DOWN TO EARTH – THE SOIL WE LIVE OFF

ON THE STATE OF SOIL IN EUROPE'S AGRICULTURE

ANDREA BESTE

COMMISSIONED BY MARTIN HÄUSLING, MEP

THE GREENS | European Free Alliance
in the European Parliament

IMPRINT

PUBLISHED BY

Martin Häusling, MEP/
European Office of the Federal State of Hessen
Kaiser-Friedrich-Ring 77
65185 Wiesbaden

Tel. 0611 - 98920-30
Fax 0611 - 98920-33
info@martin-haeusling.de

DESIGN

Dipl. Des. (FH) Annette Schultetus,
www.design-kiosk.de

FOR COPIES OF THIS PUBLICATION, PLEASE CONTACT

Ina Möllenhoff, Öffentlichkeitsarbeit
Tel. 0611 - 98920-30
Fax 0611 - 98920-33
info@martin-haeusling.de

AUTHOR

Dr. Andrea Beste

PRINTED BY

flyerheaven.de

VERSION DATED

October 2015

COVER IMAGE

Fotolia.de, Boden © eyetronic

CONTENTS

PREFACE BY MARTIN HÄUSLING

Farmers' unions in Europe like to look at the world through green-coloured glasses: they view all farmers as defenders of nature for whom sustainable cultivation of their most precious resource, the soil, is an absolute priority. Yet the results of several EU-wide research projects tell a different story: they reveal that the soils used for European agriculture are in a fairly sorry state, and that this is largely the fault of industrial farming practices.

Intensive farming, which has been held up as a highly productive solution capable of feeding most of the world from Europe, uses methods that are more akin to doping techniques for elite athletes than a sustainable, environmentally-friendly, efficient model.

Industrial farming achieves maximum output thanks to substantial inputs of external substances and energy, but this approach exhausts the most important resource of all, the soil. Like a patient hooked to a drip, the soil is being fed artificially. Though it is still able to function, increasingly frequent droughts and heavy rainfall are pushing it to its limits. Soil erosion is spreading and the soil is less and less able to purify groundwater, thus jeopardising another vital resource: drinking water.

Back in 2012, the EU research project SOILSERVICE (a partnership between 11 European universities and research institutes) came to the clear conclusion that intensive farming results in the loss of soil biodiversity. Monocultures, intensive fertilisation, frequent application of plant protection products and a lack of organic matter have all contributed to declining soil biodiversity and humus loss. Against this backdrop, the alarming erosion rates revealed by the JRC's latest study (published in 2015) hardly come as a surprise.

However, individual farmers do not farm in this 'inappropriate' way because they like it, or because these methods are all they know. Rather, as independent soil scientist and experienced agricultural soil conservation consultant Dr Andrea Beste writes in this very study, *"given the fact that producer prices are geared towards the world market, and the need to boost yields, individual farmers have virtually no leeway to attribute greater importance to other ecological soil functions. In view of the relatively meagre - and tendentially falling - value creation in agriculture, many farmers view boosting production and productivity as their only chance of securing their livelihoods".* Dr Beste makes it quite clear that soil degradation is caused not by the failings of individuals but by a flawed system.

I hope you enjoy reading this report.

Martin Häusling

1. WHY ARE HEALTHY SOILS SO IMPORTANT?

Soil is one of the key resources for plant, animal and human life on this planet. It enables vegetation to grow, thus controlling the Earth's climate. Without the purification function performed by soil, we would not have clean drinking water. Soils provide us with the most important elements for life (namely, foodstuffs) as well as the raw materials required for a wide array of other products. Humanity's ability to use this resource in a targeted way has formed – and still forms – the basis for the emergence of all world cultures.

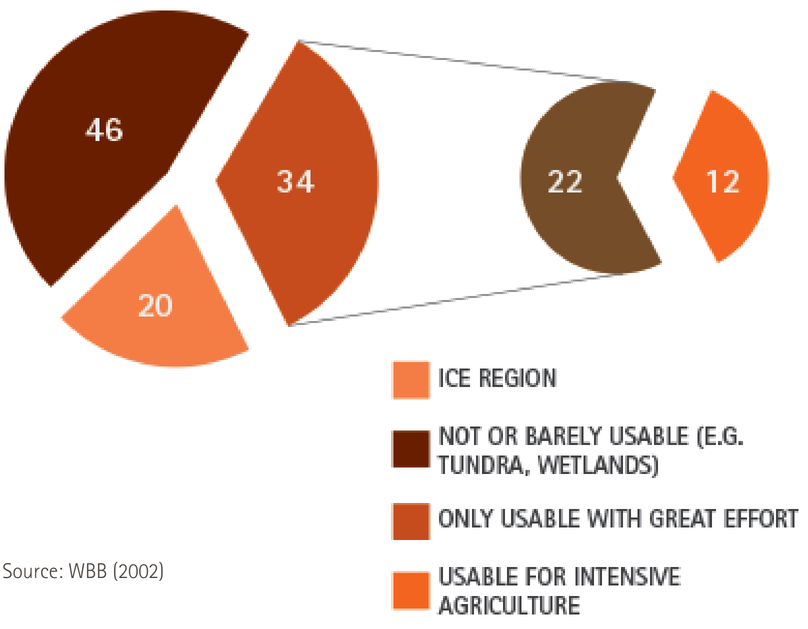
Soils are not static; they are dynamic natural bodies. Soils are formed when rocks on the surface of the earth are transformed by the climate and by a community of plants, animals and microorganisms. Processes like weathering, new mineral formation, decomposition, humification, structure formation and the movement and transformation of substances all take place over long periods.

Most of our planet's soils developed in the last hundred million years. Depending on the parent rock and the parameters (such as temperature and humidity), it can take between 20,000 and 200,000 years for one metre of soil to form. Soil is not a renewable resource. Yet only 12 per cent of the land on the planet is suitable for intensive farming, with a further 22 per cent only being suitable for limited agricultural use; the rest is composed of unusable land such as tundra or wetland (see Fig. 1). The percentage of usable land cannot be increased, which is precisely why soil degradation poses such a huge threat.

We often only realise that soil is degrading when it is already too late, as many soils are highly resilient to environmental burdens – particularly in the planet's middle latitudes, where the climate is less extreme. This could be one of the primary reasons why less attention is devoted to protecting soil than to protecting air or water.

Soil is not a renewable resource, and just 12 per cent of our land is suitable for intensive farming, with a further 22 per cent being suitable for limited agricultural use.

Fig. 1: Limited usage of the planet's land



Source: WBB (2002)

1.1 IS THE SOIL DISAPPEARING FROM UNDER OUR FEET?

Each year, 0.3 to 0.5 per cent of the world's usable agricultural land is lost to soil degradation. At the beginning of this century, a full third of usable land was so badly damaged that agricultural yields were affected[1]. As studies by the Institute for Advanced Sustainability Studies (IASS) in Potsdam have revealed, some 24 billion tonnes of soil are lost to erosion every year – approximately three tonnes for each member of the world's population. All told, soil degradation results in the annual loss of 75 billion tonnes of soil, costing the global economy USD 400 billion a year according to the latest ELD report2.[2]

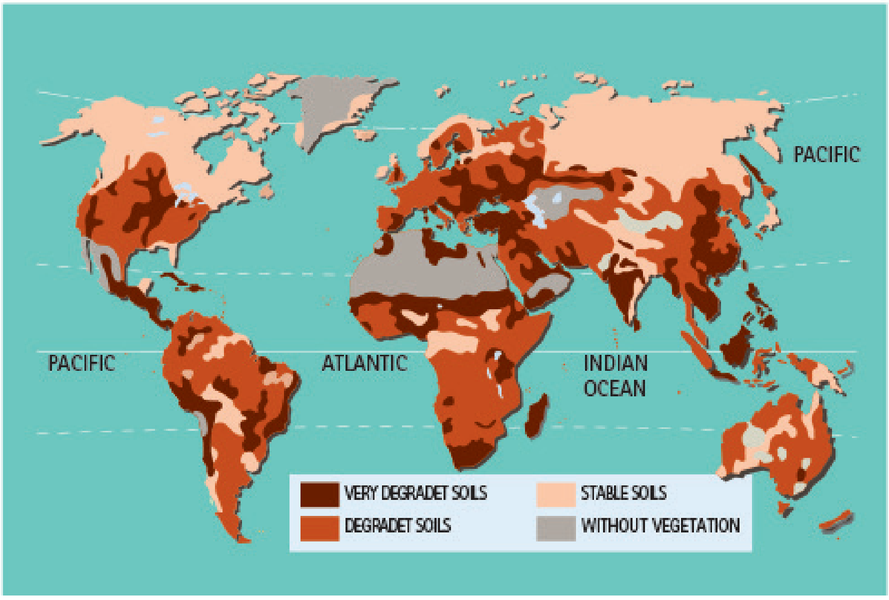


Fig.2: *Soil erosion is the greatest threat to our soils; soil cover has deteriorated especially severely in the steppes and dry savannahs*

Source: Montgomery (2010)

The rate of soil degradation is far outstripping the average rate of soil formation, by approximately 1.4 tonnes per hectare per year. Worldwide, we are losing soils 30 to 40 times faster than they can be recreated.

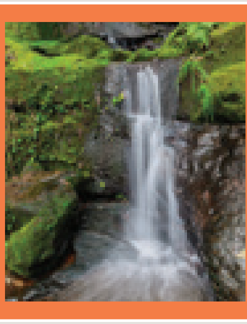
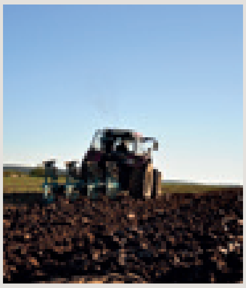
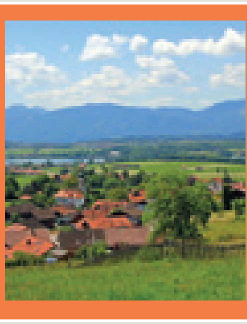
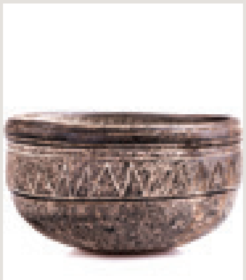
Worldwide, we are losing soils 30 to 40 times faster than they can be recreated.

Soil is extremely versatile: it serves as a basis for our food, provides a habitat for soil organisms, filters away harmful substances, protects groundwater and stores rainwater, thus acting as a defence against flooding.

1.2 SOILS ARE VITAL FOR MAINTAINING THE NATURAL BALANCE

Nowadays, soil is considered to perform five functions that are vital for a balanced eco-system. They can be defined as follows[3]:

Table 1: Soil functions

Habitat:	Habitat and means of subsistence for plants and animals	
Regulation and storage:	Filtering, buffering, storage and transformation of water and organic and inorganic matter	
Production:	Production of food, fodder and renewable raw materials	
Foundation:	Foundation for settle-ments, transport and sanitation	
Culture:	Basis of human history and culture	

Soil's effect on the climate – a frequent subject of discussion – needs to be seen as a special dimension of its regulation and storage function, since (viewed objectively) it has to do with the absorption, storage and release of organic and inorganic matter. However, it is also clearly linked to plant growth, and thus soil's production function.

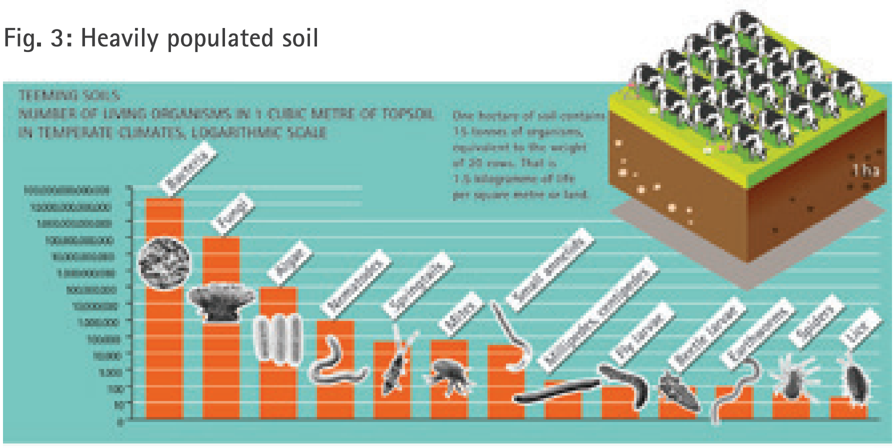
Soil scientists worldwide agree that in order to be sustainable, any form of soil use must allow these functions to be performed in the long term. Consequently, to enable sustainable, ecologically and economically viable productivity far into the future, soil use systems should not merely focus on soil's production function; they must pay greater attention to soil's habitat and regulation functions[4], which are all too often neglected at present.

Soil's three ecological functions – habitat, regulation and production – are key to ensuring a dynamic balance in ecosystems from the standpoint of both the natural balance and agricultural production. Human life is directly dependent on this balance.

1.2.1 SOIL AS A HABITAT

One gram of healthy soil can contain up to 600 million bacteria of various species, not to mention fungi, algae, single-celled organisms, pinworms, earthworms, mites, woodlice, springtails, insect larvae, and so on. If this is projected across an area of one hectare, the live weight of all the organisms in the soil would be around 15 tonnes, or the weight of 20 cows[5].

Fig. 3: Heavily populated soil

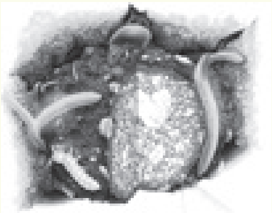


Source: WBB (2002) and LUA-Infoblatt 13, North Rhine-Westphalia Environment Agency (2003)

One gram of healthy soil can contain up to 600 million bacteria of various species, not to mention fungi, algae, single-celled organisms, pinworms, earthworms, mites, woodlice, springtails, insect larvae, and so on.

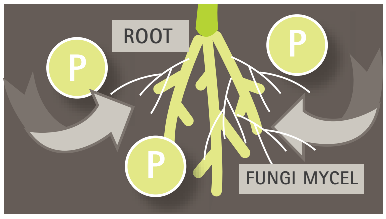
HUMUS COLLOIDS/ HUMIC SUBSTANCES

Just like the parent rock the soil organic matter – which consists of decomposing plant and animal residues – also undergoes a conversion. This is carried out by soil life (edaphons): small organisms such as earthworms, springtails, mites and fly larvae and microorganisms such as bacteria, algae and fungi, which break up organic matter mechanically before breaking it down chemically. The products resulting from this process include minerals, various carbohydrates, proteins and other compounds. Depending on the extent to which these substances are further transformed, they may then form humic substances (humus colloids).



Source: Annie Francé-Harrar: Bodenleben und Fruchtbarkeit. Bayerischer Landwirtschaftsverlag (1957)

Fig. 4: Mycorrhizal fungi



Mycorrhizal fungi colonise plants' roots. They help plants to take up nutrients, particularly phosphorus. They are harmed by mineral fertilisers.

Scientists estimate that at least a quarter of all the world's species live in the soil. This means that there are more living organisms in a single handful of earth than there are humans on the planet.

Microorganisms and soil-dwelling animals are part of a complex food web: they break down organic matter and form new substances – either food for other soil organisms and plants, or humic substances that positively influence the soil structure and facilitate the exchange of matter.

Just like the parent material, the soil organic matter – which consists of decomposing plant and animal residues – also undergoes a conversion. This is carried out by soil life (edaphons): small organisms such as earthworms, springtails, mites and fly larvae and microorganisms such as bacteria, algae and fungi, which break up organic matter mechanically before breaking it down chemically.

The products resulting from this process include minerals, various carbohydrates, proteins and other compounds. Depending on the extent to which these substances are further transformed, they may then form humic substances (humus colloids).

Soil organisms actively loosen soil, or stick soil particles together with their mucus. They make a vital contribution to soil structure formation, encourage soil aeration and enhance the soil's capacity to absorb and store water. Their ability to break down organic pollutants, such as engine oil and pesticides, provides a considerable boost to the soil's own self-purification capacity. Furthermore, the symbiotic relationship between some soil organisms (mostly fungi and bacteria) and plants enhances the plants' uptake of nutrients – particularly phosphorus – and protects them from disease[6]. Mycorrhizal fungi are the best-known example of this.

