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The upcoming European Soil Health Law – chances and challenges for an effective soil protection

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Section II 2.6 Soil Protection Measures
Section II 2.7 Soil State, Soil Monitoring
Section II 2.1 General Water and Soil Aspects
Section I 2.5 Sustainable Spatial Development, Environmental Assessments
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The upcoming European Soil Health Law – chances and challenges for an effective soil protection

by

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On behalf of the German Environment Agency

Executive Summary

The European Soil Strategy for 2030 by the European Commission (EC 2021) has set the foundations for an overarching approach to the protection of soils in Europe. The Soil Strategy provides a vision to achieve 100% healthy soils in Europe by 2050 and specifies concrete measures to reach the goals. In 2023, a European Soil Health Law will be proposed by the European Commission, setting the legal framework on how to implement successful soil protection and restoration in Europe.

The German Environment Agency strongly agrees that a new binding European legislative framework on soils is urgently needed in order to tackle the manifold and transboundary pathways to soil degradation in a comprehensive way. Poor land management, climate change, unsustainable farming, land sealing and pollution have led to more than half of European soils being in a bad status.

Knowing the outstanding importance of soils for human and ecosystem health, we fully support the European Union to adopt an ambitious Soil Health Law.
We agree that the consequences of non-action would by far be higher than the costs of action, as healthy soils are essential for sustainable development and for overcoming the climate, biodiversity and food security crises humanity is faced with.

It is high time that soils receive the same legal status as water and air and that binding legal requirements are adopted at EU-level. We fully support the plans to lay down the planned Soil Health Law as a European Directive.

We have great expectations for the upcoming Soil Health Law, even if it is still a matter of debate how the multitude of issues impacting soil health in Europe can be best addressed. The European Green Deal covers several strategies and legislative initiatives that directly or indirectly address soil protection and restoration. **It needs to be ensured that addressing soil threats and measures under different strategies and associated laws will not hamper concerted action** - by implementing unintentionally a fragmented legislation.

In Germany, legal regulations for soil protection have been in place since the 1990s. In retrospect, some measures have proven to be suitable, others did not have the desired effect. With the present Scientific Opinion Paper, the German Environment Agency provides feedback on legislative options and shares experience gained in the past years on soil protection and restoration.

Our key recommendations for the upcoming Soil Health Law are laid down in this paper and summarized in the textbox below.

Key recommendations of the German Environment Agency

To reach the goals of healthy by 2050, the Soil Health Law shall:

- **request Member States to take immediate action against the most urgent soil degradation issues**, such as soil carbon losses, pollution, soil sealing and land take. For this, the Soil Health Law should
  - formulate binding targets for soil health and land take via a European Directive
- **establish a regulatory approach along the concepts of the Water Framework Directive**, to be implemented by European Member States. The Law should
  - provide common definitions of soil health and define environmental quality standards for the physical, chemical and biological status of soils;
  - set robust and readily workable indicators for soil health, in particular for soil carbon, soil biodiversity and soil pollution; be open for future indicator integration.
- **align retrospective and prospective assessment of soils**, enabling coherent frameworks complementing each other. The Law should
  - overcome regulatory silos by addressing multiple threats co-occurring in soils;
  - link soil monitoring to the prospective environmental risk assessment and management e.g., of regulated chemicals.
- **support the transition to sustainable soil management.** The Soil Health Law should
  - define sustainable soil management practices for different land uses, soil types and pedo-climatic conditions;
  - place non-deterioration and the precautionary principle as key concepts;
  - establish an ex-ante control mechanism for activities with potentially negative effects on soils and a compensation scheme for unavoidable negative effects;
  - consider global issues of soil degradation to face current crises;
  - include land use changes when assessing sustainable soil management;
- **establish a monitoring program for soil health and land take at EU level.** The Law will
  - coordinate national and European monitoring efforts through the European Soil Observatory EUSO;
  - readily share data to help defining chemical, physical and biological status of soils, advance monitoring campaigns and identify emerging concerns.
- **prevent and manage soil pollution.** For this, the Law should
  - address equally diffuse soil pollution in all land use types in addition to contaminated sites management;
  - include soil pollution indicators in setting soil environmental quality standards;
  - define acceptable pollution limits for the re-use of materials and soils;
  - provide a methodology to assess and manage contaminated site risks;
  - apply the polluter-pays-principle.
- **support the Member States in reaching the 'no net land take' target.** The Soil Health Law should
  - provide a clear definition of the term land take, also by distinguishing between land take and soil sealing;
  - harmonize the land take monitoring across the EU to check for progresses.

Table of content

1 Background to the soil legislative framework

With the publication of the **European (EU) Soil Strategy for 2030** (EC 2021a), the European Commission has set the foundations for an overarching framework for the protection of soils in Europe.

The EU Soil Strategy for 2030 is one strategy under the umbrella of the European Green Deal (EC 2019a) and a key deliverable of the Biodiversity Strategy for 2030 (EC 2020a). The EU Soil Strategy sets concrete measures to protect and restore soils, provides a vision and specific objectives to ensure that soils are used sustainably and that healthy soils are achieved by 2050. As shown in the figure below, soils are a common thread of many strategic European and global initiatives.

Figure 1: The EU Soil Strategy interlinks with other European and international initiatives (from EC 2021a)

In 2023, a European Soil Health Law will be proposed by the European Commission. We agree that a new binding European legislative framework on soils is needed, in order to address soil threats and degradation in a comprehensive way. With this approach, the EU will be able to tackle the manifold and transboundary causes of soil degradation, like poor land management, climate change, unsustainable farming, land sealing and pollution.

With the present Scientific Opinion Paper, the German Environment Agency (UBA) provides feedback on legislative options and shares experience gained in the past years on soil protection and restoration. We aim at contributing to the ongoing stakeholder debate in support of the drafting and debating of the upcoming Soil Health Law.

2 The need for action

The pressures on European land and soils are continuously increasing, harming not only human wellbeing, but the wider ecosystems health, the biodiversity and the services they provide.

In its review of the state of the European environment and the outlook for the next decades, the European Environment Agency (EEA) identifies 'serious gaps between the state of the environment and existing EU near- and long-term policy targets' (SOER, EEA 2020a). Monitored species and ecosystems, land use by agriculture, soil conditions - all show developments along trajectories that are 'fundamentally unsustainable'. Past trends as well as the outlook till 2030 indicate that soil conditions are worsening, and **we share the concerns about protection targets for soils being largely not on track**.

Comprehensive analyses on the status of soils and the costs of non-action for human and ecosystem health are available. We mention the reviews of, e.g., IPBES (2018), EEA (2020b), FAO (2020), EFSA (2017), the European Court of Auditors (ECA 2018) and of the Mission Board for Soil Health and Food of the European Commission (Mission Board 2020) as well as the Soil Mission`s Implementation Plan (EC 2021c). The main findings are outlined in the following sections.

2.1 The bad physical, chemical and biological status of soils in the EU

According to the reviews, **60-70% of soils in the European Union (EU) are in an unhealthy state, with an additional share of soils with unquantified pollution issues.**

These results are based on the evaluation of existing soil health indicators (EEA, 2020b). For instance, on 30% area of land, the indicator for **nutrient input** is exceeded, with approx. 70% of agricultural soils experiencing overshoot of nitrogen values beyond eutrophication. Similarly, between 20-30% area of land show low and/or **declining carbon stocks**, display unhealthy **soil compaction**, undergo **soil erosion** and fail regarding the health indicator for diffuse **pollution**. All of these soils are on agricultural land. Also approx. 80% of **land take** concerns agricultural soils. Erosion takes also place on 30% of non-agricultural soils, with 25% of Southern, Central and Eastern Europe soils at (very) high risk of **desertification**.

