence between agriculture and wetlands could include occasional harvest of the willow rings. This would provide a natural biomass for fuel wood or other useful applications while preserving the wetland for future generations (Schroeder et al 2009). Occasional coppicing and removal of aboveground willow biomass could have ecological implications related to bird populations as well as hydrological functions.

An experimental willow harvester, based on an agricultural baler, was developed by AAFC and University of Laval in Quebec City (Photo 2). The prototype Bio-Baler demonstrates the feasibility of cutting, shredding and baling long-stem cultivated woody biomass in a single pass (Lavoie et al 2008). A header was designed and adapted to the original baler in 2007. The original saw blades and shredder in front of the baler were replaced by a 2.3 m wide rotor and 20 flail cutters attached to a 200 mm diameter rotor.

The three willow rings selected for this study are situated south of Indian Head in southern Saskatchewan. The area is classified as hummocky with gentle slopes (2-5 percent) with loamy alluvial surface deposits. Following winters of average snowfall, these sloughs are filled with melt water during spring but normally dry down by late June. After winters with below average snowfall, the sloughs contain little or no water in the spring, whereas during wet years, the sloughs may contain water throughout most of the summer. The vegetation of the willow ring was mainly the willow species Salix eriocephala, S.petiolaris, S. bebbiana, S. discolor as well as herbaceous species such as cattail (Typhus latifolia).
Photo 1. Aerial view of typical wetland willow ring

Photo 2. Bio-baler harvesting willow ring
Project Objectives:
1. Determine short and long term impacts of coppicing on environmental function of willow rings.
2. Evaluate the feasibility of mechanical harvest of willow from typical willow rings in the aspen parkland.
3. Determine biomass yield potential of willow rings.

Methods:
Harvest yield

Willow harvest was completed on October 23, 2007 using the modified Bio-Baler (Table 1). The harvester was powered by a Case International 7110 Tractor (130HP). A total of four willow rings with a combined area of 0.25 hectares were harvested. Harvested bales were removed from the sites and stored outdoors over winter. Time to harvest each bale was clocked (± 1 s) to estimate harvest rate; time to wrap bales, travel without harvesting or idle was not included in harvest time.

<table>
<thead>
<tr>
<th>Table 1. Bale density, field capacity and harvested biomass from the willow rings.</th>
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<tbody>
<tr>
<td><strong>Site #1</strong></td>
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<tr>
<td>Harvested area (m²)</td>
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<tr>
<td>Number of bales harvested</td>
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<tr>
<td>Wet mass per bale (kg)</td>
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<td>Wet bale density (kg/m³)</td>
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<td>Harvest time per bale (s)</td>
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<td>Capacity (t wet/h)</td>
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<td>Moisture content (%)</td>
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<td>Biomass harvested (kg DM)</td>
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<td>Yield recovery (t DM/ha)</td>
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Regeneration Following Harvest

Following mechanical harvest the willow stems were typically splintered because of the rough cutting edge of shredder hammers. We were interested in determining what effect this harvest system would have on regeneration and growth of willows. To accomplish this, five nested 1m² monitoring sites were randomly selected and staked in the harvested area. The two treatments applied at each nest were:

1. Willows harvested with Bio-Baler, stems not pruned (Photo 3).
2. Willows manually pruned to have a clean cut (Photo 4).
During the growing season we counted the number of shoots that developed in each 1m$^2$ plot. At the end of the growing season, biomass was harvested from each plot and total dry weight determined for each willow species present.

**Photo 3.** Willow stool with rough cut from Bio-Baler harvest

**Photo 4.** Willow stool with smooth cut from pruner harvest
**Key Findings:**

- The ‘Bio-Baler’ successfully cut and baled natural willow in a single operation. Willow rings were cleared with a recovery of about 62% of the original biomass. Harvest rate was between 4 and 7 tonnes/hour (fresh weight).

- Willow biomass harvested at the test site was 636 kg DM this equates to an overall yield of 10.6 TDM/ha. The biomass harvested could provide a renewable combustible fuel. The harvested willow had a combustion value of about 19 MJ/kg (dry basis).

- The management of willow rings in agricultural fields requires a balance between wildlife habitat, renewal of the natural woody vegetation, protection of the natural water control function of the marshes and profitable agricultural production. The prototype Bio-Baler is a new tool which can potentially improve the overall management of these ecosystems.

- Species response to bio-baler harvest varied. Regeneration kg/dm per m$^2$ increased for *Salix eriocephala* and *S. discolor* when harvested with the bio-baler, but declined for *S. petiolaris* and *S. bebbiana* (Figure 1).

- Willow regeneration was not affected by the harvesting system. Shoot density was 93 stems/m$^2$ for Bio-Baler harvested stools compared to 105 stems/m$^2$ for smooth cut stools (Figure 2). Overall stem density increased by over 300% when compared to density prior to harvest.

- The site was dominated by *Salix eriocephala* with lesser quantities of *S. bebbiana*, *S. petiolaris* and *S. discolor* (Figure 3).

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**Figure 1.** Impact of harvest method on willow biomass regeneration.
**Figure 2.** Impact of harvest method on number of stems regenerated per m$^2$.

**Figure 3.** Distribution of *Salix* species in project willow rings.
References: