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PART 5/12

# COMMISSION STAFF WORKING DOCUMENT

# IMPACT ASSESSMENT REPORT

## ANNEX VI-b

*Accompanying the*

**proposal for a Regulation of the European Parliament and of the Council**

**on nature restoration**

{COM(2022) 304 final} - {SEC(2022) 256 final} - {SWD(2022) 168 final}

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# Annex VI: Analysis by ecosystem

## *(VI-b: Chapters 6-10)*

Summaries of Impact Assessments of ecosystem-specific EU restoration targets

Because of its size, annex VI is split in two parts. Chapters 1-5 are in annex VI-a:

1. **Inland wetlands**
2. **Coastal and other saline wetlands**
3. **Forests**
4. **Agro-ecosystems**
5. **Steppe, heath, scrubland, dune and rocky habitats**

**Table of contents of VI-b:**

# 6. Freshwater: Rivers, lakes and alluvial habitats

## 6.1 Scope

The freshwater ecosystems of Europe comprise habitats mainly dominated by plants that are strictly aquatic, emergent, or amphibious, or by grasses or herbs that are adapted to occasional floods and able to develop during dry periods. Freshwater habitats are widely distributed across Europe but vary in character and distribution according to climatic and geomorphological conditions. Permanent water bodies are mainly concentrated in the northern and Atlantic regions, while the temporary ones are more typical in areas with a Mediterranean climate. Some of these habitats can be part of very broad ecosystems (like long rivers or large lakes), while others occur as small and localised patches (like springs or ponds). Natural or anthropogenic supplies of nutrients and minerals are important factors determining the species composition of the biotic part of most freshwater habitats, which can thus be grouped according to their trophic level: they can be oligotrophic, mesotrophic, eutrophic or dystrophic, or exhibit a range of such conditions.

According to the Mapping and Assessment of Ecosystems and their Services (MAES) framework, river and lake ecosystems comprise the following EUNIS habitats[1]:

- C1 Surface standing waters (Lakes, ponds & pools, permanent lake ice)
- C2 Surface running waters (Springs, upstream tidal and non-tidal rivers including temporary ones)
- C3 Littoral zone of inland surface water bodies (Various vegetation types in around freshwater)

All EU Habitats Directive Annex I lake and river habitat types (codes 31xx and 32xx) are included within the scope of this thematic Impact Assessment (IA). Acknowledging that rivers are wider than the channel associated to them, riverbanks and areas next to rivers, which may be covered by water only during floods, are also considered as part of the river system and therefore the scope of this IA also includes Habitats Directive Annex I habitats covering alluvial forests- and meadows. Floodplains acting as interface between catchment and the river are an important ecological part of the system and its healthy functioning and are therefore also part of the river ecosystem.

Detailed data on the geographical distribution, area (km²), conservation status and condition of rivers, lakes and alluvial habitat types of Annex I of the Habitats Directive in EU Member States is provided in Annex VIII-f.

## 6.2 Problem, current trends and ecosystem-specific baseline

Freshwater ecosystems deliver a wide range of ecosystem services, providing water for drinking, energy infrastructure cooling, irrigation, the provision of fish, flood protection, water purification and recreational, cultural, and spiritual values. In addition, freshwater ecosystems play a critical

[1] The EUNIS habitat classification is a comprehensive pan-European system for habitat identification. The classification is hierarchical and covers all types of habitats from natural to artificial, from terrestrial to freshwater and marine. The habitat types are identified by specific codes, names and descriptions. The full EINIS https://eunis.eea.europa.eu/habitats-code-browser.jsp

role in adaptation to climate change, as projected changes in seasonal and annual flood patterns, water availability and dilution capacity will affect the functioning and societal reliance on services obtained from such ecosystems. Floodplains play an integral role in water retention, particularly when such habitats are maintained in good condition and unhindered from human interventions such as soil sealing, and alterations made to the flow of rivers, thus providing flood prevention and mitigation services. Lastly, freshwater ecosystems provide key services purifying water and recharging groundwater supplies, essential for the EU's drinking and agriculture water supply.

Many of the ecosystem services provided by freshwater ecosystems in the EU rely upon them being in good status and the waters of good quality, but only 38 % of surface waters are in good chemical status, and 40 % of surface waters are in good ecological status/potential[2]. When it comes to the conservation status of Annex I lake and river habitats of the Habitats Directive, 22 % of habitats assessment show a not good status, and more than 22% of assessments show deteriorating trends compared to previous reports compared to improving trends in only 4,5% of assessments. Adding to the poor status of a significant proportion of water bodies and habitats, a significant proportion of assessments, for both the Water Framework Directive and the Habitats Directive reporting on freshwater habitats, report an unknown status, which could mean that the extent of degraded ecosystems may currently being underestimated.

The first EU Ecosystem Assessment described several pressures affecting freshwaters[3]. While certain pressures have been decreasing over time, as policy measures have taken effect, others have continued to increase including land take of floodplains, diffuse source of pollution, such as nutrients from agricultural sources, and over-exploitation. As outlined in the European Waters Assessment[4], which is based on data reported under the EU Water Framework Directive, hydromorphological pressures, which alter aquatic habitats and hydrology, are the most common pressure for surface waters, affecting 40 % of water bodies. Barriers, obstacles, and transverse structures are examples of hydromorphological pressures that disturb river continuity, alter the flow and modify the habitats. Reporting under the Habitats Directive allowed the identification of the top three groups of pressures (in percentage of the total) on river, lake, alluvial and riparian habitats Annex I habitats. These are:

- **Modification of hydrology and hydro-morphology** accounting for over **33 %** of all pressures; this includes e.g. drainage, water abstraction, and dams and reservoirs;
- **Pollution** from different origins close to **22 %**; from these, over two-thirds (67 %) is originated from agriculture activities, about 18 % from mixed sources and 12 % from residential, industrial, and recreational activities;
- **Habitat management**, with over **18 %**; these include inadequate agricultural practices like under or over grazing and mowing (32 %), forestry practices such as

[2] According to the latest water status reporting under the Water Framework Directive.
[3] Maes et al. (2020). Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161, EN, Publication Office of the European union, Ispra, 2020.
[4] EEA (2018) European waters Assessment of status and pressures 2018.

logging and removal of dead and old trees (44 %), mineral extraction (14 %) and freshwater fish and shellfish activities (9 %)[5].

While restoration actions are, either implicitly or explicitly, required under the EU water and nature legislation, to achieve the policy objectives, and while data on current ecosystem maintenance and restoration efforts in the EU is incomplete, studies have indicated that current restoration activity is significantly below what would be required to fulfil policy objectives[6].

## 6.3 Target options screened in/out

Table VI-11 below presents a short summary of the options screened for the freshwater ecosystem impact assessment, highlighting which options were retained for further analysis.

**Table VI-1 Summary table screened target options**

| Target option | Screened in/out for assessment | Key reason(s) for screening in/out |
|---|---|---|
| Restore all HD Annex I freshwater habitats to good condition, with all necessary restoration measures completed on 30 % (or 15 %) of degraded areas by 2030, 60 % (or 40 %) by 2040 and 100 % by 2050. | **Screened in –** the target would require MS to restore at least 15 % of the area of degraded habitats to achieve good condition. The target would apply to all freshwater habitats listed under the Habitats Directive (32 habitats), using the reporting frameworks currently in place for this Directive. The target would aim to improve condition status of freshwater habitats, whilst also improving the data availability on their condition. | Good conditions of a habitat refer to its structural and functional condition, which includes biological as well as abiotic factors, covering components under the HD and WFD. The good condition is one of the pillars required to achieve Favourable Conservation Status (FCS) under the HD. The aim of the target is to take the restoration actions on at least 15 % of degraded freshwater habitat area by 2030 required to achieve good condition. Important here is that the restoration of particularly floodplains will directly assist in the achievement of the BDS 2030 free-flowing river target, as it ensures that lateral connectivity is restored. We recognize that degradation of habitats can be significantly different between regions. However, since the restoration action covers a percentage, it will count for all Member States and as such, those with the largest area of degraded habitats will also have the largest effort. |
| Re-create area as necessary to achieve Favourable Conservation Status of HD Annex I rivers, lakes, and alluvial habitats at national | **Screened in**- the target is largely intertwined with the option above, yet this option target would specifically require re-creation of | The target is linked to the target above- providing a means of synergistically achieving good condition of freshwater habitats. The |

[5] EEA (2018) European waters Assessment of status and pressures 2018.
[6] Eftec et al., (2017) Technical support in relation to the promotion of ecosystem restoration in the context of the EU biodiversity strategy to 2020.

| | | |
|---|---|---|
| biogeographical level by 2050, with 15 %(30%) achieved by 2030 and 40 %(60%) by 2040. | freshwater habitats to consider habitats which have been lost (for example, to other economic activities such as agriculture). | option considers areas that have been lost and require recreation. Data gaps exist on the opportunity costs of re-creation, and will be required to be estimated on a case-by-case basis. |
| Restore and re-create the area as necessary to enhance the conservation status of species listed in Annex II, IV and V of the Habitats Directive as well as wild birds associated with rivers, lakes, and alluvial habitats in view of achieving their favourable conservation status by 2050, with at least 15 % achieved by 2030 and at least 40 % by 2040. | **Screened in**- The target can be directly based on existing status reporting under the Nature Directives and is complementary to other targets. | The target could be very effective if implemented with adequate resources to follow-up on all individual species. In addition, the target would allow habitats of a wider range to be considered for restoration action, for example habitats considered under EUNIS but currently not under Annex I of the HD. However, it would need to assess progress based on a much bigger body of data, as there are many more listed species than habitats and their restoration needs are more diverging. |
| Develop an inventory of all barriers in the EU and a plan of which ones to remove by 2030 with a view to achieving free-flowing status where possible and necessary to restore the habitats depending on the natural functioning of a river system. | **Screened in**- The target would assist in building the knowledge base on the extent of freshwater barriers to longitudinal and lateral connectivity present in the EU. With hydromorphological barriers noted as a key hindrance to the implementation of the WFD and Nature Directives, this target establishes a clear pathway to the eventual removal of barriers which have been identified as removable by MS. | A lack of EU-wide data on freshwater barriers exists, yet numerous MS and research-related (such as the AMBER project) databases are present- therefore there is a clear need to combine and upscale this information. This requirement would align with reporting currently required under the WFD, meaning additional costs for inventorisation could be considered small. A body of work and actions on barrier removal have been undertaken, meaning technical expertise on removal is available, and could be deployed to initiate important restoration efforts to re-establish the natural connectivity of rivers, in line with the targets of the 2030 Biodiversity Strategy. Studies on the related parameter of length of free-flowing rivers have also been initially carried out, however, currently there is not enough information to set a specific target in terms of km to be restored or number of barriers to be removed. For this further data collection and analysis would be needed. |
| Mapping out of small water units, with a view to identify their restoration and recreation potential and asses their contribution to improve connectivity between | **Screened in –** The target would assist in building the knowledge base on the extent of small freshwater units currently not explicitly delineated or grouped the | This target would build upon existing legislation and complement the other proposed targets. Smaller water units are not necessarily explicitly delineated or grouped |

| | | |
|---|---|---|
| habitats as part of high diversity landscape features, contributing to the restoration of habitats and species. | Water Framework Directive and potentially playing a key role in maintaining biodiversity and connectivity between habitats. This target establishes a clear pathway to the eventual restoration of smaller bodies of water that may be key to the survival of important habitats and species. | together with delineated water bodies for the purpose of the characterisation of water bodies under the WFD. This is because the WFD, whilst setting clear quality objectives for all waters in Europe, relies on the concept of delineated 'water bodies' to make the compliance checking of the quality objectives under the Directive operational. Water bodies are delineated or grouped together with other water bodies based on the methodologies set out in Annex II, which may result in smaller water units not being delineated as actual water bodies under the WFD, making it more difficult also to assess compliance with the objectives which apply to all inland surface waters, transitional waters, coastal waters and groundwater.<br><br>Some of these smaller water units may host habitats and species addressed by the Nature Directives and be partly addressed by targets 1a, 1b and 1c. They may play an important role as part of a diverse landscape and can contribute to habitat connectivity. They may also have significant potential in providing valuable ecosystem services such as water purification, carbon sequestration, water retention. Considering the flexibility under the WFD for Member State authorities to delineate their water bodies and whilst the latter are the units for assessing compliance with the objectives of the directive which however apply to **<u>all</u>** waters in the EU, it could be useful to also collect better information on the water units not part of delineated water bodies, to verify how severely they have been impacted, the primary pressures and the current conditions they are in, to be able to set a specific quantified target for restoration. For this reason mapping such small water units may play a role in helping to meet EU policy objectives on water quality and biodiversity, and in closing existing |

| | | |
|---|---|---|
| | | data gaps of unknown and unmapped habitats and conditions. |
| Implement standardised ecological flow assessments | **Screened out –** due to significant overlaps with the WFD. The target would require a conceptual definition of ecological flow with reference to flow quantity and dynamics in line with the WFD objectives to be set in national frameworks. The aim of the target is to explicitly require the setting and use of environmental flow assessments in Member States and integrate these within their WFD national frameworks by a specified date, not only for the assessment of water status but also in strategic planning and development. In this regard, the target would still be allowing for variations in Member States legislation and methodological approaches to ecological flow | The WFD already requires ensuring hydrological conditions that are compatible with the achievement of good ecological status. The CIS guidance n°31 provided clarification regarding this requirement by defining ecological flow as an objective to be set in river water bodies. Setting a new legal target for ecological flow objectives would consequently be redundant with the requirements of the WFD and possibly jeopardize it by setting a conflicting deadline, considering that the objective to achieve good ecological status under the WFD (including good hydromorphological status and thus appropriate ecological flow) applies since 2015, with a limited possibility for time exemptions until 2027.<br><br>One alternative option which would go beyond the strict requirements under the WFD would be to define, in EU legislation, the specific objectives of ecological flow for the different water bodies, as opposed to the current obligation resulting from the WFD for Member states to do so. However, this option was screened out as well as the nature of ecological flow requires specific assessment to be made at the scale of the river basin or water body and may change in time due to natural events or changes in the hydrology so would require regular updates and specific knowledge which the EU legislator does not have and could impossibly gather for all water bodies in the EU. Therefore setting such objective at EU level would not be appropriate.<br><br>The data gaps regarding trends of flow changes and baseline assessments for ecological flow are too significant to allow for a realistic assessment of costs and benefits to be made. |

As can be seen in the table above, five options have been retained for further analysis. To guide the reader through the remaining sections of this report, they have been named as follows:

**Target 1a:** Restore all HD Annex I freshwater habitats to good condition, with all necessary restoration measures completed on 30 % (or 15 %) of degraded areas by 2030, 60 % (or 40 %) by 2040 and 100 % by 2050;

**Target 1b:** Re-create area as necessary to achieve Favourable Conservation Status of rivers, lakes, and alluvial habitats of Annex I of the Habitats Directive at national biogeographical level by 2050, with 15 % (30%) achieved by 2030 and 40 % (60%) by 2040;

**Target 1c:** Restore and re-create the area necessary to enhance the conservation status of species listed in Annex II, IV and V of the Habitats Directive as well as wild birds associated with rivers, lakes, and alluvial habitats in view of achieving their favourable conservation status by 2050, with at least 15 % achieved by 2030 and at least 40 % by 2040.

**Target 1d:** Develop an inventory of all barriers in the EU and a plan of which ones to remove by 2030 with a view to achieving free-flowing status where possible and necessary to restore the habitats depending on the natural functioning of a river system.

**Target 1e:** By 2030, mapping small water units, determining their restoration potential and develop a plan to restore them where possible and necessary to contribute to the restoration of habitats and species.

## 6.4 Impacts of assessed target options

The costs of restoration of freshwater ecosystems were estimated by calculating the extent of degraded ecosystems to be restored annually to meet each target and applying average unit costs. Unit cost data for river and lake restoration projects were taken from a report detailing 766 restoration projects in the EU[7], with data for restoration of bankside habitats taken from Tucker et al (2013).[8] The costs include capital costs of restoration measures (channel re-shaping and re-meandering, deconstruction of technical riverbanks, reconnection of floodplain habitats, sediment control through reforestation, floodplain restoration), as well as costs of restoration, re-creation and maintenance of bankside habitats (forests and grasslands). The latter include opportunity costs of agricultural income forgone (e.g. through conversion of cropland and reductions in grazing) as well as the cost of work undertaken.

The benefits assessment included an extensive review of literature of the value of benefits of freshwater ecosystem restoration, which identified more than 30 relevant studies. The analysis applied estimates of the total ecosystem service benefits of river and lake restoration, taken from a meta-analysis by de Groot et al (2020)[9], as well as values for bankside ecosystems taken from

[7] Ayres et al. (2014). Inventory of river restoration measures: effects, costs and benefits. REFORM – Restoring rivers for effective catchment management. Deliverable D1.4 – Inventory of restoration costs and benefits

[8] Tucker et al., (2013) Estimation of the financing needs to implement Target 2 of the EU Biodiversity Strategy. Report to the European Commission. Institute for European Environmental Policy, London. Available at: https://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/2020/Fin%20Target%202.pdf

[9] De Groot et al., (2020) Update of global ecosystem service valuation database (ESVD).

the analyses for grassland and forest ecosystems. Per hectare benefits estimates were applied to the area of ecosystem restored to give annual estimates of total benefits. Annual costs and benefits were estimated over the period 2022 -2070, recognising that, while restoration takes place to 2050, further maintenance costs continue beyond that date, while restored ecosystems continue to provide benefits into the future. Annual cost and benefit estimates were discounted, applying a 4% social discount rate, and summed to calculate their total present value. This enabled total net present value (benefits – costs) and benefit: cost ratios to be calculated.

