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INCLUDING ECOSYSTEM SERVICES IN SUSTAINABILITY ASSESSMENT OF FOREST BIOFUELS

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ABSTRACT: With increasing demand for forest biofuels the pressures on ecosystem services from forestry practices will increase. This calls for identification and assessment of tradeoffs between different uses of provisioning and other ecosystem services and establish management practices considering such tradeoffs.
Keywords: Renewable energy, Ecosystem Services, Tradeoff, Forestry, Jämtland.

1 INTRODUCTION

With increasing European demand for biofuels the interest for wooden biomass from the northern boreal forests of Sweden will most probably increase and the pressures on ecosystems will also increase [1,2,3]. To ensure the sustainability of forest biofuel production in Sweden traditional environmental optimization parameters like carbon footprint or life cycle energy use will not be enough [4,5,6,7]. For example impacts on ecosystem services also need to be assessed.

Ecosystem services are benefits humans obtain from ecosystems, a concept that has been increasingly discussed since the publication of the UN Millenium Ecosystem Assessment (MEA) in 2005 [8]. Ultimately all human life aspects depend on ecosystem services for fundamental necessities such as clean air, clean water and food production. The MEA study concludes that ecosystems and their ability to provide humanity with ecosystem services presently are under severe stress. Increasing use of biofuels should thus be furnished in ways not to unnecessarily worsening the situation, but preferably even improve it, and locally not destroy but ensure the provisioning of essential ecosystem services [3].

2 SWEDISH FORESTRY AND FOREST BIOFUEL PRODUCTION

The forestry sector is an important part of the Swedish economy, contributing to about 10 % of total export value of Sweden [9]. It has been estimated that the supply of wood biofuels from the Swedish forests could be increased from around 111 TWh (in 2006) to between 125 and 170 TWh per year [10]. Swedish energy policy drives in the direction of utilizing this potential and has expressed a vision of a fossil fuel independent vehicle fleet in 2030 and no net GHG emissions in 2050 [11]. This will probably lead to intensification of forestry practices to supply society's bioenergy demands. Swedish forests today have annual volume growth surpassing harvesting [12]. This is partly the background to the fact that land occupation parameters so far has not been considered overly relevant when it comes to forestry in Sweden; the general forms of forest management practices used has made also production forestry seen as 'nature' by the general public; about three quarters of Swedish productive forests are certified under FSC, PEFC or both certification schemes [13,14]. But with increasing competition for forest resources, harvesting pressure and intensity of forestry will likely increase, and the view that forests by default can be considered nature will have to change.

3 ECOSYSTEM SERVICES

Ecosystem services are human benefits from ecosystems. Such goods and services can be grouped into four categories [8,15]: '*Provisioning*' services such as food, water, timber, fuel and fiber; '*Regulating*' services stabilizing climate locally to globally, floods, disease, wastes, and water quality; '*Cultural*' services including non-material benefits that provide recreational, aesthetic, and spiritual benefits; and '*Supporting*' services which maintain other services; examples include photosynthesis (primary production), nutrient cycling and soil formation.

The Millennium Ecosystem Assessment [8] was carried out between 2001 and 2005 to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being. The MEA is the most comprehensive attempt to date to identify, define and globally map ecosystems services and how they contribute to human wellbeing [3]. Findings indicated that over the past 50 years, humans have changed ecosystems faster and more extensively than during any other comparable time period in human history. The MEA concludes that human utilization of ecosystems have brought about substantial gains in human well-being and in economic development, but that these gains have come at the cost of degrading ecosystems.

The concept of ecosystem services was discussed also before the MEA, from sometime in the sixties. The use of the concept has differed, and still does, over time and between authors [16,3]. Early on the concept was mainly used as a pedagogic tool to make clearer the importance of biodiversity. In recent years, there has been an increasing interest to put monetary values on

ecosystem services in different ecosystems [17,15]. Such attempts might provided new insights regarding sustainability of different processes.

