Assessing the Impact of Silvicultural Strategies on Forest Ecosystem Functions under Changing Climate

SilviStrat
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Background

Forest ecosystems are expected to serve diverse forest functions. Hence, forest managers are challenged by the task to balance multiple and often conflicting interests while meeting economic requirements at the same time.
A stakeholder dialogue served to identify objectives of multi-purpose forestry in Brandenburg and the ranking different stakeholder groups ascribe to these objectives. Using the model 4C (FORESt Ecosystems in a changing Environment) (Lasch et al. 2002), the EFI wood product model (Eggers 2002) and an economic analysis module the impact of management on diverse forest functions under the aspect of changing climate was investigated by a case study.

Study area

The forest management unit Kleinsee (927ha) is situated in Southeast Brandenburg. Kleinsee is characterised by sandy soils, low precipitation (550mm) and mean temperature of 8.7°C. Less productive areas are dominated by pure Scots pine stands (*Pinus sylvestris* L.), while on more fertile sites pine is often mixed with Sessile oak (*Quercus robur* L.).

Data

- Stand information: local forest inventory.
- Soil data: local soil map (Standortskarte) and soil ditches in Kleinsee (Schulze 2000).
- Climate scenarios: current climate (CRU), climate change ECHAM4.

Stakeholder dialogue and forest management objective setting

Methodology

The overall objective of forest management is to maximise the utility in a management unit. Based on Saaty's Analytical Hierarchy Process (AHP) (Saaty 1990) the overall utility can be described by partial objectives and measurable indicators at the stand (Fig. 1) and management unit level. Saaty's Eigenvalue method was applied to rank objectives and criteria. In this process experience and knowledge of stakeholders was integrated through a scientific stakeholder dialogue (workshop, interview, questionnaires).

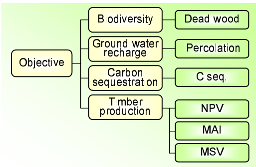

Fig. 1: Partial objectives of forest management (yellow frame) and their indicators at stand level (green frame). C seq. = carbon sequestration (in biomass, soil, deadwood and wood products), NPV = net present value, MAI = mean annual increment, MSV = mean standing volume.

Results

Forest management objectives:

- timber production (TP),
- fuel wood production (FP),
- carbon sequestration (CS),
- biodiversity (BD),
- ground water recharge (GW),
- social function(SF).

Depending on preferences setting three different groups could be aggregated (Fig. 2). The environmentalists focus on a balance between all forest functions. Private forest owner and forest companies pursue the main aim to produce timber and fuel wood, while forester employed by the federal forest service focus on social functions and biodiversity as well as timber production.

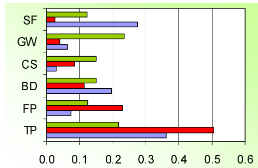

Fig. 2: Preference values of the partial objectives from 3 stakeholders (blue = forest service, red = private forest owner, green = local environmental organisation).

Impact of management and climate on forest functions

Methodology

The 140 stands in Kleinsee are classified depending on (i) tree species, (ii) age class, and (iii) soil type. A representative stand of each class was selected for the simulation runs. Six different stand treatment programs (STP) were developed according to former and present sivicultural guidelines by varying thinning intensity and intervals, harvesting system and tree species for regeneration (Tab. 1). The simulations were carried out over a period of 100 years under current climate and climate change scenario (increase in temperature and relatively unchanged precipitation).

Tab.1: Description of three of six STPs. Sivicultural operations within a STP program depend on soil type and tree species.

Stand Treatment Program	Soil fertility	Tree species	Thinning intensity	Thinning interval	Rotation period	Harvest	Regene-ration
01 no management	All	All	-	-	-	-	-
03 new guidelinies	--/-	Pine/oak	Medium	10 years	140 pine 180 oak	cc	pine
	+-/+					sh	oak
04 pine plantation	--/-	Pine	High	7 years	100	cc	pine
	+-/+				80		
	All	Oak			140		

Results

(1) Carbon sequestration

In general, a conservation strategy leads to highest increase in carbon stock, while STPs with management accumulate less carbon and differ only slightly in magnitude of carbon sequestration (Fig 3). However, management influences the distribution of carbon among the carbon pools (Fig. 4). Under a climate change scenario the carbon sequestration increases by about 12% (Fig. 3) due to an enhanced growth and therefore a higher carbon sequestration in biomass and wood products (Fig. 4).

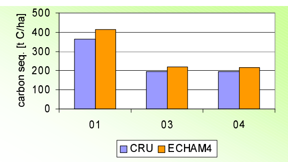

Fig. 3: Total carbon sequestration in biomass, soil, deadwood and wood products in 100 year in Kleinsee under two climate scenarios.

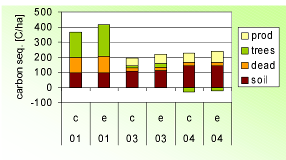

Fig. 4: Total carbon sequestration in biomass, soil, deadwood and wood products in 100 year in Kleinsee under two climate scenarios (c = CRU, e = ECHAM4).

(2) Ground water recharge

Mean annual percolation is hardly influenced by management but slightly decreases by 6 to 9% under the climate change scenario.

(3) Biodiversity

The highest amount of deadwood can be found in non management stands (STP01), while for the other STPs the portion of dead wood remaining in stands is small.
Species distribution at management unit level after 100 years is an additional indicator for biodiversity and is influenced by all management options (Fig. 5). An oak ratio of about 40% would be optimal.

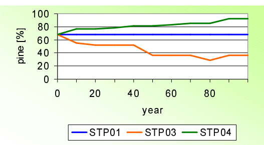

Fig. 5: Changes in species distribution under different management scenarios.

(4) Timber production

Timber production is influenced by management strategies (Fig. 6). The amount of harvested timber and mean annual increment is increased by intensive management (STP03), while the mean standing stock decreases compared to a STP with medium thinning intensity and a high portion of oak stands (STP04).
The climate change scenario leads to an increase in harvested timber by approximately 15% as well as an increase in increment and standing stock.

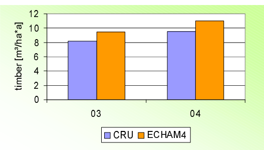

Fig. 6: Mean harvest timber under STP03 und STP04 and climate change.

Summary

A stakeholder dialogue was found to be an effective tool to incorporate stakeholder knowledge in a scientific study and analyse forest management preferences.

A conservation strategy has the advantage of high carbon accumulation, high deadwood rate in stands and preferable species distribution due to the initial ratio of pine and oak stands. Applying this strategy the stands have no direct economical value as they do not provide income through timber production. Different strategies with management mainly influence timber production and species distribution.

The selected climate change scenario positively effected carbon sequestration and timber production, while there was no clear impact on ground water recharge and biodiversity.

Outlook

- Economic analysis of STPs
- Ranking of STPs with utility function for different stakeholders groups
- Analysis of trade-off effects (e.g. between carbon sequestration and income)
- Optimisation of management at unit level with a mixture of STPs

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