**Targets 1a and 1b.**

As a first step, the scale of restoration needs across the various freshwater habitats were calculated, based on a 15 % restoration target applied to the extent of those habitats currently not in ‘good’ condition (15 % min), and an estimation on the coverage of habitats currently in an ‘unknown’ status (15 % max). In addition, comparing Member States’ data on 'favourable reference areas' with the actual habitat area allows to estimate how much area of the habitat would need to be re-created to achieve a good distribution and area of that habitat. A summary of these estimations is set out in Table VI-2 below.

**Table VI-2 Calculated freshwater habitat restoration area and recreation area needs, based on a 15 % restoration target**

| Habitat type | Habitat area | Condition (km2) | | | Target | | Restoration areas (km2) (average) | Recreation areas (km2) |
|---|---|---|---|---|---|---|---|---|
| | Total | Good | Not good | Unknown | 15 % min (km2) | 15 % max (km2) | | |
| Lakes | 59 121 | 36 760 | 9 953 | 12 408 | 1 493 | 3 354 | 2 424 | 282 |
| Rivers | 8 191 | 3 158 | 1 564 | 3 469 | 235 | 755 | 495 | |
| Alluvial forests | 23 421 | 10 932 | 8 677 | 3 812 | 1 302 | 1 873 | 1 587 | 27 |
| Alluvial meadows | 5 747 | 2 121 | 1 362 | 2 263 | 204 | 544 | 374 | 585 |
| Total | 96 480 | 52 971 | 21 556 | 21 952 | 3 233 | 6 526 | 4 880 | 894 |

The costs of restoration activities to meet the above needs were then estimated through literature, resulting in the costs detailed in Table VI-3 for a set of broad actions relevant to rivers and lakes. Each of these actions were weighted equally (i.e. each multiplied by 0.2), and their CAPEX values (capital expenditure) estimated through multiplying the costs of each weighted restoration action by the restoration area required from the table above (Table VI-2).

**Table VI-3 Estimated costs of restoration relevant to Freshwater targets 1a and 1b (rivers and lakes)**

| Restoration action | Capital cost of restoration action per km$^2$ (EUR) |
|---|---|
| Channel re-shaping and re-meandering* | 10 630 214 |
| Deconstruction of technical riverbanks* | 2 657 553 |
| Reconnection of floodplain habitats | 159 453 |
| Sediment control through reforestation | 192 589 |
| Floodplain restoration | 2 406 995 |

* Applied to rivers only as not directly relevant to lake restoration

Re-creation costs for alluvial forests and meadows (which are assumed to be the only habitats where re-creation will take place) in Table VI-4 were drawn from cost data under the Forests and Grasslands fiches (due to the overlap in habitat types), while OPEX values (operating expenditure) were obtained through literature at a broad ecosystem level.

**Table VI-4 Estimated costs of restoration, recreation and maintenance, alluvial ecosystems**

| Habitat type | Maintenance (EUR/km2) | Restoration (EUR/km2) | Re-creation (EUR/km2) |
|---|---|---|---|
| Alluvial forests | 23 200 | 403 100 | 35 000 |
| Alluvial meadows | 11 600 | 430 000 | 430 000 |

Next, the estimated annual area of restoration and recreation needed per habitat type to align with the specified restoration target was assessed, and the habitat type cumulative costs estimated over the trajectory of the target length (for example – to 2030, 2040, 2050) to derive a net present value (NPV) (2022-2050) estimate.

In relation to benefits, an assumption was made that degraded freshwater ecosystems produce only 50 % of the value in de Groot et al., 2020, which estimated that freshwater ecosystems provide ecosystem service values of €96,638/ha/yr (that is, the marginal benefit of intervention is worth (€48,319/ha). This figure includes a range of provisioning (fresh water, fisheries, genetic resources), regulating (waste treatment, water quality, flood management, climate, soil quality) and cultural (landscape, aesthetic, inspirational and recreational) services.

A summary of this is presented in Table VI-5 presenting the option of incrementing the percentage of restoration from 15 % to 40 % with a larger effort in the last decade to achieve a 90 % restoration target, and Table VI-6 presenting an option for a more linear increment of effort 30 % 60 % and 90 %.

### Target 1c

Data from reporting of Article 12 of the Birds Directive and 17 of the Habitats Directive show that the major pressures for birds are related to agriculture and conversion of land, while hydropower dams and physical alternations to water bodies (e.g. hydromorphological changes) present the greatest pressures on fish. Hence the target should be seen as a sub-target that assist in the implementation and achievement of target 1a, while also extending habitat restoration to those not covered in Annex I of the HD. Furthermore, implementation of barrier removal (target 1d) will have direct benefits towards species, especially migratory fish. However, calculating precise costs of enhancing the status of species will be case-specific, given the complexity of species interactions per habitat type, and dependent upon the biophysical conditions within the restoration/re-creation area. As such, costs estimates related to Target 1c are assumed to similar to those established under Targets 1a, 1b and 1d.

### Target 1d

For target 1d an estimate of €385 183 was estimated for the costs of creating an EU-wide inventory of barriers, based on data from the AMBER project. The lack of data available on barrier removal costs, and the context-specific nature of these removals has not allowed a full cost-benefit analysis to be developed (and the costs of barrier removal are therefore not included in the tables below - only the costs of the inventory). However, Table VI-6 provides an overview of costs for different type of barrier removal, demonstrating the variability of such costs. The benefits derived from barrier removal could be expected to be like the benefit estimates for Target 1a and 1b (i.e. barrier removal would be required to achieve the benefits outlined under 1a and 1b), however studies which explicitly ascertain the benefit values derived from such actions could not be identified. Other costs linked to a barrier mapping exercise are expected to be minimal compared to the actual removal measures, also because the exercise could draw upon data already available to Member States. The current data gaps as regards not only costs of removal, but also location and characteristics of different barriers, do not allow at present setting specific target on length of free-flowing rivers or number of barriers to be removed, but would need to be investigated further as more data becomes available.

The tables VI-5 and VI-6 estimate the costs and benefits of Targets 1a, 1b, 1d (inventory only), for the various ambition levels, up to 2030, 2040, 2050 and 2070 and Table VI-7 provides an overview of costs for different type of barrier removal.

**Table VI-5: Summary of present value cost-benefit analysis results (MEUR) of achieving restoration targets for Target 1a, 1b, and 1d 15 % 40 % and 90 %[10] target, 4 % real discount rate**

| Period | % Full restoration | Costs (MEuro) | Benefits (MEuro) | NPV | Benefit-cost ratio |
|---|---|---|---|---|---|
| 2022-2030 | 15% | 9 655* | 58 628 | 48 973 | 6 |
| 2031-2040 | 40% | 10 670 | 158 968 | 148 298 | 15 |

[10] Although the 2050 target aims to restore 100 % of the habitat, the 2050 cost estimation is for 90 % restoration as this is the maximum percentage that can be expected in practice. Furthermore, an extrapolation of current restoration costs would no longer provide reliable estimates in the range between 90 and 100 %.

| | | | | | |
|---|---|---|---|---|---|
| 2041-2050 | 90% | 13 757 | 253 218 | 239 461 | 18 |
| Total over period (to 2050) | | | | | |
| 2022-2050 | 90% | 34 082 | 470 814 | 436 732 | 14 |
| Total over period to (2070- to include projected continuation of benefits and costs) | | | | | |
| 2022-2070 | 90% | 35 232 | 862 349 | 827 117 | 24 |

* Costs include inventory

**Table VI-6: Summary of present value cost-benefit analysis results (MEUR) of achieving restoration targets for Target 1a, 1b and 1d 30 % 60 % and 90 % target, 4 % real discount rate**

| Period | % Full restoration | Costs (million Euro, annual) | Benefits (Euro) | NPV | Benefit-cost ratio |
|---|---|---|---|---|---|
| 2022-2030 | 30% | 17 891* | 116 695 | 98 804 | 7 |
| 2031-2040 | 60% | 12 554 | 257 788 | 245 235 | 12 |
| 2041-2050 | 90% | 8 616 | 288 989 | 280 282 | 34 |
| Total over period (to 2050) | | | | | |
| 2022-2050 | 90% | 39 061 | 663 382 | 624 321 | 16 |
| Total over period to (2070- to include projected continuation of benefits and costs) | | | | | |
| 2022-2070 | 90% | 40 211 | 1 053 042 | 1 012 831 | 26 |

* Costs include inventory

**Table VI-7 Costs of barrier removal**

| Barrier removal action | Metric | Average cost (EUR/$m^3$) |
|---|---|---|
| Dike removal/modification | €/$m^3$ dike volume | 31 |
| Longitudinal connectivity through migration passes for fauna | €/m obstacle height | 96 584 |
| Longitudinal connectivity through Weir removal | €/m weir height | 30 518 |
| Longitudinal connectivity through dam removal* | €/$m^3$ of concrete | 34 |

It can be expected that most costs will be incurred by the governmental agencies who ultimately decide where restoration actions/barrier removals will take place. Compensation will likely be needed for economic actors impacted by the restoration efforts. For example, energy providers who rely on cooling water may require additional flood defences following barrier removal, land managers on alluvial habitats may require compensation for crop damage following barrier removal or compensation for alternative management practices to restore degraded habitats. Compensation costs may also be required in the event of the redistribution of pollutants following the removal of barriers. Restoration actions are likely to benefit a range of stakeholders, namely:

- The local population- through changes in house prices due to improved/ decreased flood risk potential.
- Water suppliers and consumers- through overall reduced water pollution and enhanced availability.
- Recreational users of freshwater ecosystems- through greater access to previously restricted areas (due to barrier removal), enhanced aesthetic values and biodiversity of the ecosystem.
- Organisations/businesses- through their direct involvement in restoration actions (employment and knowledge) or through the enhanced recreational services provided by restoration actions.
- Society- through the enhancement of ecosystem services.

**Target 1e**

This target aims to include and delineate smaller water units with high restoration potential, increase their protection and build more coherent and functional freshwater habitat connectivity. Restoration potential can be estimated using existing assessment tools under the BHD and WFD, as well as European Red List species and habitats. The target would require a mapping *out and inventorising of small water units by 2030.* With the information collected and reported by Member States, a solid baseline assessment of the situation of EU small water units could be conducted. The baseline would enable the Commission to move forward with setting well-informed and reasonable restoration targets for small water units of the EU, with the aim for Member States to then implement restoration actions after 2030.

The mapping exercise will likely draw on upon data that Member States already have at a national level and partly build on known methodologies under WFD, as well as on data from Copernicus. Preliminary investigation into Copernicus data from 2016 identified 4 176 surface lake water units that are smaller than 0.5 $km^2$ (this does not include small rivers). The total surface area of these cover 822 $km^2$. This data does not provide information on wetlands, floodplains, riparian zones or other ecosystem that may have vegetation and could likely fall into the categories of smaller units of water. Neither is there information on how many of these water units are already integrated into the WFD as part of the water bodies covered by RBMPs. As such, Copernicus data can assist in preliminary mapping of existing small water units, but with limitations. Member States would have to further expand on existing data. Nonetheless, the use of existing data from Member States, the WFD and Copernicus could help reduce additional cost burden on Member States.

Costs for mapping and assessing smaller water units are mainly administrative. The cost on enabling measures such as establishing extent and condition of areas and ecosystems have, among others, been assessed in section 6.5 of the report.

The assessment of the restoration potential is likely to have a higher cost and will partly depend on information acquired during the mapping exercise. The key restoration measures for larger water bodies and their estimated costs listed in Table VI-3 will be similar to those required to restore smaller water units. In addition, small water units can also be restored by restoring connectivity – estimates of barrier removal costs have been given in Table VI-7. The exact type of action which would be required to assist in the restoration of the smaller water units would depend on their condition and can only be estimated once an inventory and strong baseline exist. Such exercise could be useful since the information collected would help make informed decisions on other targets and help achieve additional policy objectives.

## 6.5 Synthesis

Of the options considered, Target 1a is considered as the most effective and efficient way to return European freshwaters to good status. Target 1b is seen as a complementary measure to achieving Target 1a, and as such they could be merged as one target to achieve both restoration and re-creation. Target 1c overlaps with target 1a, 1b, 1d and 1e and is in principle unlimited in terms of freshwater area covered. This means that its potential in terms of area covered may be the highest across options. The effectiveness of this option may however depend on the specific actions taken to improve condition of species and their effect on overall ecosystem health, both in- and outside of the Annex 1. Target 1d is estimated to provide a range of benefits like those deriving from Target 1a and b, whilst also directly relieving EU waters from the frequent hydromorphological pressures reported and addressing an important data gap in terms of type and location of barriers. As for target 1e, it sets the possibility of closing a data gap regarding smaller water bodies of ecological importance. This would directly link to target 1a, 1d as the restoration of smaller water units is important for ecosystem connectivity, especially lateral. All options are foreseen as being feasible, and align with the reporting and monitoring requirements currently in place, particularly through the WFD and Nature Directives. The benefits deriving from all options are generally considered to outweigh the costs, although this is less clear-cut for target 1d, given the significant variation in the costs of barrier removal and the benefits stemming from this, due to the significantly contrasting scale and differences in biophysical conditions in each context, and target 1e, considering the potentially large variations of costs in collecting such data.

**Table VI-8: Overview table assessing options on EU impact assessment criteria**

| | Target 1a- Restore degraded freshwater habitats under HD Annex I | Target 1b- Re-create area as necessary to achieve Favourable Conservation Status of HD Annex I | 1c: Restore and re-create the area as necessary to enhance the conservation status of species | Target 1d- Develop an inventory of all barriers in the EU and remove prioritized barriers | Target 1e – Mapping of small water units |
|---|---|---|---|---|---|

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|---|---|---|---|---|---|
| Feasibility / effectiveness | High feasibility and potential for restoration. The effective restoration of freshwater habitats has been shown to provide a range of ecosystem services. | Feasibility dependent on opportunity costs of re-creation. Re-creation is intrinsically linked to restoration in freshwater habitats, and is estimated at being highly effective for biodiversity, and contributes to other ecosystem services. | High feasibility and potential for restoration, with this Target linking strongly to the other targets and assisting in the overall target of restoration (1a) | The inventorisation should be feasible as indicated through the AMBER project. The removal of barriers, once identified is considered as an effective way to restore freshwater ecosystems. | The mapping should be feasible as data is already available through WFD, Nature Directives and Copernicus data, and can be complemented by additional data from Member States. Target links strongly, but partially overlaps, to target 1a, 1c and 1d. Protection and restoration of small water units could be an effective way to achieve the other targets and considers additional waters which may otherwise be excluded under target 1a. |
| Efficiency | Strong evidence of benefits of restoration for biodiversity and ecosystem services, including climate mitigation. Available valuation evidence suggests benefits exceed restoration costs. | Due to the interlinkages with the aforementioned target, it is estimated that re-creation derives similar benefits. | Strong evidence of benefits of restoration for biodiversity and ecosystem services, including species protection and recovery of populations. | Costs of removing barriers can vary considerably, yet the inventory process will allow the identification of barriers which could, for example, be removed for the lowest cost. Furthermore, the lack of associated maintenance costs can further increase benefit: costs ratios. | Some evidence of benefits, for biodiversity restoration and the achievement of the other targets.<br>Costs of enabling measures, linked to surveying and establishing extent and condition of smaller water units can vary considerably, although data collection would rely on existing data sources and the reporting/monitoring would fall under the National Restoration Plans. |

| | | | | | |
|---|---|---|---|---|---|
| Coherence | Full coherence with EU environmental policies and climate goals. Potential to make substantial contributions to EU nature and water policy | Full coherence with EU environmental policies and climate goals. Potential to make substantial contributions to EU nature and water policy | Full coherence with EU environmental policies as this option builds on existing legislation (i.e. the HD). Benefits for other EU objectives such as on water- and flood risk management are also expected. | Full coherence with EU environmental policies and climate goals. Potential to make substantial contributions in particular to EU nature and water policy. | Coherence with EU environmental policies and climate goals. Potential to make contributions in particular to EU nature and water policy |
| Proportionality | Proportionate to the very high importance of the habitats for biodiversity and associated ecosystem services | Proportionate to the high importance of the habitats for biodiversity and associated ecosystem services | Proportionate to the high importance of the habitats for biodiversity. | Proportionate to the high importance of the habitats for biodiversity and associated ecosystem services | Difficult to assess proportionality. While such small water units may be important for biodiversity and associate ecosystems, the extent of the overlap with other targets and existing legislation is not known and it is difficult to estimate costs. This hinders the assessment. |
| **Conclusion** | **Include with high priority** | **Include with high priority** | **Include with high priority** | **Include with high priority** | **Consider further, as a possible second stage target** |

# 7. Marine ecosystems

## 7.1 Scope

There is a wide consensus at the international level that restoration efforts are as relevant to marine ecosystems as they are to the terrestrial environment. Academic research and on-site trials show that focusing on restoring habitats can be a particularly effective way to achieve the recovery of whole marine ecosystems, including species (see section 7.4). Habitats not only host individual species but are maintained through complex biological, physical and chemical interactions. They can also act as an effective surrogate for species conservation and the delivery of ecosystem services alongside species-specific conservation measures, such as those targeting the recovery of 'keystone species' or of 'ecosystem engineers'.

Science shows that restoring marine habitats (where species live, reproduce and forage) both sets the enabling conditions for species and ecosystems to thrive and allows delivering enhanced ecosystem and societal services to the benefit of multiple blue economy sectors (e.g. fisheries, tourism etc.). Restoring particular habitats, such as seagrass beds, can also help mitigate climate change by storing carbon and help society adapt to climate change by buffering storms and reducing the impact of sea level rise and coastal erosion.