1.2.2 SOILS FOR REGULATION

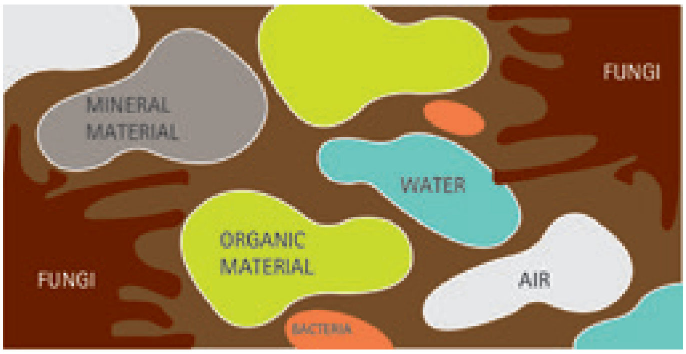
The soil's regulation function derives from its ability to absorb, sequester, convert or break down materials, including pollutants. As such, soil acts as a natural purification system for the water cycle. If soil is in good condition – i.e. not sealed, crusted or compacted – then most of the rainwater that falls on it infiltrates into it. A portion of it is naturally stored and is thus available to plants and soil-dwelling animals, while the rest seeps down and contributes to the formation of groundwater. In Germany, for instance, between 100 and 600 litres of water per square metre flow into groundwater reserves each year. The importance of this becomes clear when we consider that groundwater is the source of 65 per cent of Germany's drinking water. Sustainable soil management is therefore essential for our drinking water supply too. Assuming average consumption, it takes 256 square metres of unsealed, non-compacted, unpolluted soil to produce enough drinking water to meet one person's needs for a year[7].

Healthy soils are capable of absorbing three to five times their own weight in water. However, if soil is compacted, thus impairing its capacity to absorb and drain water, groundwater replenishment decreases too. The water runs off at surface level, which causes erosion (loss of fertile soil matter), flooding and all its consequences, as well as surface water contamination (soil particles, nutrients and pollutants are carried into lakes, streams and rivers, which interferes with their functions)[8]. Thus groundwater quality is determined by the soil.

Soil's capacity to purify itself depends on its quality. Soil filters, buffers and transforms pollutants, regardless of their origins, and its ability to perform this function is contingent upon the microorganisms present in the soil, the soil's humus content and the soil structure[9].

The substances that end up in the soil are treated by three main processes. The first of these is mechanical filtering of solid substances. This is a purely physical process, the effectiveness of which is determined by particle and pore size. The second of these processes is the adsorption and release of substances. When dissolved pollutants are adsorbed into mineral and organic soil colloids, they can be fixed. If they are released – which is undesirable in this context – they can return to the environment. A high humus content enhances the soil's capacity to absorb and purify substances, including pollutants. While this is good news for groundwater quality, it can lead to a build-up of pollutants in the soil in the long run. The third of the processes mentioned above is biological substance conversion, whereby the organisms living in the soil convert organic pollutants into other compounds[10].

Fig. 6:



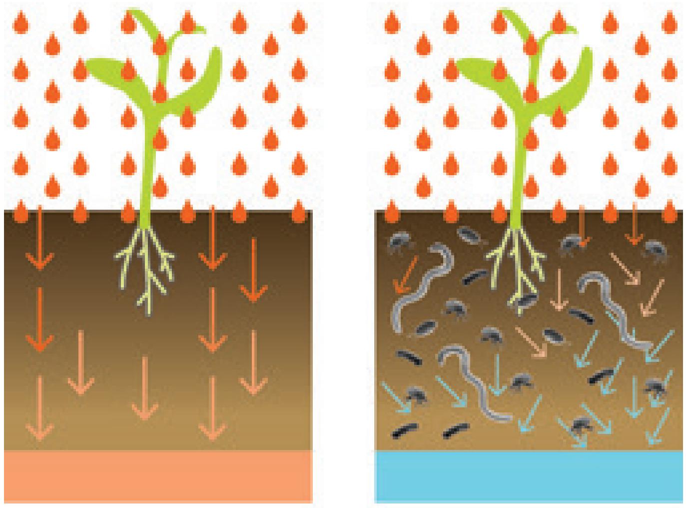
The biological purification process performed by soil is far more effective than the physical and chemical purification processes – as long as there is plenty of soil life. Any reduction in biological activity in soil thus has a decisive impact on the soil's ability to purify water.

Fig. 5: Soil's capacity to purify itself depends on its quality. Soil filters, buffers and transforms pollutants, regardless of their origins.

If soil is compacted, thus impairing its capacity to absorb and drain water, the water runs off at surface level and causes erosion and flooding.

The biological purification process performed by soil is far more effective than the physical and chemical purification processes – as long as there is plenty of soil life. Any reduction in biological activity in soil thus has a decisive impact on the soil's ability to purify water.

Fig. 7:



1.2.3 SOILS FOR PRODUCTION

Needless to say, soil's production function also has a major role in the natural and landscape balance. The effects of decreased soil fertility – in other words, the reduction of soil's ability to sustain plant growth – are most pronounced when vegetation fails to grow. This subsequently leads to erosion, a disrupted water cycle (no evaporation) and drought. Throughout the world, soil degradation through overexploitation is resulting in desertification at an alarming rate[11].

Healthy plant growth is an essential precondition for the vast majority of ecosystems. The nutrients and water stored in soil produce varied vegetation, which facilitates evaporation, air purification and CO_2 absorption. In conjunction with climate conditions, different soils can produce a broad variety of animals and plants: a genetically limitless reservoir that can also be used by humans. Soils with natural vegetation are carbon-neutral, meaning that they absorb as much CO_2 as they emit. However, due to both climate change and human usage, all that could well change.

Throughout the world, soil degradation through overexploitation is resulting in desertification at an alarming rate.

2. LESS AND LESS SPACE – SEALING AND URBANISATION

Every year in Europe, forests and agricultural land covering an area the size of the German capital Berlin are turned into urban space[12]. These areas are then no longer available for future food production. Moreover, their ecological functions are significantly curtailed.

In its 2002 joint study with the United Nations Environment Programme, "Down to earth: soil degradation and sustainable development in Europe. A challenge for the 21st century", the European Environment Agency wrote that[13]. **"the rates of real soil loss due to surface sealing through growth in urbanisation and transport infrastructure are high and similar in several EU countries, such as the Benelux, Germany and Switzerland. These countries are already so intensively urbanised that there is little space available for further expansion."**

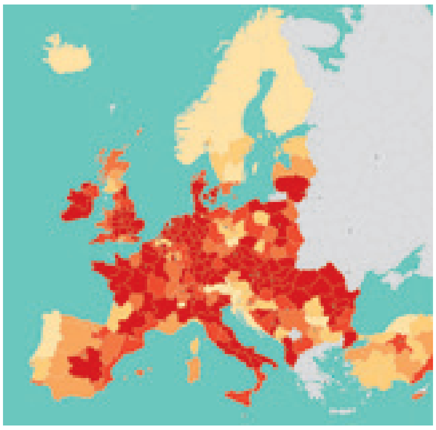
And yet sealing continues to increase. Between 2000 and 2006, approximately 116,000 hectares of land were converted into built-up areas each year. Urban areas and areas for industrial, commercial and recreational use accounted for around 70 per cent of this total, with circulation areas making up roughly another 10 per cent. The annual land consumption rate was approximately 19 per cent higher than for the previous period, 1990 to 2000[14]. More and more agricultural land is being turned into industrial estates, car parks, residential areas and roads, meaning it can no longer be used for food or biomass production.

"Mathematically speaking, just 50 years ago worldwide every individual had half a hectare (5,000 square metres) of land at their disposal to grow food, yet today this figure has halved to a quarter of a hectare, and by 2050 it will have shrunk further to just 1,000 square metres."
Thomas Strassburger, soil protection expert at the European Commission's Directorate-General for the Environment[15].

Near cities most of the land being swallowed up by urban sprawl is fertile, agricultural land, though forests and meadows are also falling victim to humanity's thirst for expansion. Not only does this have deleterious effects on our ability to produce food, it also entails the loss of valuable ecological functions.

Every year in Europe, forests and agricultural land covering an area the size of the German capital Berlin are turned into urban space. These areas are then no longer available for future food production.

Fig. 8: Land consumption – use of agricultural land to build settlements



Share of agricultural land (%) in the land used for built-up areas, 2000 to 2006

- Under 30
- 30 to under 60
- 60 to under 70
- 70 to under 80
- 80 to under 90
- 90 and over
- No data

Source: BBSR Bonn (2012)

In Germany, many of these urbanisation measures now need to be 'balanced out' under the provisions of the Federal Nature Conservation Act (BNatSchG). There are no such requirements in other EU Member States as yet. So far, efforts to comply with the Act in Germany have often resulted in hedges being planted, areas being forested, lake shores and riverbanks being renatured or traditional-style orchards being created. While these measures are sometimes both useful and welcome for biodiversity, applying them on productive agricultural land is not sustainable in the long term. In such locations, there should also be the option of switching over to organic farming as a balancing measure to prevent more valuable agricultural land from being taken out of production. In Germany, the federal state of Lower Saxony is a real trailblazer in this respect[16]. It all boils down to this: there need to be strict limitations on land consumption, especially when it comes to valuable agricultural land.

3. SOIL AS AN INVESTMENT – LAND-GRABBING EVEN IN EUROPE

> In a study currently being conducted on behalf of the European Parliament, the authors show that land-grabbing does not just affect Africa, Asia or South America; it is a real issue in Europe too.

In a study currently being conducted on behalf of the European Parliament, the authors show that land-grabbing does not just affect Africa, Asia or South America; it is a real issue in Europe too. Land-grabbing is being practised with varying intensity and is particularly (though not exclusively) concentrated in eastern European Member States. Many land-grabbing purchases are made by new groups of actors (e.g. from the banking sector) and, increasingly, land brokers. Some acquisitions are connected to the formation of agro-holdings of unprecedented size. The study clearly states that the current structure of the Common Agricultural Policy (CAP) also contributes to land-grabbing. This is particularly true of area-based direct payments, which have not been capped: they are often simply paid to farmers without them needing to do anything legally defined in terms of protecting of public goods and resources, and end up in the pockets of the landowners[17].

In principle, for the purposes of sustainable soil cultivation, it makes no difference who owns the land. However, if agricultural land ownership is concentrated in the hands of foreign investors with no agricultural background, this may pose a threat to the multifunctionality of European agriculture since ownership by such actors is often associated with structures that run contrary to sustainable regional development.

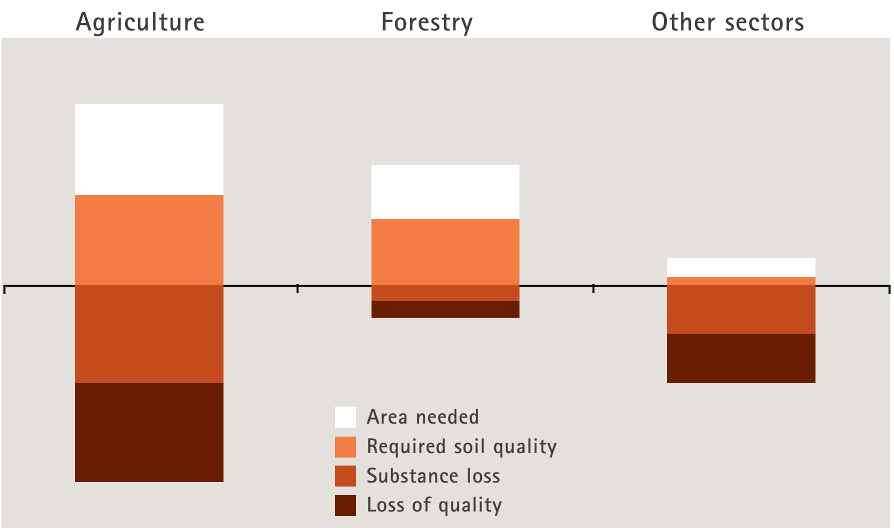
Where multifunctional agriculture and sustainable regional development are concerned, it matters a great deal whether a farm is simply an investment for tax or speculation purposes, or a regionally-integrated producer that contributes its products to the local processing and marketing chain[18].

The same goes for soil: if it is treated as a speculative acquisition made solely for the purpose of short- or medium-term profit, then there can hardly be any interest in long-term, sustainable cultivation. After all, hedge funds do not invest in soil consultations for their farmers, or in the land's capability to perform its ecological functions. The purity of a region's groundwater is of extremely limited interest to an investor a thousand kilometres away. That is why the scale of land concentration in Europe is not simply a socio-economic issue, but also a threat to the quality of our soil and water resources[19].

4. BURNED-OUT SOILS: HOW FARMING AFFECTS SOIL FUNCTIONS

Compared to other sectors, agriculture places by far the heaviest demands on the soil (see Fig. 9)[20].

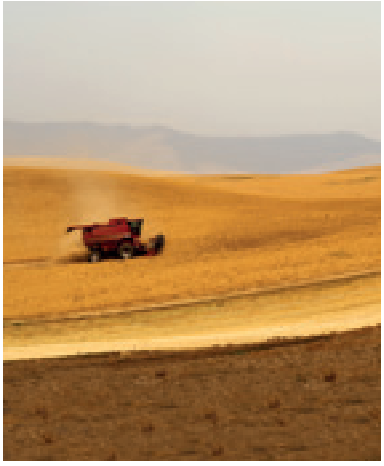
Fig. 9: Schematic comparison of the demands placed on soil through use by various sectors



Source: Lingner / Borg (2000)

Compared to other sectors, agriculture places by far the heaviest demands on the soil.

In recent decades, industrialised countries have perfected methods of making the soil produce ever greater quantities of biomass. In the past, the loss of soil fertility was the first indicator of soil degradation in an agricultural context. Nowadays, however, the early signs of soil degradation are masked by mineral fertilisers and other additives, making



This single-minded focus on cultivation, at the expense of all other soil functions, is clearly not an appropriate way of sustainably producing food and safeguarding our resources in the long term.

In view of the relatively meagre - and tendentially falling - value creation in agriculture, many farmers view boosting production and productivity as their only chance of securing their livelihoods.

it difficult to tackle the problem until it is too late. Although harvests are still acceptable, intensive agricultural usage results in ever-greater disruption of other soil functions.

In current agricultural practice, by far the greatest emphasis is placed on the production function. Given current agricultural policy, the fact that producer prices are geared towards the world market, and the need to boost yields, individual farmers have virtually no leeway to attribute greater importance to other ecological soil functions. In view of the relatively meagre - and tendentially falling - value creation in agriculture, many farmers view boosting production and productivity as their only chance of securing their livelihoods.

The overexploitation of the soil often associated with this approach constitutes a de facto abandonment of the traditional sustainable treatment of our soil, as practised for generations in agriculture. The resulting problems, like soil compaction and reduced soil fertility, have only been tackled on a short-term basis so far, by means of intensive fertilisation. However, it is becoming increasingly obvious that this practice is causing the breakdown of many soil functions. This single-minded focus on cultivation, at the expense of all other soil functions, is clearly not an appropriate way of sustainably producing food and safeguarding our resources in the long term.

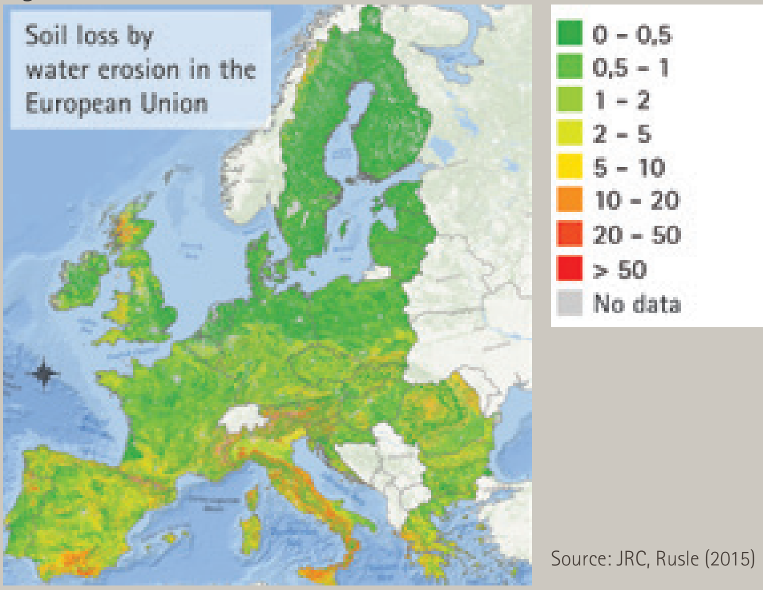
In some parts of southern, central and eastern Europe, soil degradation is so severe that it has led to the reduction of the soil's capability to support human communities and ecosystems, and to desertification. The actual extent of soil degradation is not known due to data limitations, especially in central and eastern Europe[21].

