POLICY BRIEF FROM THE SOILSERVICE PROJECT

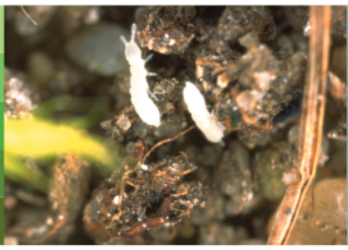
Soil as natural capital:
Agricultural production, soil fertility and farmers economy

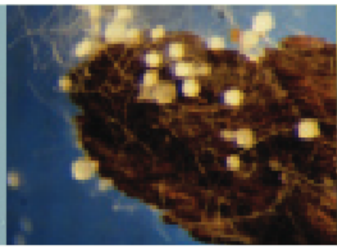
Intensification of agricultural production and shifts from extensive crop rotation towards monocultures has profound effects on soils and their biodiversity. Soils and soil biodiversity are the motor of all terrestrial production systems that generate ecosystem services such as *the provision of food, feed, fiber, clean water, and control of greenhouse gases and crop pests.* To enhance the EU's transition towards a greener economy, it is urgent to understand the impact of current farming practices on the biodiversity and sustainability of soil ecosystems.

The EU research project SOILSERVICE brings together natural scientists and economists who propose in this Policy Brief strategies for sustainable management of soil resources in Europe. We consider both security of income for farmers and society's demand for ecosystem services, particularly mitigation of climate change, reducing nutrient losses and control of crop pests and invasive species. SOILSERVICE addresses several key policy areas and strategies in the EU, and will contribute to the EU Soil strategy and a future Soil Directive, as well as the Common Agricultural Policy.

SOILSERVICE

SEVENTH FRAMEWORK PROGRAMME






How to produce commodities—now and in the future?

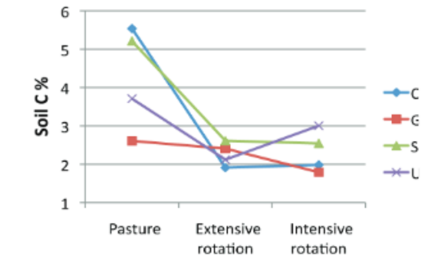
European soil biodiversity is pivotal for the production of food, fibre, biofuel, clean air, drinking water and carbon storage. However, the area of soil surface available for these different needs is limited and the production of e.g. biofuel will compete with the area available for food production and nature conservation. Soil contains an enormous diversity of organisms. Typically a single gram of soil contains over 5000 species of microbes. This biodiversity represents an enormous gene pool of potential benefit to humans, including new antibiotics and use in industrial products. Whats more, soil biota contribute to the delivery of all soil functions and are responsible for global cycles of carbon, water and nutrients. Biodiversity loss results in less complex soil communities with inhibited and even fewer functions. The ever increasing global demand for commodities and soil ecosystem services implies that improving soil management could be a key opportunity for supporting sustainable economic development.

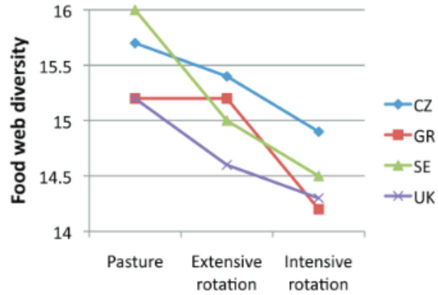
> **FACTS**
>
> Intensive agriculture influences:
> Soil carbon storage: declining at 0.5-1.0% per year
> Soil nitrogen retention: reduced by 50%
> Phosphorous uptake: reduced from 150 to 15 kg/ha per year
> Soil mixing by earthworms: reduced from 100 to 5 tons/ha per year
> Reduction of soil aggregates: > 50%

SOILSERVICE field site regions and long term experiments.

Declining soil biodiversity

Biodiversity and carbon decline with increasing farming intensity across European regions with different climates.