Considering the above, the principal scope of the marine thematic impact assessment concerns a restoration target related to groups of habitats that were selected because they have the capacity to contribute substantially to the restoration objectives under the Biodiversity strategy, in particular towards mitigating climate change, reducing the impact of natural disasters and bringing health, social and economic benefits to coastal communities and the EU as a whole. These habitats can also substantially contribute to delivering other key ecosystem services that benefit society. Some of these ecosystem services would be delivered over a longer time horizon (2050 and beyond) because of the inherent slow changes in some marine ecosystems. However, restoration efforts should be initiated now to ensure the future delivery of these ecosystem services to society, future generations, and the planet.

Focus is therefore given to these **habitat groups:**

- **Seagrass beds**
- **Macroalgal forests**
- **Shellfish beds**
- **Maerl beds**
- **Sponge, coral and coralligenous beds**
- **Vents and seeps**
- **Soft sediments**

Many natural habitat types that can be considered under these habitat groups correspond to those listed in Annex I of the Habitats Directive (HD), to the habitats of species protected by HD and the Birds Directive (BD) and to the broad habitat types listed in the Marine Strategy Framework Directive (MSFD). However, considering that different habitat types under these broad categories can have different restoration requirements and potential, as well as different contribution to the above-identified objectives of the Biodiversity strategy, it is necessary to further select and define the list of habitats that should be considered for marine restoration. This could be done by using the appropriate levels of the European nature information system (EUNIS) classification of marine habitats, which would provide a common understanding of selected habitats across all Member States.

The selected marine habitat groups are variously distributed from the coastline to depths of 5000m or more. However, the feasibility of restoration and effective tracking of results achieved by implementation of restoration measures decreases with depth. Assessing the condition of habitats in waters deeper than 1000m can be very costly, in particular for the vast area of sediment habitats below 1000m that make up about 80% of the total area of EU seabed. At the same time, anthropogenic pressures acting at those depths, such as illegal fishing (as regulated fishing is prohibited below 1000m depth), litter and energy/telecom transmission infrastructure, are expected to be very limited in spatial extent compared to the overall extent of sediment habitats below 1000m depth. Therefore, it would be appropriate to limit the application of restoration measures for sediment habitats to above 1000m depth, in order to better focus the efforts and resources.

The selected marine habitats of Annex I of the Habitats Directive cover 240 030 $km^2$ or 4.8 % of the EU seas[11]. More detailed quantitative data on the geographical distribution, area ($km^2$), conservation status and condition of marine habitat types of Annex I of the Habitats Directive, ts derived from the Member States' reports and assessments under Article 17 of the Habitats Directive in EU Member States is provided in Annex VIII-g.

## 7.2 Problem, current trends and ecosystem-specific baseline

Human impacts are radically reshaping the marine environment, including in the EU, and the scale of the challenges to restore marine ecosystems to good status should not be underestimated. Many scientific studies conclude that the oceans' carrying capacity is being degraded and there is an overriding need for urgent action, in particular to halt and reverse the decline of marine biodiversity. The effects of climate change combined with the loss of marine biodiversity (through human-induced pressures) also endanger economic prosperity worldwide. Fishing (overfishing, impact on the seabed, on juveniles and on sensitive marine species), aquaculture, pollution, eutrophication, seabed mining, invasive alien species, coastal and offshore developments are all contributing to loss and damage of marine habitats and the irreplaceable ecosystem services they supply to humanity.

A review conducted between 2011 and 2016 on the pressures on the marine realm resulting from human activities on land or at sea concluded that practically the entire EU marine area was under multiple pressures, including from hazardous substances, climate change, underwater noise, non-indigenous species, marine litter and nutrient enrichment. Fishing pressure and seafloor damage are high in the seabed shelf area, whilst impacts of invasive alien species and physical

[11] Romania is not included due to data issues.

disturbance are high in coastal areas. The highest combined effects are found along coastal areas of the North Sea, Southern Baltic Sea, Adriatic and Western Mediterranean. The most extensive combined effects in the shelf areas occur in the North Sea and in parts of the Baltic Sea and Adriatic Sea.
The success of restoration actions will depend on many factors, including current status, magnitude of human pressures, sensitivity of habitats to these pressures, knowledge and experience of what actions to take and timescales over which actions can be applied. Habitat restoration can be achieved through active measures (e.g. replanting seagrass) and/or passive measures (leaving habitats undisturbed, often through protected areas, so that habitats recover naturally). These two restoration approaches bear different constraints and costs (as discussed in section 7.4). Whatever the restoration method, the measures should be set to ensure the restored habitats do not degrade again.

A high proportion of marine habitats protected under the Habitats Directive are in unfavourable conservation status or declining and the pressures affecting them are increasing. Under the Marine Strategy Framework Directive, all EU marine waters should have reached a Good Environmental Status in 2020. Under current knowledge and latest assessments, there are indications that this goal has not been fully reached, including for marine habitats.
The following summarises the findings from the baseline scenarios for the European marine environment. Due to lack of data on individual categories, marine ecosystems were grouped together for the region:

- ***Ecological condition:*** Reporting under the HD shows that most Annex I marine habitats are in an unknown condition. Of those with a known condition, the areas in good and non-good condition are roughly equal. Trends for areas in not-good condition is largely either unknown (48 % of reports) or stable or deteriorating further (47 %).
- ***Chemical status:*** Under the WFD, the chemical status indicator includes the status of land and coastal waters as reported in the 1st and 2nd River Basin Management Plans and describes a water body as either “failing to achieve good”, “good”, or “unknown”. Even though the data between the 2 reports are not comparable due to many changes, deductions can be made (Maes et al., 2020b). According to the 2nd Plan in 2016, there had been substantial improvement in the chemical status of the Black and Mediterranean Seas compared to 2010. The number of bodies with an “unknown” chemical status declined considerably from 2010 to 2016. Most areas “unknown” in the 1st Plan are classified as “good” in the 2nd.
- ***Nutrient Concentration***: Long-term declines in nutrient concentrations have been observed in the North-East Atlantic and the Baltic Sea. An increase in nutrient load is causing noticeable deterioration of ecosystem conditions in southern EU. Long- and short-term trends highlight that nitrates and phosphates concentrations are rising in the Black and Mediterranean Seas. 98 % of the Baltic Sea is classed as problem areas in either moderate, poor or bad state. Only 0.2 % of the Mediterranean was assessed but 42 % of this area is classed as a problem area. In the Black Sea, 59 % of the sea area was assessed and 31 % is classed as problem area. In the Northeast Atlantic, 25 % was assessed and 94 % is in a good or high status.

- ***Chlorophyll-a***: Overall, eutrophication and land runoff have caused increased Chlorophyll-a concentrations. While such increases can be observed in the long-term trends for the Black Sea, Baltic Sea, and Mediterranean Sea, concentrations in the North-East Atlantic remain unchanged.
- ***Oxygen***: From 1993 to 2018 the Baltic and Black Seas have seen significant improvement with trends of increasing dissolved oxygen. The Mediterranean has seen long-term improvement but short-term degradation. The North-East Atlantic has exhibited declining trends.
- ***Litter***: Long-term trends in beach and seafloor litter could be assessed in the North-East Atlantic only. The trend in seafloor litter was unresolved, and that for beach litter was decreasing, suggesting an increase in coastal environmental quality. Data on micro litter are insufficient for evaluating short- and long-term trends.
- ***Ecological status***: Overall, marine water bodies with high ecological status (according to the WFD) decreased in 2016 compared to 2010, especially in the Mediterranean. A considerable decrease in the 'unknown' class has been recorded, possibly because of advances in assessment methods. Biodiversity quality elements reported as 'good' have increased substantially for all regions; except for the Back Sea where data is missing.
- ***Spawning stock biomass (commercially exploited fish and shellfish)***: If historic trends continue, it should increase in all regional seas by 2030 and 2050. However, it is important to note substantial uncertainty around these projections. Central estimates suggest that by 2030 indicator values could be 14 % higher than the value in 2017 for the North-East Atlantic, 16 % higher in the Black Sea, 53 % higher in the Baltic Sea and 102 % higher in the Mediterranean. Uncertainty estimates suggest biomass could decline in the future in the Baltic Sea, Black Sea and Northeast Atlantic.
- ***Invasive alien species***: Data concerning invasive alien species, their abundance and impact is incomplete and inconsistent, so short- and long-term trends cannot be calculated.

Whilst the EU biodiversity strategy for 2020 had set voluntary restoration targets, the evaluation of this strategy showed that this instrument proved ineffective in delivering the set objectives. Of the thousands of MSFD measures reported by Member States, only 35 mention explicitly restoration. Whilst passive restoration should already be happening through existing legislation, mainly through marine protected areas, less than 1% of MPAs is strictly protected, which should ensure that natural processes are left undisturbed by human activities.

A challenge in implementing existing legislation to restore degraded marine areas is that the habitats in the existing directives (HD and MSFD) are defined too broadly and comprise many ecologically different sub-types with different restoration potential, which poses a challenge for defining and prioritising restoration measures. For example, the habitat type "1170 Reefs" protected under the HD includes both shallow macroalgal communities and deep-water coral reefs, which, in the context of restoration, require very different measures. Prioritising a limited list of habitats defined at a more detailed level (or rather: habitats-structuring/habitat-forming species, such as *Posidonia* beds, kelp, etc.) would both:

- help address both the salient elements listed under the Biodiversity Strategy for 2030 (climate change mitigation, reduction of natural disasters, nursery areas/protection of juveniles)
- help improve the status of key marine habitats, thereby helping address the objectives under the HD/BD and the MSFD.

Other reasons for limited progress under the current legislation include insufficient knowledge about the condition of some habitats over their entire area of distribution, about detailed management measures needed to support the restoration for some habitat types, the complexities of addressing cumulative and in-combination pressures and effects and the need for coordinated and collective action in some cases which may be required across sectors, as well as across governance arrangements and Member States. The timescales over which positive trends become apparent for some marine habitats and species are also relevant. In extreme cases, recovery may require decades or centuries, and signs of improvement may show only long after the necessary management measures have been introduced.

Recent policy initiatives and actions which could help progress restoration include:

- The EU Biodiversity Strategy target to expand the EU MPA network to cover 30% of EU seas, with 10% of EU seas under strict protection. The Strategy should also contribute to reducing marine pollution and eutrophication in the next decade through its 2030 objective to reduce use of chemical pesticides and high-risk pesticides by 50%; and of fertilisers by 20%.
- The action plan to conserve fisheries resources and protect marine ecosystems, announced in the Biodiversity Strategy
- The 2020 Farm-to-fork strategy sets out by 2030 to reduce the use of fertilisers by 20%, reduce nutrient losses by 50%.
- The upcoming 2021 EU Soil Thematic Strategy aims to reduce the overuse of nutrients.
- The zero pollution Action plan sets 2030 targets to reduce pollution at source, some directly impacting ocean, like improving water quality by reducing plastic litter at sea by 50% and microplastics release into the environment by 30%, significantly reducing waste generation and by 50% residual municipal waste. The measures adopted in the framework of the 2018 EU Plastics Strategy will likely also have an impact on reducing plastic in marine ecosystems.
- The 2018 recast of the Renewable Energy Directive sets a new 2030 renewable energy target of at least 32%. In 2020, the EC also issued a strategy to harness the potential of offshore renewable energy. This industry will need to scale up 5 times by 2030 and 25 times by 2050 to support the Green Deal’s objectives. Maritime spatial planning will be essential to avoid conflicts with other activities and limit impacts on marine ecosystems.

- The EU climate and energy package should contribute to global mitigation of climate change. However, the impacts of these actions are unlikely to have a significant effect on marine ecosystems before 2050.

In conclusion, the state of the European seas is poor and biodiversity loss has not been halted. Faced with the increased threats posed by overexploitation of marine resources, pollution and climate change, urgent action is needed to bring them back to good condition through large-scale restoration of marine ecosystems.

How will the situation likely evolve?

- **In the Northeast Atlantic,** chemical and nutrient conditions appear likely to improve in the near term. Pressure from pollution is likely to diminish further because of forthcoming measures under the Biodiversity Strategy and the common agricultural policy. The ecological status reported under the WFD suggests improving conditions, which is consistent with projections of increasing spawning stock biomass, increasing coverage of protected areas and decreased pressure from fishing mortality.

- **In the Baltic Sea**, chemical conditions are currently poor, with much of the area categorised as problem area. However, trends point to improvement, and this is likely to be accelerated by current and proposed measures. Increases in spawning stock biomass and in protected areas coverage will help to contribute improvements. A continued reduction in fishing mortality pressure can be expected but mortality still exceeds maximum sustainable yields.
- **For the Black Sea**, marine ecosystem conditions are unlikely to improve. There has been significant degradation in nutrient conditions and chlorophyll concentrations, although dissolved oxygen concentrations have increased. The trends in spawning stock biomass is projected to lead to improvements but this is likely to be offset by high levels of fishing mortality, which have shown little change and remained more than double maximum sustainable yields in 2017.
- **The Mediterranean** is also unlikely to see improvements in ecological condition under a baseline scenario. It has seen declines in its nutrient status and in levels of dissolved oxygen. Spawning stock biomass has recently increased and could continue to increase, this is at odds with fishing mortality which has seen little change and was more than double the maximum sustainable yields in 2017.

## 7.3 Target options screened in/out

Considering the challenges identified, several approaches to setting marine restoration targets were considered and screened for adequacy. The selected approach was then impact assessed. The results of this screening are summarised in the table below.

**Table VII-1: Screened approaches to setting restoration targets**

| Approach option | Screened in/out for assessment | Key reason(s) for screening in/out |
|---|---|---|

| | | |
|---|---|---|
| Option 0 – The current policy and legislative framework is implemented without setting any specific marine restoration targets. This means that the restoration efforts would be driven by the requirements of the Birds, Habitats and Marine Strategy Framework Directives which relate to the broad habitat types and habitats of the species and by other actions identified in the Biodiversity Strategy for 2030. | Out | The lack of deadline to achieve the favourable conservation status of protected habitats and species under the Birds and Habitats Directives would continue to result in low ambition and extent of restoration measures, because of the lack of precise and time-bound restoration targets. In addition, the broad habitat types as defined under the directives would not result in the necessary focus of restoration action in accordance with the priorities in the Biodiversity strategy. Other targets and commitments in the Biodiversity Strategy could contribute to enhanced restoration, but with very uncertain or insufficient outcome for the marine environment. For example, the target on 30% improvement under the Strategy does not necessarily need to address marine habitats and species and 10% of strictly protected areas that may result in passive restoration may be insufficient and may not target all key areas or ecosystems. In addition, these targets are only voluntary commitments. |
| Option 1 - The marine strategy framework directive (MSFD) and its 2017 Decision on good environmental status contains very broad habitat types with their associated biological communities: 22 benthic/seabed and 4 pelagic/water column (Member States can select additional habitat types). Restoration efforts could focus on identifying degraded habitats and undertaking restoration efforts (passive and active) to restore them to Good Environmental Status. Under the Habitats Directive, marine habitat types listed in Annex I (also broad categories with many sub-types) should be maintained at or restored to their favourable conservation status. To ensure results are delivered, the targets could relate to a more detailed level of habitat classification than the existing directives, numerical/percentage restoration targets could be set and reached | **In** | According to international practice, the restoration of degraded habitats is the most feasible and will deliver the maximum number of multiple benefits to nature and society. Addressing the priorities identified in the Biodiversity Strategy (degraded ecosystems, in particular those with the most potential to capture and store carbon and to prevent and reduce the impact of natural disasters, and protect important fish spawning and nursery areas) is best done by restoration of habitats, in particular when priorities are set at the meaningful scale of habitat classification. Habitats have been shown to be an effective surrogate for species and the delivery of ecosystem services. Furthermore, in delivering this target, significant progress will be made against the other options. |

| | | |
|---|---|---|
| within certain deadlines. | | |
| Option 2 - The MSFD and the Decision on Good Environmental Status contain a number of broad species groups (of birds, mammals, reptiles, fish and cephalopods) as features for Good Environmental Status assessment. The Birds Directive protects all wild birds, including seabirds. The Habitats Directive strictly protects many marine species, including all cetaceans and sea turtles. The two directives also require designation and management of protected areas to contribute to reaching the favourable conservation status of habitats and species. Restoration efforts could focus on identifying and limiting key pressures impacting focal species and taking steps to rebuild the populations through targeted interventions. | Out | The focus on species restoration by direct rebuilding of populations (rearing or reintroduction) would not achieve the wide benefits of habitat restoration, which includes re-establishment of functional ecological processes necessary to support populations of species. However, restoration of habitats of species would contribute to species restoration and could be included in Option 1. |
| Option 3 - To restore habitats in order to maximise the delivery of key ecosystem services. This, the approach would not, in the first instance, aim to achieve good environmental status under the MSFD or favourable conservation status under the Habitats Directive. However, it is likely that restoring the habitat to deliver the intended ecosystem services would result in significantly improved habitat condition. Instead of focusing on a numerical / percentage area to restore, this option could be used in combination with option 1 to guide/advise where the restoration action should take place in order to maximise the delivery of (multiple) ecosystem services. | Out | The scientific knowledge and data available do not allow setting meaningful and scientifically sound targets about ecosystem services at this level. |

## 7.4 Impacts of assessed approach

The proposed target for the marine environment that was impact assessed is:

- To put in place, for each of the above-mentioned habitat groups, the necessary restoration measures to improve all areas that are not in good condition to good condition, with measures put in place on at least 30% of the areas that are not in good condition by 2030, at least 60% by 2040 and 90% by 2050.