4.1 EROSION AND FLOODING

Around 970 million tonnes of fertile soil are lost to erosion each year in the EU. That is enough soil to raise the level of the entire city of German capital Berlin by 1 metre. Sixteen per cent of Europe's land area is at risk of erosion: in some parts of southern Europe, soils have been completely lost to erosion. Many soils are threatened by erosion in northern Europe too: in the agricultural regions in the north of Europe's loess belt, and especially in areas where high-quality, erosion-sensitive soils are being intensively farmed, erosion is becoming an increasingly serious (and, sadly, underestimated) problem. Since there are no standardised measurements for soil erosion rates for the European continent, data for the whole of Europe are currently derived from modelling-based exercises.

In 2012, the European Commission's Joint Research Centre (JRC) calculated that the rate of soil erosion by water in the EU-27 was 2.76 tonnes per hectare per year[22]; the current rate is 2.46 tonnes. The mean erosion rates are far higher in southern Europe, but also in the United Kingdom, where they have fluctuated between 1 and 20 tonnes per hectare per year. A recent report by the British Committee on Climate Change (CCC) indicated that soil degradation and erosion are occurring to an unjustifiable extent in many parts of the UK[23]. The latest JRC study concluded that erosion by water alone has resulted in soil loss of 1.75 tonnes per hectare per year for Germany's agricultural land[24].

Fig. 10

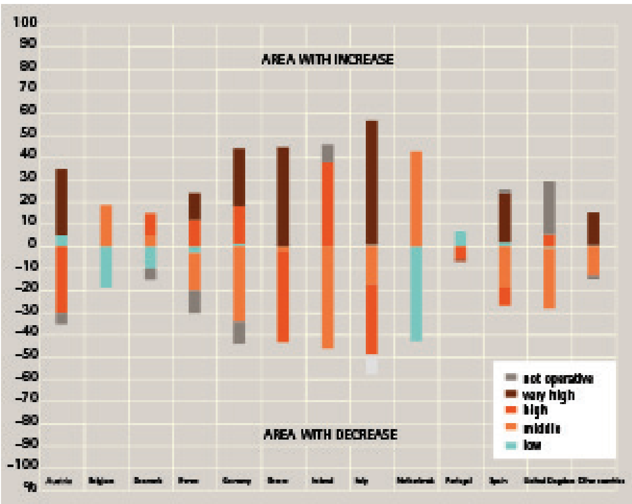


Source: JRC, Rusle (2015)

In 2012, the European Commission's Joint Research Centre (JRC) calculated that the rate of soil erosion by water in the EU-27 was 2.76 tonnes per hectare per year; the current rate is 2.46 tonnes. Climate models indicate that erosion due to rain could increase by 10 to 15 per cent by 2050.

Moreover, the European Environment Agency (EEA) believes that the erosion risk will increase further (see Fig. 11). Climate models indicate that erosion due to rain could increase by 10 to 15 per cent by 2050.

Fig. 11: Projected changes in water erosion risk in agricultural areas in the period 1999–2050 as a percentage of the total land area



Source: EEA/UNEP (2002)

While the economic impact of erosion is not often analysed, some data are available. It is estimated that worldwide, around EUR 18 billion of nutrients are washed away by erosion each year[25]. In 2003, the European Environment Agency came up with the following figures for the cost of erosion in Europe's agricultural areas[26]:

Damage to soil's ecological functions due to local erosion by wind and water (on-site effects): EUR 53/ha

Effects on nearby and more distant habitats due to nutrient and pollutant transfer (off-site effects): EUR 32/ha.

A study on extreme weather conditions affecting agriculture (conducted by the Thünen Institute of Farm Economics in Germany, among others) confirmed that the risk of ero-

Soil compaction caused by improper cultivation practices – a significant contributor to flooding – should be tackled first and foremost by appropriate farming strategies, with conversion to grassland being a last resort.

sion and flooding is set to rise in the coming years, with flood damage to crops expected to cost EUR 200 to 1,000 per hectare[27].

Annual flood damage in the EU-27 currently comes to EUR 6.4 billion. Around 250,000 people are affected by flooding each year[28].

Implementation of the EU Directive on the assessment and management of flood risks requires flood management plans to be drawn up by December 2015[29]. Alongside other flood protection measures, farms in areas at risk of flooding are expected to meet a number of cultivation requirements. However, converting farmland to grassland (one of the intended requirements) is certainly not the best solution. Soil compaction caused by improper cultivation practices – a significant contributor to flooding – should be tackled first and foremost by appropriate farming strategies, with conversion to grassland being a last resort. While it is important to avoid running excessively heavy equipment over the land when conditions are wrong this issue is not of primary importance. Above all, efforts must be made to overcome the structural compaction of many soils, which is aggravated by monoculture farming[30]. However, these options have been completely ignored by all relevant flood prevention strategies to date.

4.2 REDUCED SOIL BIODIVERSITY

Although the complex dynamics of soil biodiversity are not yet fully understood, there are indications that many plant protection products upset the balance of soil life. Pesticide use can have extremely negative effects on soil organisms, and according to some studies, certain herbicides substantially inhibit bacterial and fungal activity in the soil. Furthermore, excessive or exclusive application of easily soluble nutrients can seriously disrupt the biological balance and lead to a drop in soil biodiversity[31].

There is a lack of organic matter to sustain soil organisms. This leads to declining soil biodiversity and humus loss.

The SOILSERVICE project studied the impact of intensive agricultural use on soil ecosystem services throughout Europe.

The project results revealed that intensive farming results in the loss of soil biodiversity. Monocultures, intensive fertilisation, frequent application of plant protection products and a lack of organic matter to sustain soil organisms have all contributed to declining soil biodiversity and humus loss. The lack of organic matter in the soil then results in lower crop yields – and not the other way around, as some assume[32]. Even when yields are high, the organic matter left in the soil (roots, crop residues) is not enough to allow adequate humus formation. Besides, crop residues are generally used for other applications, so are not available either. Since their carbon content is much lower than their nitrogen content, widely-used organic fertilisers like slurry can only make a minor contribution to humus formation[33].

Although the impact of different farming methods is influenced by regional variations in climate and soil properties, the study's findings clearly demonstrate that declining biodiversity and biomass quantities are a repercussion of increasingly intensive farming throughout Europe. Climate change only serves to exacerbate the effect[34].

The SOILSERVICE project evaluated three farming systems which represent different intensities of soil use. The project studied the crop rotation methods 'pasture', 'extensive rotation' and 'intensive rotation', in the forms most prevalent locally, at study sites in four Member States (the Czech Republic, Greece, the United Kingdom and Sweden).

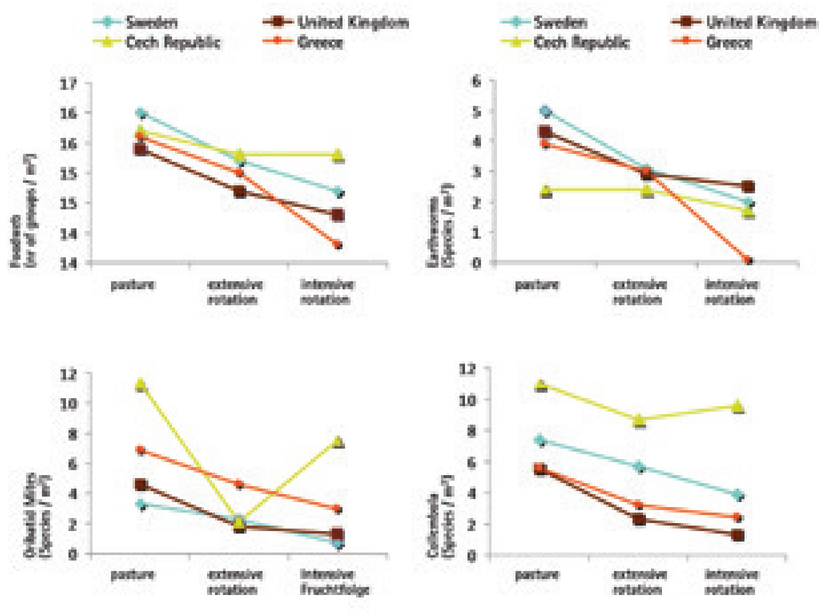
SOILSERVICE

The EU research project SOILSERVICE (EU 2008-2011) looked into strategies for balancing the conflicting demands of land use, soil biodiversity and the sustainable delivery of ecosystem goods and services in Europe.

The effects of the three intensity levels are shown in Figure 12.

1. The number of functional groups in the food chain
2. Earthworms
3. Small micro-arthropods (arthropods such as spiders, which eat decaying plant matter but are also predatory)
4. Collembola (springtails, which only eat decaying plant matter)

Fig. 12: Decline of functional groups in the soil food web based on the intensity of soil use



Source: SOILSERVICE (2012)

As we can see, increasing soil use intensity results in a drop in the populations of the studied organisms in almost every case. It seems that soil use intensity does not affect all of the studied organisms in the same way. Increasing intensity is even favourable for some groups, like bacteria and the organisms that feed on them (nematodes and amoeba) – their biomass grows, but their diversity does not necessarily expand too.

Increasing soil use intensity resulted in a drop in the populations of the studied organisms in almost every case.

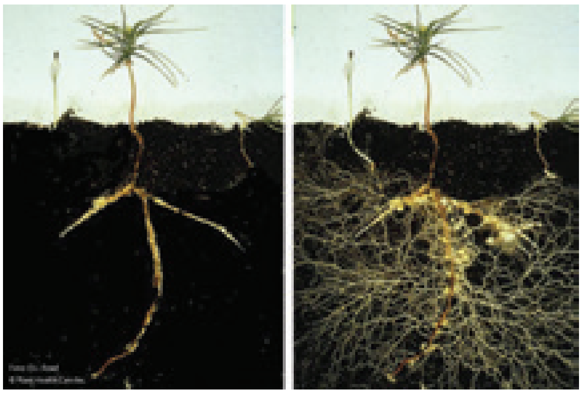
Intensive farming systems not only have a negative impact on the quantity (biomass and frequency) of most soil organisms, they also affect their biodiversity.

Increased soil use intensity results in a reduction in biomass in some associated groups in the soil food web, as well as the loss of their relationships with groups higher up in the web. A detailed study on nematodes showed that their 'metabolic footprint' declined as soil use intensity increased – in other words, their measurable biotic activity decreased[35]. Intensive farming systems not only have a negative impact on the quantity (biomass and frequency) of most soil organisms, they also affect their biodiversity and the diversity of their relationships with other species or groups, which weakens the overall structure of the soil food web.

So why is that cause for concern?

If there are fewer soil organisms, then their contribution to maintaining soil functions collapses, which compromises the soil functions themselves. For instance, fungal-based food webs show less nitrogen loss due to leaching[36]. They are also able to store more carbon in the soil[37]. The research conducted by the SOILSERVICE project showed that the organisms making up fungal-based food webs are especially vulnerable to the intensification of agriculture. Mycorrhizal fungi, in particular, are sensitive to fungicides and mineral fertilisers and their biomass declines drastically when they are exposed to these substances.

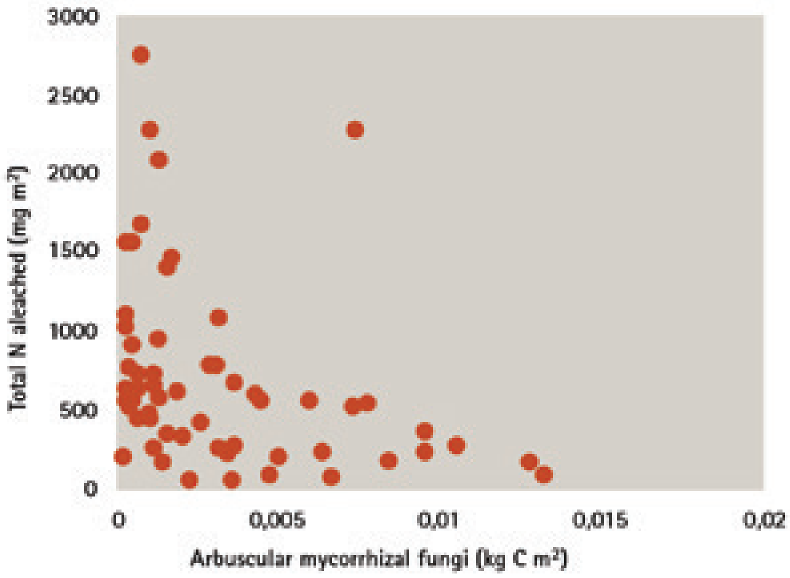
Fig. 13: Plant without (left) and with (right) mycorrhiza formation



Source: Plant Health Care Inc., Foto: D.J. Read

There appeared to be a direct correlation between increased nitrogen leaching and declines in the biomass of mycorrhizal fungi (see Fig. 14) and soil life in general. This was borne out by both field research and greenhouse experiments.[38]

Fig. 14: Negative relationship between mycorrhizal fungi and nitrogen leaching from soil



Source: SOILSERVICE (2012)

Mycorrhizal fungi play a significant role in supplying crops with phosphorus, as they can free phosphorus from the parent rock and make it available to the plants. If this function is no longer performed – as is the case for the most intensively farmed soils – then plants must rely exclusively on external sources for their phosphorus supply. Given that global phosphorus reserves are extremely limited and phosphorus fertilisers are tainted with uranium[39], this development poses a threat to both soil functions and food production.

Fungal-based soil food webs have many other benefits: they enhance soils' resistance to dryness and also emit less carbon in times of drought. Moreover, mycorrhizal fungi may also make crops more resistant to soil-borne diseases and some leaf diseases[40].

Microorganisms, soil animals and fungi are part of a complex food web: they break down organic matter and form new substances – either food for other soil organisms and plants, or humic substances that positively influence the soil structure and facilitate the exchange of nutrients. However, they also loosen the soil or stick soil particles together. As such, they make a vital contribution to soil structure formation, encourage soil aeration and enhance the soil's capacity to absorb and store water[41]. If there is less soil life, then this structuring function is not performed and soils compact more quickly.

When soil is compacted, it is less able to absorb and store water. The result is surface runoff and erosion[42], as well as water shortages in dry seasons.

Good soil structure

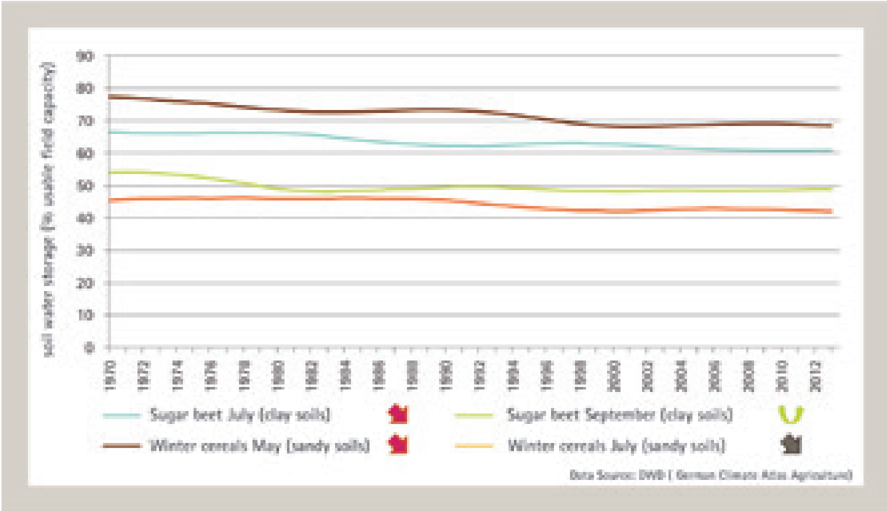
Poor soil structure

Source: Beste

When soil is compacted, it is less able to absorb and store water. The result is surface runoff and erosion, as well as water shortages in dry seasons.

For example, the data collected for Germany for 1970 to 2012 show a constant decline in the soil water supply for a number of different crops[43].

Fig. 15: Soil water supply in soils used for agriculture



A sufficient supply of water in the soil is a decisive factor for plant development. Where agricultural crops are concerned, both undersaturation and oversaturation at critical development stages can have a negative impact on yields. Over the last 40 years, we have seen a significant decrease in soil water stocks in both sandy and clay soils during vegetation periods.

