Ecosystem services of mountains - an urgent research area

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• Introduction
• Ecosystem services provided by mountains
• Fragility of mountains
• History of mountain research
• Priorities for further research

Main sources:
Key features of mountains

- Mountains cover 24% of the land surface of our planet.
- Twenty percent (1.2 billion) of the world’s human population lives in mountains or at their edges.
- Half of humankind depends in one way or the other on mountain resource.

Körner et Ohsawa 2005
Key features of mountains

• The mountain ecosystem services make specific contributions to lowland and highland economies

• Mountains are a storehouse of biological diversity and endangered species (Agenda 21). They support about one quarter of terrestrial biodiversity, with nearly half of the world’s biodiversity hot spots concentrated in mountains (Körner et Ohsawa 2005)

• Worldwide, 32% of protected areas are in mountains (9,345 mountain protected areas covering about 1.7 million square kilometers) (Körner et Ohsawa 2005)
Particularities of European mountains

- European mountain landscapes - cultural landscapes reflecting long-term interactions of human beings with biophysical systems
- The poverty not such crucial problem as in some other parts of the world, but they often represent marginal regions with typical consequences for local economies and mountain communities
- They are facing with abandonment of agricultural land and reduction of traditional systems of the land use.
- The tourism and recreation are highly developed in European mountains, provide significant contribution to national economies. Connected with urbanization of mountains, development of centres of tourism, infrastructure and transport facilities building.

EEA 2010: Europe's ecological backbone: recognising the true value of our mountains
Ecosystem services of mountains
Provisioning services

• Mountain forests are main providers of timber and fuelwood
• Mountain agriculture provides subsistence for about half a billion people worldwide.
• Genetic resources are considered as being of key importance in mountain ecosystems
• Mountains are important as centres of crop diversity.
• Wild populations of animals and plants are harvested to provide foods, such as game, fish, berries and mushrooms
• Mountains - sources of all the world's major rivers, and many smaller ones, they supply water to nearly half the human population.
• Mountain rivers are used for hydropower production
## Provisioning services

<table>
<thead>
<tr>
<th>Ecosystem service</th>
<th>Key contribution</th>
<th>Some contribution</th>
<th>No contribution</th>
<th>Poorly known</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food and fibre</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Timber/fuel/energy</td>
<td>X</td>
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<tr>
<td>Freshwater</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Ornamental resources</td>
<td></td>
<td>X</td>
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<tr>
<td>Biochemical/natural medicines</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>Genetic resources</td>
<td>X</td>
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</tbody>
</table>

Harrison *et al.*, 2010
Regulating services

- Mountains play a key role in the water cycle, with feedback to the regional climate
- Water storage and modulating runoff regime - waterholding capacity of mountain ecosystems reduces peak stream flow
- Mountain vegetation and soils play a significant role in reducing or mitigating risks from natural hazards, e.g. avalanches and rockfall
- Mountain ecosystems play crucial role in protection of fragile mountain slopes from erosion and leaching processes
- Mountains extract water from the rising air masses passing over them ("water pump"), the air mixing is important to air quality regulation.
- Mountains as "water towers" - storing water in mountain glaciers, permafrost, snowpacks, soil, or groundwater

Picture: Spehn and Körner 2005
## Regulating services

<table>
<thead>
<tr>
<th>Ecosystem service</th>
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<th>Some contribution</th>
<th>No contribution</th>
<th>Poorly known</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollination</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>Seed dispersal</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>Pest regulation</td>
<td>X</td>
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<tr>
<td>Disease regulation</td>
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<td>X</td>
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<tr>
<td>Invasion resistance</td>
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<td>X</td>
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<tr>
<td>Climate regulation</td>
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<tr>
<td>Air quality regulation</td>
<td>X</td>
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<tr>
<td>Erosion regulation</td>
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<tr>
<td>Natural hazard regulation</td>
<td>X</td>
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<tr>
<td>Water flow regulation</td>
<td>X</td>
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<td></td>
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<tr>
<td>Water purification, waste treatment</td>
<td>X</td>
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<td>X</td>
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</tbody>
</table>

Harrison et al., 2010
Cultural services

- Mountain ecosystems have intrinsic spiritual and religious value, especially for local inhabitants.
- Species diversity with many endemic or charismatic animals and plants together with spectacular landscapes are of strong aesthetic value.
- Traditional mountain ways of life and the landscape mosaics that have been created result in a strong sense of place and cultural heritage.
- Scenic landscapes and clean air make mountains target regions for recreation and tourism, tourism is often seen as a motor for economic development.
- Mountain populations - high diversity of cultures, including languages, and traditional agricultural knowledge that commonly promotes sustainable production systems.
## Cultural services

<table>
<thead>
<tr>
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<th>Some contribution</th>
<th>No contribution</th>
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</thead>
<tbody>
<tr>
<td>Spiritual and religious values</td>
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<td>X</td>
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<tr>
<td>Education and inspiration</td>
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<tr>
<td>Recreation and ecotourism</td>
<td></td>
<td>X</td>
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<tr>
<td>Cultural heritage</td>
<td></td>
<td>X</td>
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<tr>
<td>Aesthetic values</td>
<td></td>
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<tr>
<td>Sense of place</td>
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Harrison *et al.*, 2010
Summary