- To put in place, for each of the habitats classified in the above-mentioned habitat groups, the necessary restoration measures to re-establish them in areas not covered by these habitat types, with measures put in place on at least 30% of the areas needed to reach the favourable reference area, by 2030, 60% by 2040 and 100% by 2050.
- To put in place restoration measures for the habitats of marine species listed in Annexes II, IV and V of Directive 92/42/EEC and Annex I of Regulation 2019/1241, as well as of wild birds protected under Directive 2009/147/EC by 2050.

**Implementation and enforcement**

The proposed target takes into account the rationale of the approach selected, namely that the restoration effort should focus on habitats (these also host a variety of species) which are important to achieve the objectives of the Biodiversity Strategy. It proposes time-bound targets to achieve good condition of habitats, with intermediate targets for 2030, 2040 and 2050, which may be reached by incrementally establishing restoration measures. It includes both improvement of the condition of present areas covered by habitats and re-creation of habitats that were lost through human pressure on the marine ecosystem.

The habitat types and their condition vary between Member States. For example, *Posidonia* beds are only present in the Mediterranean Sea. Therefore, Member States will be able to select the habitats present in their territory from the list of habitats under each of the habitat categories. The targets for putting in place restoration measures concern each habitat of the habitat group concerned. This means that the Member States would have certain flexibility in prioritising the restoration of certain habitats, depending on their national situation. When presenting their nature restoration plans, Member States will need to justify why they chose to restore the habitats selected. The phased approach with incremental targets for 2030/40/50 enables a step-wise development and implementation of restoration measures with equal distribution of effort. This provides a very flexible but focused approach.

Considering that the condition of many marine habitats is generally not well known over their entire areas of distribution, it will be necessary to fill the knowledge gaps by putting in place additional surveillance for the targeted habitat types. Some Member States may have to put in place additional monitoring methodologies and programmes. This should be done as early as possible and at the latest in the phase of the preparation of the national restoration plans. Since the existing obligations under BHD and MSFD already require collection of this information, their implementation should also be improved to provide the necessary basis for the implementation of restoration measures.

Considering that many habitats listed in Annex I of HD correspond to the proposed habitat groups, the legal obligation to achieve favourable conservation status of Annex I habitat types would additionally benefit from a legally binding date for achievement of this target. Moreover, the implementation, enforcement and assessment of the progress towards the achievement of the target would partly rely on the same mechanisms (e.g. monitoring and reporting) as used under the BHD and the MSFD, and this would need to be supplemented, where necessary, with enhanced monitoring of the implementation of restoration measures and of the condition of habitats.

### Key stakeholders

The key economic stakeholders to be involved in the restoration of marine habitats include those economic sectors whose engagement is crucial to reduce the pressures on the marine environment, including those involved in coastal (including land-based) operations that result in changes to hydrological conditions leading to sedimentation and altered water flow (e.g. agriculture); pollution (e.g. aquaculture) and the introduction of invasive species (e.g. shipping). In addition, stakeholders whose operations result in physical damage to habitats (e.g. mineral extraction, fishing) are key to the success of restorative actions, (Table VII-2).

**Table VII-2: An indication of the key stakeholders (economic sectors) whose engagement is needed for the successful restoration of the selected habitats**

| Habitat groups | Stakeholders (economic sectors) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fishing | Shipping | Mineral extraction | Agriculture | Energy | Aqua-culture | Tourism/ Leisure |
| Seagrass beds | | | | | | | |
| Macroalgal forests | | | | | | | |
| Shellfish beds | | | | | | | |
| Maerl beds | | | | | | | |
| Sponge, coral and coralligenous beds | | | | | | | |
| Vents and seeps | | | | | | | |
| Soft sediments | | | | | | | |

Note: darker shades of blue indicate stronger engagement requirements. White shades indicate no engagement foreseen, grey indicates minimal engagement requirements.

### Costs

The cost of restoration varies considerably depending on the focal habitat, its location and condition, the level of pressure, the scale and desired outcome and the method used. There are a few irreducible costs that relate to broad actions that will contribute to the conservation and restoration of marine ecosystems, irrespective of the habitat and restoration method:

- Development of national strategies, policies and legislation to support restoration measures;
- Administration of authorities and relevant environmental organisations;

- Enforcement of regulations (including protecting restored habitats through protected areas);
- Advice and training;
- Additional research and monitoring required to develop and improve restoration measures; and
- Communications, such as consultations, and awareness raising on nature conservation and restoration issues.

The major costs will consist in assessing and monitoring the condition of habitats, establishing and enforcing marine protected areas and other spatial protection measures (as required) and transaction costs for active restoration projects, such as project planning, project selection, contracting and project oversight and financial administration. Considerations should also be given to compensation for loss of income, for example for fisheries, or for opportunity cost. However, some of these costs can be offset by direct benefits to those affected, although this will vary depending on the specific restoration measure.

As administrative processes have already been developed for numerous nature conservation and restoration projects, no major changes are anticipated, and administrative costs are likely to be similar to recent restoration projects and as experienced in the implementation of the Natura 2000 network. Similarly, Member States have existing requirements under environmental legislation, such as the surveillance of the status of Annex I habitats under the HD and of habitats covered by the MSFD, or of certain ecosystem components under the Water Framework Directive, which should facilitate the implementation of the restoration target.

Some examples of restoration costs for different habitats are given in the table below.

**Table VII-3: Estimates of financial restoration costs. Costs are given for active restoration unless stated**

| Habitats | Cost (active restoration per hectare unless otherwise stated) |
|---|---|
| Seagrass beds | 64 data entries: Range €6,683 - €2,393,726 per hectare (median €107,241 per ha for developed countries). Total costs (including all operational and in-kind costs) likely 2-4 times higher. Transplantation of cores or plugs (€29.8K ha-1) is more cost-effective than mechanical transplantation (€1.2 million ha-1) (1) |
| | Passive restoration - €2,202 - €474,340 per hectare; median €238,271 (1) |
| Kelp & macroalgal forests | ~€1 million per hectare (based on a 0.0 1hectare experiment; ~€4 million per hectare using artificial reefs (based on a 0.05-hectare experiment) (2) |
| | Passive restoration - removing sea urchins by liming, based on 90-hectare experiment): €1,433 per hectare |
| Shellfish, mussel & oyster beds | Oyster reef, (23 data entries): Range €3,796- €1,834,549; median €56,497 per hectare for developed countries (3) |
| | Noble pen shell translocation experiment: €8 per individual and assuming an aim of 100 -2000 individuals per hectare (based on densities at existing sites in the Mediterranean) gives a total of €800 – €16,000 per hectare (3) |
| Maerl bed | No information available; however similar habitat estimates below: |
| | Red coral - (based on two experiments 0.005 hectare): estimate likely €1.12 - 3.45 million per hectare (4) |

| | |
|---|---|
| | Coral reefs - Range €8,460 per hectare (low technology, low energy environments) to €5.5 million per hectare (5) |
| | Coral reef - Low-cost transplantation €1,690–10,990 per hectare. With more ambitious goals this rises to about €33,820 per hectare (6) |
| | Coral reef - Range €6466 - €121 million per hectare; median €1,544,433 for developed countries (42 observations, of which 18 for developed countries) (1) |
| | Coral reef - Range €5,070 per hectare for nursery phase of coral gardening to €3.4 million per hectare for building an artificial reef, median €338,000 per hectare (1) |
| Sponges | No information available |
| Deep-sea corals | Use of landers for colonisation: €408,000 per hectare |
| | Hypothetical for small scale restoration: > €65 million per hectare (4) |
| Soft sediment | No information available |

**Sources indicated in footnote[12]**

### Benefits

Restoration actions will benefit the whole society, as well as specific economic sectors and stakeholder groups benefiting from particular ecosystem services:

**All EU citizens and economic sectors** will benefit from the contribution of healthy marine habitats to mitigating climate change and adapting to its impacts, albeit to different degrees, and helping reverse biodiversity loss;

- The fishing sector will benefit from increased catch through the re-creation and conservation of essential fish habitat and ensuing healthy and productive marine ecosystems;
- The aquaculture sector will benefit from improved water quality;
- The tourism sector and recreational users will benefit from enhanced landscapes/seascapes, biodiversity and water quality.

Some examples of the benefits of restoration of certain habitats are given in the table below.

**Table VII-4: Estimates of financial benefits of restoration (valuation of ecosystem services to the society and economic sectors)**

| Habitats | Benefits (per hectare) | | | | |
|---|---|---|---|---|---|
| | Regulating and maintenance services (climate mitigation; flooding; erosion) | Cultural services (e.g. recreation) | Provisioning services (e.g. food, water, raw materials) | Socio-economic services | All/ unspecified |
| Seagrass beds | €95 per ha per year[13] | No financial valuation of | €866 per ha per year [14] | No financial valuation of | €284 - 514/ha/yr [15] |

[12] Spurgeon (1999) The socio-economic costs and benefits of coastal habitat rehabilitation and creation; Bayraktarov et al., (2016) The cost and feasibility of marine coastal restoration; Groneveld et al., (2019) D7.4: Restoring marine ecosystems cost-effectively: lessons learned from the MERCES project, Marine Ecosystem Restoration in Changing European Seas- MERCES; Papadapoulou et al., (2017) D1.3: State of the knowledge on marine habitat restoration and literature review on the economic costs and benefits of ecosystem service restoration Marine Ecosystem Restoration in Changing European Seas- MERCES; Corinaldesi et al., (2021) Multiple impacts of microplastics can threaten marine habitat-forming species; Knoche et al., (2020) Estimating Ecological Benefits and Socio-Economic Impacts from Oyster Reef Restoration in the Choptank River Complex, Chesapeake Bay.

[13] Tuya et al., (2014) Economic assessment of ecosystem services: monetary value of seagrass meadows for coastal fisheries.

| | | | | | |
|---|---|---|---|---|---|
| | | ecosystem services available | | ecosystem services available | |
| Kelp + macroalgal forests | US $21 440 680 climate buffer (not per ha)[16] | US $25 957 253 source of scientific information (not per ha) [17] | US $409 527 000 direct harvest (not per ha) [18]<br>US $82 257 712 supporting fisheries (not per ha) [19] | No financial valuation of ecosystem services available | US $434 000 000 per year (not per ha) [20] |
| Shellfish, mussel + oyster beds | $860 / ha (shoreline protection) | No financial valuation of ecosystem services available | Oyster US $22.8 million (964 acres)19; Oyster US $39 000/year/ 930 ha | Oyster (labour income) $7.8 million (964 acres)19; USD $2.8 million (labour incomes) / 930 ha; $4 123 / ha | $5 500-99 000 per ha per year[21] |
| Maerl beds, Sponges, Corals, Seeps and vents, Soft sediments | No financial valuation of ecosystem services available | No financial valuation of ecosystem services available | No financial valuation of ecosystem services available | No financial valuation of ecosystem services available | No financial valuation of ecosystem services available |

## Costs vs Benefits

There are many uncertainties and gaps in knowledge regarding the economic costs and benefits of restoring marine habitats , which limits the accuracy of a cost-benefit analysis. This challenge is recognised in the published literature, where there is a limited number of restoration cost-benefit-analysis for terrestrial and marine ecosystems. Nevertheless, those that do exist clearly show that restoration has a net positive value. For example, Blignaut et al. found that the average benefit-cost ratio varies between 0.4 (coral reefs, seagrass meadows) and 110 (coastal wetlands), with most biomes recording an average benefit-cost ratio of 10, with similar cost-benefit ratios observed in other systems, including between 0.4 to 15.7 for oyster reefs. In a theoretical study, the economic benefit of restoration and conservation of marine life in the world's ocean is estimated to be 10 times higher than the expected costs.

Looking at the costs and benefits for certain affected sectors, in the short term, the fisheries will be the most impacted stakeholder group in terms of potential lost income. However, a recent analysis by the International Council for the Exploration of the Sea (ICES) shows for example that 90% of the value of the catch by bottom fishing is obtained from just 30-40% of the total area fished. ICES consequently recommends that efforts to reduce the impacts of fishing on seabed habitats should focus on removing bottom fishing from the 'peripheral' fishing areas that yield only 10% of economic value, and continuing to fish in the more profitable 'core' fishing areas which generate 90% of the catch value. This general strategy offers a way to reconcile the

[14] Tuya et al., (2014) Economic assessment of ecosystem services: monetary value of seagrass meadows for coastal fisheries.
[15] Campagne et al., (2015) The seagrass Posidonia oceanica: ecosystem services identification and economic evaluation of goods and benefits.
[16] Vásquez et al., (2014) Economic valuation of kelp forests in northern Chile: values of goods and services of the ecosystem.
[17] Vásquez et al., (2014) Economic valuation of kelp forests in northern Chile: values of goods and services of the ecosystem.
[18] Vásquez et al., (2014) Economic valuation of kelp forests in northern Chile: values of goods and services of the ecosystem.
[19] Vásquez et al., (2014) Economic valuation of kelp forests in northern Chile: values of goods and services of the ecosystem.
[20] Vásquez et al., (2014) Economic valuation of kelp forests in northern Chile: values of goods and services of the ecosystem.
[21] Grabowski et al., (2012) Economic valuation of ecosystem services provided by oyster reefs.

need to protect seabed biodiversity and its carbon sequestration capabilities with the need to maintain the sector's socio-economic viability. The potential direct costs of removing bottom fishing from 'peripheral' fishing areas, for example to achieve a 30% area undisturbed by bottom fishing, would require a 3.9% reduction in fishing effort, resulting in €88m reduction in gross landings value for the studied area. This direct cost would be partially offset by shifting some fishing activity from peripheral to core fishing areas, and by increased catch per unit effort through fuel and fishing time savings. Furthermore, there is evidence that a number of fisheries may benefit from increased catch in the medium to long term through the re-creation and restoration of essential fish habitats. Finally, EU funds are available to reduce the impact on the sector. This indicates that restoration efforts through removing pressures could be done in a way which is acceptable for different stakeholders.

## 7.5 Synthesis

- The state of the European seas is poor and biodiversity loss has not been halted. A high proportion of marine habitats protected under the Habitats Directive are in unfavourable conservation status or declining and the pressures affecting them are increasing. Under the Marine Strategy Framework Directive, all EU marine waters have not reached good environmental status in 2020. Faced with the increased threats posed by overexploitation of marine resources, pollution and climate change, urgent action is needed to bring them back to good condition through large-scale restoration of marine ecosystems.

- Restoration of habitats can be a particularly effective way to achieve the recovery of whole marine ecosystems, including species. Science shows that restoring marine habitats (where species live, reproduce and forage) both sets the enabling conditions for species and ecosystems to thrive and allows delivering enhanced ecosystem and societal services. Several groups of habitats were prioritised for restoration because they have the capacity to contribute substantially to the restoration objectives under the Biodiversity strategy, in particular towards mitigating climate change, reducing the impact of natural disasters and bringing health, social and economic benefits.

- Since the broad habitat types as defined under the existing directives would not result in the necessary focus of restoration action in accordance with the priorities in the Biodiversity strategy, it is proposed that the selection of the habitat types in each group is done according to the European nature information system (EUNIS) to ensure equal interpretation across regional seas.
- The proposed target therefore entails a step-wise implementation of the necessary restoration measures to improve all areas of selected habitat types that are not in good condition to good condition, with incremental targets for 2030, 2040 and 2050. Setting the targets at national level and assessing the progress of restoration actions will require additional data collection, however, there are already many relevant monitoring frameworks and guidelines in place.

- The benefits of restoration to biodiversity and fisheries have the potential to be realised within a decade (varying by habitat) whilst the benefit of restoration to climate change adaptation and mitigation and pollution effects may take multiple decades. However, the long-term benefit to society and nature means action should start as soon as possible, even if the benefits are not immediate.

- Effective, representative and coherent networks of marine protected areas (MPAs) can be vital in restoring degraded marine habitats to good condition and ensuring that they don't degrade again.

- High variability in the costs and benefits of restoring habitats and the lack of a baseline to determine the area needing restoration means it is not possible to undertake any accurate cost/benefit analysis. However, whilst the evidence is limited, the benefits of restoring marine ecosystems outweigh the costs. Though there may be some short-term losses to certain economic sectors, these are outweighed by the long-term gains.

# 8. Urban ecosystems

## 8.1 Scope

The urban ecosystem is defined as *'the ecological system located within an area of high to moderate population density that is composed of physical and biological components that interact with each other'.* (Maes et al., 2013, 2018, 2020).

For the purposes of this impact assessment, the reporting units for urban ecosystems are broken down according to 'local administrative units' (LAUs), which are low-level administrative divisions of a country below that of a province, region or state. (established in accordance with Regulation (EU) 2017/2391 on 'Territorial Typologies'[22]) These LAUs are classified in line with Eurostat definitions of municipalities and communes[23] as cities (areas of high population density), towns and suburbs (areas of medium population density) and rural areas (areas of low population density). This impact assessment will consider those LAUs classified as 'cities' and 'towns and suburbs' in the LAU dataset of 2020 (the most up to date available[24]).