Contamination and waste management are 'the biggest unknowns' that cause soil degradation on a considerable share of land (EC 2020b). Pollution comprises contaminated hotspots as well as diffuse pollution, the latter covering atmospheric and wider direct and indirect inputs, e.g. plant protection products (da Silva 2019), pharmaceuticals (aus der Beek et al. 2016), metals (Ballabio et al. 2018), biocides (Lozano et al. 2010) and emerging pollutants as per- and polyfluoroalkyl substances, PFAS (Röhler et al. 2021 and references therein).

Even if ubiquitous data at European level are currently missing, all of the above pressures are deemed to impact **soil biodiversity**. A meta-analysis of monitoring data from Germany (Lehmitz et al. 2016) reports negative population trends for common earthworm species. Studies aimed as disentangling the impact of pollution from other anthropogenic impacts on soil biodiversity conclude that e.g., reducing plant protection products inputs by 50% would increase earthworm species densities up to a factor of 5 (Pelosi et al. 2013, 2014). A monitoring campaign in Switzerland has indicated soil pollution as one main driver of soil microorganisms' diversity loss (Walder et al. 2022).

2.2 The costs of non-action for human and ecosystem health

Land and soil continue to be subject to severe degradation processes in the EU, reflecting diverse pressures such as overexploitation, climate change and pollution. **We understand that the consequences of non-action would be much higher than the costs of action**: land degradation costs the EU €50 billion per year, which outweighs the cost of action by a factor of 6 (EC 2021).

The benefits of taking action to protect soils go beyond the mere economic calculation. Investing in prevention and restoration of soil degradation will secure food provision, carbon sequestration, soil biodiversity, clean groundwater, water retention and pollutant attenuation. In addition, preventing soil degradation will, e.g., increase nutritional values of food, contribute to a strong sense of place and so even more to overall human wellbeing.

The following major facts indicate the need for urgent action to protect and restore soils in the next decades:

- **Soils sustain a great share of the terrestrial biodiversity**, and 25% of the overall biodiversity on the planet lives in soils;
- **Soils secure our food supply**, since more than 95% of our food is grown directly or indirectly on soils;
- **Soils are essential for climate change mitigation and adaptation,** as they harbour the largest terrestrial carbon pool on the planet and reduce the risk of flooding and drought;
- **Soils deliver further central ecosystem services,** e.g., nutrient cycling, primary production, water retention and purification, carbon sequestration, food web support, pest control and natural attenuation;
- **Soils suffer from strong degradation** (e.g. chemical pollution, carbon loss, erosion, soil structure degradation), also through unsustainable use;
- **Soils are an unrenewable resource**, since soil development takes place in long-lasting, geological time frames.

Considering the bad physical, chemical and biological status of European soils and the extremely valuable services for society and ecosystems, we fully support the development and adoption of a binding Soil Health Law at European level.

3 Implement an EU-wide regulation

3.1 Overcome past weaknesses and lock-ins

We agree that weaknesses in policy frameworks and their integration particularly in relation to land, soil and chemicals led to failing the overall environmental protection targets for 2020 (e.g., EC 2022c).

The EU Biodiversity Strategy for 2030 (EC 2020a) concludes that there are ecosystems and habitats not sufficiently covered by current legislations, and these are particularly soils. Therefore, to avoid further risks and impacts on human and ecosystems health, 'soils deserve the utmost and urgent attention of governments, parliaments, public authorities at all levels as well economic operators, soil users, local communities and citizens' (WBCSD 2018).

Hence, the dedicated EU Soil Strategy for 2030 aims at overcoming the previous lock-ins and strives to the vision that, by 2050, 100% soils are in a healthy status (see box below).

To reach the vision and guide the transition, the upcoming Soil Health Law needs to lay down binding goals and streamline the efforts of different actors at EU level, since soils currently are i) not sufficiently addressed and ii) under the remit of a multitude of policies.

The aims of the upcoming Soil Health Law are described by the European Commission as to 'address transboundary impacts of soil degradation, secure equal market conditions, promote policy coherence at EU and national level and thus be able to achieve our goals on climate change, biodiversity, food security and water protection'.

It is high time that soils receive the same legal status as water and air and that binding legal requirements are adopted at EU-level. We fully support the plans to lay down the planned Soil Health Law as European Directive.

It is envisaged that better regulation requirements are fulfilled, including a subsidiarity check and full respect the competences of Member States. We therefore understand at this stage that the European Commission will table a proportionate and risk-based framework for soil protection and restoration.

Vision and objectives of the European Soil Strategy for 2030 (EC 2021a)

Vision:

- By 2050, 100% soils are in a healthy status.

Long-term objectives by 2050:

- Reach no net land take;
- Soil pollution should be reduced to levels no longer considered harmful to human health and natural ecosystems, thus creating a toxic-free environment;
- Achieve a climate-neutral Europe and, as the first step, aim to achieve land-based climate neutrality in the EU by 2035;
- Achieve for EU a climate-resilient society, fully adapted to the unavoidable impacts of climate change by 2050.

Medium-term objectives by 2030:

- Combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive for a land degradation-neutral world;
- Restore significant areas of degraded and carbon-rich ecosystems, including soils;
- Achieve an EU net greenhouse gas removal of 310 million tonnes CO2 equivalent per year for the land use, land use change and forestry sector;
- Reach good ecological and chemical status in surface waters and good chemical and quantitative status in groundwater by 2027;
- Reduce nutrient losses by at least 50%, the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides by 50% by 2030;
- Significant progress has been made in the remediation of contaminated sites.

3.2 Embrace the necessity to achieve soil health by 2050

The German Environment Agency fully supports the conceptual approach to strive to achieve healthy soils throughout the European Union by 2050. As outlined above, healthy soils provide a multitude of services central to a sustainable development in Europe and beyond. In our opinion, the upcoming EU Soil Health Law should not only ensure that further degradation of soils is prevented, in order to keep at least the status quo of healthy soils, but should also truly strive to improve soil quality if deteriorated.

Non-deterioration and the restoration of degraded soils should be set as key principles of the new EU-wide soil framework, so to achieve the goal of 100% healthy soils by 2050.

The objective of healthy soils by 2050 is nevertheless an ambitious target. Given the experiences with the implementation of the Water Framework Directive (EC 2000) and the Marine Strategy Framework Directive (EC 2008), it is understood that a thorough and holistic assessment of soils in Europe will take time. Concerns could be raised that too ambitious expectations regarding the soil assessment might divert from the main current challenge - which is to immediately reduce the detrimental pressure on soils. To this end, it is recommended that indicators for the assessment of soils should be simple and easy to implement (see dedicated chapter 4).

If at all, the investment of time and human resources to follow up the status of soils in Europe till 2050 must not divert resources from required and immediately applicable actions to tackle core drivers of soil degradation.

3.3 Understand soil protection as a cross-cutting issue

We have great expectations for the upcoming Soil Health Law, even if it is still a matter of debate how the multitude of issues impacting soil health in Europe can be best addressed. The general way forward is outlined in the European Green Deal (EC 2019a), aiming at an overall sustainable development. However, the European Green Deal covers several strategies and legislative initiatives that directly or indirectly address soil protection and restoration.

