Ecosystem approach in soil protection and land management

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Introduction

Forums

- Soils in the Ecosystem, Monitoring, and Conservation. Assembly meeting of CNC EAS. May 18, 2004, Saku
- Soil Conservation Issues in Nordic Countries. ESSC Conference. May 25-25, 2005, Tartu

Society's perception of soils

- The more conscious part of society, knowing and respecting well known global theses in relation to soil conservation, is often not able to appreciate adequately their validity or invalidity on local level
- Media often exaggerates global problems forgetting very essential problems of local area
- Estonian society needs a well-defined and realistic conception on land management, where the global and local soil managing strategies are balanced

Objectives

- to analyze soil functioning in composition of various types of ecosystems => for ecologically sound management and protection of soils
- to show possibilities for more detailed treatment of soils role in environment and ways for its introducing into every day practice
- to demonstrate the indicative role of epipedon in soil cover functioning
- to introduce the environment protection ability (EPA) of soils => for accentuation of environmental concerns of soil cover

General principles

- In characterization of soil functioning the ecosystem approach was used; the functioning of soil is observable in composition of ecosystem
- The mutual causal relationships between soil and plant covers were tested on the base of ecosystems' phytoproductivity and fluxes of organic carbon (input & output) in soil ⇔ plant system
- The relationships between soil and plant covers are site specific i.e. are influenced by local meteorological conditions
- The problems are treated from the pedocentric viewpoint

Climatic conditions

- In region the ***frigid udic*** and ***frigid aquic*** pedoclimatic conditions are dominating; in reduced extent ***frigid ustic*** conditions may be found
- Temperature: *gelic : cryic : **frigid** : mesic : thermic : hyperthermic*
- Moisture: ***aquic : udic : ustic :*** *dry&torric&xeric*

Macroclimate => (modified by landscape) mesoclimate => (modified by soil cover) microclimate => (modified by soil status) pedoclimate

Acting by principle of locality

- By soil convention - the soil cover composition in every pedoclimatic region has certain individual properties peculiar only to this region. This emphasizes the importance of local know-how on land use, land tillage, fertiliser load etc
- Therefore, we must save a valuable experience acquired by our fathers, but we are obligated to add to this present day scientific advantages

Land use

- From the total soil cover (42,400 km^2) 48% are forest, 27% arable, 7% grassland and 18% other soils
- During previous century in typical to Estonia landscapes with dispersed settlements around villages for agricultural use the best soil varieties by their texture, moisture conditions and fertility are taken
- In most parts of Estonia the optimum in land use is reached. But everywhere certain corrections on land use are needed (reforestation low fertile fields, amelioration of *Gleysols* etc.)

Role of soil cover

- Soil cover determines the pattern of natural terrestrial ecosystems, the agricultural activity of society (spreading of arable, semi-natural grasslands and forest areas) and ecologically sound methods for the exploitation of land resources
- On forested and semi-natural areas the leading role in forming and functioning ecosystems belongs to the soils
- On arable areas the fluxes of organic matter depend besides soil properties on management conditions (from low to high input)
- The composition of soil cover, its productivity, biological activity and its influence on the environmental status of area are globally very different and site specific

Composition of soil cover

- Easy attainable large scale (1:10,000) soil maps
- The decreasing order of soil groups in Estonia are:
  - (1) on arable lands: *Cambisols, Albeluvisols, Luvisols, Gleysols, Histosols* and *Podzols*
  - (2) on forest lands: *Gleysols, Histosols, Podzols* and *Cambisols*
  - (3) on grasslands: *Gleysols, Cambisols, Histosols, Luvisols and Fluvisols*
- Most of arable lands are gained from forest area with hard work
- To avoid of disharmonies between our endeavour and local site conditions the local soil cover should be taken into account

Soil humus status

- Each soil type has a certain specific humus status, which depends on soil properties (texture, moisture conditions, calcareousness) and in arable lands on soil tillage technology
- The main quantitative parameters of soil humus status are humus content, stocks, and distribution in soil profile. The regulation of these features is possible mainly in the epipedon. The tools for this in cultivated areas may be crop rotation, tillage methods, liming, water regime regulation, soil loosening and others
- The quality of humus is determined by epipedon type

Biodiversity of the area caused by soil cover

- geodiversity ➔ pedodiversity (*via* soil forming processes)
- pedodiversity ➔ biodiversity of plant cover (in natural ecosystems formed *via* succession processes)
- The induced by pedodiversity biodiversity is observable in low input soil management
- In high input agriculture the hereditary biodiversity is over shadowed by anthropogenic impact
- The disharmonies between induced by geodiversity and depending on this pedodiversity and biodiversity should be overcome by pedo-ecologically proved management

Soil constraints

- The constraints of soil (or soil cover) are features or circumstances (deficiency, shortcoming, disability) which hinder (limit, prevent) the optimal functioning of soil and to reach it normal productivity level

- By Kõlli, R., Ellermäe, O. & Rannik, K. 2006. Soil cover constraints and degradation in Nordic rural areas. *Archives of Agronomy and Soil Science,* **52***:* 139—147*.*

Main constraints decreasing soil cover productivity and functioning in pedo-ecological conditions of Estonia.