Source: German Federal Environment Agency (UBA) (2015)

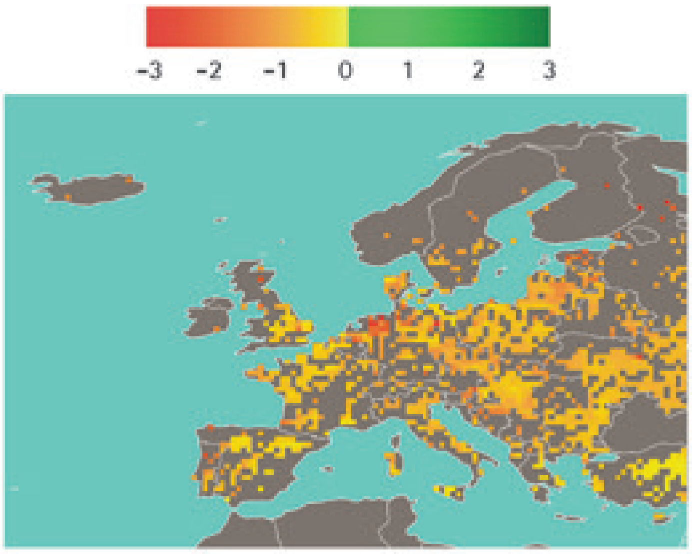
4.3 HUMUS LOSS

According to agronomists from the European Soil Bureau Network, soils that contain less than 3.6 per cent organic matter are in the early stages of desertification.

Soils used for intensive production exhibit much faster organic matter decomposition, and they are less able to store nutrients and carbon. The carbon content of agricultural soil is declining worldwide[44] – including in Europe[45]. When agricultural practices tend towards greater specialisation, monoculture and intensive use of mineral fertilisers, soil organic matter is not replaced in sufficient quantities. As a result, there is not enough decomposing matter in the soil to feed the soil life and proper root system development cannot occur. According to agronomists from the European Soil Bureau Network (ESBN), soils that contain less than 3.6 per cent organic matter are in the early stages of desertification[46]. The cross-compliance conditions for CAP direct payments call for a humus content of 1.0 to 1.5 per cent (depending on the soils' clay content): measured against the ESBN's findings, this would certainly seem to be insufficient for maintaining soil functions and enabling adaptation to climate change. As long as research projects focus on optimising yields rather than optimising soil functions in their quest to find the best possible proportions of organic matter for soils[47], the major effects of a sustainable humus supply (water storage, water purification, reduced nitrogen leaching, soil biodiversity) will continue to be neglected and accorded too little importance. We cannot afford this attitude as we seek to tackle the challenges of climate change, and it is certainly not compatible with the aim of creating resilient agricultural ecosystems that require fewer external resources (fertilisers and chemical plant protection products) and would thus help to protect the climate, the environment and human health.

A 2008 analysis by the Federal Institute for Geosciences and Natural Resources (BGR) found that 4 per cent of Germany's soils had a humus content of less than 1 per cent, while 30 per cent of the country's soils contained 1 to 2 per cent humus. Humus contents of 2 to 4 per cent were to be found in 47 per cent of soils, and 4 to 8 per cent in 15 per cent of soils. These calculations included forest and grassland soils, which are rich in organic matter[48]. Freibauer et al. (2004) carried out a simulation to determine how soil organic matter content would evolve in Europe between 2008 and 2012 were current agricultural practices to be maintained: the resulting values were almost all negative[49].

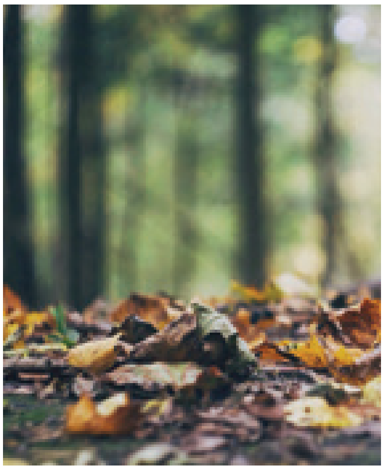
Fig. 16: Mean organic matter content in topsoil, agricultural land



Modelling results from the CAPRESE project suggest that prior assessments may have overestimated the soil organic matter content of Europe's soils by around a quarter.

Source: Freibauer et al (2004) and SOER (2015)

According to the findings of the SOILSERVICE project, the continued application of current agricultural practices will lead to a further decline in soil biodiversity. This will also mean a sharper drop in yields, which could actually be stabilised by fostering biodiversity. Moreover, the mineral fertilisers that are so widely applied today are not enough to maintain soil functions. The project report's authors come to the conclusion that soil cultivation that replenishes carbon and humus stocks would improve the sustainability of food production. Farmers' incomes would rise too (see Fig. 17), as this approach would enhance yields without requiring increased application of mineral fertilisers.

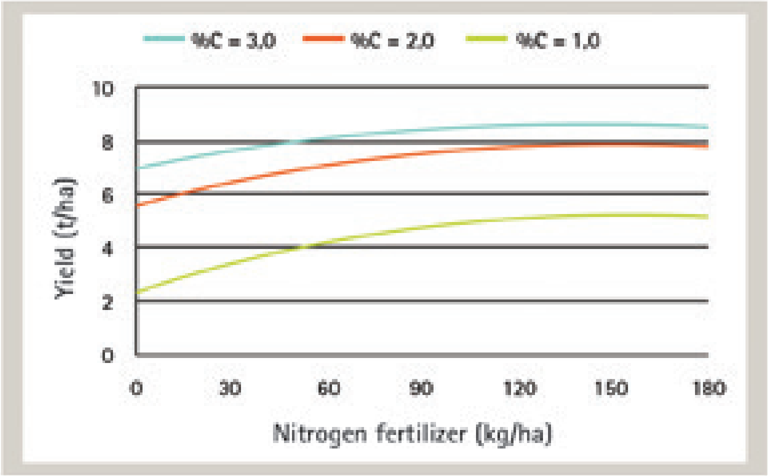


Mean values are much higher when forest and grassland soils, which are rich in organic matter are included.

Soil cultivation that replenishes carbon and humus stocks would improve the sustainability of food production, say the authors of the SOIL-SERVICE project report.

More humus, better yields!

Fig. 17: Yield response of winter wheat to N-fertiliser application for increasing concentrations of soil organic carbon



Source: SOILSERVICE (2012)

In view of these findings, it would be foolhardy to focus exclusively on intensifying agricultural production at the cost of soil ecology, which would result in the deterioration of soil functions.

4.4 MEDICINAL PRODUCTS IN SOILS AND WATER

Organic fertilisers like animal excrement (slurry and solid manure) and fermentation residues are commonly held to be valuable fertilisers. This assumption is not entirely correct in terms of their effect on soil fertility; it must be considered in a more critical way (see section 6.1.2). Furthermore, far too little research has been conducted into the potentially damaging effects on soil functions of the disinfectants and medicinal products (e.g. antibiotics or substances that can interfere with hormones, like endocrine disruptors) that these fertilisers may contain. Additionally, too few precautionary measures are imposed to counter these effects. The quantities of pharmaceuticals being released into the environment are unknown, and their behaviour in the environment has not been systematically examined (this applies, in equal measure, to human and veterinary medicinal products)[50].

Medicinal products used in agriculture do not undergo any form of purification treatment. Some of them are particularly toxic. Since they barely degrade, they then have the same effects in the soil.

The active ingredients in medicinal products are biologically highly active and were developed to affect organisms' regulation mechanisms: they can alter their metabolism, shift the hormonal balance and change how signals are passed from cell to cell. Of course, they do not just have this effect on the target group for which they were developed – if they end up in the environment, they affect any organisms. The lack of impact data and long-term research for many medicinal products is the primary reason that it is hard to grasp the full extent of the risks associated with the release of these substances into the environment. Nevertheless, there is unequivocal proof that certain pharmaceutical active ingredients have damaging effects on organisms in the environment[51]. Medicinal products used in agriculture can end up in the environment especially quickly and easily, as they do not undergo any form of purification treatment. Some of them are particularly toxic as they are intended to combat parasites and fungal infections in animals.

Since they barely degrade, they then have the same effects in the soil – or in aquatic ecosystems[52]. The uncertain effect on soil life is not the only issue associated with the antibiotics used in animal husbandry, which then end up in the environment – there is also the problem of increased antibiotic resistance[53].

For adequate precautionary management, medicinal products must be subject to stricter environmental impact tests during the licensing procedure, and their environmental effects must continue to be monitored after they have been licensed. Furthermore, animal husbandry methods that require livestock to be treated with medication in order to reach slaughtering weight (because their housing systems are not animal friendly) should be abolished – they are unsustainable and are not accepted by modern society.

Animal husbandry methods that require livestock to be treated with medication in order to reach slaughtering weight are unsustainable and are not accepted by modern society.

5. IMMER MEHR BIOMASSE AUF IMMER WENIGER FLÄCHE?

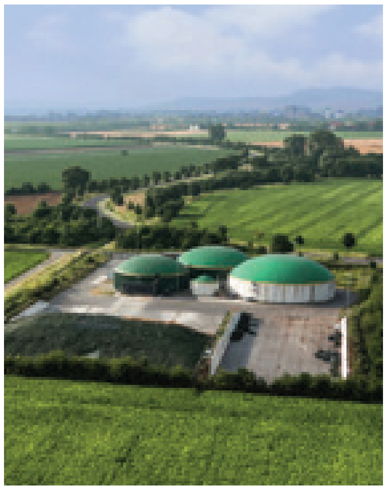
Do we really have enough space to grow not just food and fodder, but also biomass for use as an energy source and an industrial raw material?

The 'bioeconomy strategy' championed by the European Commission and a number of European economic representatives is intended to promote a switch from fossil fuels to bioenergy and a bio-based economy. This would have major consequences for large-scale land use, biodiversity and the sustainability of land use systems.

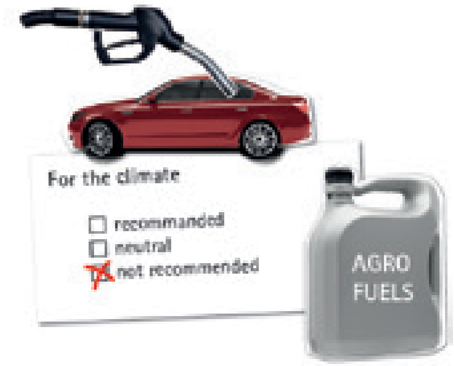
The authors of the SOILSERVICE project's final report warn that[54]:

"Production of bioenergy causes major land-use changes, adding a new dimension to the traditional conflict of using land for food production versus land for nature conservation. Intensification of agricultural production and shifts from a crop rotation to monocultures of crops for food and bioenergy has potentially profound effects on soil biota, soil biodiversity and landscape patterns across Europe. Soils used for intensive production have faster, mostly bacterial-driven, decomposition cycles that are less efficient in storing nutrients and carbon than natural soils. In addition, current climate change is predicted to increase the frequency of extreme weather events, potentially leading to severe nutrient leaching, soil erosion and further declines in soil organic matter and soil biodiversity."

Furthermore, when biomass is used for energy purposes, more carbon is taken out of the cycle (e.g. biogas generation: biogas = CH_4) but is not returned to the cycle in the form of fermentation residues, leading to further humus loss[55].



When biomass is used for energy purposes, more carbon is taken out of the cycle (e.g. biogas generation) but is not returned to the cycle in the form of fermentation residues.



It goes without saying that ecologically compatible food production must be PRIORITISED OVER use of biomass for energy or industrial raw materials.

When it addresses conflicting land uses, the SOILSERVICE report makes no explicit mention of the vast tracts of land taken up by fodder production – perhaps because this phenomenon is primarily found outside Europe for the time being.

But can we in Europe really turn a blind eye to the fact that the methods used in North and South American countries to produce fodder for European meat production (both consumption and export) are mostly based on far more intensive soil usage than is seen in Europe? Mean soil losses in the Midwestern USA have been calculated at 16 tonnes per hectare per year and estimates indicate that mean annual soil losses in Brazil and Argentina are between 19 and 30 tonnes per hectare[56].

So in a manner of speaking, Europe is 'importing' the soil degradation that is occurring in the Americas[57]. With that in mind, any attempt to address conflicting land use and ensure sustainable management of soil resources (and water resources too!) needs to look beyond Europe's borders.

For there to be any real prospects of a more widespread implementation of bio-based raw materials, then these materials must be produced in line with soil-friendly, agro-ecological concepts both in Europe and elsewhere in the world. As regards the highly questionable sustainability of using biomass for energy (sun and wind energy and, to some extent, even hydropower perform far better in this respect), it goes without saying that ecologically compatible food production must be PRIORITISED OVER use of biomass for energy or industrial raw materials (e.g. textiles, cosmetics, bioplastics). This is also vital from a soil conservation point of view.

This brings us to the question of how much agricultural land can be given over to meat production in future.

Pasture-based forms of meat production must therefore play a far more significant role in future, as they are very much superior to all other forms of meat production when it comes to:

- **making efficient use of land that cannot be used for agriculture;**
- **reducing the climate footprint (maintaining grassland);**
- **securing soils' humus content (grassland);**
- **and, last but not least, ensuring animal welfare[58].**

Pasture-based forms of meat production must play a far more significant role in future.

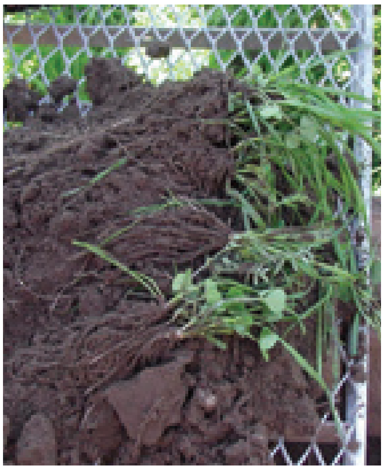
6. HOW CAN WE BETTER PROTECT OUR SOILS?

6.1 INDIVIDUAL MEASURES

6.1.1 EXTENSIVE CROP ROTATION AND INTERCROPPING

Crop rotation is part and parcel of good agricultural practice – or so you may believe. Every single farming textbook underlines the importance of alternating humus-sapping crops with humus-building crops, a principle that comes up time and again in training courses and at university.

Intercropping promotes root system development and increases biological activity, thus stabilising the soil structure. This comes about in two ways: firstly, the roots bind soil fragments; secondly, the roots provide a food supply for soil life (more so than the green mass that is later incorporated into the soil), whose biological activity structures and stabilises the soil fabric. This is especially true when an extensive, network-like root system forms throughout the entire soil profile (as with vetches, phacelia and plant mixes like winter-hardy rye and hairy vetch and the German crop mixture known as Landsberger Gemenge (hairy vetch, crimson clover and Italian ryegrass)). Such root system development can even loosen damp clay soils and make them more crumbly. Planting a simple intercrop like mustard, which only has a tap root, does not achieve this effect.



Catch cropping promotes root system development and increases biological activity, thus stabilising the soil structure.

Moreover, an increasing number of German agricultural journals are now recommending extensive crop rotation or the planting of intercrops like phacelia, Persian clover, Egyptian clover, crimson clover, false flax, cress or the plant mix known as Landsberger Gemenge as a means of loosening soil[59].

For many years, it was impossible to find any such recommendations in agricultural advisory literature in Germany.

Intercrops

An increasing number of German agricultural journals are now recommending extensive crop rotation or catch cropping as a means of loosening soil. For many years, it was impossible to find any such recommendations in agricultural advisory literature in Germany.

Intercrops boost the ecosystem's capacity for self-regulation by increasing biodiversity and encouraging antagonists. Among other things, this has the beneficial effect of limiting the need for pesticides. In fact, intercrops can even contribute to preventing plant disease and pest infestation. As a general rule, intercropping – and more specifically, the associated phenomena of more extensive crop rotation, better growing conditions and positive interactions (allelopathy) between individual plant species – reduces the negative impact of harmful organisms, particularly epidemic diseases affecting main crops and a wide variety of pests[60].

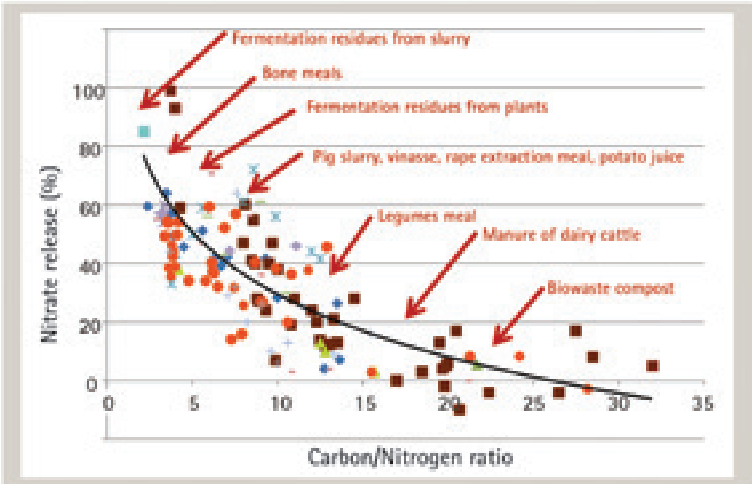
Maintaining the humus balance requires a steady supply of suitable organic matter to serve as food for soil organisms (nutrient humus) and form long-lasting humus colloids.