On the one hand, adopting an overarching approach has evident advantages, since soil threats and pressures cannot to be fully subsumed under the one or the other single legislative framework.

On the other hand, **it needs to be ensured that addressing soil threats and measures under different strategies and associated laws will not hamper concerted action - by implementing unintentionally a fragmented legislation**.

We indicate that, currently, the overarching framework of the European Green Deal and the related strategies are not fully harmonized regarding soil protection. It will be very challenging to consistently follow the progresses in reaching envisaged soil targets, unless the methodological approaches are harmonized, competencies clearly communicated and legislative frameworks further streamlined.

Examples of cross-cutting issues and missing links: soil pollution and soil biodiversity losses

i) Soil contamination

Pollution issues are the core of the European Green Deal (e.g. Zero Pollution Action Plan, EC 2021b): By 2050, 'air, water and soil pollution is reduced to levels no longer considered harmful to health and natural ecosystems'. The cross-cutting approach is to include pollution prevention in all EU policies, with the clear advantages of maximizing synergies (Conrad et al. 2021). We note that the EU Soil Strategy does present key overarching targets. However, the implementation of the specific measures is planned to take place in different Directives and Regulations - but is currently not there.

For instance, the target of reducing by 50% nutrient losses shall be addressed in the Soil Health Law, while reducing by 50% the use and risk of chemical plant protection products is regulated in the Sustainable Use of Plant Protection Products Regulation (SUR, EC 2022b; Farm-to-Fork Strategy, EC 2020c). Unfortunately, the current SUR draft does not include any specific provisions for soils, while it refers explicitly to the protection of water and groundwater (EC 2020c; Bär et al. 2022).

- **We strongly advise EU COM to close the existing gaps by inserting dedicated provisions for soils and streamline the different legislative frameworks**[1].

ii) Soil biodiversity

Similarly, we are concerned about the missing concrete requirements regarding the support and restoration of soil biodiversity.

The EU Soil Strategy states that we will achieve healthy soils also in respect to soil biodiversity. This view is shared in the new Regulation on Nature Restoration (EC 2022c) as part of the Biodiversity Strategy: 'the [Nature Restoration Regulation] proposal has clear links with the EU Soil Strategy because many terrestrial ecosystems depend on and interact with the underlying soils. Any other soil-related targets will be integrated into future legislation governing soils. However, to date, no specific targets to support and restore soil biodiversity are included in the EU Soil Strategy, neither for 2030, nor for 2050 (see box in previous chapter).

- **We expect the upcoming Soil Health Law to clearly detail how the goals of the EU Soil Strategy regarding biodiversity losses shall be reached and to outline procedures for amendments in the future**. We agree with Köninger et al. (2022) that EU-wide, legally binding protection targets could complement national laws to provide for a standard level of soil biodiversity protection 'while preventing surging costs of not acting'.

[1] for instance, insert in the Sustainable Use Regulation, 'Member States shall have in place appropriate measures to avoid deterioration of soils and allow achievement of good soil status, to protect the soil and terrestrial environment from the impact of …'[e.g., plant protection products or other regulated chemicals] to achieve, at least, the objectives set out in [the respective Regulation or Directive].

Summarizing, we call on the European Commission to provide a clear overview of the targets and measures for the protection and restoration of soils in the forthcoming Soil Health Law – including if needed indications about specific implementation plans in other related legislations. It should be avoided to 'miss the forest for the trees'.

3.4 Enable the loop between prospective and retrospective soil assessment

From our point of view, **it is also central to align the aims of restoring soils and protecting biodiversity in land, soils and waters with the environmental risk assessment frameworks for regulated chemicals** (e.g. plant protection products and biocides, pharmaceuticals, REACH chemicals) - as well as overarching provisions (e.g., CLP, EC 2008) and other policies such as the Common Agricultural Policy (e.g., EU 2021).

With regards to the interface between European soil policies and the frameworks for regulated substances, there should be a link between identified hazards and risks from prospective risks assessments and the setting of overarching environmental goals in the Soil Health Law. Integrating the aims of the different approaches will, in a best case, lead to interoperable frameworks that complement each other. For this, **protection goals need to be defined in a holistic way** (EFSA 2022), so to overcome regulatory silos and address multiple threats co-occurring on the same spot (Sousa et al. 2022). Moreover, the upcoming Soil Health Law should allow for feeding results of monitoring data and trends to soil management cycles.

Linking retrospective findings to prospective environmental risk assessment will help identifying appropriate risk mitigation measures for regulated chemicals to maintain and improve soil health status.

4 Provide a common definition of soil health

According to the vision of the EU Soil Strategy, by 2050, 100% of European soils will be in a healthy status. However, a common definition of soil health is still to be agreed upon.

The general description of healthy soil as given in the EU Soil Strategy relates to their condition. "Soils are healthy when they are in good chemical, biological and physical condition, and thus able to continuously provide as many […] ecosystem services as possible" (EC 2021). Next to ecosystem services very closely linked to human activities (e.g., agriculture and forestry production), also more regulating services are specified (e.g., water and carbon storage), as well as provisioning services related to the soils' biological status ("basis for life and biodiversity, including habitats, species and genes").

What can be considered to be a soil in good physical, chemical and biological conditions is specific to soil type and land uses (e.g., European Environment Agency, Baritz et al. 2022). Nevertheless, **we support the development of an overarching approach, where agreed general definitions are established across Member States and land units, in order to install a level playing field in the European Union**.

This means that not all soils should and will be in the same conditions when defined as healthy, but that the rules and methodologies to define such status are consistent among Member States. There are currently several options and related scientific and legal questions to be addressed when defining the health status of soils, that are explored in the following.

4.1 Determine spatial and temporal scales of assessment

Identifying the appropriate spatial and temporal scales is a prerequisite for the monitoring, assessment as well as the management of the soil health status. Spatial and temporal scales determine how closely assessment points will need to be measured, the potentials of the data evaluation, the informative value and scope of the results and finally the costs associated to the assessment and compliance to the goals and provisions of the Soil Health Law.

Spatial scales can range from the field or parcel level, to administrative units of different aggregation scales (e.g. NUTS[2] regions), to specifically defined soil units based on wider soil type distribution. The monitoring and assessment efforts do not directly increase along the mentioned options; it will be greatest at field scale, while taking NUTS regions as basis will leave open how many units in the region should be assessed.

Based on the current knowledge, we would at present suggest a combined approach: the definition of assessment units related to soil types under broader climatic regions could be integrated by spatial explicit statistical analyses.

In doing so, appropriate but wider soil/land use combinations with related expectations on their typical status could be identified (i.e., differing biological, physical and chemical status of soils under different land uses but similar soil types).

[2] The 'NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU and the UK' (NUTS 1: major socio-economic regions, NUTS 2: basic regions for regional policies, NUTS 3: small regions for specific diagnoses). https://ec.europa.eu/eurostat/web/nuts/background

The practical identification and follow up by soil monitoring and management in such wider but land-use-specific units can be in the remit of Member States, the methodology to define such units and the temporal scale of assessment should be agreed at European level.

4.2 Identify the appropriate benchmarks to define soil health

It is generally acknowledged that the so called Normal Operating Ranges (NOR) for measured parameters or indicators will in most cases relate to specific soil type and land use combinations (e.g., Orgiazzi et al. 2016). Nevertheless, general limit values that indicate the tipping point for a system to shift to an unsustainable state might also exist, independently from e.g., the land use type. In the balance between specificity and complexity, a reference system to benchmark soil health should be as simple as possible without losing its meaningfulness (e.g., EEA, Baritz et al. 2022).