Soil constraints	% on total area	% on arable area
Low sum of efficient temperatures	100	100
Water-logging (high ground water level, perched water)	43	51
Thin or poor in organic carbon epipedon	8	<5
Extremely coarse (skeletal) soil texture	1.5	<0.5
Presence of lithic horizon in topsoil	1.2	0.8
Very highly variable and contrast soil contours pattern	2-3	7-8
Soil compaction	5	21
Eluviation, podzolization, acidification	15	21
Water and snow melt erosion hazard	2	8-10
Creeping and formation of skeletal talus	<0.1	0
Flooding, inundation, ponding	2.3	<0.1
Wind erosion hazard	<0.5	2-3
Drought hazard	3	9

Soil degradation features (1)

The soil degradation is the deterioration of soil quality i.e. the partial or entire loss of one or more potential functions of the soil (Lynden van, 1997)

(1) Occurring on whole territory

- Destroying the soil type specific (normal) functioning
- Degeneration of soil type specific biological activity
- Diffuse pollution and contamination of soils
- New anomaly (deficiency or excess) in trace elements contents
- Loss of arable soils needed for self-providing of local inhabitants

Soil degradation features (2)

(2) Features deteriorating arable soils quality

- Depletion of soils from nutrition elements under the critical level
- Worsening soil humus status
- Compaction of arable soils
- Excessive non-controllable weeding
- Water and tillage erosion of soils
- Soil acidification caused by regional climate peculiarities
- Water-logging on formerly drained hydromorphic soils

Soil degradation features (3)

(3) Degradation connected with certain soil type

- Wind erosion on excessively drained sandy and peaty soils
- Water-logging and permanent anaerobic conditions
- Accelerated mineralization of peat on drained shallow *Histosols*
- Flooding of Fluvisols on coastal areas and river valleys
- Soil eluviation and podzolization (with acidification)
- Formation of thapto-humic and humus-illuvial horizons
- Formation of ironstone hardpan on strongly gleyed and peaty Podzols

Soil degradation features (4)

(4) Locally occurring soil degradation

- Soil pollution from point sources
- Blockage of natural drainage by road construction and building
- Formation of miscellaneous soils on mined areas
- Alkalinization of soils by fly ash
- Dumping of mining residues of oil shale and chemical stations
- Radioactive contamination of soils

Measures to prevent soil degradation

- The measures to prevent soil degradation are as numerous and various as factors, which cause the problem
- For prevention, mitigation or regulation degradation processes the ecologically proper land utilization, soil remediation (liming, fertilization, drainage, input additional organic matter), balanced nutrition elements cycling and locally suitable technology of conservation agriculture (minimum tillage, mulching) are used.
- In natural areas the matching of soil cover with suitable plant cover, and with crops on arable lands, is of decisive importance in the arrangement of sustainable land use.

Activities at the state level for prevention of soil degradation

- Introduction of sound measures for the sustainable use and protection of soils
- Enforcement of legislation for protecting fertile soils
- Ecological expertise of projects concerning to soils
- Programs for restoration of contaminated soils
- Enhancement of public awareness concerning the soil protection
- State supported programs for liming of arable soils
- Reconstruction of drained areas

Tasks of research and extension services for prevention of soil degradation

- To make the soil mapping materials available for land users
- Systematic monitoring of soils with information distribution
- Integrating the extension services with research institutions
- Creating soil survey institutions for information sharing and dissemination

Activities at the farm level for prevention of soil degradation

- Propagation of good local agricultural practice about sustainable soil use
- Investments into new technologies suitable for local soil conditions
- Using of large scale digitised soil maps for arrangement of land management
- Restoring vegetation around the buildings, roads and areas vulnerable to degradation
- Establishing field protective shelter belts

Activities at the personal level for prevention of soil degradation

- To take into account the environment protection functions of soils
- To reduce the sealing of soils with a high agronomic quality
- Try to respect knowledge and practice of local communities
- In planning of landscape the soil properties must be taken into account

Conservation agriculture

- The tools of conservation agriculture: equilibrated and exactly timed fertilization, establishment of suitable for soil crop rotations, consideration the soil's humus status and biological activity
- Very important (a key) problem is matching of soil cover with suitable plant cover

Environment protection ability of soils (1)

- The EPA of soil is an integrated capability of the soil cover to stabilize the functioning of the soil's ecosystem in the discharging of environmentally harmful fluxes of substances
- For evaluation of soils' EPA the soil humus status, texture, specific surface area, cation exchange capacity, calcareousness, thickness, biological activity and fabric of epipedon were used
- For an integrated evaluation of soil EPA (from I - good to V – weak) four aspects (biological, physical, soil climate and substratum) were analyzed separately
- The EPA of epipedon is determined first of all by the content and quality of soil organic matter, but the EPA of metric soil layer mainly by soil particle size composition and the presence of coarse soil material

Environment protection ability of soils (2)

- Soil management strategies, which lead to higher soil productivity, also enhances the soil's ability to protect environment. Soil EPA determined by more dynamic properties may be enhanced by environmentally sound land use
- Estonian soil cover has sufficiently soils (44% of arable lands) with high environmental rating providing a good possibility for developing intensively managed sustainable agriculture. Soils with high EPA are more resistant to negative influences, but those with a low EPA are highly vulnerable to degradation
- By Kõlli, R., Ellermäe, O. & Soosaar, K. 2004. Soil cover as a factor influencing the status of the environment. *Polisj J. Soil Science,* vol. XXXVII/1:67-75.

Conclusions (1)

- The management of soil resources should be arranged in accordance with need, awareness and scientific-technological level of society. For successful implementation of sustainable land use and in protection of soils against degradation the long-time experience of local farmers, the scientific researches about soils and causality of their degradation features (monitoring) are needed
- The best results in soil cover protection may be reached by a ecologically sound management of ecosystems. The soil cover is protected (or sustainable land use is attainted) in circumstances when soil fertility and functioning is maintained according to the soil type characteristics

Conclusions (2)

- The philosophy of soil conservation should be much more refined and scientifically proven on the ground of local ecological conditions and sustainable soil use on the detailed taxonomic or soil mapping unit level
- Soil cover should be taken as a medium through which is possible to improve the environmental status of the area. Therefore in all environmental and agriculture subsiding projects the role and needs of soils must be taken into account

Thank you !

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