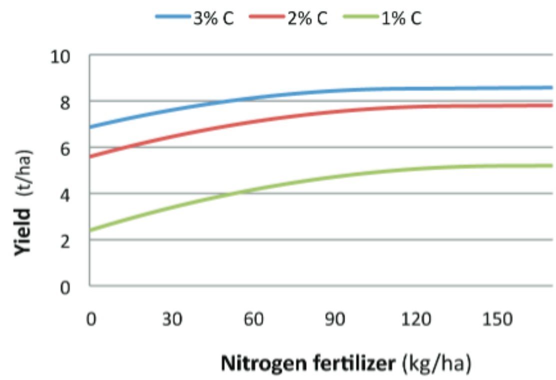




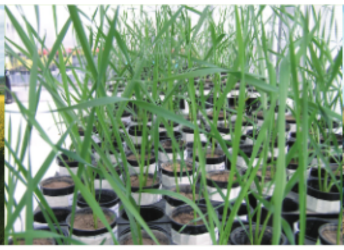
Decline of food web diversity and soil carbon with farming intensity.

Ecosystem services and the value of soil as natural capital

Soil biodiversity is the natural capital of farming. Soil organic carbon is the currency of this capital, as it determines the amount of soil life and consequently soil fertility and yields. There is also a positive relationship between soil biodiversity and control of greenhouse gases, retention of nutrients and biotic resistance to pests. Conserving and increasing soil organic matter is an investment in natural capital, because it will be beneficial for soil biodiversity and hence the continual generation of ecosytem services into the indefinite future.

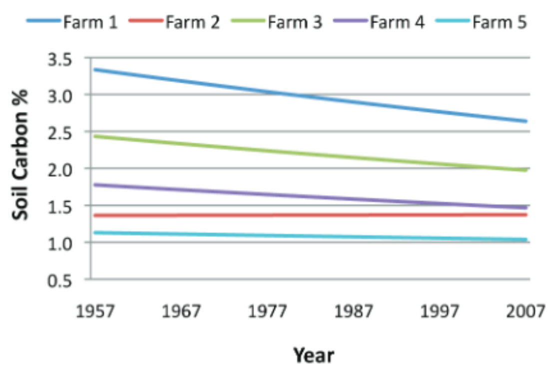


Production functions showing the influence of soil carbon on wheat yield

Long term perspective on economy and ecosystem service production

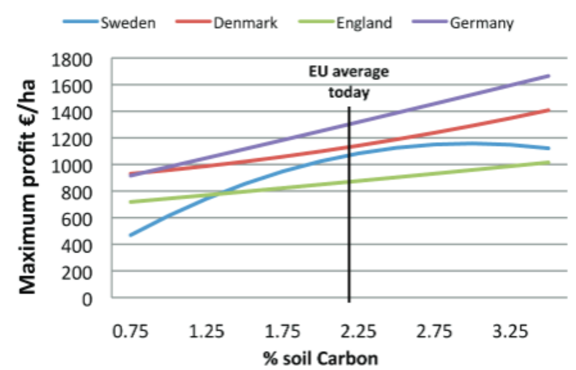
Arable farming in the EU is characterized by short rotations of annual crops (e.g. wheat, rapeseed, sugarbeets), high rates of fertilizer and chemical application, and absence of organic amendments (manure, grass break crops, straw, etc.). These practices result in degradation of soil biodiversity and declining soil carbon. The figure shows rates of carbon decline on five farms in southern Sweden that have been cropped using typical management practices.



Decline of soil carbon at five Swedish long-term farm experiment sites

CAN WE RESTORE SOILS AND PRODUCE MORE FOOD IN THE FUTURE?

Current arable farming practices in the EU imply that soil biodiversity will continue to decline and consequently the maximum yield will be lower. Investing in soil carbon will not only improve the sustainability of food production but also farmers' incomes. The figure shows how farmers' maximum income, in four arable regions of Europe, will increase with soil carbon. Not only do farmers benefit from higher yields but also from lower costs of inputs that are replaced by soil ecosystem services (i.e. improved fertility).



Value of soil carbon in producing farmers profits and use of fertilsers.

