Sustainable Utilization of Forest Biomass

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Content

- Trends in forest biomass utilization in Austria
- Forest ecosystem and its function
- The effects of forest biomass extraction and utilisation
  - Acidification
  - Loss of organic carbon
  - Soil compaction and erosion
  - Other effects
- What you have to care for?
- Wood ash and compensatory fertilization
Wood based biomass for energy is to a high percentage supplied as by-products of the sawmill, pulp and paper industry (bark, sawdust, black liquor).
Forest Biomass for Domestic Energy

Total domestic energy consumption in 2009: 1354 PJ
Nearly 60% of the renewables is energy from biomass

![Diagram showing energy sources in 2009]

**Quelle:** Statistik Austria, Energiebilanzen 1970-2009, Österreichische Energieagentur
Forest Biomass for Domestic Energy

While the temporal trend for fire wood stays fairly constant, biofuels & pellets as well as garbage incineration are on the rise.
Harvest percentage by ownership and slope angle

- Kleinwald bis 200 ha
- Betriebe > 200 ha
- ÖBf AG

Ownership categories:
- Smallholder
- Forest enterprise
- Federal forests

Slope angle categories:
- bis 30 %
- bis 50 %
- > 50 %

Annual allowable harvest
Forest Biomass Utilization

- Analyzing the current situation: How do increase the biomass supply?
  - A) timber reserves only in smallholder forests
  - B) or in less accessible forest sites
  - C) slash and logging residue become attractive
  - D) short rotation energy forests

- ad A) problem to mobilize these resources
- ad B) harvesting costly
- Ad C + D) impacts upon soils & forest ecosystems need special consideration see the following!
Forest ecosystem and its function
Characteristics: open, cycling, self regulating

Cycles in the forest ecosystem

Kimmins, 1987
Forest ecosystem and its function

when forest trees are taking up nutrients and when they grow, then they are acidifying the forest soil

Soil root

n.Glatzel 1990

n.Marschner, 1995
Forest ecosystem and its function

when the biomass is dying off and decomposes, then acidification may be buffered at the same rate as base ions are set free to the soil solution and exchanged to the soil colloids

n.Glatzel 1990
Forest ecosystem and its function

Therefore all extractions which are interrupting or retarding the cycles in the forest ecosystem are leading to acidification or depletion of nutrient stores in the mineral soil.

Marschner, 1995
Effects of biomass utilisation

Naturally all biomass utilisation results in acidification and depletion of forest soils → BUT the effect is not the same for all biomass fractions!

![Bar chart showing acidification levels for different biomass fractions: Humus, needles, bark, twigs, branches, and wood.](chart_image)

Acidification Versauerung (kmol/ t atro)

Humus needles bark twigs branches wood

altered after Englisch, 1976
Comparison of biomass fractions and their relative contribution to the acidification

Norway spruce yield class 9 ($m^3$/yr.ha)
Effects of biomass utilisation

During the rotation period the proportion of nutrient rich biomass fractions (e.g. leafs, needles..) is changing. The younger a forest stand is the higher is the proportion of needles, bark and fine twigs within the total amount of biomass which may be utilized and therefore in such stands nutrient removal and acidification are higher.

Biomass by fractions

DF1 bis DF4=Thinnings; EN=Final harvest

n.Englisch 1976
Effects of biomass utilisation

During the rotation period the proportion of nutrient rich biomass fractions (e.g. leaves, needles..) is changing. The younger a forest stand is the higher is the proportion of needles, bark and fine twigs within the total amount of biomass which may be utilized and therefore in such stands nutrient removal and acidification are higher.
Acidification and nutrient removal

It follows: the younger and the smaller the dimensions of biomass fractions, which are utilised the higher is the nutrient removal and on site soil acidification is. Very bad is the extraction of branches and twigs with needles or leaves.

Compare:

<table>
<thead>
<tr>
<th>1 t stem wood i. bark</th>
<th>1t twigs with needles</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7kg N</td>
<td>0.2kg P</td>
</tr>
<tr>
<td>2.0kg Ca</td>
<td>0.3kg Mg</td>
</tr>
<tr>
<td>188mol H+ /t</td>
<td>950 mol H+ /t</td>
</tr>
</tbody>
</table>
Forest biomass and carbon loss

When forest biomass removal means an enhanced mobilisation and utilisation of forest biomass then:

this does not only result in more acidification

but also this enhancement means more Carbon is removed from the biogeochemical cycle:

In consequence less carbon is stored in forest soils and less humus will be in forest sites → see examples

and less dead wood is left standing or on the ground (habitat loss for div. fauna)
Short term influences of final harvest intensity upon carbon stores in forest soils (Johnson & Curtis, 2001)

Harvest effects on soil carbon, A horizon

- Overall
- Whole-tree
- Sawlog
- Conifer
- Hardwood
- Mixed

Percent change in soil carbon
Midterm effects of different intensity utilizations

C-Stores in forest ecosystems 15 years after final harvest (Johnson et al., 2002)

SAW...Sawtimber
WTH...whole tree harvest
CTH...canopy whole tree

TN: Mixed hardwoods
SC: Pinus taeda
NC: Mixed hardwoods
FL: Pinus elliottii
Forest biomass and carbon loss

The examples given above are still a bit inconclusive and heterogenous:

Because of the large spatio- temporal variability of carbon contents in forest soils

But if less carbon is left with the logging debris in the forest over longer terms there will be lower carbon stores in the forest soils

Consequently: there will be lower humus content;

1g Humus = 3-5g more water storage  (Trianet; 1999)
Soil compaction and erosion

If heavy forest machinery is travelling to the tree and the tree is not transported to machines then pore space is lost and soil is compacted.

