Multi-functional biomass production systems

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Introduction

Replacing fossil fuels with biomass leads to environmental benefits such as reduced emissions of greenhouse gases. However, prospects exist for generation of additional environmental benefits besides those obtained from fossil fuel substitution. By optimising the design, location and management of biomass production systems, several local environmental benefits could be obtain. Such environmental benefits could increase the value of the production systems, thereby improve future market conditions for biomass. This conference paper, which is mainly based on a study presented more extensively in paper [1-3], describe the potential of multi-functional biomass production systems in Sweden and their economic value.

Methodology

We define multi-functional biomass production systems as systems that, besides producing biomass, also generate additional environmental services. In this paper, we discuss such environmental services within the following themes: (1) greenhouse gases, (2) nutrient leaching, (3) nitrogen balance (4) toxic compounds, (5) acidification, (6) soil fertility and erosion, (7) municipal waste treatment, and (8) biodiversity. Biomass production systems included here are short-rotation forestry (SRF), or Salix, cultivated on agricultural land, and logging residues recovery (LRR) on forest land (tops and branches left over on felling sites after stem harvest). Nutrient compensation, e.g. wood ash recirculation, is included in the LRR system because it is a prerequisite for a long-term sustainable utilisation of logging residues to maintain the nutrient balance and fertility of the forest soil. The reference cases are cultivation of traditional annual food crops, and no LRR , respectively.

The economic value of additional environmental services has been estimated by using two different methods. When there exist a relation between an environmental service and a change in, for example, food production cost, this relation is used for valuation. An example is increased crop yields when Salix plantations are used as shelter belts preventing wind erosion. When no such direct cost relation exist, the substitution cost method has been used. The substitution cost describes the cost of providing the same environmental service, but in another relevant, and cost-efficient way. An example is the cost of reducing nutrient leaching through the restoration of wetlands, which have the same purification function as buffer strips along streams consisting of Salix.

Results

(1) Greenhouse gas emission from arable land may be reduced in three different ways when annual crops are replaced by SRF; by (i) accumulation of soil carbon in mineral soils, (ii) reduced emission of carbon dioxide (CO_2) from organic soils, and (iii) reduced emission of nitrous oxide (N_2O) caused by a reduced use of fertilisers. LRR, on the other hand, may lead to a slight increase in net emission of CO_2, compared with on site decomposition. (2) SRF can reduce nutrient leaching from arable land by being located and designed as buffer strips along open streams. LLR after final felling will lead to a reduced risk of nitrogen and potassium leaching from clear cutting sites. (3) LRR will also result in a long-term improved nitrogen balance in forest ecosystems heavily exposed to anthropogenic nitrogen deposition. When logging residues are combusted, about 95% of the nitrogen in the biomass will be converted into inert N_2 gas, and about 5% could theoretically be returned to the forest by atmospheric deposition of nitrogen oxides.

(4) Salix plantations could also be used to lower the content of heavy metals, e.g. cadmium, in the soil (phyto remediation), as the uptake of heavy metals in Salix shoots is normally much higher than in other crops. In areas contaminated by radioactive compounds, SRF and LRR may lead to a net output

of these compounds. The toxic compounds could then be removed from the ash during combustion. (5) LRR will result in a decrease in soil acidity. This is due to the output of nitrogen, which is potentially nitrifying and acidifying, and also due to the liming effect of wood ash. (6) An increase in the proportion of SRF on farmland will increase the soil fertility by increasing the organic matter content, and reducing water erosion. On sandy soils, wind erosion could be reduced by using SRF as windbreaks.

(7) Salix plantations are being tested in large-scale trials in Sweden as vegetation filters for municipal waste water. Salix plantations can also be utilised for the treatment of landfill leachate and sewage sludge. The interest in vegetation filters, as a complement to conventional treatment methods, are due to the high purification efficiency and low costs. (8) The biodiversity is estimated to be slightly increased in open farmland when SRF replace annual food crops. LRR are estimated to only have a minor, or reversible, effect on the flora and fauna in the forest ecosystem. However, it is important that current guidelines for forestry management methods are followed and that granulated, slowly dissolvable wood ashes are utilised.

In Fig. 1, the maximum annual production of woody biomass (Salix and logging residues) in Sweden at different costs is shown, when the economic value of additional environmental services is included in the production cost. A conclusion is that large quantities of biomass could be produced to significantly reduced costs when potential multi-functional production systems are extensively utlised.

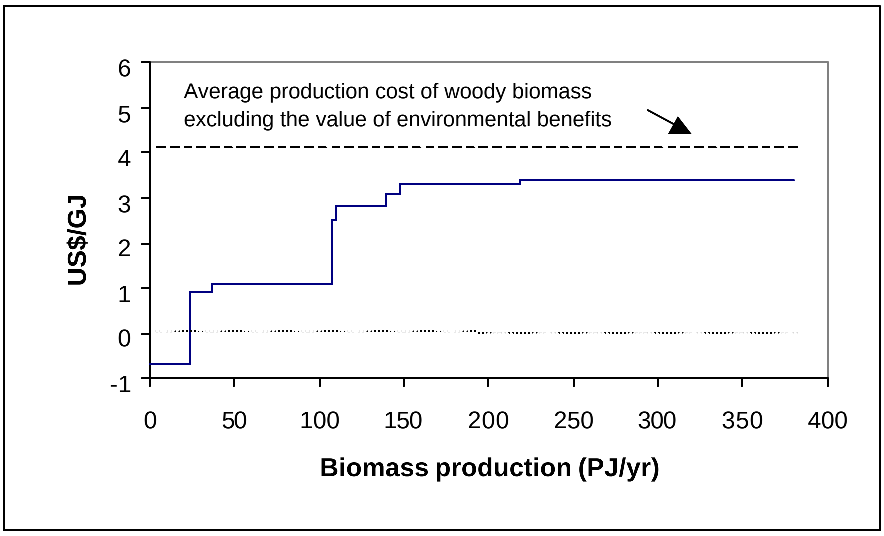

Figure 1. The cost of woody biomass (Salix and logging residues) in Sweden when the economic value of additional environmental benefits, compared with current management practices, is included, as a function of the annual biomass production. Multi-functional biomass production systems that generate the highest value are given priority.

References

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