Nutrient dynamics associated with field-drying of harvest residues on clearcut sites in northwestern Ontario

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Introduction

Background:

Increasing pressures to find inexpensive and renewable energy has turned attention to the utilization of forest harvesting residues as a supplemental fuel source. This increased utilization raises two key concerns:

1) leaves, twigs, and branches, are very high in nutrient concentration and continued removal may negatively effect long-term site productivity,
2) on average, 50-60% of this material's green weight is water, which makes transportation and burning costs much higher.

There is great incentive to reduce both the moisture and nutrient content of the green biomass before transporting off site. Moisture content of residues left on site to field-dry have been shown to decrease to 25% in one year. Field-drying has also been found to leave nutrients on site through mechanical mass-loss (shedding of foliage), decomposition, and leaching.

Purpose of Research:

To investigate the effects of field-drying on the release of nutrients from black spruce [*Picea mariana* (Mill.) B.S.P.], jack pine [*Pinus banksiana* Lamb.], and trembling aspen [*Populus tremuloides* Michx.] harvesting residues.
Specific research questions include:

- What is the overall nutrient contribution after one year of field-drying by shedding of foliage, nutrient leaching , and decomposition?
- Are these release rates influenced by residue type (species & component) and microsite conditions (soil moisture and temperature)?

Materials and Methods

Site Description:

- 6 clearcut sites situated in the Lakehead Forest, near Thunder Bay ON.
  - 3 wet mineral soil ecosites -
  - 3 dry upland ecosites -

Biomass Pile Construction:

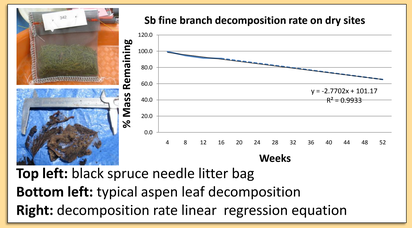
- In late June 2008, trees of each species were felled and delimbed
- 36 biomass piles were created inside netted, framed enclosures (91x91x150cm)
- To contain the material, tops and sides were covered with a ¼" clear, polypropylene mesh netting and the bottoms were covered with a 2mm fibreglass screen. And weighed

Sampling Procedure and Analysis:

- Samples were collected immediately after felling in June 2008 and at four-week intervals for 16 weeks.
- Piles will be left to overwinter from October to May and then sampled again in May (T_5) and June (T_6) 2009.
- At each time interval samples were collected and components [foliage, fine branches (<0.5cm), coarse branches(>0.5cm)] were analyzed for moisture content, leaf to branch mass ratio, and nutrient concentration
- Moisture content and leaf to branch mass ratio were both determined gravimetrically, C & N concentrations were determined using a LECO CNS2000 and all other nutrients (C, P, Mg, Mn, Al, B, Fe, Cu & Zn) were determined by acid digestion followed by ICP-AES analysis.

Litter Bag Experiment:

- 448 nylon mesh bags were filled with a known mass of each component (Coarse and fine branches, and leaves. As above)
- Litter bags were incubated in the biomass piles for 4, 8, 12, and 16 weeks
- Dry weights were determined in the lab and decomposition rates were calculated for each component



Top left: black spruce needle litter bag
Bottom left: typical aspen leaf decomposition
Right: decomposition rate linear regression equation

Nutrient Dynamics: Leaching and Decomposition

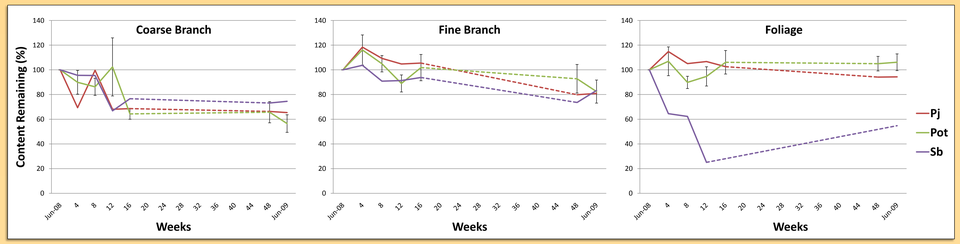
Nitrogen

- The nitrogen content of both the fine and coarse branches was found to be significantly lower only after overwintering (decreased by approximately 20%)
- Within the first 8 weeks there is an accumulation (immobilization) of nitrogen in the coarse branches of all species and the foliage of black spruce (only significant in the spruce foliage)