We agree that most likely different approaches will be needed for different assessment goals and their respective indicators. For instance, ensuring healthy soil organic carbon stocks might be verified against a threshold for minimum soil organic carbon contents, while for assessing the status of soil biodiversity, expected ranges in species composition of soil faunal communities should be defined.

When developing such thresholds or ranges of values, it needs to be decided which assessment units are appropriate. We see here two options.

One option might aim at defining healthy vs. unhealthy conditions for a wide range of different soils types under different land uses and climatic regions. This would result for instance in very specific thresholds or parameter ranges for e.g., (purely illustrative) 'healthy sandy soils under conventional agricultural use in central Europe'. The strength of such an approach would be its selectivity, since a detailed separation would reduce parameter variability. A weakness might be seen in the purely dual approach, telling by definition only healthy from unhealthy soils.

Another option would expand the range of status definition to more than the two options healthy vs. unhealthy soils. Such an approach would work in analogy to the methodology applied in the Water Framework Directive (EC 2000): a soil could be in a e.g., healthy/intermediate/unhealthy status, or any other agreed classification. The Water Framework Directive indicates for instance bad, poor, moderate, good and high biological status of water bodies. The pros of such an approach would lie in the lower amount of reference units needed, since for the same soil type and land use, a different maximal deviation from the achievable good status might be considered acceptable under different land use intensities.

In our opinion, a more differentiated approach to the definition of soil health status (e.g., healthy, unhealthy or intermediate) associated to land uses would be more appropriate. A 'traffic light system' could be linked to different type of risks.

In any case, the legal consequences related to the definitions of soil health status need to be considered when finally deciding on the conceptual approach to be brought forward.

Both discussed options above have drawbacks regarding the knowledge gaps in the determination of ranges and/or limits of operation for soil parameters and indicators. This might hamper the implementation of the strategic aims in the EU Soil Strategy and related legislation. **Therefore, after evaluation and consolidation by Member States**

and stakeholders, we urge EU COM to apply available indicators without delay. In parallel, knowledge gaps can be addressed.

4.3 Set indicators of soil health

Indicators for soil conditions have a long-lasting tradition, but have been mostly used as soil fertility proxy. In Europe, new comprehensive analyses of soil parameter range and indicators have been performed by EEA (e.g., Baritz et al. 2022), by the Joint Research Centre (JRC) (e.g., Land Use and Coverage Area frame Survey, LUCAS Soil dataset, Orgiazzi et al. 2018) and by several dedicated European projects (e.g., LANDMARK[3], ISQAPER[4], ENVASSO[5]). As a result, sets of indicators are available, in part with established limit values or benchmark ranges.

However, and as expected due to the past focus on soil fertility, gaps in the definition of indicators exists, especially regarding soil biodiversity and soil pollution and how to best link chemical, physical and biological status.

Regarding **soil pollution** with synthetic organic compounds, EEA suggest to focus on some persistent chemical groups with long lasting impacts on soils and groundwater. We agree that toxic and persistent substances (e.g., PFAS) should by any means be considered and prioritized for limit derivations. We would additionally indicate that also faster degradable compounds might have very strong impacts on soils, especially in the case of e.g., intended mode of action or continuous input. The persistence of substances does not always equal the persistence of effects, which might endure after the substances are degraded.

In order to tackle the definition of soil pollution indicators, we suggest to strengthen the cooperation between European and National agencies dealing with prospective risk assessment and experts for soil protection, monitoring, biodiversity and ecotoxicology. As stated before, an approach similar to the Water Framework Directive (EC 2000) would allow to quickly integrate chemical indicator values for regulated substances. Open issues are how to streamline the methods and the inclusion of multiple residues/mixture toxicity in soil chemical indicators. We think that the work on the Water Framework Directive can help streamlining the process, avoid prior mistakes and focus the efforts. Envisaged output would be, e.g., priority (group of) substances for soils, watchlists and routines for including emerging substances of concern. With such an approach, prospective and retrospective risk assessment could be best linked to each other.

For **soil biodiversity**, data collection and derivation of Normal Operating Ranges for soil communities is developing, also with the help of novel techniques. Gaps have been identified, and there is still a way to go for full databases on soil biodiversity (Cameron et al. 2018, Eisenhauer et al. 2019). However, given the available data, **we strongly suggest to develop an indicator based on earthworm species presence and abundance, possibly supported by a trait-based approach** and in the future by DNA metabarcoding (e.g., Kaufmann-Boll et al. 2022; EUdaphobase[6]). Indicators for soil microbial diversity and antimicrobial resistance are already implemented in the LUCAS

[3] https://esdac.jrc.ec.europa.eu/projects/landmark
[4] https://esdac.jrc.ec.europa.eu/projects/isqaper
[5] https://esdac.jrc.ec.europa.eu/projects/envasso
[6] EUdaphobase, 2022. European Soil-Biology Data Warehouse for Soil Protection. EU COST Action CA18237. https://www.eudaphobase.eu/the-action/

Soil survey for 2018, and the data of the monitoring campaign are being currently evaluated (JRC, Orgiazzi et al. 2022).

However, with regard to soil biodiversity, the current sample points in the LUCAS Soil survey need in our opinion to be expanded.

At a more integrative level, the water holding capacity of soils has be brought up by soil scientists as a potentially very useful indicator for soil health. We suggest to examine this option further as it would be a simple and easily measurable indicator.

Regarding the **indication trends in land degradation**, the European Commission has pointed out that the methodology might be aligned with the approach used by the UN Convention to Combat Desertification (UNCCD, Sims et al. 2021). There, the indicators are calculated by evaluating changes in Land Cover, Land Productivity and Carbon Stocks over time.

For all type of indicators, the European Commission suggests to apply the so called one-out-all-out (1OAO) method, in which a significant limitation or negative change in any one of the indicators mentioned above is considered to compromise soil health.

We urge EU COM to apply available indicators without delay. In parallel, knowledge gaps can be addressed. As soon as further sufficiently robust indicators for soil biodiversity are available, they should be integrated (e.g. through Commission implementing Acts).

5 Support the transition to sustainable soil management

According to the EU Soil Strategy (2021a), all European soil ecosystems are more resilient by 2050, being in healthy conditions. To reach this goal, 'sustainable use and restoration of soil becomes the norm', so that currently unhealthy soils will improve over time.

Sustainable soil use or management is a wide concept without narrow boundaries. Next to clear definitions of the used terms (e.g., 'sustainable soil management', 'sustainable soil use', 'measure', 'practice'), it would be desirable to examine the interrelationships between the provisions in the upcoming Soil Health Law and other existing regulations and initiatives (e.g. CAP, EU 2021 or carbon farming, EC 2021c). A throughout analyses of possible overlaps with other frameworks can also help identifying land use competition and drivers for soil degradation, which may possibly go along with unintended incentives.

We fully agree that the requirements for a sustainable use of soils should be fostered and that these activities need to be coordinated at local, regional, national, EU and global level. Next to introducing and implementing sustainable soil management practices for different land uses, we believe that the application of the precautionary principle cannot be emphasized enough. **Following the precautionary approach as well as the principle of non-deterioration of soil conditions should be specifically stipulated in the upcoming Soil Health Law**.

Similarly, sustainable soil management practices should be understood in the Soil Health Law also as instruments to restore degraded soils, as announced in the Nature Restoration Regulation ('any other soil-related targets will be integrated into future legislation governing soils', EC 2022b).