High-quality compost provides a mixture of nutrient humus and stable humus, making it highly beneficial to many soil functions.

6.1.2 ORGANIC FERTILISER AND COMPOST

Maintaining the humus balance requires a steady supply of suitable organic matter to serve as food for soil organisms (nutrient humus) and form long-lasting humus colloids[61]. Both are vital for stabilising the soil structure, preventing erosion and boosting the soil's water absorption capacity. One of the main reasons for the current rate of humus loss in agricultural soils is that not enough high-quality humus is being added to these soils to replace that which is lost. Plant residues from the main crop, mineral fertilisers or slurry are not enough to make up the loss[62]. Thus the positive effects of organic fertilisers cannot be replicated by mineral fertilisers. In principle, this also applies to slurry and fermentation residues of biogas production, since they provide soil life with fewer nutrients and are fairly ineffective when it comes to forming humus colloids. They are quickly soluble – and so fast-acting– plant fertilisers, but their low carbon-nitrogen ratio (not much Carbon and a lot of Nitrogen) means that there is a risk of rapid nitrogen leaching[63] (see Fig. 18). In many experiments, however, there was no humus loss when organic fertilisers were applied consistently, even when conventional soil cultivation methods were used[64].

Fig. 18: Statistical relationship between the C/N ratio of organic fertilisers and N release over a year, as revealed by field, pot and incubation experiments for estimating nitrogen availability



Source: Association for Technology and Structures in Agriculture (KTBL) expert discussion (2014)

Solid manure and high-quality compost provide a mixture of nutrient humus and stable humus, making them highly beneficial to many soil functions.

The various positive effects are[65]:

- greater aggregate stability, better soil structure;
- higher porosity, plus improved water storage and filtering capacities;
- increased biological activity;
- higher humus content;
- less vulnerability to erosion, protection against flooding;
- better temperature and pH balancing;
- higher nutrient transfer capacity;
- improved plant metabolism and better root formation;
- less susceptibility to disease among crops.

6.1.3 TERRA PRETA

For some time now, especially in Germany and Austria, there has been talk of an apparent agricultural innovation: Terra Preta. The idea is based on some soils of the Amazon region, which are extremely fertile and owe their black colour to their high carbon content[66]. 'Terra Preta' is often used as a name for a synthetic bio-charcoal substrate designed as a technical means of offsetting humus loss in our soils. Similar products are offered under the names 'Biochar' and 'Hydrochar' – while their production methods and properties are very different, they are commonly associated with the legendary, exotic 'Terra Preta'.

At present, it is not quite clear if Terra Preta improves soil conditions. One frequently-heard explanation is that its charcoal particles have a very large surface area, making them particularly effective at fixing humus and nutrients in the soil. This is certainly true, which is why charcoal produced by pyrolysis is so effective at increasing yields in sandy soils which would otherwise have a low capacity for water and nutrient exchange[67]. However, it is uncertain whether improving the soil by adding bio-charcoal is actually preferable to the traditional, centuries-old agricultural methods of balancing crop rotation and replenishing soil organic matter by treating the soil with solid manure, crop residues and compost.

There is still the question of whether these suspected improvements of soil conditions, yields and other agricultural factors justify the substantial amount of energy (and money) that goes into producing and adding pyrolytic charcoal, either in the short or long term. To be considered preferable to conventional practices that have proved effective in Central Europe (crop rotation and compost/manure application), Terra Preta would have to achieve the same positive impact on the soil whilst using less energy. Unfortunately, there is hardly any research offering a serious comparison of application of Terra Preta with these practices[68].

Terra Preta should not be used to treat the symptoms of poor agricultural practices.

Another key argument put forward by proponents of bio-charcoal is that it helps to reduce global climate change by removing carbon from the air. While it is true that agriculture needs to minimise its CO_2 emissions, it cannot gear its entire economic model towards balancing out CO_2 emissions from other sectors of the economy. Whereas transforming moors or grassland into agricultural land has a huge impact on the climate, the worldwide carbon sequestration potential offered by different crop management practices has no significant effect on the climate (even though they have considerable consequences for the soil)[69]. Lowering agricultural greenhouse gas emissions through sustainable animal husbandry (fewer animals per hectare and pasture-based husbandry systems) has far greater potential to improve the climate than using charcoal produced by pyrolysis.

While it seems that this technique is not particularly suitable for agricultural application, it may nevertheless prove beneficial in recultivation areas or in intensive vegetable and market gardening, but only if the production process, pyrolysis, is carried out with care (pollutants?)[70].

In the current agricultural system, a no-tillage approach is only feasible if total herbicides, insecticides and fungicides are applied. In view of this, and given that resistance to pesticides and herbicides is rising and the EU has launched a pesticide reduction programme, no-tillage cultivation is not an effective solution to our soil problems.

6.1.4 NO TILLAGE

Reduced tillage or no-tillage is often (and increasingly frequently) recommended as a way of enriching soils with organic matter and preventing erosion. However, less intense tillage does not benefit the soil – quite the opposite, in fact.

Main soil tillage processes:

- Conventional tillage: regular ploughing as part of basic tillage, mechanical weed control.
- Conservation tillage (synonym: minimum soil tillage): no ploughing, use of cultivators for loosening and/or mixing soil, mulch seeding, mostly chemical weed control.
- Direct seeding: no tillage whatsoever (synonyms: no-till/zero tillage), chemical weed control.

Source: Beste 2005

If the soil is not ploughed, then crop residues are no longer incorporated into the soil and the plant matter remains at the surface. Although this layer of surface cover does indeed protect the soil from erosion when it rains, the same effect can be achieved with intercrops or nurse crops, which perform the additional service of providing food for soil organisms and loosening and stabilising the soil with their roots. In the current agricultural system, a no-tillage approach is only feasible if total herbicides (particularly glyphosate, sold under the names Roundup and Basta in Germany), insecticides and fungicides are applied, as weed and pest presence increases substantially with this technique. In view of this, and given that resistance to pesticides and herbicides is rising and the EU has launched a pesticide reduction programme[71], no-tillage cultivation is not an effective solution to our soil problems. In July 2015, the Agra-Europe news service cited a survey conducted by agricultural publishers Beckmann-Verlag, which stated that contractors employed to cultivate soil believed that the future lay in "traditional ploughing for all types of soil", since increased herbicide resistance has apparently led to a renewed interest in mechanical methods of combating weeds[72].

Moreover, the soil analyses conducted by the author over twelve years of research, commissioned studies and workshops with field demonstrations[73] indicate that switching to conservation tillage or direct seeding often results in a more compacted soil structure (Fig. 19).

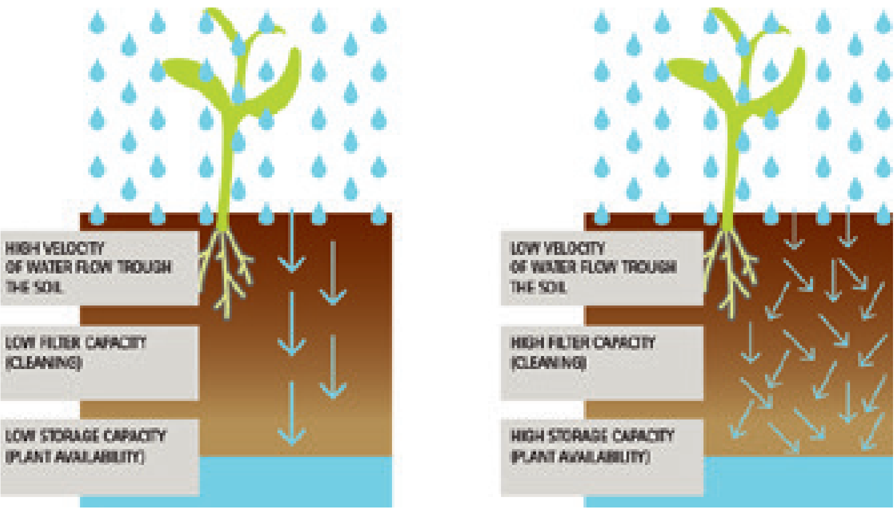
Fig. 19: Maize with no-tillage (left) and maize with ploughing plus clover as a nurse crop (right)

Source: Beste (2009)

Recently, this observation has even appeared in German agricultural magazines that were not previously critical of no-tillage. In this case, soil compaction is clearly evident in the fact that rapeseed roots curve just a few centimetres under the soil surface[74].

If they are not supported by extensive crop rotation or intensive intercropping, no- tillage techniques do not actively promote the development of a healthy, robust soil structure. It has often been observed that a compacted soil structure is only broken through by macropores (high earthworm population)[75]. However, if there are a lot of these vertical macropores (a characteristic judged to be positive by most studies) with a high capacity to absorb rainwater, there is a risk that the percolation water may run into the groundwater too quickly[76]. If compacted layers of soil are only penetrated by earthworm tunnels but do not have a sponge-like structure in any other respect, the water cannot be retained or purified sufficiently. While it does seep through the soil, it does so too quickly[77]. As such, it is practically unfiltered – and so potentially contaminated with plant protection products and fertilisers – when it flows into the groundwater[78]. Thus the soil's filtering function is compromised[79].

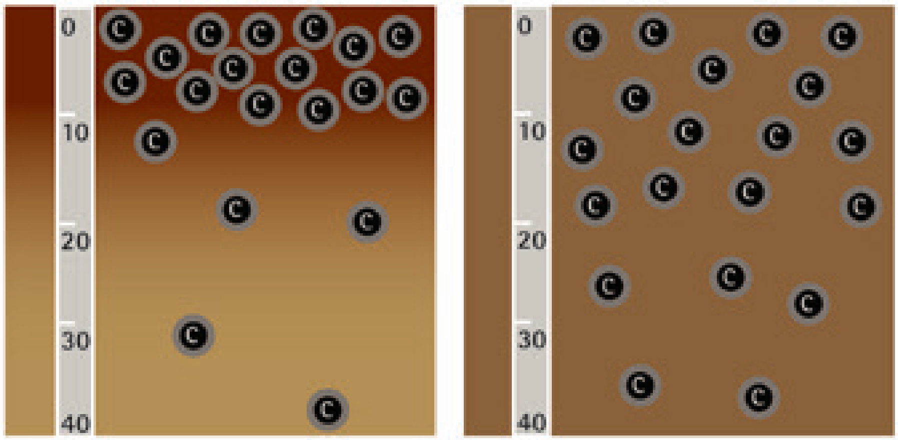
Fig. 20: Soil structure without ploughing **Healthy soil structure**



If compacted layers of soil are only penetrated by earthworm tunnels but do not have a sponge-like structure in any other respect, the water cannot be retained or purified sufficiently. As such, it is practically unfiltered when it flows into the groundwater.

Since no-tillage management is believed to enhance carbon retention in the soil, it is even being advocated by the FAO and many climate researchers. But this belief is mistaken. Quite simply, it is based on a lack of measurements, as Luo et al. demonstrated in 2010 with 69 paired comparison studies from all over the world[80]. Even the EU's Catch-C[81] project came to this conclusion: if measurements are only taken in the top 10 centimetres of the soil profile, the carbon content appears to be higher because no ploughing has taken place to shift organic matter into lower soil layers. However, when measurements are taken to a depth of 40 centimetres (so throughout the whole agriculturally used soil profile), the carbon content is lower further down in the same soil. Comparatively speaking, carbon stocks are neither higher nor lower across the entire soil profile.

Fig. 21: Cross-section of carbon distribution



No-tillage *Ploughed*

The belief that no-tillage techniques enhance carbon retention in the soil is simply based on a lack of measurements. When measurements are conducted across the entire soil profile, carbon stocks are, comparatively speaking, neither higher nor lower.

Enhanced water storage capacity (which would be crucial, since climate change is expected to result in longer dry seasons) through humus creation across the whole soil profile cannot be guaranteed either.

Conversely, far more nitrous oxide – which is extremely damaging to the climate – is formed in unploughed soils because they are packed more closely and soil humidity is higher. As such, no-tillage agriculture does not encourage humus development, climate adaptation or even climate protection[82].

In June 2015, even the German magazine DLG-Mitteilungen, viewed as an opinion-leader on the German agricultural scene, published an article (Wird ‚pfluglos' überbewertet? – Is no-tillage agriculture overrated?) that quoted the Catch-C project's critical findings[83].

Given what has been said above, we can conclude that no-tillage techniques in conventional farming systems primarily benefit the manufacturers of plant protection products. There are far better ways to protect our soils (and for sustainable plant protection management).

6.2 THE ORGANIC ALTERNATIVE

6.2.1 ORGANIC FARMING

Soil organisms are extremely high-performing 'co-workers' that produce healthy plant nutrition and create a sound soil structure in a completely natural way. Is there really any reason to deprive soils of that? Of course not, but conventional agriculture does so anyway. Mineral fertilisation passes over this entire system by feeding plants with minerals straight from fertiliser bags, causing many soil organism populations to decline through lack of food. When this happens, many of the positive effects of soil life are lost too. The result? Crops that are much more susceptible to pest infestation, humus loss, erosion and compaction.

Fig. 22: *Left: soil structure when there is plenty of soil life – organic farming. Right: soil structure when there is little soil life – conventional farming. Clay soil, Finland.*

Source: Beste

The fundamental principle of organic farming is that high biological activity in the soil should be encouraged so that crops can be fed as naturally as possible through the degrading and conversion of organic matter. This form of plant nutrition makes crops more resistant to pests. Organic farming provides crops with optimal conditions for growth – and for a good harvest, since that is the key consideration for organic farmers too. All of the other agricultural measures applied in organic farming are attuned to this 'soil nutrition strategy', with diverse crop rotation playing a vital role.

Mineral fertilisation of crops passes over the entire system for healthy plant nutrition by feeding plants with minerals straight from fertiliser bags, causing many soil organism populations to decline through lack of food.

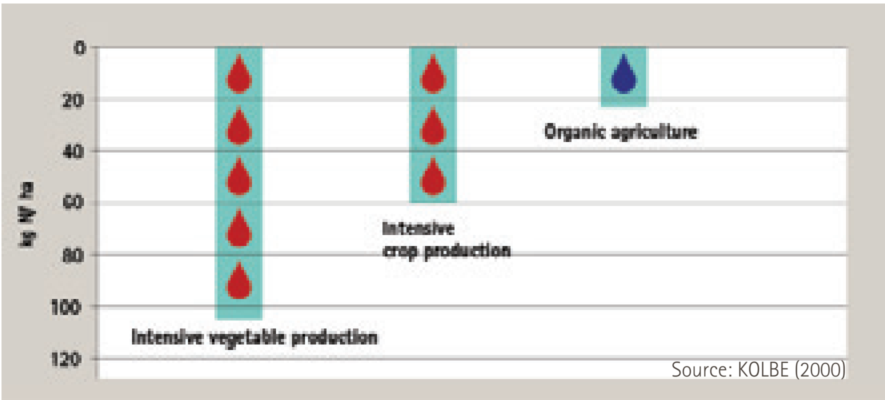
Organic farming requires a third less fossil energy per hectare than conventional farming and, on average, sequesters twice as much CO_2 in the soil. Average nitrate losses are also 50 per cent lower.

Moreover, organic farming contributes to a sound soil structure, which is less susceptible to erosion and more capable of storing water. Many studies have proved that organic soil management results in less soil erosion[84]. This is mainly because organic farming improves the soil structure by enhancing aggregate stability and boosting the soil's capacity for water storage[85].

Agricultural use practically always means a certain degree of monoculture (except in cases of permaculture). Planting as many varieties of crops as possible and rotating them over appropriate periods helps to combat biodiversity loss both in and on the soil. Extensive crop rotations enhance the system's capacity to self-regulate in the face of pest or weed infestation. Furthermore, they protect the soil's surface from silting and erosion and ensure varied root system development throughout the soil. This last feature of organic farming, root system development throughout the soil, provides food for soil life (on top of organic fertilisers) and strengthens the soil structure which, in turn, helps the soil to absorb, store and purify water.

Thanks to all of these factors, year-round, varied plant cover in fields is a key feature of organic farming. Organic farming requires a third less fossil energy per hectare than conventional farming and, on average, sequesters twice as much CO_2 in the soil[86]. Average nitrate losses are also 50 per cent lower[87]. So far, concerns that the combination of higher humus content and higher mineralisation would lead to nitrogen leaching have not been confirmed[88].