Scientists also differ in exactly what is an ecosystem service, where some would argue that the presence of earthworms in soil is an ecosystem service, where others argue that the improvement of soil structure (brought by the worms and which will give increased productivity of that soil) is the ecosystem services in this case, and still others would say it is the increased biological production harvested by humans that is the ecosystem service. In a 2002 paper, de Groot *et al*. [16] argues for a nomenclature that differentiate between 'ecosystem structure and processes', 'ecosystem functions' (distinguishable functions that arise from the ecosystem structure and processes), 'ecosystem goods and services' (such functions that are in some way used by humans) and finally the attribution of value to such goods and services.

Neo-Classical Economics has been criticized for leaving important issues outside the area of study – 'externalities' sometimes of great importance to society. Environmental economics in the early sixties addressed such shortcomings by 'internalizing costs' like environmental degradation. From this perspective, non marketed ecosystem services can be seen as 'positive externalities' [18]. Marketed ecosystem services (generally found among provisioning services) already have market prices. For other services we sometimes can see actual market payments to preserve a continuous flow or an ecosystem service, thus giving at least a minimum market value for that service [16]. Where there are no such market valuation, different approaches to identify value can be used, like avoided cost (e.g. flood regulation avoids property damage), replacement cost (e.g. cost for a human made flood protection) or hedonic pricing (e.g. higher price for a beach front house compare to a nearby similar house not at the beach front).

Ecological economics in the early seventies introduced the idea that the human society, including its economic transactions, is a sub part of the ecological systems [18]. In practical considerations, ecological economists generally do not differ much from environmental economists. An important difference however, is that some environmental economists endorse 'weak sustainability', whereas ecological economists do not.

When it comes to ecosystem services and the concrete values of them, there are several further distinctions that can be made, and there is not yet any scientific consensus on what should be included. Some argue that only such flows that have a direct impact on human well being and that can be given a price shall be included, other include also such flows that are hard to give a price, other still include also such ecological functions that indirectly are necessary for the flows directly important for human well being (e.g. supporting services). Recently, corporate use of ecosystem services has become more frequent, e.g. through corporate ecosystem service review [19]. This is basically a micro economic use of the ecosystem service concept. Here, costs and benefits are very real in terms of money, and to a large extent can be seen as a normal support for corporate investment or business risk decisions. This later way of conceptualizing ecosystem services is the base for the following discussion of the present paper.

4 ECOSYSTEM SERVICES IN SUSTAINABILITY ASSESSMENT OF FOREST BIOFUELS

Although there is a societal focus on sustainable biofuels, the definition and assessment of sustainability regarding biofuels remains a debated issue [6]. Forest biofuels harvested are in themselves an example of a provisioning ecosystem service. Forests also provide us other benefits and values, such as recreation, hunting, fishing and wildlife experiences. They support biodiversity and interconnected components of complex ecosystem. In a specific area, there are several ecosystem services which are affected by forestry practices [20]. Thus also biofuel production from forest biomass will directly or indirectly affect ecosystem services, impacts that need to be assessed.

Ecosystem services of concern in relation to increased forest biofuel production could for example be flood protection, soil degradation, nutrient cycling and biodiversity. At the same time, more intensive forestry may create conflicts between business enterprises related to cultural ecosystem services and enterprises related to biofuel production. More intensive forestry due to increasing demand for forest-biomass based biofuels can alter the conditions of other provisioning services (e.g. local food or fresh water) and cultural services (e.g. recreational activities, tourism, fishing, skiing etc.).

Ecosystem services is already to some extent, but can be increasingly considered, in forestry management schemes [21]. Beside forest management schemes, we also need to parameterize impacts on ecosystem services so that we can compare different alternatives using for example life cycle assessment, LCA [22]. How should we compare on per MJ basis (LCA) if two fuels are from totally different areas with totally different ecological characteristics? We need to find a theoretical base to make possible the inclusion of ecosystem service impacts into function related assessment tools like LCA and be able to report such impacts e.g. per MJ of a biofuel, to furnish optimizations over the value chains as well as comparisons between different routes for biofuel generation.