5.1 Implement urgent measures and consider the global perspective

Without the protection of healthy soils and measures to restore degraded ones, sustainability, climate mitigation and adaptation cannot be achieved (e.g., IPBES 2018). **Healthy soils are key for a social and ecological transformation and only a sustainable soil management will enable achieving the goals of the EU Green Deal.**

We need to embrace transformation now, postponement of measures is not a responsible option (UNEP 2022). The UNEP reports indicates that humanity is facing the crises of climate change, biodiversity losses and pollution, not to forget the various military conflicts, the finance and refugees' crises, political destabilizations and the pandemic (European Green Deal EC 2009; UBA, TES Academy 2022). Sustainability is a key mechanism to ease or even prevent the impacts of these multiple crises.

The objective of healthy soils throughout Europe by 2050 is in our opinion reasonable. **To reach the goals the EU Soil Health Law should oblige the Member States to immediately take appropriate measures to address the well known and most pressing drivers of soil degradation**.

Sustainability can only be achieved in global cooperation and shared responsibility. To this end, the EU must not only cope with the above-mentioned challenges – but also strive at supporting sustainability developments in the Global South (EC 2021a). Unless the focus is broadened beyond the European boundaries, multiple crises will impair successful and sustainable soil management.

Fair, mutually beneficial and respectful cooperation with the Global South is a prerequisite for a global soil sustainable development.

5.2 Install control mechanisms and compensation measures

Given the dramatic situation with regard to climate change, biodiversity loss and pollution as well as other global crises progressing at high pace, we should not be wasting time.

The envisaged EU Soil Health Law should set a clear legal framework for Member States to take measures to avoid or at least minimise the ongoing degradation processes and at best to immediately restore soil quality on specific sites.

In order to manage pressing forms of soil degradation, changes in land use (e.g. to infrastructure or settlement) should be subject to authorization throughout Europe under the upcoming EU Soil Health Law. Within the framework of such ex-ante mechanisms, the party causing potentially negative impacts on soils should be obliged to minimize adverse effects.

In addition, an effective compensation obligation for deteriorating land use changes should be established in order to ensure that unavoidable soil degradation is compensated. The compensation obligation must be designed in such a way that the compensation is orientated on qualitative standards and corresponds to the degree of the soil degradation. In order to be able to implement the compensation obligation, Member States must assess areas at least in terms of natural soil functions and use functions. Member States must be committed to develop an appropriate and comprehensible assessment methodology.

Such a regulatory approach would essentially contribute, *i.a*., to the implementation of the obligation to 'Land Degradation Neutrality' and 'Halt Biodiversity Loss' according to Sustainable Development Goal 15, Target 15.3 and 15.5, respectively (UN 2015 and weblink[7]). At the same time, it would ensure that there would be "no net land take" throughout Europe by 2050, as required by the EU roadmap for a resource-efficient Europe (EC 2011) and the European Soil Strategy for 2030.

5.3 Adopt the sustainable use of soils as the new normal

Sustainable soil management concerns the prevention of soil pollution and the rehabilitation of contaminated sites. However, sustainable soil management need to address more stringently the biological and physical elements of soils, as these are essential for their ecological functioning and the linked social benefits. Measures should avoid or at least minimize soil erosion, compaction, salinization, loss of soil carbon and soil biodiversity. Similarly, the Water Framework Directive (EC 2000) focuses on the ecological dimension of aquatic systems for a successful water management. A similar approach should be envisaged for soils, whereby drivers, challenges and the social/political consequences of soil degradation depend on the land use.

The future sustainable soil management needs to emphasize the biological and physical elements of soils; different land uses require targeted management measures.

[7] https://sdgs.un.org/goals/goal15

In view of the present concurrent multiple crises, further adverse developments might be expected. In order to be able to deal with these crisis, resilient systems for food provision and other goods are needed (European Green Deal EC 2019a).

The EU Soil Health Law should entail as one objective the long-term establishment of resilient soil systems, via a given set of specific sustainable soil management practices.

At this stage of the process it is challenging to discuss which concrete sustainable soil management practices should and will be included in the upcoming Law. Most of the available sustainable practices for soil management refer to agricultural systems, which should be implemented without delays (including Integrated Pest Management Measures to reduce degradation through pollution, e.g. SUR, EC 2022a and Bär et al. 2022). Since the goal of the EU Soil Strategy is to bring all European soils in a good status, measures should be agreed upon which address also other land uses. For example, forest soils would profit from reduction of airborne N-deposition rather than compost fertilization measures.

Summarizing, sustainable soil management practices will be best defined for different land uses, soil types and pedo-climatic conditions. For some land uses, effective and well-established practices can be concretely set in the upcoming Soil Health Law or referred to it. For other land uses, principles to identify sustainable soil management measures could be laid down in the Law, which would need to be refined by Member States according to their specific situations. Given a certain lack of knowledge, there should be the possibility to include new scientific findings, without preventing prompt action when the Soil Health Law will be implemented.

6 Establish an EU wide soil monitoring and soil data sharing

Currently, an overarching integrated monitoring system for soils or for other terrestrial compartments in the EU is being developed. The EU wide LUCAS-Soil project provides information for several soil sites (e.g., Orgiazzi et al. 2018). However, the integration of the existing national systems and the acquired data is still at the beginning.

At the EU level, soil monitoring is mentioned under different frameworks and strategies, resulting in e. g. measurements of antibiotics via the LUCAS-Soil survey as result of the Strategic approach on Pharmaceuticals in the Environment (EC 2019b). For other regulatory frameworks, e.g. industrial chemicals, plant protection products or biocides, representative soil monitoring data is still lacking. **We advocate for the implementation of a 'pollution module' in the LUCAS soil survey, as anticipated in the EU Soil Strategy for 2030**. For this, the LUCAS framework should be further developed, in order to strengthen the methodological reliability, representativeness and reproducibility of data.

The estimation of total contaminations of chemicals in European soils as well as concluding on soil health for different regions, land uses and habitats by considering various adverse impacts is hampered by the lack of harmonized data and the poor availability of existing datasets at Member State level. In addition to this, EU Member States do use different soil classification schemes (soil types, texture classes, as indicated at, e.g., UBA[8] or FAO[9]). A common scheme for all Member States might enhance the comparability of results and at the same time, reduce requirements of intercalibration from the outset. The Soil Health Law would require Member States to provide data through a dashboard including indicators and also to ensure that LUCAS Soil programme will be fully integrated with national soil monitoring systems. It should ensure seamless and harmonised data flows, possibly using advanced web service technologies.

We strongly support the planning and implementation of a European monitoring program and the creation of a central database with open access for the public. The goal is to identify unhealthy soils and to establish management plans so to be able to meet the target of achieving 100% healthy soils by 2050. For this, Member States should be asked to monitor the state of soils regarding soil health in their territory, as well as the improvements in soil health trends.

It is mandatory that existing monitoring gaps are identified, especially concerning parameters, indicators and representativity. Close collaboration with the European Commission and within the EU Member States will be necessary, and the European Soil Observatory (EUSO) launched in December 2020 will play a major role in this huge effort. The EUSO benefits from the extensive preparatory work of the European Soil Data Centre at JRC (ESDAC) and should integrate data from EU-funded projects, and from important national monitoring programmes. EUSO will help set up an EU-wide soil monitoring system pursuant to the so-called INSPIRE Directive (EC 2007) and in connection with national reporting under the National Emission Ceiling Directive (EU 2016) and the Land Use, Land Use Change and Forestry Regulations (LULUCF, EU 2018).

