Ecosystem goods and services and human vulnerability

Wolfgang Cramer
Potsdam-Institut für Klimafolgenforschung (PIK)
& Institut für Geoökologie, Universität Potsdam

with contributions from Alberte Bondeau, Hermann Lotze-Campen, Wolfgang Lucht and others
Ecosystem goods and services and human vulnerability

A. Preamble – a view on vulnerability
B. The European ecosystem vulnerability project ATEAM/AVEC – implications for the European carbon balance
C. The carbon balance of the Amazon – more vulnerable to climate change or to deforestation?
D. Conclusion
Ecosystem goods and services and human vulnerability

A. Preamble – a view on vulnerability
Vulnerability...

...is the degree to which an ecosystem service is sensitive to global change.

plus

the degree to which the sector that relies on this service is unable to cope with the changes.
Multiple drivers of ecosystem services

Driver

- Climate Change

Response

- Energy Sector
- Biodiversity
- Food Supply
- Water

Climate Change
Land Cover Change
Biodiversity Loss
Nutrient Loading
Etc.

Ecosystems

Human Impact

- Health
- Economics
- Social

IPCC

- Health
- Economics
- Social

MA

Ecosystem goods and services
(as defined by the Millennium Ecosystem Assessment)

<table>
<thead>
<tr>
<th>Agricultural Lands</th>
<th>Coastal Zones</th>
<th>Forest Lands</th>
<th>Freshwater Systems</th>
<th>Arid Lands &amp; Grasslands</th>
</tr>
</thead>
</table>

- Food and Fiber Production
- Provision of Pure and Sufficient Water
- Maintenance of Human Health
- Maintenance of Biodiversity
- Storage of Carbon, Nitrogen, Phosphorus
Ecosystem goods and services and human vulnerability

B. The European ecosystem vulnerability project ATEAM/AVEC – implications for the European carbon balance
The ATEAM framework

Multiple scenarios of change: climate, land use, N deposition

assessment framework

changes in ecosystem services

indicators

maps of vulnerability

(multiple) exposure

numerical models

sensitivity

adaptive capacity
## Ecosystem services and indicators

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Services</th>
<th>Indicators (examples)</th>
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<tbody>
<tr>
<td>Agriculture</td>
<td>Food &amp; fibre production</td>
<td>• Crop yield, yield variability &amp; profitability</td>
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<tr>
<td></td>
<td>Biofuels</td>
<td>• Physical suitability of crops</td>
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<tr>
<td></td>
<td>Wood production</td>
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<td>Forestry</td>
<td>Wood production</td>
<td>• Tree productivity</td>
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<td>Biofuels</td>
<td>• Biomass energy wood suitability and yield</td>
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<td>C storage &amp; Energy</td>
<td>Carbon storage</td>
<td>• Carbon storage in Vegetation &amp; Soil</td>
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<tr>
<td>Water</td>
<td>Water supply</td>
<td>• Stream flow quantity &amp; quality</td>
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<td>Drought &amp; flood prevention</td>
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<tr>
<td>Biodiversity &amp; Nature</td>
<td>Aesthetics</td>
<td>• Species richness &amp; persistence</td>
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<td>Conservation</td>
<td>Landscape diversity</td>
<td>• Habitat richness</td>
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<tr>
<td>Mountains</td>
<td>Tourism &amp; Recreation</td>
<td>• Snow dynamics</td>
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<td>Carbon and Water</td>
<td>• Slope stability</td>
</tr>
</tbody>
</table>
Multisectoral assessment in ATEAM

Agriculture  Water
Forestry     Biodiversity
Carbon Storage & Energy  Mountains

$CO_2$ concentration (ppmv)

![Graph showing CO2 concentration over time with Legend: A1fi, A2, B1]
Temperature (deg C)