Figure 1 shows the distribution of LAUs classified as '**Cities' and 'Towns and suburbs'. Together they represent 21.5 % of the area of the EU territory. (**City LAUs covering 3.7% and towns and suburb LAUs 17.8%**)**. City, and town and suburb LAUs are where more than 73% European citizens live: respectively 39.4% in cities and 34% in towns and suburbs. (JRC 2022[25]) The average EU make-up of land cover classes inside these LAUs, is as follows:

| **Class** | **Km2** | **% of LAUs** |
|---|---|---|
| Artificial surfaces | 111,044 | 12.5 |
| Agricultural areas | 425,233 | 47.8 |
| Forest and semi-natural areas | 315,460 | 35.5 |
| Wetlands | 7,514 | 0.8 |
| Water bodies | 30,047 | 3.4 |

[22] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32017R2391
[23] https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/ks-02-20-499
[24] dataset corrected to remove LAUs misclassified as 'cities', 'towns and suburbs'.
[25] data used for the calculation: see references at end of chapter.

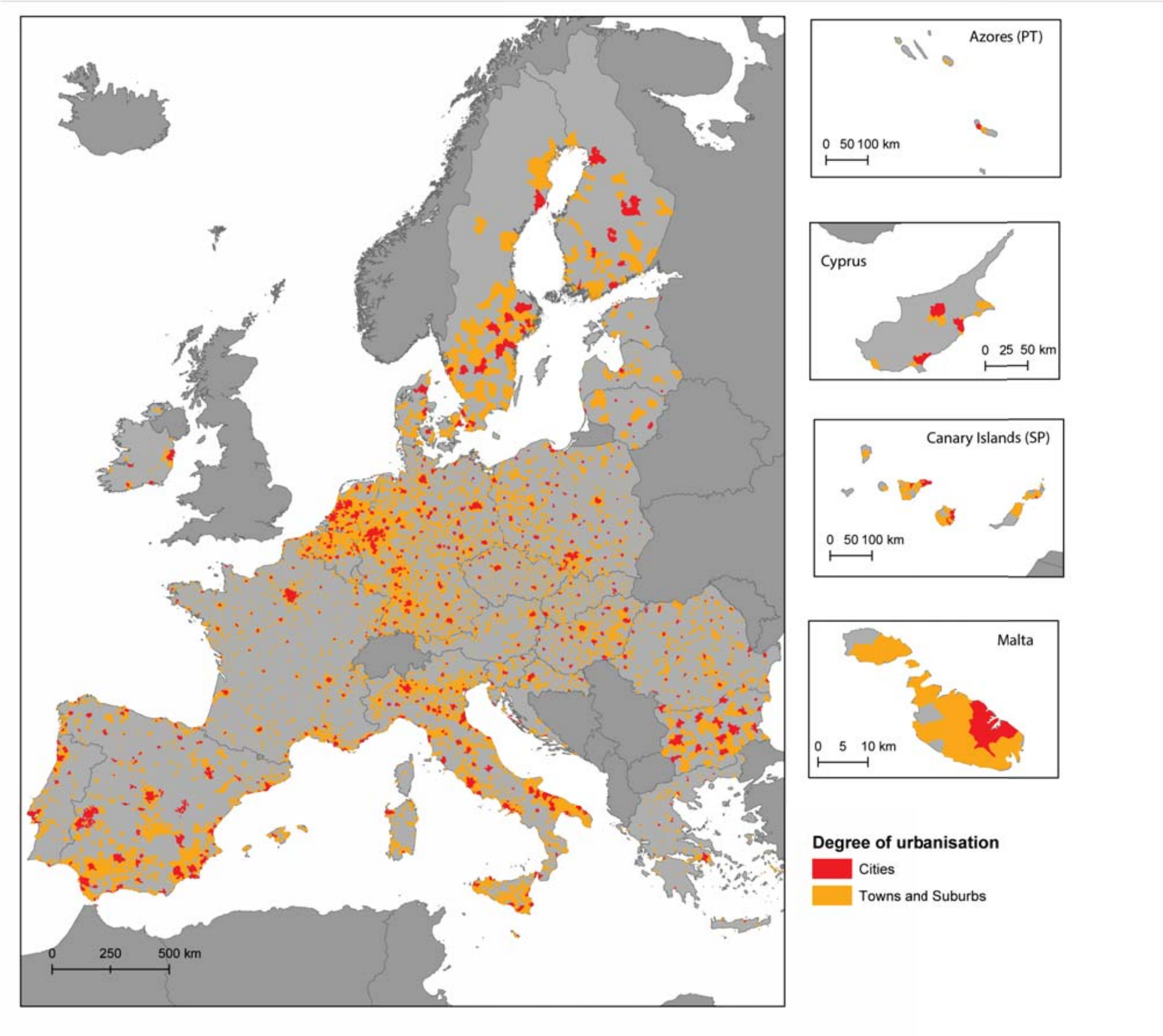



**Figure 1: Map of the distribution of LAUs classified as 'Cities' and 'Towns and suburbs'.**

The EU has experienced an increase in the area of urban 'artificial surface' over the last 20 years averaging 3.4 % per decade (2000 – 2018). Between 2019 and 2050, the overall urban population is projected to increase in 15 EU Member States, ranging from +2.3% in Croatia to +35.4% in Malta. Along with Malta, Ireland and Sweden are also projected to record increases of more than 20% in their overall urban populations (+29.2% and +25.1% respectively)[26]. Additional housing and infrastructure will need to be built to accommodate this growth. Overall urbanization is considered to be the second largest pressure on terrestrial and marine ecosystems (EEA 2020). It will not be feasible to address loss of green areas and biodiversity without improving the condition of 'managed' urban ecosystems as they grow. Therefore it is critical to ensure new development is undertaken in a way that protects and enhances urban ecosystems, rather than the

[26] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210520-1

opposite and that policies are implemented at the local level that enhance and restore urban ecosystems.

Urban ecology and the study of urban ecosystems are important for the following reasons: urban environments are extensive and growing; the nature of urban environments affects the health and wellbeing of their human inhabitants[27]; they are influence the conservation of biological diversity; they have an impact on their close surroundings (McPhearson et al. 2018); and they have an impact across boundaries on other cities or other ecosystem types. Achieving European and international goals for biodiversity will partly depend on the policies and actions deployed in urbanized regions of the world.

The 2020 MAES EU ecosystem assessment[28] has the following to say on Urban Ecosystems:

*When focusing on the balance between abrupt greening (defined as a relatively sharp upward trend in urban vegetation) and browning (defined as a relatively fast loss in urban vegetation), cities are not able to compensate for land taken. This means that when a loss of vegetation is observed (usually due to land use change, i.e. housing or infrastructure policies) there is no corresponding compensation strategy in place to recover the vegetation within the green infrastructure. This can result in progressive increase in fragmentation of semi-natural patches and consequential loss of city resilience. Cities and their surroundings can be part of the solution. They can host biodiversity spots and Urban Green Infrastructure (UGI) can deliver important benefits and be part of a regional eco-networks.*

*However, defining a clear role of urban ecosystems within sectoral EU legislation and policies is required. Clear rules need to be set to compensate for land taken and vegetation loss. Moreover, there is a need for setting targets to specifically monitor urban condition, urban biodiversity and urban their ecosystem services.*

The capacity of urbanized areas to support ecosystems varies widely and is related to their configuration and to the structure and extent of their Urban Green Infrastructure (UGI), and to what extent they incorporate 'nature-based solutions' to address local societal challenges. (Babí Almenar et al., 2021; Beninde et al., 2015; Ingo Kowarik, 2011; Pellissier et al., 2012; Xie & Bulkeley, 2020).

- 'Urban Green Infrastructure' is defined as: *"a strategically managed network of urban green spaces and natural and semi-natural ecosystems situated within the boundary of an urban ecosystem"* (European Commission 2013).

- 'Nature-Based Solutions' are defined as *"solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience"*. (European Commission 2015, 2016)

[27] Sarkar and Webster 2017, Gascon et al. 2016, Gascon et al. 2017, Dadvand et al. 2016, van den Berg et al. 2016, Tischer et al. 2017
[28] https://publications.jrc.ec.europa.eu/repository/handle/JRC120383

Urban development does not have to have a negative impact on biodiversity, it can have a positive local impact in existing urban ecosystems, while still providing the local services needed by humans in them.

*Political context*

The EU Biodiversity Strategy to 2030 seeks the *"greening of urban and peri-urban areas"* and calls on European cities of at least 20,000 inhabitants to develop ambitious Urban Greening Plans by the end of 2021. Previously, the European Commission's EU Environment Action Programme to 2020 (7th EAP) committed to having policies in place by 2020 to achieve 'no net land take' by 2050 and has also set targets for reducing soil erosion and the loss of soil organic matter.
On a global level, world leaders at Rio+20 (the United Nations Conference on Sustainable Development) argued that urgent action is needed to halt land degradation, given the increasing pressure on land from agriculture, forestry, pasture, energy production and urbanisation. They agreed to strive to achieve zero net land degradation (UNCCD, 2012)

While land take can be defined generally as the loss of undeveloped land to human-developed land, it can also be defined as the loss of agricultural, forest and other semi-natural and natural land to urban and other artificial land. This includes areas sealed by construction and urban infrastructure as well as urban green areas and sport and leisure facilities (EEA, 2006**). Since the 1950s, EU land take has largely been driven by urban sprawl. As well as a simple conversion of land from non-urban to urban use**, sprawl is characterised by a decrease in urban density, a decentralisation of urban functions and the transformation of a compact urban form to an irregular, discontinuous and dispersed pattern (Siedentop and Fina, 2010).

The targets proposed within this impact assessment will however focus on the implementation of the objectives of the biodiversity strategy, and the restoration of urban ecosystems – not on land take. Any biodiversity targets should not aim at preventing or halting growth of urban areas, but rather **promoting *biodiversity-positive* growth**, ensuring urban ecosystems are protected, enhanced and restored. Specifically, targets will ensure that when urban planning decisions are made, the green spaces and tree canopy cover of urban ecosystem are taken into account, and that their multiple services are not undervalued. In other words, urban planning should not only prioritise new developments that have the lowest environmental impact on local urban ecosystems, but also ensure that they actually enhance them. To achieve this balance of enhancing urban ecosystems while allowing for greening urban development means that the levels and timeframe of any targets is critical.

The nature and level of the targets also needs to be considered carefully within the context of other relevant EU policies that have an impact on the development and greening of cities including *inter alia:* climate, energy and adaptation plans, the Horizon Europe Cities mission, sustainable urban mobility plans (SUMP) and logistics (SULP) and noise action plans, air quality plans (AQP), land-use and waste/waste water management. Many of these policies already promote urban greening for the many benefits it provides.

## 8.2 Problem, current trends and ecosystem-specific baseline

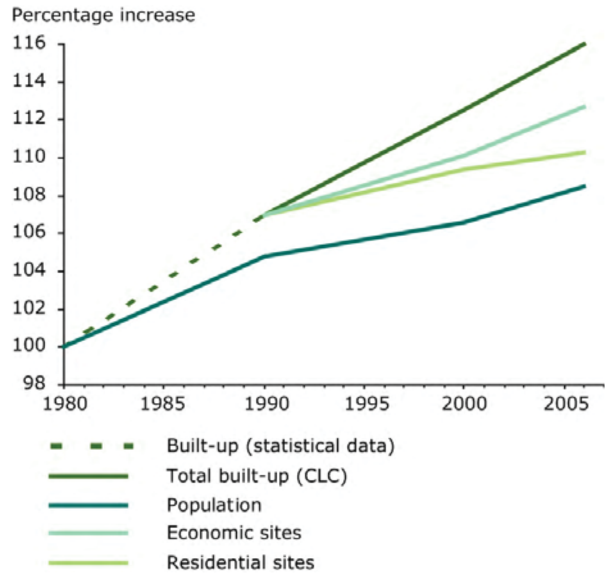
Land is the ultimate common resource as it provides habitat for flora and fauna, is the basis for most human activities and supplies the resources for meeting most human needs. It is the space required for living, as well as natural space, cultural space, economic space, and recreational space. When natural land is built over without due care and attention, the surface of the ground is sealed and most ecological functions are permanently destroyed. Infrastructure costs, noise, and the distance between home and work all increase while carbon pools, open landscapes and biodiversity hotspots are lost. All efforts for sustainability will ultimately fail if land use is not organised in a sustainable way.

Cities and Towns constitute a highly altered ecosystem, and one most steadily degrading. At the same time urban green spaces provide many vital services such as: protecting and enhancing biodiversity; supporting pollinators; providing green corridors for wildlife; cooling urban space; flood protection; mental and physical wellbeing and recreation; as well as filtration of air and water. water (La Notte and Zulian, 2021; Haase et al 2024; Marando et al 2022; Marando et al 2016)

Important pressures on urban ecosystems are related to habitat conversion and land degradation, pollution (air, water and noise pollution) and unwanted introduction of invasive alien species. (Ferreira et al. 2019, Kondratyeva et al. 2020, Villalobos-Jiménez et al. 2016, Marzluff et al. 2008)

The graph below depicts the steady growth in built-up area and population increase in 25 EEA countries[29] up until 2006. This trend has broadly continued since and is predicted to continue into the future.

[29] https://www.eea.europa.eu/articles/analysing-and-managing-urban-growth




**With continued urban growth and development in Europe comes a growing pressure for land, and in general, this has meant that green spaces in and around cities have been steadily replaced with grey over recent decades.**

This simple approach has been the easiest and cheapest one for the rapid development of urban areas in the short term. The result is the degradation of urban ecosystems, and of the many valuable services they provide: a loss of valuable habitats for species including pollinators and birds; an increased urban runoff rate and higher risk of flooding and associated waste water pollution into EU rivers; significantly higher urban temperatures in summer due to a loss of microclimate regulation services and climate change mitigation potential; a loss of pollution filtration for air and water; and the loss of local recreational services (Marando et al., 2022; Seppelt et al., 2011).

Urban development, undertaken without due consideration of the urban ecosystem, considerably decreases the intactness of habitats, through the conversion of natural and semi-natural land, and through the fragmentation of the landscape caused by transport connections and other hard infrastructure - critically affecting the species depending on these habitats (EEA, 2020).

*Trends in LAUs classified as 'cities' and 'towns and suburbs*

According to the MAES Ecosystem assessment, Europe has experienced an increase of all artificial land cover types over the last 20 years by 3.4% per decade in the long term ("Urban" consists of all artificial land cover types included in Corine land Cover Map (Level 1)).

There has also been a steady reduction in urban green space, over recent decades. By year we see the following averages:

i. Increase of urban areas (artificial surface) **0.34 % per year**
ii. Loss of urban green space and tree canopy cover per year: **0.1% per year**

The MAES report says: "*One proxies of land degradation were soil sealing"* and that "*The share of sealed soil is significantly increasing in core cities, both in densely built areas and even more so in not-densely built areas where there are still opportunities for alternative solutions for dealing with territorial development."*

The overall trend then is one of steady expansion of urban fabric. New development has tended to be on agricultural land in urban fringes, (around 50%) with only around 12-13% of new developments on brownfield (abandoned) sites in cities. The remaining expansion is into natural and semi-natural areas including forests.

Some projections used for assessing the 'business as usual scenario' are shown below, that show what the situation would be if trends seen since 2000 were to continue (assuming no new policy action at EU of MS level) :

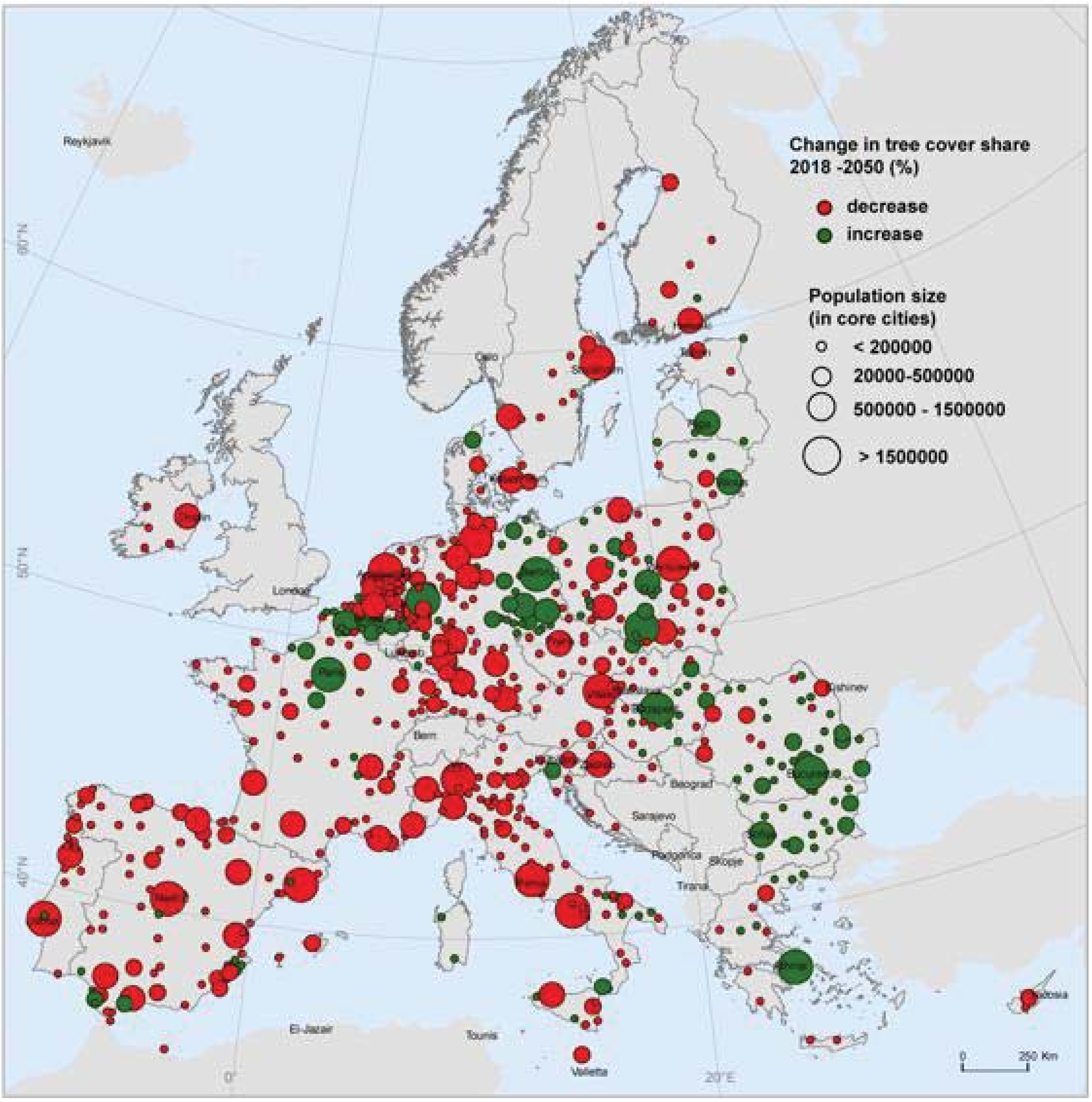



Figure: BAU scenario: Projected change in tree cover within functional urban area between 2018 and 2050 (JRC 2021)

Here we see that across a majority of MS and their urban areas are likely to continue to see a loss of tree canopy cover if no further policy action is taken. Details per Member State are show below.