[8] Soil types | Umweltbundesamt
[9] https://www.fao.org/soils-portal/data-hub/soil-classification/national-systems/ru/

An EU-wide expert group on monitoring should be established, also for the clarification, collection and storage of data as well as to guarantee information flow and to meet reporting obligations.

As mentioned above, indicators (and related parameters) should focus on chemical, physical and biological condition of soils which can be measured over time in addition to proxies of soil loss and pressures (land take, sealing, erosion, pollution). Moreover, the occurrence of chemicals in soils should be monitored in combination with occurring soil biological communities.

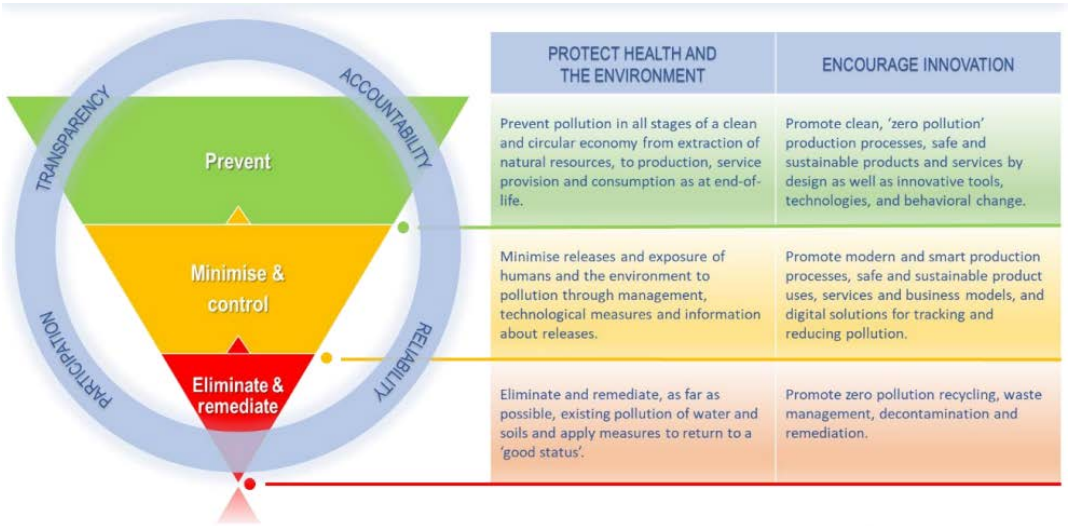
Monitoring data are the basis to holistically evaluate soil state and trends and the link between prospective and retrospective risk assessment.

Very promising soil monitoring schemes are implemented and/or currently developed at Member State levels. **In our opinion, even preliminary data should be shared at EU level**. Such data will help to i) advance upcoming campaigns by communicating chances and challenges; ii) identify co-occurrences and substances of (emerging) concern; iii) define good and bad soil chemical, physical and biological status; and iv) single out promising indicators for soil health.

7 Prevent and manage soil pollution

According to the EU Soil Strategy (EC 2021a), healthy soils should also be in good chemical condition. This means that new contamination should be avoided for all soil related activities as much as and whenever possible. Soils store and accumulate pollutants, but also pollutant transport and dissipation can occur. The presence of chemicals, contaminants and harmful substances and mixtures in the environment is one of the biggest challenges for a good chemical status of soils, waters and air (EC 2020b). Soil is one target of the European Zero Pollution Action Plan (EC 2021b, Conrad et al. 2021) and, as can be seen for the figure below, the policy is based on the precautionary principle, so that preventive action should be taken, damage should be rectified at source and the polluters pay principle implemented.

Figure 2: The zero-pollution hierarchy – reversing the pyramid of action and indicating the approaches for tackling pollution (Zero Pollution Action Plan, EC 2021b)



The EU Soil Strategy differentiates between diffuse soil pollution and contaminated sites. In principle, there are commonalities but also specific differences between contaminated sites due to (more or less) confined point source pollution and pollution by diffuse sources. When defining limits for the contamination with specific substances (e.g. for preventing impacts on soil biodiversity), comparable approaches for both types can be used, since the same pollutants might emerge at contaminates sites as well as following diffuse pollution. A difference between the two types of pollution exists for the area coverage, since diffuse pollution often concerns broader shares of land. Therefore, provisions for preventing and managing diffuse contamination might differ compared with e.g., contaminated site remediation.

7.1 Address and reduce diffuse soil pollution

The EU Soil Strategy as well as the publications by EEA (SOER, EEA 2020b) clearly state that the 'diffuse soil contamination by atmospheric depositions, pesticides, antibiotics, excess fertilisers, microplastics, sewage sludge and other waste disposed of on land is widespread'. Cumulative effects arise, caused e.g., by agricultural practices including direct (and often sequential or combined) application of plant protection products as well as indirect contamination by application of slurry and sewage sludge containing

pharmaceuticals, biocides and chemicals and additionally diffuse soil contamination by atmospheric deposition.

We strongly advocate that the upcoming Soil Health Law specifically addresses diffuse soil pollution - additionally to the attention paid to contaminated sites.

As outlined above, commonalities and differences exist between contaminates sites and diffuse soil pollution, especially regarding the extent of the areas concerned and suitable management options. Therefore, we support the EU Soil Strategy efforts to list not only remediation possibilities but also management options for soils affected by diffuse pollution, with a focus on supporting of soil health (e.g. for soil biodiversity restoration).

It is central to set and implement reduction targets for diffuse pollution of soils in Europe. Reduction targets for plant protection products (PPP) have been set in the Farm to Fork Strategy (EC 2020b) and also reported in the EU Soil Strategy, aiming at reducing the use and risks deriving from the use of PPP to 50 % until 2030. **Comparable reduction targets as for PPP are missing for other chemicals and should be implemented as soon as possible**.

Diffuse soil pollution is often caused by regulated products co-occurring and accumulating in the environment. For several classes of regulated chemicals or products, assessments of toxicological and ecotoxicological risks have been performed prior or accompanying their placement on the European market. The assessment is based on available test results on non-target organisms and/or on extrapolation following agreed scientific and legal frameworks. **Acceptable concentrations of chemical residues in soils can be derived for regulated substances, indicating levels below which healthy soil conditions can be assumed, e.g. in relation to human threat and soil biodiversity**. If further differentiated according to spatial and typological soil units, the approach would be similar to the one implemented in the Water Framework Directive (EC 2000) or the Marine Strategy Framework Directive (EC 2008). In further analogy to the Water Framework Directive, an agreed approach to identify priority substances should be established (see chapter 4.3).

For agricultural uses, thresholds for potential pollutants in materials such as sewage sludge, fertilisers, composts, digestates, soil improvers are necessary in order to prevent the entry and enrichment of pollutants in soil and groundwater as well as in feed or food. **Food safety should be interconnected with pollutant levels in the soils used for food and feed production.** Especially persistent and non-degradable pollutants like PFASs may cause tremendous problems for human health and the environment when no limits in are set for materials applied to soil (e.g., Röhler et al. 2021).