Management to promote soil ecosystem services in agriculture

Maintaining a permanent cover of plants or incorporating residues of plants and organic manure contribute to the pool of soil carbon. Cover crops and green manure provide not only retention of nitrogen but also add carbon to soils. Including fast growing grasses (e.g leys or bioenergy crops) in crop rotations improves soil fertility and retention of carbon and nitrogen. Low tillage promotes organisms such as earthworms and fungi that can improve soil structure and water infiltration.

Management Practise	C decline per year
Inorganic fertilisers	-0.5%
Farm yard manure (5 ton/ha)	-0.2%
Straw addition (3 ton/ha)	-0.2%
Management Practise	C increase per year
Cover crops	0.2%
Straw addition (12 ton/ha)	0.3%
Farm yard manure (35 ton/ha)	0.4%
Sewage sludge	0.9%
Miscanthus grass (bioenergy)	1.5%

FACTS

European dimension and contribution to EU policy

Soil biodiversity generates a range of critical ecosystem services and SOILSERVICE results indicate that future flows of these services are threatened by current intensive arable cropping systems. Since the benefits to farmers of conserving soil biodiversity occur in the future, it can be costly—in the short-term—to adopt the recommended conservation measures. Further, services such as carbon storage are a public good and hence unlikely that farmers will consider this value in their soil management decisions. As a result, there seems to be a case for policy intervention in the management of European soils.

Two particular complications need to be considered in the formulation of policy: First soils constitute natural capital that can only be built up over time, hence policy must have a long-term perspective similar to that of investing in infrastructure. Secondly, soils generate multiple services, hence policy should target variables that are correlated with services to the farmer as well public goods.

POLICIES BASED ON ECOSYSTEM SERVICES

In practice, monitoring flows of multiple services is likely to be infeasible and paying individually for potentially correlated services will be expensive for taxpayers. SOIL SERVICE shows that carbon is the common currency of soil ecosystem services—most soil ecosystem services are positively correlated with soil carbon. Under these circumstances a single policy instrument for multiple soil ecosystem services could be based on soil carbon content and long term comittment.

CARBON PAYMENTS

Rewarding farmers for increasing soil carbon would ensure cost-effective conservation of soil biodiversity, given a relevant measurement of carbon content. The payment could also be differentiated to reflect potential spatial variation in the value of particular soil services (e.g. nitrogen retention in regions suffering from water pollution). These payments should also be considered investment support and could decrease over time, since increasing soil carbon would also increase farmers' profits.

PERENNIAL GRASSES (BIOFUEL MARKETS)

If payments based on measurements of ecosystem services (i.e. soil carbon) are infeasible then an alternative approach would be to base the policy on land use. For example inclusion of perennial grasses in the crop rotation is an effective measure to conserve and regenerate soil biodiversity. Plants as perennial grasses provide good carbon resources to soil organisms and increase soil fertility when included in a crop rotation. If the biomass is also permitted to be harvested then farmers could also benefit from biofuel markets. In this way land use change could be financed by taxpayers to the extent that it is not covered by the market for biofuels.

Summary

Soils and soil biodiversity form the basis of agricultural production systems and generate a range of fundamental ecosystem services. Most obvious are yields of agricultural crops but soils also control greenhouse gases, retain nutrients, and combat pests and invasive species. Yet soil degradation is widespread in the EU: erosion, loss of soil organic matter, compaction and salinisation are some of the degradation processes that are threatening soil fertility. The SOILSERVICE project has quantified the negative impacts of intensive arable cropping systems on soil fertility—due to loss of soil organic matter and soil biodiveristy. With scenarios of future land use the project has predicted how soils can be better managed to improve the long-term incomes of European farmers, mitigate climate change and reduce nutrient and chemical inputs. This can be achieved by conserving soil biodiversity—the natural capital that generates ecosystem services. Ecosystem services link farmers' economic decision making with production, land use (food vs. biofuel), soil biodiversity and sustainability. This information can be useful for a broad range of decision and policymakers, in particular the ongoing reform of the Common Agricultural Policy, but also environmental policy.

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