The water infiltration rate decreases.

Surface runoff and erosion (soil loss) is increasing.
Other effects

If logging debris and dead wood is removed

Habitat and life supporting resources for many small organisms are lost (dead wood fauna, decomposers → nature conservation aspects)

Or the C-storage of forest ecosystems is decreased (see Kyoto-protocol 3.4)
### Wäldersstruktur: Totholz  

**Ertragswald**

<table>
<thead>
<tr>
<th>Naturraum</th>
<th>Steh. TH fm</th>
<th>Lieg. TH m³</th>
<th>Summe stehend + liegend</th>
<th>Steh. Vorrat Vfm/ha</th>
<th>AFBl. wert</th>
<th>Waldfl. Ertrw[ha]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innen- und Zwischenalpen</td>
<td>9,05</td>
<td>14,62</td>
<td><strong>23,67</strong></td>
<td>336</td>
<td>67</td>
<td><strong>1104832</strong></td>
</tr>
<tr>
<td>Mühl- und Waldviertel</td>
<td>4,33</td>
<td>3,54</td>
<td><strong>7,87</strong></td>
<td>344</td>
<td>21</td>
<td><strong>362758</strong></td>
</tr>
<tr>
<td>nördliches Alpenvorland</td>
<td>4,98</td>
<td>4,43</td>
<td><strong>9,40</strong></td>
<td>359</td>
<td>24</td>
<td><strong>134172</strong></td>
</tr>
<tr>
<td>Randalpen</td>
<td>9,94</td>
<td>14,03</td>
<td><strong>23,97</strong></td>
<td>333</td>
<td>70</td>
<td><strong>1418176</strong></td>
</tr>
<tr>
<td>sommerwarmer Osten</td>
<td>5,64</td>
<td>5,02</td>
<td><strong>10,66</strong></td>
<td>273</td>
<td>37</td>
<td><strong>322397</strong></td>
</tr>
<tr>
<td><strong>Gesamt</strong></td>
<td><strong>8,42</strong></td>
<td><strong>11,83</strong></td>
<td><strong>20,25</strong></td>
<td>330</td>
<td>59</td>
<td><strong>3342335</strong></td>
</tr>
</tbody>
</table>

*) ohne Strauchflächen
Large diameter trees (<0.1% should be 1% of tree number)
WHAT WE HAVE TO LOOK OUT FOR?

To guarantee the sustainability of the utilisation

The nutrient removal and acidification can be controlled to a certain extent: the earlier and the smaller the assortments, the higher the proportion of biomass rich in nutrients (needles, leaves, small twigs, bark) the higher is the removal of nutrients and soil acidification

Take care of the site quality, nutrient reserves and the potential of the soil to replenish nutrient by weathering of soil minerals

Consider site & soil properties when you plan mechanised harvesting and transport logistics
Wood ash recycling and compensatory fertilization

Wood ash functions as a strong basic and very reactive fertilizing medium

Element content (%) of

<table>
<thead>
<tr>
<th></th>
<th>Wood ash</th>
<th>Lime</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>15</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>2.6</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>1.0</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>Al</td>
<td>1.6</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>0.84</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.53</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>0.15</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

Many nutrients are contained in wood ash in easily soluble oxidized form.

Attention!

Content of toxic substances.
Wood ash recycling and compensatory Fertilization

Because of the above problems application of wood ash in forest sites should not be done indiscriminately and without considering site specifics and site quality.

Otherwise there is the imminent danger of high nutrient exports with seepage water and the litter layer may be rapidly decomposed (sometimes this may be desirable, but not in all circumstances).
Wood ash recycling and compensatory fertilization

Example Sweden: National Board of Forestry 2002: Recommendations for the extraction of forest fuel and compensation fertilization

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Habitats index, compensation dosage, tonnes of dry matter (DM) in ashes/hectare and rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>G18</td>
</tr>
<tr>
<td>All stemwood during rotation</td>
<td>1.5</td>
</tr>
<tr>
<td>Final felling</td>
<td></td>
</tr>
<tr>
<td>Logging residue without the greater part being needles *</td>
<td>0.7</td>
</tr>
<tr>
<td>Logging residue with the greater part being needles **</td>
<td>1.1</td>
</tr>
<tr>
<td>Cleaning-thinning</td>
<td></td>
</tr>
<tr>
<td>Delayed cleaning***</td>
<td>0.4</td>
</tr>
<tr>
<td>All thinning: logging residue without the greater part being needles ****</td>
<td>0.3</td>
</tr>
<tr>
<td>All thinning: logging residue with the greater part being needles *****</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Amount of wood ash allowed per ha
THANK YOU FOR YOUR ATTENTION!