The Federal Soil Protection and Contaminated Sites Ordinance (Germany 1999, 2020) lists precautionary values for some heavy metals, PCBs, benzo(a)pyrene and PAHs that are depending on the respective soil type. Precautionary values are set on the basis of ecotoxicological impact thresholds and aligned with background values for rural areas. If precautionary values are exceeded, further input of pollutants into soils via all input pathways must be limited to a maximum load in order to prevent hazards to soil. The precautionary values are applied, for example, when materials (especially soil material, sewage sludge, biowaste) are placed on or in soils and when new industrial facilities are approved. They can also serve as reference for the remediation of already polluted soils, if proportionality is considered and hazard threshold are not exceeded. Although emerging pollutants such as PFAS have not yet been included, this approach could be used on an EU wide basis. In order to reach the target of 100% of soil in healthy status, it

is central to include all land uses affected by diffuse soil pollution – also agricultural soils – and to amend the list of pollutants (see also chapter 4).

Also airborne pollutants can affect the physical, chemical and biological state of soils. Nitrogen inputs lead to eutrophication and acidification with effects on the nutrient balance, the humus layer and soil biodiversity. Toxic heavy metals can accumulate in the soil and cause long-term effects. **Therefore, ecologically oriented concepts from air pollution control should be integrated into soil protection**. Suitable approaches are, for example, the critical load approach or deposition modelling (e.g. Bull, 1992).

Summarizing, not only reduction targets, but also **quality standards to address and limit diffuse soil pollution should be defined.** Preventing and managing diffuse soil pollution can best be achieved by harmonising the protection goals and the requirements of prospective and retrospective risk assessment of chemicals. A common definition of unacceptable consequences from diffuse soil pollution across different legislations would enable to best link prospective to retrospective assessments and to feed monitoring data into the authorization procedures for chemicals.

7.2 Define acceptable limits for materials applied in or on soils

Germany has set precautionary soil values for a range of inorganic and organic substances and acceptable loads of priority substances for (soil)materials. Similar values set by Member States could be harmonized at EU level and built the starting point for further developments. The implementation of an overarching concept would enable the circularity of mineral waste, recycled products and soil material, overcome the landfill scarcity and lead simultaneously to a better soil and water protection as foreseen by the Soil Health Law and the Circular Economy Action Plan.

Excavated soils and mineral construction material are a major waste stream. In Germany, approximately 220 million tonnes of mineral construction waste were generated in 2018, of which 130 million tonnes were soil and stones. From these, 100 million tonnes were recycled in surface mining or, predominantly, in landfill construction. 86 % of the fraction of stones and soils were recycled under waste legislation. The remaining 14 % were deposited in landfills, i.e. disposed of in accordance with waste legislation. Thus, the two most important recycling routes for mineral waste are recycling, i.e. processing and subsequent incorporation in structures, as well as other material recycling used for backfilling excavation sites and opencast mines.

It is therefore necessary to define requirements for re-used and recycled materials to be applied in or on soils to ensure soil health. The German Substitute Building Materials Ordinance (Germany, 2020) will be enforced in August 2023. It defines precautionary requirements for the production and incorporation of mineral substitute building materials for the first time in a legally binding and uniform manner throughout Germany. Mineral substitute building materials within the scope of the Ordinance include recycled building materials from construction and demolition waste, slags from metal production and ashes from thermal processes. On the installation side, technical structures are primarily affected in civil engineering, such as roads, railways, paved surfaces, pipe trenches, noise and privacy barriers.

On the one hand, the ordinance specifies limit values for the respective substitute building materials or their individual classes with regard to certain pollutants, compliance with which must be ensured by the manufacturer within the framework of

quality monitoring. On the other hand, it provides for installation methods adapted to these limit values, which are to be observed by the user during installation in the technical structure according to the local conditions. This is intended to limit the entry of pollutants through leachate into the soil and groundwater and to exclude contamination.

It should be explored if similar provisions could be a basis for harmonized regulations in Europe. A level playing field is needed at EU level, in order to sustainably protect soil and ground water resources in the long term. **The presence of possible pollutants needs to be considered when re-using excavated soils and when (recycled) mineral building materials are installed in or on soils.**

A European Soil Health Law should focus on appropriate requirements for the use of mineral waste, recycled products and soil material when incorporated into engineered structures or fills to protect soil and groundwater. European provisions should on one hand promote the circular economy to protect and reduce the consumption of natural resources and on the other hand ensure proper and harmless recycling. **We support the principle to trace permanently the properties, type and extent of the placement of residual contaminated excavated soil via a register or certificate**, as suggested in the EU Soil Strategy.

In our opinion, the following criteria should assure soil protection requirement levels when using or re-using soils or (recycled) mineral materials:

- limit values for excavated soils and soil material to avoid harmful soil and groundwater changes or pollution;
- material values linked to quantitatively derived limits that ensure compliance with legal precautionary values (groundwater);
- science-based examination catalogue for quality monitoring;
- requirements for the (re-)use of materials (e.g., (recycled) mineral materials) in so called technical structures.

Therefore, a harmonization of the assessment procedures of material standards and the soil and groundwater protection regime are essential. However, the Soil Health Law should focus on the impact assessment of these materials with regards to harmful changes or pollution of soils and groundwater.

7.3 Identify and manage contaminated sites

Contaminated sites in the context of this paper are local soil contaminations by hazardous substances posing risks to environmental and human health. Examples of contaminated sites are industrial sites with harmful soil pollution, mining sites, abandoned industrial and waste disposal sites.

At suspected contaminated sites, a site-specific risk needs to be investigated and evaluated, before the site is officially called a 'contaminated site'. The competent authority then formally confirms contaminated sites. In cases with justified risk or hazard, a fundamental need for action is required. Measures and associated management concepts for contaminated sites serve to avert hazards and are subject to proportionality.

When publishing data on contaminated sites, **we strongly recommend to publish only data on officially approved contaminated sites** and not on suspected sites. As long as

the site status is only based on suspicion, devaluation of private properties must be prevented.

In order to confirm the suspicion of a contaminated site, a largely harmonized tiered approach is the state of the art in Europe. **We recommend conducting a series of investigations (historical exploration, orienting investigation, detailed investigation) with the aim of ruling out suspected cases with proportionate effort and as early as possible.**

For operative industrial sites, the obligations under the Industrial Emission Directive (IED, EU 2010) to protect soil and groundwater should be better linked to the EU Soil Strategy. The Environmental Liability Directive (ELD, EU, 2004) also contains a list of potentially contaminating risk activities (Annex III), and requires operators to remediate contaminated sites that pose risks for human health. However, this Directive does not provide an initial trigger for soil investigations, but rather aims to apply the polluter pays principle for the soil remediation phase.

A working aid compiled from the many existing documents **could help unexperienced Member States to assemble a sector catalog with main contaminants and technical and technological indications on where and for which substances and mixtures to expect.** Furthermore, additional information on sampling, sample preparation and (standardized) analytics and possible triggers for further soil investigation should be offered to competent authorities.

Member States should decide on the assessment of the significance of risks for human health and the environment. However, a level playing field is needed, so that the aims of the EU Soil Strategy and the upcoming Soil Health Law can be accomplished across the European Union.

For the complex definition and the assessment of dangerous substances, the Regulation on classification, labelling and packaging (Annex VI CLP, EC 2008) should be used and enhanced as crucial reference archive and data base. For this sake, CLP classification needs to be amended for terrestrial systems as the classification for toxicity as well as bioaccumulation are based on aquatic systems, only. This would strengthen the existing cross-references to other EU legislations, in particular to REACH (Regulation (EC) No 1907/2006) and Industrial Emissions Directive (Directive 2010/75/EU).