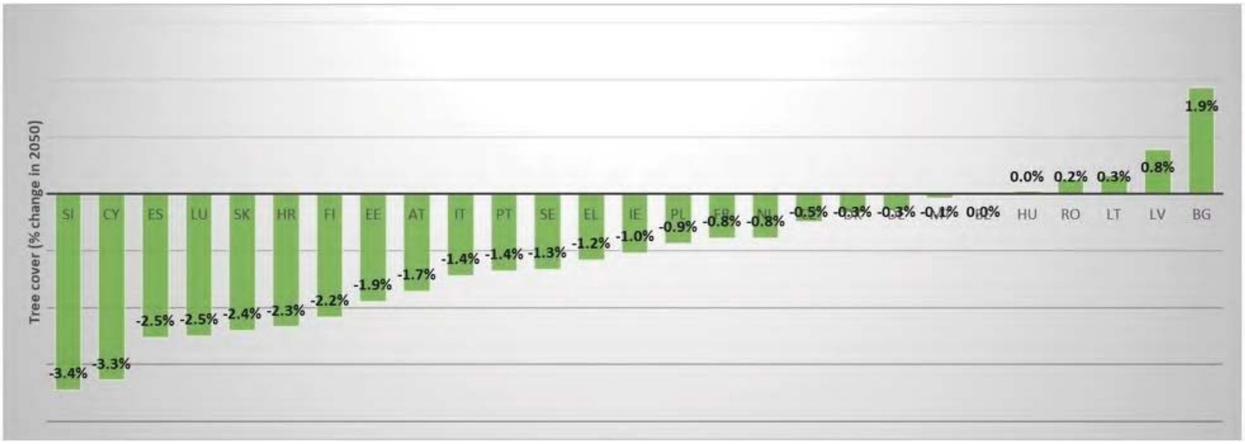



Figure: BAU scenario: Projected change in tree cover within functional urban area between 2018 and 2050 at MS level (JRC 2021)

It is clear that the competition for land in urban areas has, and will continue, to rise overall, with growing urban populations forecast across the EU. However, designing cities and towns and undertaking urban planning and development in an integrated way can however protect and actually enhance urban biodiversity and help maintain the many ecosystem services they provide, without restricting growth. Brownfield remediation and regeneration, for example, may represent a valuable opportunity, not only to prevent the loss of pristine countryside, but also to enhance urban green spaces, tree cover and remediate contaminated soils.

According to Haaland,et al. (2015) the most important barriers for cities implementing green urban development plans (that integrate ecosystem restoration objectives) are:

- The lack of integrated urban planning strategies incorporating ecosystem thinking. (and therefore a lack of coherence across urban departments *inter alia* water, transport, housing, education etc);
- Pressure for housing / development, and scarcity of land;
- Availability of funding for integrating greener urban development aspects;
- Lack of awareness of the benefits of investing in nature and ecosystem restoration.

There is now, however, a growing awareness of the potential of using nature-based solutions to address key urban challenges, and an increasing body of evidence evaluating and demonstrating the multiple/co-benefits they offer when compared to comparable technical/industrial scale solutions (European Commission, 2021). A number of actions considered highly valuable, which are founded on ecological principles, connectivity and natural regeneration are set out below:

- Integrating ecosystem thinking/accounting into urban planning processes, to realize the multiple benefits of NBS over alternatives, and to protect and enhance biodiversity;
- City regeneration — including rehabilitation of vacant buildings, degraded city districts and green spaces;
- The protection and maintenance of existing trees and the planting of new trees and woodlands;

- Creating large scale regional parks and forests in the urban fringes.
- Planning for urban green corridors to ensure a robust and functional network of green infrastructure;
- Improving the quality and function of existing green and blue infrastructure through multiple management modes;
- Using appropriate green and blue infrastructure as an integral component of new developments;
- Improve connectivity and accessibility to green and blue infrastructure within the city and beyond;
- Improving and promoting a wider understanding and awareness of the benefits that green and blue infrastructure provides;
- Encouraging ecological management mode of private green areas (including *inter alia* enhancing/improving the biodiversity value of existing green spaces, and providing green roofs and walls)

Currently **urban ecosystems are not specifically covered by any existing targets for ecosystem restoration**, although some areas covered by the Habitats Directive are found in urban areas. There are more than 12 thousand *Natura 2000* sites within, or partly within, city, and town and suburb LAUs. Protected areas within cities, towns and suburbs represent 16.65 % of the total area of the *Natura 2000* network. (Of which 2.4% are within cities and 14.2% are inside towns and suburbs[30].)

While many local / city urban greening plans do exist, and while many local authorities are taking action to protect and enhance urban ecosystems, these actions are, at the European level, mostly not coordinated, sporadic and insufficient overall – in short they provide no guarantee that urban ecosystems will not continue to degrade in the EU overall. At present, in many local administrations there are no drivers to implement urban greening measures, or if there are, they is significantly outweighed by the pressure for quick short-term development. The result of failing urban ecosystems is not only urban spaces themselves, but also on their surroundings and on the wider EU environment. For example, degraded urban ecosystems offer poorer levels of water filtration and flood protection, meaning significantly increased river pollution. They also do not support biodiversity effectively, both locally and more widely, including migrating birds and pollinator species.

There some important EU and international targets closely related to urban ecosystem degradation, including a number of SDG targets, *inter alia*:

SDG 15: *"Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss."*

Including the following specific targets:

[30] Data: Natura 2000 (2018); LAU-DEGURB version 29/06/2021: https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/population-distribution-demography/degurba

- *15.3: "….restore degraded land and soil…..and strive to achieve a land degradation-neutral world"*

- *15.5 "Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity…"*

- *15.9 "By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes…"*

SDG 11: *"Make cities and human settlements inclusive, safe, resilient and sustainable"*

Including the following specific targets:

- *11.6: "By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management"*

- *11.7 "By 2030, provide universal access to safe, inclusive and accessible, green and public spaces…."*

- *11.a: "Support positive economic, social and environmental links between urban, per-urban and rural areas by strengthening national and regional development planning"*

- *11.b: "By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters…"*

The 7th EAP sets the target that *"By 2020, EU policies take into account their direct and indirect impact on land use in the EU and globally, and the rate of land take is on track with an aim to achieve no net land take by 2050; soil erosion is reduced and the soil organic matter increased, with remedial work on contaminated sites well underway."*

However, in spite of these aspirational, voluntary, targets, there is no evidence of an overall change in the direction of the trends seen over recent decades. If they are to be achieved, coordinated policies or action at national and/or EU is considered essential - and thus the need to consider some urban ecosystem restoration targets with the aim of resorting urban ecosystems, by steadily steering urban planning towards systematically integrating urban ecosystem thinking into their processes.

## 8.3 Target options screened in/out

Based on the above considerations several legally binding targets options were proposed and assessed for protecting and restoring urban ecosystems in LAUs classified as 'cities', and as 'towns and suburbs'. Various targets were considered related to urban sprawl/soil sealing; to urban green space; and finally to tree canopy cover (being a sub-set of urban green space).

For all options, high quality Copernicus satellite data is already available going back to 2000, and will be available every three years through future ‘Corine Land Cover’ analysis that provides information on urban growth, soil sealing, tree cover density, and various layers of urban green, down to the $10m^2$ level of detail. This data can very easily be assessed within the relevant reporting units (in this can LAUs: cities, towns and suburbs) and is available freely online. It can be used for setting the baselines and for measuring and monitoring the targets.

The aim of the screening process was to select options for assessment that would be **realistic and feasible** for Member States and their growing urban populations, **while ensuring that the steady decline in the quality of urban ecosystems over recent history was addressed**, and then over time, **reversed**.

Some of the key data for establishing and assessing the various target options is set out below:

Key figures (JRC 2022):

**<u>Totals</u> (2021)**

| | | |
|---|---|---|
| iii. | Total area of LAUs ‘city’+ ‘town and suburb’: | **890,000 km²**<br>*(21.5% of EU surface)* |

*of which:*

| | | |
|---|---|---|
| iv. | Area of LAUs classified as ‘city’: | **152,870 km²**<br>*(3.7% of EU surface with 32.7% of EU population)* |
| v. | Area of LAUs classified as ‘towns and suburbs’: | **737,130 km²**<br>*(17.8% of EU surface with 28% EU population)* |
| vi. | Area of green space in LAUs ‘city’+ ‘town and suburb’: | **320,000 km²** |
| vii. | Area of tree cover in LAUs ‘city’+ ‘town and suburb’ | **230,000 km²** |

**<u>Trends</u>** *(averages since 2000)*

| | | |
|---|---|---|
| viii. | Increase of urban areas (artificial surface) | **0.34 % per year** |
| ix. | Loss of urban green space and tree canopy cover per year: | **0.1% per year** |

*<u>Potential land availability</u>*

Two main types of potential land availability have been considered below for analysis, aimed at supporting the selection of suitable targets for urban ecosystems, these are: levels of abandoned land, and the rate at which urban building stock is renewed and renovated. Together these give an idea as to the types of actions which could support enhancing urban green and increasing tree canopy cover, i.e. by ensuring residential, commercial and industrial developments are ‘greened’ over time (such as green roofs, green permeable parking, provision of parks and gardens) and by ensuring that brownfield sites (i.e. abandoned and/or contaminated urban land) is restored and used for parks and gardens or for new developments (rather than building on semi-natural habitats or forests).

It is important to note that around half of new urban development takes place on agricultural land in urban fringes. Clearly this agricultural land provides important environmental, social and economic services. It also offers potential for biodiversity restoration, addressed through, for example, greening measures in the Common Agricultural Policy; policy actions set out in the EU soil strategy for 2030; and within other targets in the nature restoration law. In some cases abandoned agricultural land (data on levels of such land are presented below) may offer opportunities for greening/tree planting in and around cities. As such, the aim of this assessment is to set targets to ensure the protection and restoration of urban ecosystems – any targets should work in conjunction with, and be supported by, any greening and enhancing the biodiversity value of peri-urban agricultural land. (i.e. such greening should count towards any urban ecosystem targets). Bastin et al (2020) estimate that the total area of abandoned agricultural land in the EU is as much as 116,410 km$^2$, but do not give any figures for what proportion of this can be found in city and town and suburb LAUs. Given, however, that these LAUs represent more than 20% of the EU land surface and contain around 50% agricultural land, the levels of abandoned land in these LAUs could be significant.

*<u>Potential of abandoned artificial land.</u>*

**Land availability** (source: Bastin et al., 2020, JRC 2022)

| | | |
|---|---|---|
| **i.** | Total **artificial surface** inside LAUs classified as cities and towns: | **110,000 km$^2$** |
| ii. | **Abandoned land** in this artificial surface: | **7,468 km$^2$** |
| iii. | Land without current use (in Functional Urban Areas): | **1,532 km$^2$** |

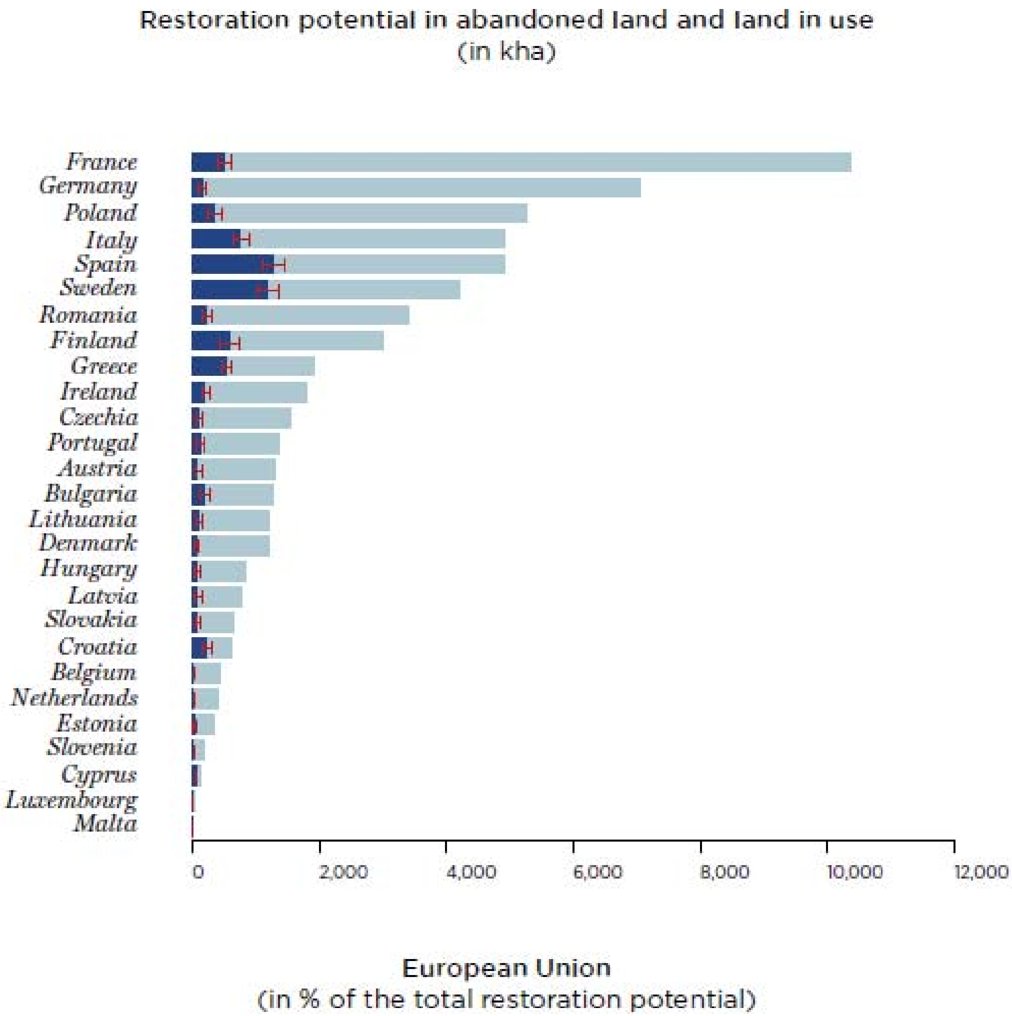
‘Brownfield’ sites are derelict and underused and include abandoned former industrial or commercial sites, which may have real or perceived contamination problems (EC, 2012). Redevelopment of brownfield sites gives many environmental advantages: relieving pressure on rural areas and greenfield sites, reducing the costs of pollution, allowing more effective use of energy and natural resources and facilitating economic diversification. (EEA, 2016). The European Environment Agency (EEA) has estimated that **there are as many as three million brownfield sites across Europe** and the figures above show that there are significant areas of abandoned sites in artificial land surface with potential for greening or for urban development. Of the figures above it is not only the abandoned land with potential for greening and tree canopy cover. In use artificial surface also clearly has potential for greening too, such as by:

- Planting additional trees (tree lined streets/corners/roads/etc., enhancing existing parks with trees, tree planning on brownfield sites around cities)

- Developing new public parks and gardens (i.e. in urban fringes, conversion of brownfield)
- Maximising green space on new and/or redeveloped sites (green roofs, greener more permeable parking etc.)

Brownfield sites are often located within urban boundaries with good connections to local infrastructure, making them a competitive alternative to greenfield investments.

Bastin et al (2020) estimate the total land available for restoration for tree canopy cover in all EU artificial surfaces (about 75% of which fall in LAUs classified as cities, and towns and suburbs) of both 'abandoned' and 'in use' land, at around **40,500 km².** Below is a figure showing the distribution by MS of this restoration potential by Member State.