5 TRADE OFFS FOR FOREST BIOFUELS - THE EXAMPLE OF JÄMTLAND

The county of Jämtland is located in central northern part of Sweden. The area is approximately 34,000 km^2 and has population of 127,000, and to 50% covered by forest. Forestry is an important industry, for pulp and paper, timber and bioenergy production (1.6 TWh of mainly forest residuals annually directly for bioenergy). At the same time the county has a large and increasing tourism industry, skiing but also for experiences of undisturbed nature, hiking, hunting and fishing. The county is also marketing itself as a 'Quality Food Area' having a focus on traditional, small scale and local production of food products and food experiences, with the clean environment for agriculture, game and fish as a cornerstone [23].

There are at least 19 specific water resources which are contributed to fishing in the region [24]. Intensified forestry could potentially impact water flow and quality which in turn might alter the fish population. This could decrease the number of fishers and tourists who are

interested in fishing in the region. Thus, revenues of tourism, an important business sector in Jämtland county, could be affected. Also the pattern of skiing and hiking tourism in the region could change. In a study of tourism from 1995 it was shown that a considerable portion of the value to nature tourists was related to forest characteristics, and that this value was impacted by forest management practices [25]. Increased pollution from more intensive forestry could also impact on marketing of local food of the 'Quality Food Area', which is depended on clean air, soil and water in the region.

The regional development in Jämtland and efforts to enhance the development is thus strongly connected to ecosystem services. The priority of ecosystem services in a region with such trade-off situation regarding ecosystem services is currently absent in developing programs. This requires assessment of ecosystem services at a higher resolution, and relevant principles for the trade-off decisions

6 CONCLUSIONS

Regarding impacts on ecosystem services from increased biofuel production from Swedish forests there are needs to:

- Screen ecosystem services in different regions and establish which are relevant to consider.
- Quantify impacts on ecosystem services, identify tradeoffs and establish management practices.
- Include relevant impacts on functional base in e.g. LCA for optimizing production chains and comparing different production routes.
- Consider impacts on ecosystem services in policy making, like regional development plans, taking into account for example tradeoffs between biofuels, tourism and other business interests.

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8 REFERENCES

[1] Londoa M., Lensinka S., Wakkera A., Fischerb G., Prielerb S., Velthuizenb H., Witc M., Faaijc A., Jungingerc M., Berndesd G., Hanssond J., Egeskogd A., Duere H., Lundbaeke J., Wisniewskif G., Kupczykf A. and Könighoferg K. (2010). *The Refuel EU road map for biofuels in transport: Application of the project's tools to some short-term policy issues biomass and bioenergy* 34: 244-250.

[2] Murphy R., Woods J., Black M. and McManus M. (2011). *Global developments in the competition for land from biofuels.* Food Policy 36: S52–S61.

[3] Gasparatos A., Stromberga P. and Takeuchi K. (2011). *Biofuels, ecosystem services and human wellbeing: Putting biofuels in the ecosystem services narrative.* Agriculture, Ecosystems and Environment 142: 111– 128.

[4] Clancy G., Fröling M. and Svanström M. (2012). *Changing from petroleum to wood-based materials: Critical review of how product sustainability characteristics can be assessed and compared. Manuscript.* Chemical Environmental Science, Chalmers University of Technology, Götreborg, Sweden.

[5] Arvidsson R., Fransson K., Fröling M. Svanström M. and Molander S. (2012). *Energy use indicators in energy and life cycle assessments of biofuels: review and recommendations.* Journal of Cleaner Production, 31: 54-61

[6] Gnansounou E. (2011). *Assessing the sustainability of biofuels: A logic-based model*. Energy 36: 2089-2096.