Fig. 24: Nitrate leaching in different farming systems



Average nitrogen leaching values for different agricultural land use systems in Germany

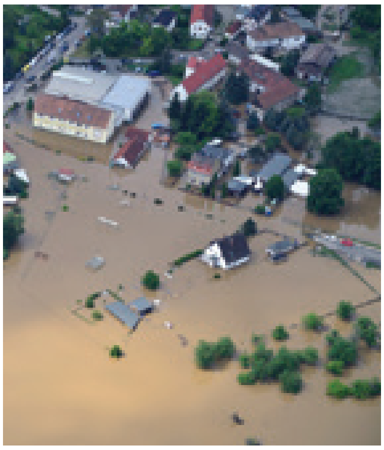
For a system to be considered successful and sustainable in the long term, it must produce the highest possible yield per unit of healthy ecosystem.

And what about yields?

An analysis of 160 studies revealed that for the cultivation systems applied in industrialised countries, the average yields achieved by organic farming were 92 per cent of those achieved by conventional farming. In the tropics, however, as shown by an analysis of 133 studies, the yields achieved by organic farming can be up to 174 per cent of those achieved by conventional farming[89]. Organic farming is also far more energy-efficient in the tropics: in these regions, organic systems can produce up to 300 energy units of food with just 5 energy units. By contrast, conventional systems require 300 energy units to produce just 100 energy units of food[90].

And yet focusing on yields only showcases one side of a system's productivity. Strictly speaking, a system's yield – or in other words, its output – also includes its output in the form of fertile soil, clean water and biodiversity. With that in mind, for a system to be considered successful and sustainable in the long term, it must produce the highest possible yield per unit of healthy ecosystem. High yields that leave soils burned out and ecosystems (soils/water) polluted cannot really be counted as a success[91]. Systems based on maximising yields may produce higher yields per area unit to begin with, but they cannot maintain such high performance for long. This is now evident from the state of Europe's soils.

Due to climate change, heavy rainfall and droughts are expected to become more frequent in future. Leached, compacted soils are far less capable of offsetting these climate extremes than soils with a healthy soil structure. What is needed are soils with good carbon and humus contents (though no satisfactory answers have been found to the question of whether such contents can be built up in livestock-free systems). Organic farming techniques produce significantly higher carbon contents than conventional methods: according to measurements taken by an international research team, organically-cultivated soils contain an average of 3.5 tonnes per hectare more carbon than conventionally-cultivated soils[92].



Living soil with a good soil structure can store up to four times its own weight in water. If we are to offer a proactive, preventive response to the effects of climate change, our soils must be managed appropriately, in line with the principles of agroecology.

Living soil with a good soil structure can store up to four times its own weight in water. If we are to offer a proactive, preventive response to the effects of climate change, our soils must be managed appropriately with a view to boosting their water absorption and storage capacity. In view of this, there is an urgent need for the consistent application of sustainable agroecological soil use systems. The required effect cannot be achieved by simply switching to no-tillage agriculture whilst continuing to practise monoculture and mineral fertilisation[93].

Organic farming also outperforms conventional farming when it comes to phosphorous provision (which will be a serious issue for conventional agriculture in future, as global phosphorous stocks are declining). Plants grown with organic farming methods are able to mobilise greater quantities of phosphorous because organic systems leave soil life intact; mineral fertilisers harm the mycorrhizal fungi that help plants to take phosphorus from the soil, whilst organic farming methods promote the development of such fungi, generally reducing the need for external input of synthetic phosphorus.

Organic fertilisers and humus-balanced crop rotation are classic cornerstones of organic farming – and fundamentals of good agricultural practice. They can be seen in many old textbooks that were written long before organic farming was developed, but are also recommended in current textbooks[94]. Unfortunately, current agricultural practice is rather different.

6.2.2 ONE STEP FURTHER: PERMACULTURE

The practice of permaculture is far older than the term itself, which was coined by Australian Bill Mollison in 1978 in reference to permanent, sustainable agriculture. The practice of simultaneously cultivating several crops on the same plot of land was already being applied in rice paddies in Asia and on Berber terraces in Morocco, where farmers have been using these methods for thousands of years.

Example 1: Clover, radishes, lettuce and medicinal herbs, sown as nurse crops after the wheat has flowered, will provide a second harvest (for fodder) after the wheat has been harvested.
Example 2: When a mix of maize, sunflowers and hemp is grown along with peas or beans, the taller plants support the legumes and the legumes return the favour by producing nitrogen.[95]

Permaculture: organic farming in Argentina
Source: Beste

Measuring individual crop yields does not do permaculture justice or reveal the full extent of its benefits: these can only really be understood by looking at the protein and carbohydrate output per area unit. When this is taken into account, permaculture – like the layering system seen in sustainable rainforest management – far outperforms the industrial monoculture-based farming methods currently favoured in Europe. [96]

And this does not only apply to tropical regions – permaculture has great potential in middle latitudes too, though it has been very much under-researched to date. In principle, permaculture is just one step up from organic farming and has considerable potential to improve biodiversity in and on the soil, especially for permanent crops like fruit production or viticulture. Although the system makes more intensive use of the soil, it does so in an agroecological way.

7. IS THE CURRENT FRAMEWORK ENOUGH TO PROTECT SOIL?

7.1 THE EU SOIL PROTECTION STRATEGY

There is still no Europe-wide political concept of soil protection, as there is for air and water protection.

Soil protection and land protection were accorded central importance for the first time in the Sixth EU Environmental Action Programme, published in 2001. The programme calls on the European Commission to develop a comprehensive thematic soil protection strategy for Europe. The Commission's 2002 communication on soil protection¸"Towards a specific strategy on soil protection", was the first step, followed by the drafting of a Soil Protection Directive. The Directive contains legal provisions for the introduction of an EU-wide soil information and monitoring system and sets out recommendations for future measures.

Attempts to adopt an EU Soil Protection Directive last failed in 2010 because Germany opposed it, largely due to pressure exerted by the agriculture lobby. In this discussion Germany referred frequently to the Federal Soil Protection Act, which was considered to be sufficient (see below). [97]

The soil protection expert at the European Commission's DG Environment had the following to say about the situation in 2011:

"Any policy designed to protect the climate and biodiversity cannot succeed if it does not protect the soil too. Refusing to accord soil the same protection as air, water or endangered species and their habitats is a purely political decision and, in view of the accelerating loss of soil (quality) in Europe, not tenable in the long term."[98]

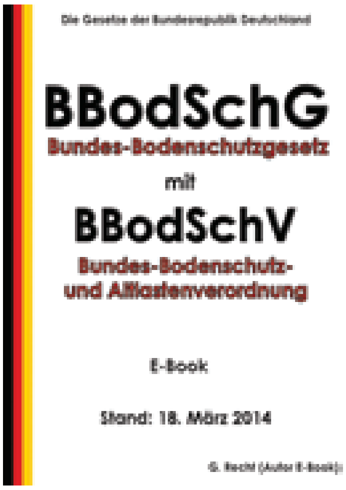
7.2 THE EU COMMON AGRICULTURAL POLICY (CAP)

The "Cross-compliance"-system introduced by the 2003 reform of the CAP made the receipt of direct payments conditional upon compliance with certain requirements. The provisions setting up the system specified that receipt of direct payments would be linked to compliance with EU minimum standards on environmental protection, animal welfare and food safety and to keeping land in a "good agricultural and environmental condition"[99]. However, the principles for maintaining land in a good agricultural and environmental condition are formulated extremely vaguely when it comes to soil protection. They do not even require recipients to practise humus-balancing crop rotation. The latest agricultural reform has done nothing to alter this.

The conditions for maintaining land in a good agricultural and environmental condition are formulated extremely vaguely when it comes to soil protection. They do not even require recipients to practise humus-balancing crop rotation.

Ready for the future?? Source: eu-infothek (2012)

Latacz-Lohmann and Buckwell call for proper soil protection advisory services to be offered to individual farmers in order to gain positive effects from cross-compliance[100]. However, there has been no coordination or support for soil protection advisory services in the European Union to date. Moreover, the latest agricultural reform neither makes soil advisory services a cross-compliance condition nor creates special structural eligibility conditions for Member States as part of its agri-environmental measures. Any bodies wishing to introduce such standards in the Member States (in Germany's case, the federal states are responsible) are free to do so (in whatever form they like), but are not under any obligation. There are no binding criteria whatsoever in this respect. Given the problems affecting Europe's soils and threatening the very basis of our food supply and our production, this is extremely short-sighted.



7.3. THE GERMAN FEDERAL SOIL PROTECTION ACT

With the entry into force of the Federal Soil Protection Act (BBodSchG) in 1999, Germany's lawmakers took an initial step towards according more importance to the need to protect soil. The BBodSchG aims to protect soil from damage and rehabilitate it where it has been damaged. The soil is to be used in such a way that no harmful changes will be made to it, and soil consumption through sealing is to be limited as far as possible. For some years now, scientists and associations have criticised the law's excessive focus on the issue of contamination and polluted sites. In their view, it is imbalanced given the range of potential soil problems encountered in the agricultural sector[101].

Furthermore, the agricultural sector has no exact definition for the term 'good professional practice' in connection with agricultural management (Art. 17 BBodSchG). In 1999, a position paper by the Federal Ministry of Consumer Protection, Food and Agriculture, "Gute fachliche Praxis der landwirtschaftlichen Bodennutzung" (Good professional practice in agricultural soil use) explained the term for the first time in connection with the soil-protection aspects of land use (the term is used in many other German ordinances, and is often defined rather arbitrarily). The ministry's definition gives a relatively specific description of the goals for sustainable soil management in agriculture. However, key areas that are certain to affect soil protection within the context of agricultural practice are only covered in the specific ordinances (Plant Protection Products Regulation, Fertilisers Ordinance). As such, the issue is not addressed fully. Moreover, since the paper in question merely issues recommendations, they are of course non-binding[102].

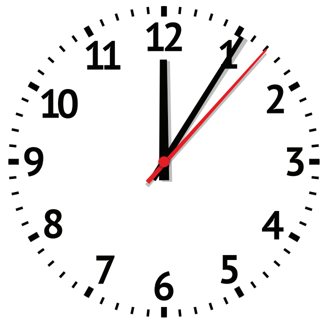
8. CONCLUSION: URGENT NEED FOR ACTION

The symptoms of soil degradation described in this study are simply not compatible with the "Cross Compliance" agreement's principle of "maintaining the land in a good agricultural and environmental condition" – neither where soil protection is concerned, nor in terms of ensuring the continued, sustainable existence of agricultural regions. For many soils, it is now no longer a question of providing protection and preventing damage, but rather of restoring soil functions as a matter of urgency.

The work carried out by the SOILSERVICE project in four of Europe's agricultural regions showed that agricultural incomes could rise if the soil's carbon content – a good indicator for natural soil functions – were to increase. Not only would farmers enjoy better yields but their costs would also be lower thanks to improved soil system services (e.g. better soil fertility). The SOILSERVICE project has proved that there is a positive correlation between most soil ecosystem services (clean drinking water, prevention of erosion, protection from flooding) and the soil's carbon content. Although enhancing the soil's carbon content is a lengthy process, it is an effective means of preventing soil erosion, nutrient loss and the transfer of substances to surface water. In this connection, organic farming offers considerable potential in terms of both resource conservation AND productivity.

There is an urgent need for action with regard to:

- implementing a European soil protection strategy;
- advising on and implementing known, sustainable soil protection measures on farms;
- updating and defining the concept of 'good professional practice' in soil management, both in Germany and throughout Europe;
- introducing stricter licensing and environmental monitoring systems for medicinal products;
- ensuring monetary recognition by society of sustainable (soil) cultivation.



For many soils, it is now no longer a question of providing protection and preventing damage, but rather of restoring soil functions as a matter of urgency.

Organic farming offers considerable potential in terms of both resource conservation AND productivity.

DEMANDS FOR BETTER PROTECTION OF EUROPE'S SOIL

MARTIN HÄUSLING

In 2015, the expert on soil protection at the European Commission's DG Environment said that, **mathematically speaking, just 50 years ago worldwide every individual had half a hectare (5,000 m^2) of land at their disposal to grow food, yet today that figure has halved to a quarter of a hectare, and by 2050 it will have shrunk further to just 1,000 m^2.**

The study presented here cites the SOILSERVICE project, claiming that the continuation of present-day agricultural management practices in the EU will lead to further declines in both soil biodiversity and yields. Merely continuing the current management with application of mineral fertilisers will supposedly preclude the maintenance of soil functions. The project's authors conclude that soil management which replenishes its carbon and humus content is absolutely essential for improving the sustainability of food production.

Attempts to adopt an EU Soil Protection Directive last failed in 2010 because Germany opposed it, largely due to pressure exerted by the German Farmers' Association (DBV). Among other things, the directive would have resulted in clearer and more specific soil protection requirements being imposed on recipients of direct payments than those applying today.

You may well ask how anybody could oppose something like that?

Well, an overly narrow focus on export-oriented intensive farming is all it takes to make people lose sight of what is needed for sustainability.

The relative lack of substantiated statistics on the degradation of agricultural soil in Central Europe before now meant that farmers, farmers' associations and the agro-industry could always fall back on their claim that everything was alright. Yet the study presented here demonstrates that this claim is far from the truth.

In view of the data presented in this study and the conclusions reached by the EU's SOILSERVICE project, the EU's Clim-Soil-Report, the European Environment Agency (EEA), the European Soil Bureau Network, the European Commission's Joint Research Centre, the German Federal Environment Agency (UBA) and several other individual studies, my demands are as follows:

1. Europe needs a soil protection strategy. Germany must take its responsibility for protecting Europe's soil, stop blocking a European Soil Framework Directive and play a constructive, formative role.

2. We need a total reorientation of the Common Agricultural Policy (CAP). Payments must only be made to those farmers whose methods meet the strictest requirements of ecological compatibility and animal welfare. Organic farming must be held up as the model to follow.

3. The Cross-Compliance-rules need to be extended. Anyone who opts out of agricultural subsidies in future must comply with their provisions as legal minimum standards. To this end, binding good professional practices for soil management need to be clearly specified.

4. We need a support programme implemented throughout the EU that advises individual farmers on soil protection management.

5. More funding must be made available for research into crop mixtures, nurse crops and intercropping in organic and conventional agriculture.

6. No-tillage cultivation systems that use total herbicides must not receive financial support from agri-environment schemes.

7. Europe's soil needs a humus creation programme (research, training and advice), to prepare it for the challenges posed by climate change.

8. Slurry and biogas fermentation residues do not create humus in the soil like compost or solid manure do. The quality of organic fertilisers must be judged more finely in terms of its impact on the soil and be either suitably encouraged or restricted by law.

9. The authorisation of veterinary drugs must give greater consideration to their environmental impact. The spread and impact on resistance development of antibiotics through organic fertilisers derived from intensive animal husbandry urgently needs to be reduced. Livestock farming that pollutes waterways and soil with drug-contaminated organic fertilisers is no longer tenable.

10. Apart from the use of pure vegetable oil in agriculture machines, the encouragement of biomass production for energy purposes, damages the environment and competes directly with food cultivation, and must therefore be stopped.