The Germany´s Soil Protection Act and ordinance regulates trigger values (“Prüfwerte”) and action or intervention values (“Maßnahmenwerte”) in addition to precautionary values. An exceedance of the trigger values is an indication that soil health may be at risk, so that further detailed investigation and a site-specific risk assessment needs to be performed. A site-specific assessment clarifies whether there is a risk to the protection targets (e.g., groundwater, human health but also for food and feed). If the unacceptability of risks is confirmed, a formal decision is taken by competent authorities about e.g. the definition of a contaminated site and the necessity of remediation measures. Exceeding action values has far reaching consequences and usually directly requires remediation measures. In view of the consequences, a high level of scientific knowledge, consolidated (eco-) toxicological baseline data reliable impact assessment are required when deriving these values. For these values, European harmonization would be most conceivable and justifiable.

We recommend that a basic methodology for determining the action values be established throughout the EU, but not concrete values. The selection of remediation

or management measures is elaborated in a remediation study where options are compared for their suitability, adequacy and proportionality.

The objectives of soil remediation are the elimination or containment of the source of contamination or the interruption of the transfer along relevant pathways or of the protected property with respect to the authorized site use. **Remediation objectives and associated measures or management should always be site-specific and reflect the authorized use of the site and follow the principle of proportionality. Authorities should apply the polluter-pays-principle** including polluters, legal successors, current land owners or tenants. A risk-based approach as opposed to precautionary soil protection can be accepted as a guiding criterion.

Most Member States have some form of register for suspected contaminated and/or contaminated sites, or are working on the development. However, there are considerable differences in terms of scope and structure, also because of the regulatory variation between Member States. The responsibility for the management of these registers can lie with different administrative levels (national, regional or local authorities) which sometimes results in different approaches, even within a Member State. **We see the need to harmonize the basis for the indicator "progress in management of contaminated sites", as this is the only way to make a reliable statement about the progress of the remediation of contaminated sites.**

In addition to the polluters and their legal successors, long-term financing instruments covering the default risks should also be introduced or required. Financial guarantees are the most difficult to implement. Solutions could be pollutant-related fund solutions, insurance solutions, specific remediation programs and brownfield development incentives.

8 Reach no net land take

Land is a finite resource. Therefore, we highly appreciate the European Commission intention to implement the no net land take target of the EU Soil Strategy in the Soil Health Law. **However, across EU Member States, there are terminological differences and demarcation difficulties between different, often synonymously used terms addressing land take.** Land take is the cause of soil damage and the loss of soil ecosystem services. Negative consequences arising from land take are e.g., soil sealing and landscape fragmentation, and also of economical and social nature. The EU Soil Strategy is not clear if land take is understood as soil sealing or in a broader sense of losing open space. **Therefore, a clear definition of the term land take is needed, providing conceptional clarity and monitoring guidance for Member States**.

Basically, **the term land take may not be equated with the term soil sealing** - as it is partly done in the EU Soil Strategy. According to the definition of the EEA, '[…] land take addresses the change in the area of agricultural, forest and other semi-natural land taken for urban and other artificial land development. Land take includes areas sealed by construction and urban infrastructure, as well as urban green areas, and sport and leisure facilities […]' *i.e.*, **land take may include soil sealing but does not necessarily include it in any case.**

Land take in Germany is defined and registered as the increase of land that is used for 'settlement and transport', measured in hectares per day. Monitoring of land take is based on national land registers and reported as part of official land use statistics which is published annually by the German Federal Statistical Office (DESTATIS). The land use type 'settlement and transport' includes residential, industrial, retail and service surfaces, waste disposal and public facilities, sports, leisure and recreation surfaces, cemeteries, roads and paths, public squares, as well as rail, air and shipping infrastructures. At European level, published land take data primarily relate to remote sensing data from the Copernicus Earth observation programme (Copernicus Land Monitoring Service/Corine Land Cover CLC), as in the EEA SOER Report (EEA 2020).

For monitoring and harmonisation reasons it is essential to note that **significant discrepancies between land take recorded on the basis of aerial and satellite images and land take recorded from official national land registers may arise**. Such differences result for example from resolution limitations and inconsistencies in the collection of CLC data that have dominated European spatial observations for many years. Furthermore, land use nomenclatures for earth observation survey methods and land register survey methods are slightly different. As a result, land take recorded from national land take registers and land take recorded from aerial photos and satellite images may differ significantly. Therefore, it must be made clear how to deal with such effects concerning EU wide monitoring regulations.

Quantified land saving targets (land take limits) exist in Germany, Belgium (Flanders) and France, although the targets in Germany and Belgium are not legally binding but merely political in nature. In other countries, there are mostly only qualitative targets for the protection of soils and open spaces. In some cases, certain land uses are protected by law or the conversion of agricultural land for the implementation of certain projects is only permitted under certain conditions. **Therefore, we see the need to harmonize the basis for land take monitoring across the EU, as this is the only way to make a reliable statement about the progress of land take reduction in Europe.**

9 Conclusions

With the EU Soil Strategy for 2030, the European Commission paves the road to an overarching framework to protect and restore soil. We agree that binding targets are needed in order to overcome past inconsistencies and unite Member States in their efforts to tackle the transboundary causes of soil losses and degradation.

It is high time that soils receive the same regulatory status as air and water, given their outstanding importance for facing current climate, biodiversity and food security crises.

We strongly encourage the EU Commission to adopt an ambitious Soil Health Law, proposed as European Directive and with binding targets to be implemented by Member States.

In order to be able to reach the appropriate but also ambitious goal to achieve 100% of European soils in a healthy status by 2050, we strongly suggest to:

- **formulate binding targets** for soil health and land take via a European Directive, following e.g., the concepts implemented in the Water Framework Directive;
- **require Member States to take immediate action** against the most urgent issues leading to soil degradation, e.g. carbon losses, pollution, soil sealing and land take;
- **provide a common definition of soil health and set soil quality standards** for the physical, chemical and biological status of soils;
- **implement robust and readily workable indicators for soil health;** include right away soil biodiversity, soil pollution and land take indicators and their range values; ensure that novel knowledge can be included regularly;
- **specify measures leading to sustainable soil management**, covering different land use types and including land use changes;
- establish an **ex-ante control mechanism for activities with potentially negative effects on soils** and **a compensation scheme for unavoidable negative effects**
- **set up a monitoring programme for soil health and land take at European level,** including agricultural, urban and rural areas;
- **create effective regulatory instruments** to follow up on target achievement, enabling Member States to arrange for appropriate management cycles;
- **address diffuse as well as point source pollution,** propose management measures for protecting soils from diffuse contamination as well as for remediating contaminated sites;
- **link the findings from soil monitoring to the prospective risk assessment** of regulated substances; **implement the 'no net land take' target,** provide a clear definition of land take and align the requirement for land take monitoring.

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List of abbreviations

CLP	Regulation on classification, labelling and packaging
DNA	Desoxyribonucleic acids
EEA	European Environment Agency
EFSA	European Food Safety Authority
EC	European Commission
EUSO	European Soil Observatory
FAO	Food and Agriculture Organisation by the United Nations
INSPIRE	Infrastructure for Spatial Information in the European Community
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
JRC	Joint Research Centre of the European Commission
LUCAS	Land Use and Coverage Area frame Survey
LULUCF	Land use change and forestry regulations
NOR	Normal operating range
NUTS regions	Nomenclature of territorial units for statistics
PAH	Polyaromatic hydrocarbons
PFAS	Per- and polyfluorinated alkyl substances
PCB	Polychlorinated biphenyls
PPP	Plant protection products
UBA	German Environment Agency
UN	United Nations
UNEP	United Nations Environment Program