[7] Markevicius A., Katinas V., Perednis E. and Tamasauskiene M., (2010). *Trends and sustainability criteria of the production and use of liquid biofuels.*Renewable and Sustainable Energy Reviews 14: 3226–3231.

[8] Millenium Ecosystem Assessment [MEA], (2005). *Ecosystems and Human Well-being Synthesis*. Island Press, Washington, D.C., United States of America.

[9] SCB. (2012). *Foreign Trade – Exports and imports of goods January - December 2011*. Statisktiska meddelanden HA 22 SM 1201**,** Statisktics Sweden, Stockholm. www.scb.se, accessed April 21, 2012.

[10] Näslund Eriksson L. (2008). *Comparative analyses of forest fuels in a life cycle perspective with a focus on transport systems.* Resources, Conservation and Recycling (52) 1190–1197.

[11] Joelsson J. M. (2011). *On Swedish bioenergy strategies to reduce CO_2 emissions and oil use.* Ph.D. thesis, Mid Sweden University, Östersund, Sweden.

[12] SLU. (2012). *Growth. Forestry Statistics from the Swedish Ntional Forest Inventory.* Swedish University of Agricultural Sciences. http://www.slu.se/en/webbtjanster-miljoanalys/forest-statistics/growth/ , accessed April 21, 2012.

[13] Elbakidze M., Angelstam P., Andersson K.,Nordberg M. and Pautov Y. (2011). *How does forest certification contribute to boreal biodiversity conservation? Standards and outcomes in Sweden and NW Russia.* Forest Ecology and Management 262: 1983–1995.

[14] Johansson J. and Lidestav G. (2011). *Can voluntary standards regulate forestry? Assessing the environmental impacts of forest certification in Sweden.* Forest Policy and Economics 13: 191–198.

[15] TEEB (2010) *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB.* ISBN 978-3-9813410-3-4.

[16] de Groot R.S., Wilson M.A. and Boumans R.M.J (2002). *A typology for the classification, description and valuation of ecosystem functions, goods and services.* Ecological Economics 41: 393-408.

[17] Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., 1997. *The value of the world's ecosystem services and natural capital*. Nature 387: 253–260.

[18] Gómez-Baggethun E, de Groot R., Lomas P. L. and Montes C. (2010). *The history of ecosystem services in economic theory and practice: from early notions to markets and payment schemes*. Ecological Economics 69: 1209-1218.

[19] WRI (2008). *Corporate ecosystem service review - Guidelines for Identifying Business Risks and Opportunities Arising from Ecosystem Change - Version 1.0*. World Resources Institute – WRI, , Washington DC, United States of America. ISBN-978-1-56973-679-1.
[20] Matero J. and Sa astamoinen O. (2007). *In search of marginal environmental valuations – ecosystem services in Finnish forest accounting.* Ecological Economics 61: 101-114.
[21] Deal R. L., Cochran B. and LaRocco G. (2012). *Bundling of ecosystem services to increase forestland values and enhance sustainable forest managment.* Forest Policy and Economics 17: 69-76.
[22] Zhang Y., Singh S. and Bakshi B. (2010) *Accounting for ecosystem services in Life Cycle Assessment, Part I: a critical review*. Environmental Science and Technology 44: 2232–2242.
[23] Fakhari Rad M., Fröling M. and Grönlund E. (2012). *More forest biofuels from Jämtland - ecosystem services tradeoffs*. Poster presentation at the 5th SETAC Europe Special Science Symposium: Ecosystem Services: from policy to practice, Brussels, 15-16 February 2012.
[24] Cinclus C Fishing Guide, (2012). http://www.cinclusc.com/spfguide/eng/province/jamtland.htm, accessed April 18, 2012.
[25] Bostedt G. and Mattsson L. (1995). *The value of forests for tourism in Sweden.* Annals of Tourism Research 22 (3): 671-680.