Potassium

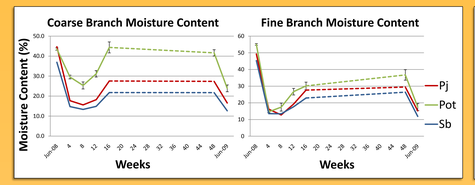
- A significant decrease can be seen as early as week 4 (Pot foliage) and significant losses are exhibited in the branch and foliar material of all species by week 16.
- Field-drying for 16 weeks was found to leave approximately 20, 30, and 25% of the potassium on site for coarse branch, fine branch and foliage, respectively. If the material is left to dry for one year these values increase to 40, 60, and 60% for coarse branch, fine branch and foliage, respectively.
- It is not understood why potassium content increased over the first 16 weeks for spruce foliage.

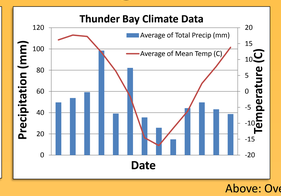
Calcium



- The general trend for calcium is a very slight decrease in content over the entire length of the experiment, however it is insignificant in most cases. Exceptions to this trend are:
  1. a highly significant and rapid loss of calcium in the foliage of black spruce immediately after harvest
  2. a significant difference appearing at week 16 in trembling aspen coarse branches, and
  3. no decline at all in jack pine or aspen leaves.

Moisture Content Changes

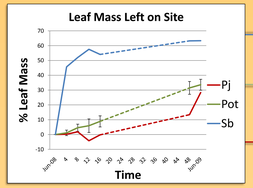




Above: Overwintering biomass piles

- The moisture content of the green biomass dropped significantly in the first 4 weeks. Fine branch and foliar moisture content decreased by approximately 40%, and coarse branch by 30%
- All materials, however, began to increase in moisture again and in some cases (aspen coarse branch) gained 20% back by October 2008. Since the drying rate of biomass is highly dependent on fluctuations in temperature and precipitation, the increase in moisture around week 12 and 16, could be related to the increased precipitation and cooler temperatures of September 2008 (see Thunder Bay climate data).
- The October 2008 and May 2009 moisture contents were very similar, although winter moisture content levels were likely significantly higher due to snow and ice coverage.
- By June of 2009 the moisture contents reached their lowest levels (15-20%), similar to those seen after four weeks of field drying.

Mechanical Mass Loss



Black spruce
63% after 1 yr

Jack pine
29% after 1 yr

Aspen
33% after 1 yr

Black spruce: Shed 48% of its foliage within the first 4 weeks of drying and reached approximately 63% after one year. Needles dried quickly and fell very easily.
Trembling aspen: Lost foliage at a consistent rate over the one-year drying period. Approximately 10% of its foliage was shed after 4 weeks and after one year, foliar lost was 33%. Trembling aspen leaves were most often shed in clumps attached to small branchlets.
Jack pine: Retained all of its foliage until after the winter, at which point it shed around 29% of its original foliar mass by June 2009.

Management Implications

- Findings support that field-drying of biomass before removal can be a successful method for retaining nutrients on site. The most significant contributor in this process is foliar mass loss. However, even if the foliage is not shed, a significant percentage of nutrients can be left on site through leaching and decomposition.
- From a bioenergy harvesting perspective, weeks 4 and 52 (one year) are the most suitable times to remove the material off site, since this is when the moisture content reached lowest point (15-20%).
- Spruce biomass could be removed off site shortly after harvest, since it loses almost 50% of its foliage within the first 4 weeks of field-drying.
- To maximize nutrient returns, jack pine and trembling aspen should be dried for at least one year, since they require an overwintering period to begin shedding foliage.
- If site calcium is of concern, it should be noted that calcium will only be left on site through the physical loss of mass; it is not leached from the material.
- Since increased site disturbance and harm to forest regeneration is of concern, a one-year harvest of the biomass could take place when the stand is revisited for site preparation and before planting seedlings