1 WBB (Wissenschaftlicher Beirat Bodenschutz) (2002): Ohne Boden bodenlos – eine Denkschrift zum Bodenbewusstsein, Berlin
2 http://www.iass-potsdam.de/sites/default/files/files/09.11.2013_erosion_zerstoert_nahrung_neues-deutschland.pdf
ELD/GIZ (2015): The Value of Land. http://eld-initiative.org/index.php?id=111
3 Zur Definition von Bodenfunktionen u.a.:
EK (Europäische Kommission) (2002): Mitteilung der Kommission an den Rat, das Europäische Parlament, den Wirtschafts- und Sozialausschuss sowie an den Ausschuss der Regionen. Hin zu einer spezifischen Bodenschutzstrategie. Brüssel
http://europa.eu.int/comm/environmant/soil/pdf/opinion020918_de.pdf
EK (2006): Thematische Strategie für den Bodenschutz
EK (2006): Begleitdokument zur Thematische Strategie für den Bodenschutz, Zusammenfassung der Folgenabschätzung.
De Kimpe, C.; Warkentin, R. (1998): Soil Functions and the Future of Natural Resources. In: Blume H.-P. et al. (Hg.): Towards sustainable land use. Furthering cooperation between people and institutions, Selected papers of the 9th conference of the International Soil Conservation Organisation (ISCO) = Advances in Geoecology 31, Reiskirchen
UBA, UMWELTBUNDESAMT (1998): Maßstäbe bodenschonender landwirtschaftlicher Boden-nutzung - Erarbeitung von Beurteilungskriterien und Meßparametern als Grundlagen für fachliche Regelungsansätze. Umweltbundesamt (Hg.), Berlin
Glöss, St. (1997): Bodenbewertung im Rahmen von Umweltplanungen. In: Hierold W. und R. Schmidt (Hg.): Kennzeichnung und Bewertung von Böden für eine nachhaltige Landschaftsnutzung = ZALF-Bericht 28, Müncheberg
ISCO, International Soil Conservation Organisation (Hg.) (1996): Conclusions and recommendations of ISCO'96. Bonn
4 Beste, A. (2005): Landwirtschaftlicher Bodenschutz in der Praxis. Grundlagen, Analyse, Management. Erhaltung der Bodenfunktionen für Produktion, Gewässerschutz und Hochwasservermeidung. Verlag Dr. Köster
5 WBB (2002)
Schinner, F.; Sonnleitner, R. (1996): Bodenökologie 1: Grundlagen, Klima, Vegetation, Bodentyp. Mikrobiologie und Bodenenzymatik. Berlin
LUA-Infoblatt 13, Landesumweltamt Nordrhein-Westfalen (2003)
6 Beste, A. (2005), Schinner, F.; Sonnleitner, R. (1996)
7 WBB (2002)
8 Ehlers, W. (2004): Acker unter Druck. In: Bioland, H. 8, 2004, Mainz
Frede, H.G. (2004): Anforderungen an Grundwasser und Oberflächengewässerschutz. In: Bodenschutz und landwirtschaftliche Bodennutzung – Umweltwirkungen am Beispiel der konservierenden Bodenbearbeitung. = Texte 35/04 Umweltbundesamt, Berlin
Beste, A. (2002): Das Problem mit dem Wasser ist ein Bodenproblem. In: Ökologie & Landbau 124, Schwerpunkt: Gesunder Boden als Ziel
Schnug, E. und Haneklaus, S. (2002): Landwirtschaftliche Produktionstechnik und Infiltration von Böden: Beitrag des ökologischen Landbaus zum vorbeugenden Hochwasserschutz. FAL, Landbauforschung Völkenrode 52
9 Gisi, U. (1997): Bodenökologie. Stuttgart, New York
Schinner, F.; Sonnleitner, R. (1996)
10 Preetz, H. (2003): Bewertung von Bodenfunktionen für die praktische Umsetzung des Bodenschutzes. Dissertation Martin-Luther-Universität Halle-Wittenberg, Gisi (1997)
11 EEA/UNEP (2002): Auf dem Boden der Tatsachen: Bodendegradation und nachhaltige Entwicklung in Europa
WBGU, Wissenschaftlicher Beirat der Bundesregierung Globale Umweltänderungen (1994): Die Welt im Wandel - Die Gefährdung der Böden. (= Jahresgutachten 1994). Bonn.
UNEP (2004): UNEP's Strategy on Land Use Management and Soil Conservation. A Strengthened Functional Approach
UNEP (1990): The extend of human-induced soil degradation. Annex 5. United Nations Environment Programme; International Soil Reference and Information Center (Hg.), Wageningen. Netherlands
12 EK DG Environment (2011): Report on best practices for limiting soil sealing and mitigating its effects; www.ec.europa.eu/environment/soil/sealing.htm
13 EEA/UNEP (2002)
14 EEA (2011): Land take Assessment, BBSR Bonn (2012): Flächenverbrauch landwirtschaftlicher Flächen für Siedlungen, http://www.bbsr.bund.de/BBSR/DE/Raumentwicklung/RaumentwicklungEuropa/Projekte/Archiv/Flaechenverbrauch__Europa/Flaechenverbrauchlawi.pdf?__blob=publicationFile&v=3
15 http://www.bodenbuendnis.org/fileadmin/docs/downloads_2015/2015-05-19_Nachgefragt_Thomas_Strassburger.pdf
16 http://www.oekolandbau.nrw.de/aktuelles/aktuelles_2014/quartal_3_2014/pm_koen8-7-14_niedersachsen_umstellung_ausgleichsmassnahme.php
BBSR (2012): http://www.bbsr.bund.de/BBSR/DE/Raumentwicklung/RaumentwicklungEuropa/Projekte/Archiv/Flaechenverbrauch__Europa/Flaechenverbrauchlawi.pdf?__blob=publicationFile&v=3
17 EP (Europäisches Parlament) (Hg.) (2015): Extend of Farmlandgrabbing in the EU. http://www.europarl.europa.eu/RegData/etudes/STUD/2015/540369/IPOL_STU%282015%29540369_EN.pdf
18 Beste, A., Börnecke, S. (2011): Die Ernte der Heuschrecken. Das weltweite Landgrabbing und die Verantwortung Europas.
19 EP (Hg) (2015)
20 Lingner, St., Borg, E. (2000): Präventiver Bodenschutz. Problemdimensionen und normative Grundlagen. Graue Reihe Nr. 23, Europäische Akademie zur Erforschung von Folgen wissenschaftlich-technischer Entwicklungen.
21 EEA/UNEP (2002)
22 JRC, (Joint Research Centre) (2012): In State of Soil in Europe.
23 Committee on Climate Change (CCC) (2015): Reducing emissions and preparing for climate change: 2015 Progress Report to Parliament Summary and recommendations.
24 Panagos, P. et al. (2015): The new assessment of soil loss by water erosion in Europe. In Environmental Science & Policy Volume 54, December 2015
EUROPEAN SOIL DATA CENTRE (ESDAC), Rusle2015 model http://esdac.jrc.ec.europa.eu/themes/rusle2015 (2015)
25 World Economic Forum, Times, What If the World's Soil Runs Out?, 2012
26 EEA (European Environment Agency) (2003): Europe's Environment: the third assessment. Environmental assessment report No, 10, Copenhagen
27 Thünen-Institut für Betriebwirtschaft (2015): Agrarrelevante Extremwetterlagen und Möglichkeiten von Risikomanagementsystemen Studie im Auftrag des Bundesministeriums für
Ernährung und Landwirtschaft (BMEL).
28 Feyen, L. et al. (2011): Fluvial flood risk in Europe in present and future climates, Climatic Change, DOI 10.1007/s10584-011-0339-7

29 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:288:0027:0034:de:PDF

30 Beste (2003/2004)

31 SOILSERVICE (2012): Conflicting demands of land use, soil biodiversity and the sustainable delivery of ecosystem goods and services in Europe

SOILSERVICE has brought together natural scientists and economists in an inter- and trans-disciplinary approach in order to understand how competition for land use influences soil biodiversity, and sustainable provision of ecosystem goods (bioenergy, food and timber, nature) and services (clean water, control of greenhouse gases, control of pests and invasive weeds).

SOILSERVICE has studied ecosystem services and biodiversity in European agricultural soils in order to test and promote strategies for sustainable management of soil resources, and to mitigate degradation of soils that are under pressure from intensive land use, climate change and urbanisation.

Partners:

Lund University, SE

Swedish University of Agricultural Sciences, SE

Netherlands institute of Ecology of the Royal Dutch Academy of Arts and Sciences, NL

Justus-Liebig-University of Giessen, DE

University of Wageningen Research Centre, NL

University of Helsinki, FI

University of Copenhagen, DK

University of Lancaster, UK

University of Reading, UK

Aristotle University of Thessaloniki, GR

Biology Centre ASCR v.v.i. CZ

32 Wiesmeier, M. et al. (2015): Stagnating crop yields: An overlooked risk for the carbon balance of agricultural soils? Science of The Total Environment 7/15

33 VHE (Verbände der Humus- und Erdenwirtschaft) (Hg.) (2004): Wieviel Humus braucht der Acker. In: Humus Nr. 11

Beste (2005), Freyer, B. (2003) Fruchtfolgen

34 Wiesmeier et al. (2015)

35 Ferris, H., (2010): Form and function: Metabolic footprints of nematodes in the soil food web. European Journal of Soil Biology, 46.

36 De Vries/Van Groenigen et al. (2011): Nitrogen losses from two grassland soils with different fungal biomass. Soil Biology & Biochemistry 43(5)

37 Six/Frey et al. (2006): Bacterial and fungal contributions to carbon sequestration in agroecosystems. Soil Science Society of America Journal 70(2)

Wilson GW et al. (2009): Soil aggregation and carbon sequestration are tightly correlated with the abundance of arbuscular mycorrhizal fungi: results from long-- term field experiments.

38 SOILSERVICE (2012)

39 S. Kratz; E. Schnug (2006): Rock phosphates and P fertilizer as sources of U contamination in agricultural soils, in Broder J. Merkel, Andrea Hasche-Berger (Ed.), Uranium in the Environment, Springer-Verlag Berlin Heidelberg S. 57-67

Deutscher Bundestag (2011): http://dipbt.bundestag.de/dip21/btd/17/060/1706019.pdf

Beste, A. (2015): Industrielle Landwirtschaft - mit Zukunftsproblemen. In: Bodenatlas. Daten und Fakten über Acker, Land und Erde.

40 Schinner, F.; Sonnleitner, R.(1996 b): Bodenökologie 2: Bodenbewirtschaftung, Düngung und Rekultivierung. Mikrobiologie und Bodenenzymatik. Berlin, BAEUMER (1994)

RBS (Robert Bosch Stiftung, Hg.) (1994): Schwäbisch Haller Agrarkolloquium zur Bodennutzung, den Bodenfunktionen und der Bodenfruchtbarkeit. Denkschrift für eine umweltfreundliche Bodennutzung in der Landwirtschaft. Gerlingen

Gisi, U. (1997), Beste (2005), Wilson (2009)

Elsen, A., D. Gervacio, et al. (2008): AMF-induced biocontrol against plant parasitic nematodes in Musa sp.: a systemic effect. Mycorrhiza 18(5)

41 Bauchhenss J. (1999), Aichinger, S. et al. (1995): Die Bedeutung von Mikroorganismen für die Aggregatstabilisierung von Böden unterschiedlicher Nutzung. Mitteilungen DBG 76

Anderson, T.-H. (1991): Bedeutung der Mikroorganismen für die Bildung von Aggregaten im Boden. Zeitschrift für Pflanzenernährung und Bodenkunde 154

Krebs, M. (1995): Biogene Bodengefüge: Pflanzenartspezifische Oberboden-Mikrogefüge und Aspekte ihrer Entstehung. Dissertation Universität Hohenheim. Stuttgart

42 BMELF (Hg.) (1992): Bodennutzung und Bodenfruchtbarkeit. Bodengefüge, Berichte über Landwirtschaft, Sonderheft 206, Hamburg, Berlin

43 Umweltbundesamt (2015): Monitoringbericht 2015 zur Deutschen Anpassungsstrategie an den Klimawandel. Bericht der Interministeriellen Arbeitsgruppe Anpassungsstrategie der Bundesregierung.

44 Lal, R. (2004): Soil carbon sequestration impactson global climate change and food security. Science 304

45 SOILSERVICE (2012)

Seibt, P. (2007): Anwendung einer neuen standortabhängigen Methode zur Humusbilanzierung an sächsischen Dauertestflächen und Vergleich mit anderen üblichen Methoden zur Feststellung des Versorgungsgrades mit organischer Substanz im Hinblick auf Sicherung der Nachhaltigkeit der Betriebe im konventionellen und ökologischen Landbau. Diplomarbeit, TU Dresden

46 EK (2002)

47 UBA (2008)

48 Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) (2008): Gehalte an organischer Substanz in Oberböden Deutschlands.

Hüttl, R., Bens, O., Prechtel (Hrsg.) (2013): „Zum Stand der Humusversorgung der Böden in Deutschland".

Cottbuser Schriften zur Ökosystemgenese und Landschaftsentwicklung Bd.7

http://www.umweltbundesamt.de/sites/default/files/medien/384/bilder/dateien/2_abb_humusgehalte_2013-08-26_0.pdf

49 Freibauer A. et al (2004): Carbon sequestration in the agricultural soils of Europe. Geoderma 122

Lugato et al. (2014): Carbon sequestration potential in European agricultural soils: scenario analysis with a new platform of simulation

SOER(2015): http://www.eea.europa.eu/soer-2015/europe/soil

50 KTBL (2005): Schwermetalle und Tierarzneimittel in Wirtschaftsdüngern. = KTBL-Schrift 435. Darmstadt

BIO Intelligence Service (2013): S.A.S.: Study on the risks of environmental effects of medicinal products.

51 UBA (2011): Arzneimittelrückstände in der Umwelt Datenbankauszug aus der Umweltforschungsdatenbank UFORDAT

Adler, N. et al. (2013): Pharmaceuticals in Soil, Sludge and Slurry. Presentation Workshop Pharmaceuticals in Soil, Sludge and Slurry, UBA Dessau

BIO Intelligence Service (2013)

52 Backhaus, T. (2015): Environmental impacts of Veterinary Medicines - State of knowledge, options for improvement. Presentation, Brussels

Margalida, A., et al. (2014): One Health approach to use of veterinary pharmaceuticals. In: Science 346.6215

53 De La Torre, A. et al. (2012): An approach for mapping the vulnerability of European Union Soils to Antibiotic Contamination. Science of the Total Environment. 414

Birkel K. (2013): Masse statt Klasse. Eine Haltung, die krank macht. Über den Antibiotikaeinsatz in der Tierhaltung und die Zunahme von resistenten Bakterien. Aktualisierte Auflage 2015

54 SOILSERVICE (2012)

55 Beste A. et al. (2000): Biomasse umweltfreundlicher Energieträger? In: „Ökologie & Landbau", H. 116, Bad Dürkheim

Becker, M.; Beste, A. (2009): Biomasse: Forschungsschwerpunkte klammern Nachhaltigkeit bisher aus. In: Bodenschutz 1/2009

Franko, U. (2015): Large-scale identification of hot spots for soil carbon demand under climate change and bioenergy production. J. Plant Nutr. Soil Sci. 178

Blanco Canqui, H. (2013): Crop Residue Removal for Bioenergy Reduces Soil Carbon Pools: How Can We Offset Carbon Losses? BioEnergy Res.

56 Altieri, M. / Bravo, E. (2007): The ecological and social tragedy of crop-based biofuel production in the Americas.

57 Antoniou, M. et al. (2010): GM SOY Sustainable? Responsible? A summary of scientific evidence showing that genetically modified (GM) soy and the glyphosate herbicide it is engineered to tolerate are unsustainable from the point of view of farming, the environment, rural communities, animal and human health, and economies. Hg.: GLS Gemeinschaftsbank eG, Bochum, Deutsche Zusammenfassung: http://www.bund.net/fileadmin/bundnet/pdfs/gentechnik/20101014_gentechnik_gv-soja_studie_zusammenfassung.pdf

Beste, A., Boeddinghaus, R. (2011): Artenvielfalt statt Sojawahn. Der Eiweißmangel in der EU. Wie lässt sich das seit langem bestehende Problem lösen?

58 Idel, A. (2012): Die Kuh ist kein Klima-Killer! Wie die Agrarindustrie die Erde verwüstet und was wir dagegen tun können.

59 Zum Beispiel in Top Agrar 7/15: Bodenlockerer und Nährstofflieferant für Mais.

60 Freyer (2003)

61 UBA (Umweltbundesamt) (2008): Ermittlung von Optimalgehalten an organischer Substanz landwirtschaftlich genutzter Böden nach § 17 (2) Nr. 7 BBodSchG

62 VHE (Hg.) (2004)

Raupp, J. (2002): Wie die Humusentwicklung langfristig sichern? In: „Ökologie & Landbau", H. 124, Bad Dürkheim

63 UBA (2008), Sauerbeck, D. (1992): Funktionen und Bedeutung der organischen Substanzen für die Bodenfruchtbarkeit – ein Überblick. In: Bodennutzung und Bodenfruchtbarkeit 4, Humushaushalt. BMELF (Hg.), Hamburg, Berlin.

RBS (1994), Raupp (2002)

Guteser, R.; Ebertseder, TH. (2006): Die Nährstoffe in Wirtschafts- und sekundärrohstoffdüngern – ein unterschätztes Potential im Stoffkreislauf landwirtschaftlicher Betriebe. In KTBL (Hg.): Verwertung von Wirtschafts- und Sekundärrohstoffdüngern in der Landwirtschaft. Nutzen und Risiken. = KTBL 444

64 Stolze et al. (2000): The Environmental Impacts of Organic Farming in Europe. = Organic Farming in Europe: Economics and Policy, Vol. 6. Stuttgart

65 Beste (2005), Diacono, M.; Montemurro F.(2010): Long-term effects of organic amendments on soil fertility. A review. Agron Sustain Dev 30.

Schreiber, A. (2005): Ökonomische und ökologische Beurteilung der Kompostverwertung in der Landwirtschaft. Dissertation Universität Hohenheim.