Contribution of mountains to the ecosystem services

<table>
<thead>
<tr>
<th>Ecosystem service group</th>
<th>Key contribution</th>
<th>Some contribution</th>
<th>No contribution</th>
<th>Poorly known</th>
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</thead>
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<tr>
<td>Provisioning services</td>
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<tr>
<td>Regulatory services</td>
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<tr>
<td>Cultural services</td>
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<td>1</td>
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</table>

Mountain ecosystems contribute to all the ecosystem services considered

Multifunctionality of mountains
Processes, threats, fragility
Processes, threats, fragility

• Mountains are subject to both natural and anthropogenic drivers of change
• Mountains are highly vulnerable to human and natural ecological imbalance
• The impacts of disturbances are more rapid, heavier, the recovery of mountain ecosystems from disturbances is typically slow or does not occur
High Tatra Mts. (Slovakia) – November 2004
12,000 ha of forest damaged
Followed by pest outbreak
Processes, threats, fragility

- Land use pressure puts mountain ecosystem integrity at risk in many parts of the world.

- The fragility of mountain ecosystems represents a considerable challenge to sustainable development.

- Abandonment of mountain agriculture in industrial countries while overexploitation has reached dramatic dimensions in many developing countries.

- Mountain biota - adapted to relatively narrow ranges of temperature and precipitation – potentially bigger impact of climatic change can be expected.
• Mountains – high biological diversity
• Mountains – highly important for all considered ecosystem services
• Not all mountain ecosystem services are sufficiently known
• Mountains are fragile, sensitive to disturbances
• They are under strong impact of global changes and other pressures

More intensive and targeted research of ecosystem services needed
Mountain research history

• 1972 – UNO Conference on Environment, Stockholm
• MAB Project 6 „Impact of Human Activities on Mountain Ecosystems“ - the first international interdisciplinary research programme on mountain regions, projects in Andes, Himalaya, Alps and Pyrenees
• 1980 - International Mountain Society (IMS)
• 1981 - Journal Mountain Research and Development
• 1983 - International Centre for Integrated Mountain Development (ICIMOD)
• 1991 – Alpine Convention
• 1992 - Rio summit
Mountain research history

1995 – Mountain Forum
2000 - Global Mountain Biodiversity Assessment
2001 - Mountain Research Initiative
2002 - International Year of Mountains; Johannesburg summit, Mountain Partnership
2003 - Carpathian Convention
2005 – Global Change and Mountain Regions research strategy
2008 – Science for Carpathians
2009 – SEEmore – South Eastern European Mountain Research Network
Future research priorities
Global Change and Mountain Regions

RESEARCH STRATEGY

Climate
Land Use Change
The Cryosphere
Water Systems
Ecosystem Function and Services
Biodiversity
Hazards
Health Determinants and Outcomes
Affliciting Humans and Livestock
Mountain Economies
Society and Global Change

Global Change and Mountain Regions

RESEARCH STRATEGY

Ecosystem Function and Services

• **Role of Alpine Areas in N and Water Cycles**: to understand how biogeochemistry changes under different climate change, land use and pollution scenarios, and how these changes affect ecosystem services, and to investigate the relative importance of those external drivers.

• **Role of Forest in C Cycle and Resource Production**: to predict the amount of carbon and the potential yield of timber and fuel sequestered in forests under different climate and land use scenarios.

• **The Role of Grazing Lands in C, N and Water Cycles, Slope Stability and Household Economy**: to predict the future structure and function of mountain grazing lands along with the likely impacts on material cycles, geomorphic processes and household incomes.
Ecosystem Function and Services

- **Soil Systems**: to assess and understand the impact of global change on soils (evapotranspiration, soil organic matter levels and pools, carbon store, and biodiversity - in particular keystone species or species with unique functions such as symbiotic microorganisms).

- **Pollution**: to explore the effects of changing and increasing levels of organic chemicals on physiological, species, community and especially ecosystem-level processes.

- **Plant Pests and Diseases**: to predict the future abundance, distribution and impacts of pests and diseases on natural and cultivated systems.
Key messages for research
Key information needs
Key gaps
Most urgent research topics in Carpathians

- Air pollution impact to functions of mountain ecosystems
- Massive spruce forest dieback – common and most pressing concern for the entire region
- Grassland habitats were found most threatened due to the loss of cultural and historical landscapes
- Consequences of land cover and land use changes for ecosystem services and biodiversity
Section Ecosystem Services and Human Well-being

- to develop a clearer understanding of multiple ecosystem service concept and approaches for their evaluation;
- to develop novel non-market methods to evaluate ecosystem services
- importance of institutional analysis and new forms of governance with more active public engagement in decision-making related to ecosystem services;
- to comprehend local knowledge and consult relevant stakeholders and the public on sustainable use and management of ecosystem services
- climate change and biodiversity issues are the cross-cutting themes that merit more attention also by socio-economy and policy science
Recent EEA publications on mountains

Europe’s ecological backbone: recognising the true value of our mountains

10 messages for 2010
Mountain ecosystems