Methodology

ATEAM, Land use change

Scenarios*

Economic

Global

Environmental

Regional

Land use types

Urban

Food crops

Agriculture

Grassland/fodder

Forestry

Biofuels

Protected areas

Time slices

2020

Spatial resolution

10’ grid

2050

2080

*IPCC Special Report on Emissions Scenarios (SRES)
Global scenarios (SRES)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Population</th>
<th>Economy</th>
<th>Environment</th>
<th>Equity</th>
<th>Technology</th>
<th>Globalization</th>
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</thead>
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<tr>
<td>A1FI</td>
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</table>
Land use change (10^6 km^2)

- Agriculture (A2)
- Agriculture (A1)
- Forest (A2)
- Forest (A1)
The LPJ DGVM

climate CO₂ soil

biochemistry

metabolism

space and time loops

competition

functional differentiation

APAR = PAR \times [1 - \exp(-k \cdot LAI)]

C budget H₂O budget biogeography

functional relationships

soil water supply

yearly NPP

mean structure of an individual

old structure

new structure

vulnerabilities of the carbon-climate-human system, unesco, paris, 15 june 2005
Ecosystem carbon storage
(NBE, Gt C/yr)
A2-CC scenario
changing carbon storage

2050

2100

A2-LUCC scenario
changing carbon storage
B1-LUCC scenario
changing carbon storage
NEE Anomaly 2091-2100
(A2 Emission-Scenario)
Climate model uncertainty
(same emission scenario: A2)
Emission scenario uncertainty
(same climate model: HadCM3)
Biofuel suitability

A1FI
2080
HADCM3

Liquids
Non-woody
Woody

A2
2080
HADCM3

Source of data: Gill Tuck, Rothamsted Experimental Station

ATEAM Partners

Wageningen Universiteit
University of Life Sciences
The Netherlands

European Forest Institute
Joensuu, Finland

Max Planck Institute for Biogeochemistry,
Germany
Institute of Arable Crops Research, Rothamsted,
United Kingdom

ETH
Switzerland

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Toledo
Spain

Universidad de Barcelona
Barcelona, Spain

Tyndall Centre
for Climate Change Research

Laboratoire des Sciences du Climat et de l’environnement
Paris, France

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United Kingdom

UNIVERSITY of ABERDEEN
Department of Plant Soil Science

The University of Georgia
United Kingdom

University of Sheffield
United Kingdom

Lund University
Sweden

SYKE
Finnish Environment Institute, Helsinki, Finland

PIK, Germany

Ecosystem goods and services and human vulnerability

C. The carbon balance of the Amazon – more vulnerable to climate change or to deforestation?
Global net ecosystem productivity (NEP)

NEP ($10^{15}$ g C yr$^{-1}$)

Net ecosystem productivity
(g C m\(^{-2}\) y\(^{-2}\))
Land biosphere C balance for different DGVMs
C balance of the Amazon for different rates of deforestation (10yr running means)
C balance of the Amazon for different rates of deforestation (10yr running means)
C balance of the Amazon for different rates of deforestation (10yr running means)

ECHAM4 Climate Scenario

C balance of the Amazon for different rates of deforestation (10yr running means)

HadCM3 Climate Scenario
Ecosystem goods and services and human vulnerability

D. Conclusion
Summary

• Ecosystems...
  ...provide multiple services
  ...are sensitive to climate and land use change
  ...can be assessed quantitatively in a multi-scenario approach

• Quantitative assessment is necessary...
  ...for estimation of damage
  ...planning of adaptive measures
Global Biogeochemistry

Socioeconomic Metabolism

Climate Change

Geologic Substitution
Sequestration

CO₂

Wood Products
Bioenergy

Demography
Economy
Life Styles
Technology
Trade

(Non-Climatic) Global Change

From Wolfgang Lucht, PIK
Thank you very much for your attention!

More information to be found at http://www.pik-potsdam.de/ateam

Photograph: Peyresq, France, where 35 students discussed vulnerability of ecosystems in September 2003