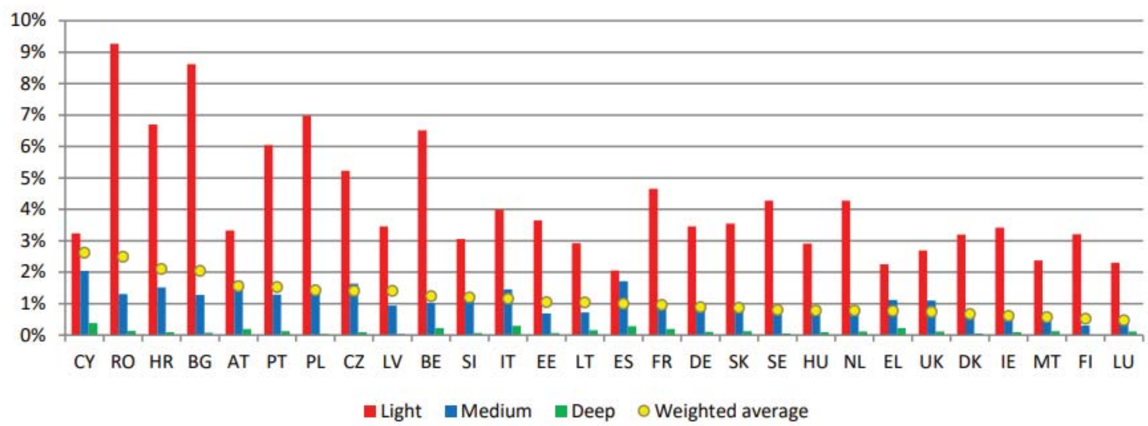

*Potential for greening linked to renovation of buildings.*

**Renovation rates**[31]

i. Average residential: **1% per year**
ii. Average non-residential: **1.2% per year**

For **residential buildings**, the annual weighted renovation rate is estimated at 1.0%. Results show important variations between Member States. In general, values are higher in Eastern – European Member States, possibly as a result of the high renovation rates on light renovations.

Renovation rates in residential buildings in the EU28 Member States by renovation level, annual average 2012-2016.

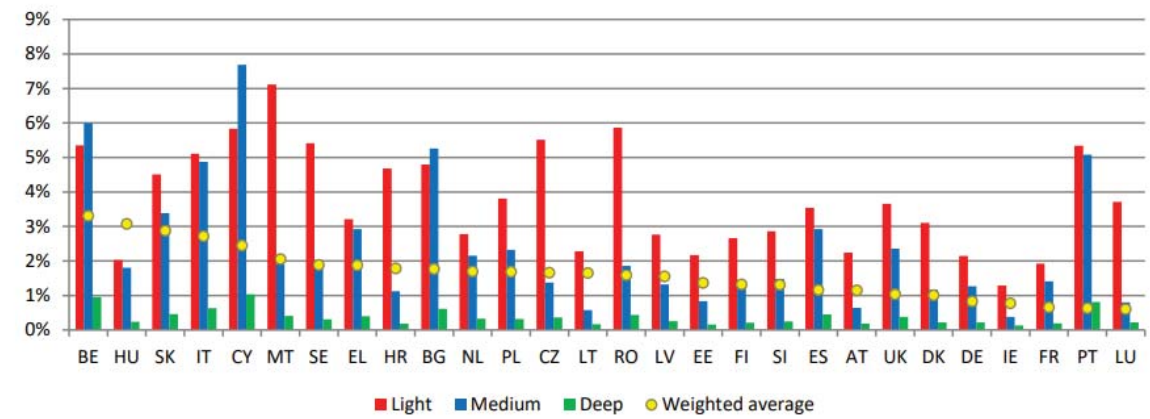



*Source*: JRC, 2020

For **non-residential buildings**, the annual weighted energy renovation rate was estimated to 1.2%. The weighted average also shows variations between Member States ranging from 0.6% in Luxembourg to 3.3% in Belgium.

[31] https://ec.europa.eu/energy/sites/ener/files/documents/1.final_report.pdf , https://publications.jrc.ec.europa.eu/repository/handle/JRC122347

Renovation rates in non-residential buildings in the EU28 Member States by renovation level, annual average 2012-2016.




*Source:* JRC, 2020

Converting renovation rates into potential for urban greening:

Total artificial surface in LAUs classified as city, and town and suburb fit for renovation[32]:

| | |
|---|---|
| Residential plots: | 55,143 km$^2$ |
| Non- residential plots: | 21,472 km² |
| Total: | 76,615 km² |

If the **average** renovation rate is considered (which included deep, medium and light renovations) the figures are 551 km² per year for residential and 258 km² per year for non-residential. This represents a total of 20,200 km² over 25 years.

Assuming that a renovated building plot could increase its green area (via, for example, green roofs, greening parking places, tree planting, adding green recreational land etc) by a factor of 0.25 to .5, we can see a rough range of potential additional urban greening of **5,000-10,000 km² over a 25-year period**.

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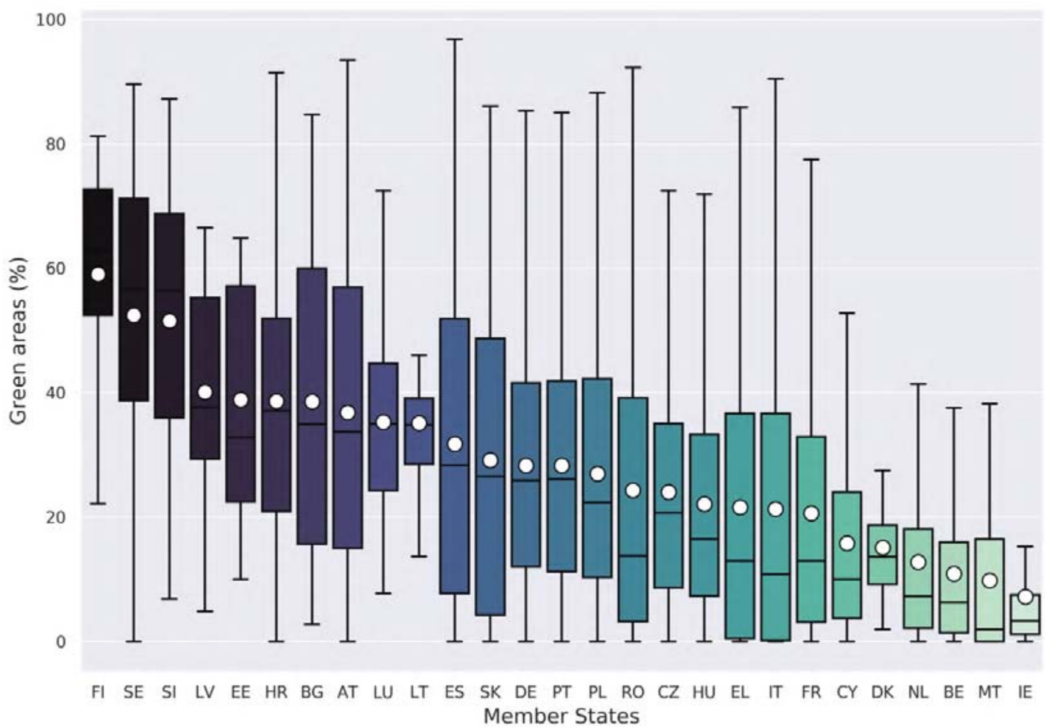
In addition to looking at land availability and renovation rates, the following tables show the current variation by Member State in terms of urban green space and tree canopy cover. This information, in combination with the data above, was used as the basis for setting the targets for this assessment.

*Urban Green:*

[32] *Values based on artificial surface not classified as road, harbour or railway, so includes courtyards, private plots not occupied by buildings and therefore some building plot open space. (JRC 2022)*

Urban green spaces provide several key regulating, cultural and provisioning ecosystem services, such as microclimate regulation, flood control, air quality regulation, noise pollution mitigation, nature-based recreation. Urban green is the amount and extent of vegetation that composes an urban green infrastructure. It is represented by public and private green spaces, characterized by different uses and management practices.

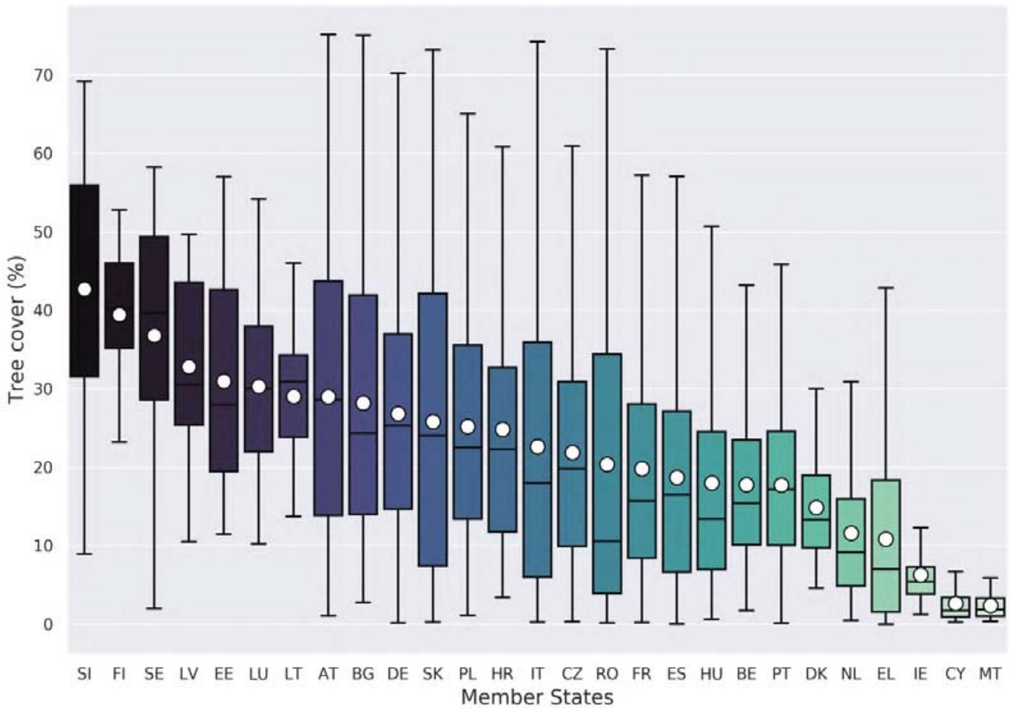
*Below: the distribution of the share of green areas in EU Cities, Towns and suburbs, represented by Member State (data: Corine Land Cover).*




Here we can see that the levels of urban green vary greatly by Member State, ranging from an average (white dot) of nearly 60% green space in some LAUs, down to as low as 10% in others. The range of green space within the LAUs in each Member States (95% of LAUs are represented in the bar for each Member State) also shows that there is significant variation within country borders too.

<u>*Tree canopy cover:*</u>

*Below: the distribution of the share of Tree canopy cover in EU Cities, Towns and suburbs, represented by Member State (data: Copernicus HRL Tree Cover Density map 2018).*




For tree canopy cover we see a similar pattern to that of urban green, (tree canopy cover is often a sub-set of urban green, so this is not surprising) with the range of average tree cover in city, and town and suburb LAUs from nearly 45% down to around 2% in some smaller island Member States. Again, the variation within the LAUs of each MemberState is also broad, with some showing more than 30% differences. Overall 11 Member States have at least some LAUs with less than 10% tree canopy cover.

The reasons for these variations for both urban green space and tree canopy cover are diverse, ranging from the geographical to the historical, as well as partly being related to the manner in which Member States establish their administrative boundaries within the confines of their borders. It is very important to stress that **these numbers do not directly represent or show ‘good’ vs ‘bad’ historical urban planning practices**. Some LAUs have much longer histories, some are smaller and confined more to city limits, and at the same time the local climate and native vegetation and tree cover vary greatly across the EU.

All cities, towns and their suburbs should address this loss of green space and tree canopy cover in the future if our biodiversity (and many other climate and environmental) objectives are to be met at least by ensuring new developments and renovations are greened as far as possible, and that abandoned land is prioritised over pristine natural habitat.

Some of these urban areas should also be the focus for funding, and policy action, in relation to the 2030 target of planting an additional 3 billion trees, so setting the targets with consideration of this overarching EU climate and biodiversity objective is also relevant.

Based on the analysis and data shown above, looking at existing levels of green and tree cover, how they are distributed across Member States, and the trends in recent history, and taking account of how important urban ecosystems are, for biodiversity and for society – but also taking into account the very different histories, natural climates of our urban areas - an effective approach to setting a target on green space and trees is first aim to halt the their decline, and then to encourage a steady and positive growth. Halting the loss in green and trees in many LAUs will not be difficult, and some are even already on this path, however for others it will require some change in planning processes, integrating and prioritising the protection of green space and restoration and greening of new developments and restorations.

To ensure a fair and feasibly approach for restoration across cities, such that those who already have higher levels of green space are not penalised for this, the targets proposed are set relative to the total area of each LAU, rather than relative to existing areas of green. i.e. every LAU will have the same target according to the area of their administrative area.

**Table VIII-1 Summary table screened target options for urban ecosystem restoration**

| Target option | Screened in/out for assessment | Key reason(s) for screening in/out |
|---|---|---|
| Option 1 *** **No net soil sealing in cities towns and suburbs by 2030:** any new soil sealing must be compensated for by an equal area of green land-recycling (i.e. the development of green urban areas using previously built-up or brownfield areas); and<br><br>**2:1 ratio for 'green land recycling: soil sealing' in cities towns and suburbs achieved in 2050:** all new soil sealing must be compensated with double the area of green land-recycling | Built-up areas have been mainly enlarged at the expense of agricultural land. Progressive soil sealing will take place especially for Western Europe where the area of built-up land increases at a faster rate than the population. Spatial planning strategies determine to a great extent the progression of soil sealing. Unfortunately, neither the economical nor the ecological or the social effects of irreplaceable soil losses have been considered adequately so far. A rational land-use planning to enable the sustainable management of soil resources and the limiting of sealing of open space is needed. Possible measures include the redevelopment of brownfield sites, of vacant and derelict land, and the rehabilitation of old buildings. | Screened out: European cities have sealed, on average, 22 % of their soil but this increases to 58 % if only soil sealing in artificial areas is considered. Land recycling is considered a response to land take within urban areas, i.e. urban development on arable land, permanent crop land or semi-natural areas. It is a key planning instrument for achieving the goal of no net land take by 2050 (EC, 2016) and could be key to improving land management and maintaining and developing the green infrastructure that is so important for the provision of ecosystem services.<br><br>However, a target on soil sealing only in functional urban areas is considered too blunt a tool for meeting the aim of improving the quality of urban ecosystems, and in turn the overall aims of the EU Biodiversity Strategy. Different cities are at different stages of growth/development, and each may have very different, highly complex landscapes, needs, surrounding ecosystems, as well as different availabilities of land for recycling. |

| | | |
|---|---|---|
| | | In reality the environmental impact of urban developments can vary greatly – so to ensure the overall quality of urban ecosystems improves, it is more appropriate to set a target directly on this (giving Member States the flexibility to implement this, while still meeting other urban developmental needs.) In other words, accepting that growth may be inevitable, but ensuring that it is implemented thoughtfully, respecting good ecological principles as far as possible, and is part of a wider plan to ensure protection and enhancement of urban ecosystems. |
| **Option 2:**<br><br>**No net loss of green urban space by 2030, compared to 2021, within each LAU containing cities, towns and suburbs.**<br><br>**A national average increase in the area represented by green urban space cover across LAUs containing cities, towns and suburbs, of at least 3% of the total area of these LAUs by 2040 and at least 5% of the total area of these LAUs by 2050, compared to 2021.** | Urban Green and Blue Infrastructure will be capable of generating a substantial range of social, environmental and economic benefits for urban citizens, whilst also providing protection against the effects of climate change. Key components are the promotion of:<br>multifunctional design (where a range of benefits are provided in one area through careful planning, integrated design and management) to deliver these benefits.<br>a) Ecosystem-based management modes<br>b) Intersectoral planning<br><br>This target will measure the proportion of existing green and blue infrastructure, with indicators that build on quality of ecological values and climate change adaptation and mitigation potential. | Screened in: Urban green in almost all forms provides a wide range of very clear, well defined, relatively low-cost benefits, not least protecting and enhancing biodiversity, supporting pollinators, protecting from the negative impacts of climate change and supporting the mental and physical well-being of citizens. However due to pressure for land in developing and growing cities often urban green is being lost unnecessarily, rather than preserved and enhanced. Overall levels should be protected and increased modestly over time, restoring and enhancing the quality of these important ecosystems. This option does not imply a restriction on urban development set at this level, (that is not the remit of this initiative) it rather means new developments should be encouraged to be nature-enhancing, land should be recycled when possible and/or compensated for if necessary. The IA has shown that this is a feasible option that, if the benefits of urban green are accounted for correctly, will actually also save costs in the medium term. It is implemented already in many cities. |

| | | |
|---|---|---|
| **Option 3: no net loss of tree canopy cover by 2030, compared to 2021, within each LAU containing cities, towns and suburbs..**<br><br>**a minimum of 10% tree canopy cover in each LAU containing cities, towns and suburbs by 2050.** | Trees and other woody plants along streets and in public squares and car parks as well as private gardens can contribute to biodiversity, climate change mitigation and adaptation, for example by reducing urban air temperature and therefore the urban heat island effect through evapotranspiration and by providing shade, the mitigation of extreme weather events, such as the reduction of stormwater run-off during heavy rainfall events. Trees can help to clean the air of harmful pollutants and can increase surrounding property values by 2-10 %. Moreover trees contribute to the provision of recreation services and to the suitability of land to support insect pollinators (Zulian et al 2013; Stange et al . 2017)<br><br>Tree cover is a key and simple element in understanding the magnitude of the urban forest resource and can be used to assess various ecosystem services and values derived from the forest. Average tree cover in European urban areas is 19.6 % (Nowak, 2020), but in many individual city LAUs the area is below 10%. | Screened in: This options fits well with option 2 on protecting and enhancing relative levels of urban green. (Tree cover is obviously a subset of urban green. Meeting this will impact positively on the other) It aims to ensure that a modest, and achievable minimum level of tree canopy cover over time (and therefore high quality form of urban green) is achieved by 2050 for those most densely populated urban areas (city LAUs) with the fewest tress at the present.<br><br>This minimum level is such that is will ensure the minimum threshold of tree canopy cover is reached to ensure biodiversity can thrive, and that all cities are equipped to deal with the inevitable impacts of climate change, namely: protection from excessive heat, and reduction in the risks from flooding. The multiple benefits related to mental health and well-being, and helping to deal with filtering polluted air and water should also not be underestimated. |

Following from this screening process, Option 1 was rejected. When considering the growth of urban development, it was considered too be blunt a tool for cities to integrate in their planning processes. As the aim of this initiative is to enhance the condition of urban ecosystems, a target based on levels of soil sealing is not considered to be a sufficiently accurate and comprehensive indicator. Soil can be partly sealed while maintaining or enhancing urban ecosystem condition, for example with green roofs, tree lined streets, permeable car parking with trees. In addition, issues related to sprawl and soil sealing may be addressed as part of the developing soil strategy/policy framework.

