Indirect carbon dioxide emissions from producing bioenergy from forest harvest residues

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Why the interest for bioenergy is increasing worldwide?

Offers solutions to many problems:

- Decreasing fossil fuel resources → renewable energy resource
- Countries dependence on imported energy → local energy
- Climate change → a mean to cut down greenhouse gas emissions into the atmosphere

  • Rationale: Bioenergy is carbon neutral as CO₂ emissions released in the combustion are taken up again by the next plant generation
Bioenergy is carbon neutral – or is it?

• Bioenergy production can cause:
  → e.g. deforestation
  → decrease in carbon stocks

• Indirect emission occur when bioenergy production reduces carbon stock of biomass or soil.

• Changes in carbon stocks should also be included in the emission calculations [palm oil, ethanol]
Emissions resulting from changes in carbon stock

What to do with logging residues after logging in a mature (80-100 years) Norway spruce stand?

a) Leave residues at the site

b) Remove residues and use them for bioenergy
Emissions resulting from changes in carbon stock

a) Leave residues at the site
- Carbon is released little by little into the atmosphere in decomposition
- Logging residues act as a carbon stock
- Fossil fuels cannot be replaced

b) Remove residues and use them for bioenergy
- Carbon is released into the atmosphere at once
- Carbon stock of logging residues is lost
- Fossil fuels can be replaced.
Logging residue decomposition simulations

Yasso07 (Tuomi et al. 2009, 2010) is based on a large collection of measurements across the globe:

- litter decomposition measurements (n = 9605)
- measurements on soil carbon stocks and their development (n = 4204)
- woody litter decomposition measurements (n = 2102)

Yasso07 has been shown to give unbiased estimates for the decomposition of woody (Tuomi et al. 2010) and non-woody litter (Tuomi et al. 2009)
How much carbon stored in residues is lost?

- The lost carbon = carbon that would be left in the logging residues if left decompose at the harvest site.
Emissions resulting from changes in carbon stocks?

- The cumulative indirect emissions caused by combusting the harvest residues until year $i$ were calculated by summing up the amounts of carbon left in the harvest residues until this year ($i$) and relating these emissions to the cumulative amount of bioenergy produced.
Bioenergy from logging residues – total emissions?

A) Emissions resulting from changes in carbon stock

B) Emissions from energy production chain
1. collecting, chipping, and transporting the harvest residues,
2. emitting methane (CH4) and nitrous oxide (N2O) from combustion,
3. fertilizing the forest to compensate for nutrient loss,
4. recycling ash
range typically from 5 - 18 kg CO2 eq.MWh⁻¹
Emissions from energy production chain

- Coal
- Oil and diesel
- Natural gas
- Direct wood fuel chain emission

Time since starting the practice of energy production (year)

Total emission (kg CO2 eq./MW/h)
Bioenergy from logging residues – total emissions

A) Emissions from wood fuel production chain + B) from changing carbon stock

Repo et al. 2010
”Why should we worry about these emissions as the emissions are taken up again by the next plant generation?”

- Comparison: logging residues removed or left at site in addition to ordinary forest management (stems removed)
- If residue removal does not affect growth of the next vegetation generation, the only difference between systems is that less carbon is stored at the logging residue removal site.
- If removal reduces growth, emissions are even bigger.
- Comparisons between energy sources emissions per energy unit produced.
"Why not use logging residues for energy as they decompose releasing CO₂ into the atmosphere anyway?"

- In decomposition CO₂ is released little by little
- In combustion CO₂ is released at once.

→ mining
Climate impact of different energy sources

Repo et al. unpublished results
Conclusions 1/2:

- Logging residue bioenergy causes CO$_2$ emissions.
- A great majority (85-97 %) of these emissions result from a decline in the carbon stock of the harvest residues.
- Emissions per energy content are highest and comparable those of fossil fuels when practice is started (first 4-22 years).
- The logging residue bioenergy emissions decrease over time.
- Logging residue with small diameter decomposes faster than one with large diameter.
Conclusions 2/2:

- Emissions can be reduced by allocating residue removal to quickly decomposing harvest residues
  - Energy use of stumps causes 1.5-2 times larger CO₂ emissions than the use of branches
- Logging residue bioenergy is not as effective tool for climate change mitigation as reductions in emissions are in next the years and decades
- Effective climate change mitigation requires emission reductions now.