Bruns, C. et al. (2003): Suppressive Effekte von Komposten gegenüber bodenbürtigen Krankheiten – Qualitätsmerkmal hochwertiger Komposte. Ein Überblick zum Stand des Wissens. In: 64. Informationsgespräch des ANS e.V. in Witzenhausen. Tagungsband, Weimar

Bauchhenss, J. (1999): Die Bedeutung der Bodenorganismen für die Bodenfruchtbarkeit. Bayerische Landesanstalt für Bodenkultur und Pflanzenbau, Freising

Larink, O. (1998): Bodenbearbeitung und Bodenleben. In: Kuratorium für Technik und Bauwesen in der Landwirtschaft) Arbeitspapier 266 Bodenbearbeitung und Bodenschutz. Darmstadt

KTBL-Fachgespräch (2014): Möglichkeiten und Grenzen der zugelassenen organischen Handelsdüngemittel, PD Dr. Kurt Möller

Ingham, E. (2006): How the soil food web and compost increase soil organic matter content. in Org.— Solut. Clim. Change 13.

66 Scheub et al. (2013): Terra Preta. Die schwarze Revolution aus dem Regenwald. Oekom Verlag, München

67 Kammann, C. et al. (2012): Biochar and Hydrochar Effects on Greenhouse Gas (Carbon Dioxide, Nitrous Oxide, and Methane) Fluxes from Soils, J. Environm. Quality

68 Beste, A.; Faensen-Thiebes, A. et al. (2015): Terra Preta / Pyrolysekohle - BUND-Einschätzung ihrer Umweltrelevanz. http://bodenschutz.bund.net/themen/terra_preta_pyrolysekohle/

69 ClimSoil-Report (2008): http://eusoils.jrc.ec.europa.eu/esdb_archive/eusoils_docs/other/climsoil_report_dec_2008.pdf

70 Beste/Faensen-Thiebes et al. (2015)

71 http://europa.eu/legislation_summaries/other/l28178_de.htm

72 Agra-Europe 28/15: Trendwende bei der Bodenbearbeitung

73 Das Büro für Bodenschutz und Ökologische Agrarkultur hat u. a. von 2001-2008 die Firma Iglo-Langnese (UNILEVER) zum Bodenschutz im Vertragsgemüseanbau beraten, was neben ausführlichen Analysen der Bodenqualität von über 250 Flächen – u. a. in Zusammenarbeit mit der Fachhochschule Südwestfalen – auch eine regelmäßige Fortbildung der Vertragslandwirte in Bodenbeurteilung und Bodenschutzmanagement beinhaltete.

74 Topagrar 9/2013: Raps: Gute Wurzeln, bestes Wachstum. http://www.topagrar.com/archiv/Raps-Gute-Wurzeln-bestes-Wachstum-1229932.html

75 Beste, A. (2003): Untersuchungen zum ökologischen Bodenzustand ausgewählter landwirtschaftlicher Nutzflächen des westlichen Münsterlandes mit Hilfe der qualitativen Strukturanalyse, Teil 1. Im Auftrag von UNILEVER/IGLO-Langnese, unveröffentlicht

Beste, A. (2004): Pflugsohlenuntersuchung Holthausen. Im Auftrag von UNILEVER/IGLO-Langnese, unveröffentlicht

Beste, A. (2004): Untersuchungen zum ökologischen Bodenzustand ausgewählter landwirtschaftlicher Nutzflächen des westlichen Münsterlandes mit Hilfe der qualitativen Strukturanalyse, Teil 2. Im Auftrag von UNILEVER/IGLO-Langnese, unveröffentlicht

76 Titi, Adel El (Hg.) (2003): Soil Tillage in Agroecosystems. London, New York

Peschke, G. (2001)

77 Ackermann, M. (2004): Beurteilung des Einflusses einer angepassten Ackernutzung auf den Hochwasserabfluss. Dissertation Universität Hannover.

Beven, K. und Germann, P. (1982): Macropores and water flow in soils. Water Ressour. Res. 18

78 Frede, H. G. (2004)

Schmidt, W.-A. (2004): Erfahrungsbericht aus Sachsen. In: Bodenschutz und landwirtschaftliche Bodennutzung – Umweltwirkungen am Beispiel der konservierenden Bodenbearbeitung, Berlin.

Titi/Adel (Hg.) (2003)

PESCHKE, G. (2001)

79 Preetz, H. (2003)

80 Luo et al. (2010): Soil carbon change and its responses to agricultural practices in Australian agro-ecosystems: A review and synthesis. Geoderma 155

Höper, H.; Schäfer, W. (2012): Die Bedeutung der organischen Substanz von Mineralböden für den Klimaschutz. Bodenschutz 03.12

81 Catch-C (2014): Compatibility of Agricultural Management Practices and Types of Farming in the EU to enhance Climate Change Mitigation and Soil Health. Das Catch-C-Projekt startete 2013. Zwölf Forschergruppen aus acht Ländern werteten in den letzten 3 Jahren 300 Langzeitversuche aus.

http://www.catch-c.eu/deliverables/WP3 Prozent20Task Prozent203 Prozent203 Prozent20CC_D3.334_final.pdf

82 Gensior et al. (2012): Landwirtschaftliche Bodennutzung. Eine Bestandsaufnahme aus Sicht der Klimaberichterstattung. In: Bodenschutz 3/12.

Catch-C (2014)

Beste, A. (2009): Gefügeuntersuchungen im Bodenbearbeitungsvergleich FILL im Auftrag der Landwirtschaftskammer Luxemburg.

Holland, J. M. (2004): The environmental consequences of adopting conservation tillage in Europe: reviewing the evidence. Agriculture, Ecosystems and Environment 10.

ohnepflug.de: http://www.ohnepflug.de/index.php/forschung-und-versuche/auswirkungen-auf-umweltaspekte/emission-von-klimagasen

83 Mallast, J. et al. (2015): Wird ‚Pfluglos' überbewertet?. In DLG-Mitteilungen 6/2015

84 Unter anderem: Verity, G. E. et al. (1990): Soil erosion effects on soil quality and yield. Can. J. Soil Sci. 70

Beste, A. (2015): Ökolandbau: Der lange Kampf für bessere Böden. In: Bodenatlas. Daten und Fakten über Acker, Land und Erde.

K. Auerswald et al. (2003): Erosion potential of organic versus conventional farming evaluated by USLE modelling of cropping statistics for agricultural districts in Bavaria. Soil Use Management 1

Kainz M. et al. (2009): Wirkungen des Ökologischen Landbaus auf Bodenerosion. http://orgprints.org/14385/

Sebastian Arnholda et al. (2014) Conventional and organic farming: Soil erosion and conservation potential for row crop cultivation. In: Geoderma Volumes 219–220, May 2014

Beste A. (2004): Vorsorgender Erosionsschutz im Ackerbau - Förderung der Lebendverbauung durch Fruchtfolge, organische Düngung und angepasste Bodenbearbeitungstechnik. In "local land and soil news", the bulletin of the European Land and Soil Alliance (ELSA) e.V., "Erosion and Landslide - When Soil is moving away" 10/11, 04

85 Rodale Institute (2013): The Farming Systems Trial.

86 FAO (2007): Report of the International Conference on Organic Agriculture and food security, 3.-5. May. Rome

SOILSERVICE (2012)

87 STOLZE et al. (2000): The Environmental Impacts of Organic Farming in Europe. = Organic Farming in Europe: Economics and Policy, Vol. 6. Stuttgart

Kolbe, H. (2000): Landnutzung und Wasserschutz. Der Einfluss von Stickstoff-Bilanzierung, Nmin-Untersuchung und Nitrat-Auswaschung sowie Rückschlüsse für die Bewirtschaftung von Wasserschutzgebieten in Deutschland. Leipzig

88 Neve, S. et al. (2003): Temperature effects on N mineralization: changes in soil solution composition and determination of temperature coefficients by TDR. European Journal of Soil Science: Incorporating Journal of Soil Science, Pedologie and Science du Sol. 54/2003

89 Badgley, C. et al. (2007): Organic Agriculture and the global food supply. Renewable Agriculture and Food systems 22.

Ähnliche und zum Teil höhere Werte (bis zu 250%) wurden ermittelt in:

PRETTY,J.; HINE, R (2001): Reducing Food Poverty with Sustainable Agriculture: A Summary of New Evidence, Essex - sowie

IFAD (2005): Organic Agriculture and Poverty Reduction in Asia: China and India Focus. Report No. 1664. Rome

90 Badgley, C. et al. (2007)

DePonti, T. et al. (2012): The crop yield gap between organic and conventional agriculture. Agric. Syst.

Pimentel, D. et al. (2005): Environmental, energetic, and economic comparisons of organic and conventional farming systems. BioScience.

91 Mondelaers K. et al. (2009): A meta-analysis of the differences in environmental impacts between organic and conventional farming. Br Food J 111.

Schader, C. et al. (2012): Environmental performance of organic agriculture. Green Technologies in Food Production and Processing, New York.

92 Gattinger, A. et al. (2012): Enhanced top soil carbon stocks under organic farming. In: PNAS, 15.

Leifeld, J. et al. (2009): Consequences of conventional versus organic farming on soil carbon: Results from a 27-year field experiment. Agron J 101.

93 Muller, A. et al. (2012): Reducing Global Warming and Adapting to Climate Change: The Potential of Organic Agriculture (Working Papers in Economics 526) (Göteborg University, Göteborg, Sweden).

94 Freyer, B. (2003)

95 Holzer, S. (2004): Sepp Holzers Permakultur, Graz

96 http://permacultureglobal.org/projects

Hülsebusch, C. et al. (2007): Organic Agriculture in the Tropics and Subtropics – Current Status and Perspectives. In: Journal of Agriculture and Rural development in the Tropics and Subtropics.

Mitschein TH. ; Magave J.; Junqeiro R. (1994): Amazônia. Alianças em Defesa da Vida = Série Poema.

FAO 2002: Organic Agriculture, environment and food security.

97 Beste, A. (2007): Den Boden vor dem Kollaps retten. Plädoyer für ein Umdenken im Umgang mit der Ressource Boden. In: Der Kritische Agrarbericht 2007.

Beste, A.; Valentin, I. (2010): Bodenschutz in der Landwirtschaft. Ein Streifzug durch Paragraphen, Felder und Forschungslandschaften. In: Der Kritische Agrarbericht 2010.

98 Straßburger, Th. (2011): Zeit des Stillstands? Bodenschutz in Europa. In Bodenschutz 3/2011.

99 http://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:32013R1306&from=DE

100 Latacz-Lohmann, U.; Buckwell, A. (1998): Einige ökonomische Überlegungen zu „Cross Compliance". Agrarwirtschaft 47, Heft 11

101 Peine, F.-J. (2002): Landwirtschaftliche Bodennutzung und Bundes-Bodenschutzgesetz. Natur und Recht, Heft 9, Blackwell, Berlin

Lingner/Borg (2000)

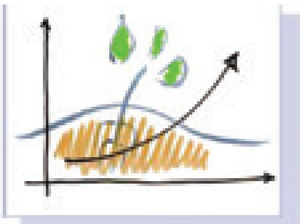
102 Beste, A. (2008): Kommentar zum Standpunktpapier des BMVEL zum Paragraph 17 des Bundesbodenschutzgesetzes: "Grundsätze und Handlungsempfehlungen zur guten fachlichen Praxis der landwirtschaftlichen Bodennutzung" vom 20.04.1999 unter besonderer Berücksichtigung des landwirtschaftlichen Bodenschutzes in Entwicklungsländern. Im Auftrag von MISEREOR

PICTURE CREDITS:

Titel: fotolia.de, Boden©eyetronic

S. 4, Hand © Martin Häusling, S.7 Boden/Risse © Pabkov // **S. 8** Regenwurm © Andrea Beste/ fotolia.de, Wasserfall © Jikung4u/ fotolia.de, Dorf © SusaZoom/ fotolia.de, Schüssel © Dario Lo Presti/ Traktor © Martin Häusling // **S. 9** Boden © eyetronic // **S.10** Zeichnung Amt für Umwelt Kanton Solothurn, Schweiz: https://www.so.ch/verwaltung/bau-und-justizdepartement/amt-fuer-umwelt/boden-untergrund-geologie/bodenschutz/boden-ein-kostbares-gut // **S.11** fotolia.de, Hochwasser © Francesco Scatena // **S.12** fotolia.de, Kulturlandschaft © Markus Haack // **S. 15 Collage:** fotolia.de, Bauernhof © Thorsten Schier/ depositphoto.de, Hand © inxti74/ fotolia.de Feld © Cornelia Pithart // **S. 16** fotolia.de, Mähdrescher © Natalia Bratslavsky // **S.17** fotolia.de, Hochwasser © T. Linack // **S. 20** Regenwurm © So happy / Pflanze Mykorrhizierung © D.J.Read Plant Health Care // **S.21** Bodenstruktur © Andrea Beste // **S.23** fotolia.de, Waldboden © alicemaze // **S. 24** fotolia.de, Weizen © Robert Asento // **S. 25** fotolia.de, Biogasanlage © fineart-collection / agrarfoto.de, Schweinemast // **S.26** depositphoto.de, Kanister © mrHanson, Auto © , Tankstutzen © PicsFive / Kühe Steffen © Eichner // **S. 27** Zwischenfrüchte © Andrea Beste / Leguminosen © landpixel.eu // **S. 28** fotolia.de Hand © showcake // **S. 29** fotolia.de, Terra Preta© dima_pics // **S. 30** Traktor Pflug © Martin Häusling // **S. 31** Bodenproben © Andrea Beste // **S. 33** fotolia.de Dünger © Stockr / Bodenproben © Andrea Beste // **S. 34** fotolia.de Erdkugel mit Keim © blueringmedia // **S. 35** fotolia.de Hochwasser © mb67 // **S. 36** Permakultur © Andrea Beste // **S. 37** 50 Jahre ... © ec.europa.eu/agriculture/50-years-of-cap // **S. 38** Hochwasser © Francesco Scatena // S. 39 Wecker © Gina Sanders // **S. 40** Martin Häusling © FKPH

ABOUT THE AUTHOR



Institute for Soil Conservation & Sustainable Agriculture
Kurfürstenstr. 23, 55118 Mainz
www.gesunde-erde.net
gesunde-erde@t-online.de

DR. ANDREA BESTE

is a geography graduate and agronomist. She founded the Institute for Soil Conservation & Sustainable Agriculture in 2001. The Institute offers international analysis and consultancy services in the fields of soil conservation and sustainable agriculture.

DOWN TO EARTH – THE SOIL WE LIVE OFF

ON THE STATE OF SOIL IN EUROPE'S AGRICULTURE

Around 970 million tonnes of fertile soil are lost to erosion each year in the EU. That is enough soil to raise the level of the entire city of Berlin by 1 metre. These figures, published by the European Commission's Joint Research Centre (JRC) in September 2015, are truly shocking.

In the study presented here, Dr Andrea Beste, founder of the Institute for Soil Conservation & Sustainable Agriculture (BBÖA) and co-author of the soil atlas (Bodenatlas) published by Friends of the Earth Germany (BUND) and the Heinrich Böll Foundation (HBS), takes an in-depth look at the state of the soil beneath Europe's agricultural land.

Over the past 15 years, Andrea Beste has personally investigated the state of soil structure at more than 400 different locations in Europe, mostly in Germany. This work was either commissioned by food companies, universities and chambers of agriculture or carried out within the framework of soil protection training seminars for farmers.

In this study, the independent scientist and soil consultant presents current data and conclusions from a number of recent European research projects on the state of our soil. Her findings are alarming, with many soils clearly showing veritable 'burn-out' symptoms. What makes the situation particularly grave is that with climate change on the way Europe could really do with particularly fit and healthy soils to enable us to produce sufficient quantities of food, guarantee a plentiful supply of clean drinking water and prevent flood damage.

The author of the study also describes which therapy Europe's soils urgently need if they are to recover. The potential methods she proposes are nothing new. Some have been overrated for a long time or simply misjudged, whilst other, more effective methods are still being too sparsely applied. Also, far too little lobbying is done on behalf of Europe's soil, even though its health is fundamental to our own wellbeing. Meanwhile, Germany has thwarted the EU Soil Protection Directive, and the so-called 'greening' of the EU's latest agricultural reform has proved unable to prevent humus-sapping crop rotation and monocultures. Furthermore, the EU has no truly effective training and advisory programmes whatsoever for agricultural soil protection management. Nor are there any in Germany's federal states.

So what about farmers? What role do they play in all this?

Based on her experience from more than 15 years' training and advisory work on soil protection, the author says:
"Given current agricultural policy, the fact that producer prices are geared towards the world market, and the need to boost yields, individual farmers have virtually no leeway to attribute greater importance to other ecological soil functions. In view of the relatively meagre - and tendentially falling - value creation in agriculture, many farmers view boosting production and productivity as their only chance of securing their livelihoods. The overexploitation of the soil often associated with this approach constitutes a de facto abandonment of the traditional sustainable treatment of our soil, as practised for generations in agriculture. Some farmers want this to change, but so far there have been too few of them".