Options 2 and 3 were selected, but refined to bring together the tree canopy cover with the urban green area target (rather than as an independent target) as follows:

**No net loss of green urban space, including tree canopy cover, by 2030, compared to 2021, within each LAU containing cities, towns and suburbs;**

**A national average increase in the area represented by green urban space, including tree canopy cover, across LAUs containing cities, towns and suburbs, of at least 3% of the total area of these LAUs by 2040 and at least 5% of the total area of these LAUs by 2050, compared to 2021:**

**A minimum of 10% tree canopy cover in each LAU containing cities, towns and suburbs by 2050**

This combined option can be operationalized as an integral part of urban infrastructure independent of the historical developments and geographic location of the city, as the multiple benefits of green infrastructure and in particular trees are increasingly known to urban planners and decision makers and stimulated by initiatives such as the Green City Accord and the Urban Greening Plans part of the ambitions of the EU Biodiversity Strategy for cities above 20,000 inhabitants.

For tree planting, this would need to be done in full respect of ecological principles, for example, prioritizing native tree species and avoiding the use of non-native species.

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During the assessment process, it also became clear that any target should promote the greening of any new urban developments, and ensure that no 'rebound effects' could come from the setting up of any targets that might mean the building of new all grey infrastructure on natural land simply being compensated elsewhere. (Compensation may have an important role to play, but it should not be used to make up for low quality new developments degrading natural land). Thus the following requirement was also added:

**Ensure a net gain of green urban space is integrated into existing and new buildings and infrastructure developments, including through renovations and renewals, in LAUs containing cities, towns and suburbs.**

Below are some of the key figures related to the targets established:

TableVIII-2 *shows the areas needed to meet the respective targets for 2030, 2040 and 2050 for the options considered.*

**Table VIII-2: areas needed to meet the respective targets for 2030, 2040 and 2050.**

| **Targets** | **Area (km²)** | **Area (% of LAUs)** |
|---|---|---|
| Urban green for no-net-loss by 2030: | 2,900 km² | |
| Urban green for 2040 target | 26,679 km² | 3.00% |
| Urban green for 2050 target | 17,786 km² | 2.00% |
| Total additional urban green | **44,465 km²** | 5.00% |
| | | |
| Tree cover for no-net-loss by 2030 | 2,059 km² | |
| Tree cover for 2040 target | 19,176 km² | 2.15% |
| Tree cover for 2050 target | 12,784 km² | 1.43% |

| | | |
|---|---|---|
| Total additional tree cover | 31,959 km² | 3.58% |
| Tree cover for 2050 target of 10% in cities, towns and suburbs* | 9,522 km² | 1.06% |

* The area of tree cover in km² needed in order to meet the 2050 target of 10% will mostly already be met by the increase of 5% tree cover (i.e. most LAUs below 10% are near enough to mass this milestone anyway) so the total tree cover figure does not include the 10% area in addition.

The headline figure here of total urban green by **2050 of 44,456km²**. This is considered to be in line with, or below, the potential land available to meet the targets, especially if looked at over the 2050 time frame.

Considering the areas that have been estimated (and presented earlier in this document) we can see that contributions could be made by:

**a)** Abandoned land / contaminated artificial surfaced land potential: **9,000 km² (up to 40,000 km² in one study)**

This abandoned artificial surface, however, only represents around 12% of the land surface of the LAUs in question. The rest is made up, around this artificial surface, of natural and semi-natural land and including significant agricultural land. Any tree planting in these areas, around cities or the enhancing of agro-ecosystems with 'landscape features' could also contribute to improving urban ecosystems and to meeting the targets proposed. Total abandoned agricultural land in the EU is as much as 116,410 km², so levels of abandoned land in LAUs classified as city, and town and suburb, could be significant.

**b)** Renovation of building stock at average rate (over 25 years): **5,000-10,000 km²**

c) Active green restoration: the figures above relates to normal rates of renovation, and then to the levels of abandoned land, however, there is also potential for more actively greening of 'in use' artificial surface that may not fall within the definitions of 'renovations' set out previously - i.e. by going beyond normal renovation rates to undertake more active greening of roofs, car parking areas, tree lining streets etc,. For this type of specific green renovation considerably more land is potentially available. Bastin et all estimate this potential land availability to be more than **30,000km²** (Bastin et al. 2020)

## 8.4 Impacts of assessed target options

Due to the innate nature and variety found across different European cities, providing simple assessments for the cost and benefits of urban green space and levels of tree cover is not possible: Land values vary by multiple orders of magnitude; pressures for space vary tremendously, as does the age and historical development of cities; access to green space varies widely; existing climate and likely future impact of climate change also vary widely.

However, in spite of this extreme variation, when looking at some of the basic costs and benefits of setting targets for halting the steady degradation of urban ecosystems currently being seen, and then setting feasible and achievable restoration targets for 2030, 2040 and 2050, (i.e. those selected), and targets in line with other commitments (such as for the planting of additional trees in the EU) the costs are seen to be lower than assessed benefits, (see table below for examples of the range of costs / benefits of urban ecosystems and their restoration), and that is even when many of the benefits that are difficult to quantify are not accounted for.

The **costs** of provision of green urban space and increasing tree cover in cities vary widely by location and are influenced by factors such as the density of urban development, the price of land, and the extent of available land for green spaces, trees and woodlands, all of which vary widely between urban locations across the EU. **As a result, it is difficult to identify generalised unit costs that can be applied to assess the overall costs of meeting urban ecosystem restoration targets.**

However, the typical **costs** of meeting urban ecosystem restoration targets include:

- Capital costs of green space provision or restoration. These include construction and site preparation costs (e.g. works required to recycle brownfield land for creation of urban green space) and costs of planting trees, parks, gardens, green roofs and other green infrastructure features. They include costs of labour, machinery, energy, materials, plants/saplings and other inputs.
- Ongoing costs of green infrastructure maintenance. These include costs of managing parks, gardens and green spaces, and maintaining trees and woodlands. They include similar types of inputs as the capital costs of green infrastructure provision.
- Opportunity costs. Where land managed as green space or woodland cannot be developed for other purposes, such as for commercial, residential or infrastructure development, there are opportunity costs in terms of forgone revenues and economic development opportunities. These opportunity costs are reflected in the high price of land in most urban areas, but overall they are enormously variable, (from luxury flats in town centres to out of town parking/storage lots for example) and therefore and estimates are somewhat speculative/generalised.

Administrative and information costs. These include the costs of establishing management bodies, developing and implementing urban green infrastructure plans and strategies, public consultations, conducting surveys and monitoring, and the costs of administering capital works and ongoing maintenance programmes (Naumann et al., 2011) (Tempesta, 2015).

The **benefits** of urban ecosystem restoration include a range of ecosystem services (Haase et al 2014):

- Provisioning services – e.g. provision of food, fibre and fuel through gardens, allotments and community orchards and woodlands;

- Regulating services – e.g. regulation of climate, air quality, water quality and flooding;
- Cultural services – e.g. benefits for recreation, tourism, urban landscape and visual amenity, and resulting impacts on physical and mental health and wellbeing (Naumann et al., 2011).

In turn these ecosystem services deliver broad economic and social benefits, e.g.

- Reduced costs of flooding, water treatment and climate change impacts;
- Reduced costs for morbidity and mortality due to the various health benefits of ecosystem services
- Business benefits, by enhancing the working environment and attracting paying visitors;
- Community benefits, by providing spaces for social interaction, meetings and events;
- Enhanced property prices, with evidence of price premium for developments close to green space;
- Enhanced investment, as an improved urban environment encourages new development, regeneration and business investment;
- Creation of jobs in green infrastructure provision and maintenance (Naumann et al., 2011).

The **benefits of green spaces and urban tree cover vary widely by location**, and are influenced by factors such as:

- The extent, proximity to residential areas and accessibility of existing urban green space (and hence the degree to which this currently provides opportunities for recreation, exposure to green spaces and associated health and wellbeing benefits);
- The climate of urban areas (and hence the benefits of trees and vegetation in cooling and insulation)
- The prevalence of environmental hazards such as flooding (and hence the benefits of reduced run-off)
- The extent and distribution of physical or biological hazards for urban dwellers and ecosystems (i.e. air/water pollutants, noise, pests) and the potential to address these through trees and green infrastructure.

As a result of wide variations in both benefits and costs, the benefit: cost ratios of urban greening vary widely by context. In general, they are highest in places where ecosystem services are constrained (e.g. where access to green space is limited, air quality is poor, a lack of tree cover limits temperature regulation and other problems such as flooding are prevalent) and where the costs of action are lower (where land for planting trees and creating new green spaces is available, inexpensive and not difficult to recycle, and where expensive re-planning and reconstruction can be avoided).

While benefit values vary and are difficult to generalise, **the available evidence suggests strong benefit:cost ratios** in investment in provision of street trees and increasing urban tree cover, which yields benefits for air quality, regulation of climate and visual amenity, as well as for provision and enhancement of green space, enhancing recreational opportunities, health and wellbeing and amenity values. (see details in summary in next section)

There is good evidence that provision of urban green space – including green spaces, natural areas and increased tree cover – delivers a wide range of ecosystem services to citizens and businesses, and that the benefits of protecting, and undertaking modest restoration of urban ecosystems, significantly exceed the costs. At the same time, rapid and significant restoration of urban ecosystems is neither feasible or practical, especially in core cities. **The aim of setting these targets for restoring the urban ecosystem is to slowly but steadily steer urban planning process towards systematically integrating urban ecosystem thinking into their processes** – prioritising *inter alia*:

- development in locations that have the lowest biodiversity/ecosystem value, (i.e. brownfield restoration);
- developments that actually enhance and improve urban ecosystems by fully integrating green infrastructure (green roofs, extensive tree cover, parks and gardens, minimal soil sealing);
- compensating for loss of urban green or tree canopy cover as a last resort.

Quaranta et al[33] show that green roofs could deliver significant benefits to European cities. They estimated that they can cool surfaces by between 2.5° and 6°, causing a reduction of sensible heat to the atmosphere, a driver of urban heat island effects, reducing air temperature of about 50% with respect to the surface temperature reduction.
Urban greening has the potential to reduce urban runoff by about 17.5%, helping reduce urban diffuse pollution and the frequency of combined sewer overflows. As such, the role of green roofs should be considered in the context of river basin management. Other benefits include:

- the reduction of heat flow to buildings, corresponding to a potential cooling energy saving, the effects of carbon dioxide sequestration by biomass growing on green roofs.
- benefits related to runoff reduction and combined sewer overflow mitigation,
- increase of property values, socialization (e.g. related to community gardening) and wellbeing.
- Biodiversity improvement, supporting pollination and improving the environmental quality of urban landscapes.

They point out that due to the fact that urban greening requires for a large part private investments, if it is to be implemented on a large scale on European urban surfaces, appropriate fiscal and funding policies will be needed. They say urban greening could represent a multifunctional no-regret, cost-effective solution meeting the aspirations of the European (and global) sustainability agenda.

[33] https://www.nature.com/articles/s41598-021-88141-7

This section therefore summarises the range of costs and benefits relating to the targets assessed.

The following information shows the potential benefits and costs related to the options proposed, although the differences across EU Member States with regards to costs of urban development and green infrastructure implementation should be considered.

The following benefits, which are based on local examples, give an indication of the large potential that investment in urban greening has.

### Summary of Benefits Estimates for urban ecosystem restoration option

**Biodiversity**:

**Tree cover and/or other urban green has a significant and meaningful beneficial impact on biodiversity, particularly if part of a wider green-infrastructure urban greening plan.**

Urban green space has a positive impact upon local biodiversity by helping to increase habitat areas and by creating 'wildlife corridors' that can make it easier for species to move between individual green spaces. The green spaces found in cities and towns can form a vital habitat for pollinators, such as bees, butterflies and hoverflies. Urban environments can play an important role in helping to build habitat for these species. Urban areas can provide a wide variety of flowering plants and also mostly avoid pesticides that are used in agricultural areas.

A comparison of biodiversity levels between more than a hundred cities worldwide showed that bird and plant species densities vary substantially among cities and were explained best by a city's urban land cover, age of urban area as well as an intact urban vegetation cover (Aronson et al. 2014a). The city-wide vegetation cover is commonly assessed to derive conclusion on a city's species richness or its capacity therefore. Some key relevant findings are that:

**Vegetation cover below 10% has been found to cause rapid declines in species richness** (Radford *et al*. 2005), and that:

**A landscape-level threshold of 20–30% of a specific habitat has to remain to prevent the combined effects of habitat loss and fragmentation to exacerbate the loss of species or populations** (Hedblom & Soderstrom 2010).

Aronson *et al*. (20142015) concluded that intact vegetation cover is the strongest explanatory variable for variation in species density among cities worldwide. **The proportion of green surroundings as well as many other biotic habitat categories have a significant positive effect on urban species richness**.

**Flood risk reduction:**

**Increasing tree cover and/or urban green has a very significant and measurable impact on flood prevention.**

**A 10% increase in green space can reduce run-off in residential areas by 5%, while a 10% increase in tree cover can reduce run-off by 5.7%. Adding green roofs to all urban buildings could reduce run-off by 17-20%;**

Vegetated surfaces reduce the volume of surface water runoff by storing and intercepting rainfall. For example, studies have shown that green roofs have the capacity to capture 70% of rainfall during a flood risk period.

Urban trees and forests are now being regarded as important and cost-effective way of reducing flood risks and reducing the impact of rainstorms – studies estimate that for every 5% increase in tree cover area, run-off is reduced by 2%.

Sustainable 'nature-based' urban drainage systems have 50% lower capital costs and 20-25% lower annual maintenance costs than traditional drainage systems, while also providing valuable services to biodiversity.;

*Examples of effectiveness of small-scale NBS for flood mitigation (see also Ruangpan et. al., 2020)*

- Porous Pavements: Runoff volume reduction ~30–65%; Peak flow reduction ~10% - 30% (Shafique et al., (2018), Damodaram et al., 2010);
- Green Roofs: Runoff volume reduction up to 70%; Peak flow reduction up to 96% (Burszta-Adamiak and Mrowiec (2013), Ercolani et al. (2018), Carpenter and Kaluvakolanu, (2011), Stovin et al. (2012));
- Rain Gardens: Runoff volume reduction up to 100%; Peak flow reduction ~48.5% (Ishimatsu et al. (2017), Goncalves et al. (2018));
- Vegetated Swales: Runoff volume reduction up to 9.60%; Peak flow reduction ~23.56% (Luan et al. (2017), Huang et al. (2014));
- Rainwater Harvesting: Runoff volume reduction ~57.8-78.7%; Peak flow reduction ~8%-10% (Khastagir and Jayasuriya (2010), Damodaram et al. (2010)) ;
- Detention Ponds : Runoff volume reduction up to 55.7%; Peak flow reduction up to 46% (Liew et al. (2012), Damodaram et al. (2010), Goncalves et al. (2018));
- Bioretention: Runoff volume reduction up to 90%; Peak flow reduction up to 41.65% (Luan et al. (2017), Huang et al. (2014), Khan et al., (2013));
- Infiltration Trenches: Runoff volume reduction up to 55.9%; Peak flow reduction up to 53.5% (Huang et al. (2014), Goncalves et al. (2018))
- Quaranta et al (2021): 35% of the EU's urban surface (>26,000 km2) would transpire about 10 km3/year of rainwater, absorbing about 17.5% of water that is now urban runoff, helping reduce water pollution and urban flooding.

**<u>Urban heat island effect</u>:**

**Tree cover and/or other vegetation cover has been demonstrated to have a very marked impact on urban temperatures in the surrounding areas.**

Urban Green Infrastructure implementation is recognized as one of the key strategies to mitigate heat impact in cities, since green areas provide the microclimate regulation ecosystem service**. The net cooling effect of a young, healthy tree is equivalent to ten average sized air-conditioners operating 20 hours per day** (FDA, 2021[34]). Nature can help to reduce the risks associated with heat stress by providing cooling through shade and evapotranspiration. However, a substantial proportion of urban population currently lives in areas with high heat exposure (EEA, 2020; Marando et al., 2022[35]).

> *Examples of studies on the effects of NBS on thermal mitigation (reduction of degrees C) in different European case studies (after GreenInUrbs project and Hiemstra et al., 2017):*
>
> - Israel 2-4°C, with Grass lawn / trees (Shashua-Bar et al., 2006)
> - Portugal 2.5-6°C and up to 9°C, with green areas (Andrade and Vieira 2007)
> - Netherlands 0.6°C and up to 4°C, with green areas (Heusinkveld et al., 2014)
> - Sweden 2-4°C and up to 6°C, with parks (Upmains et al., 1998)
>
> - **EU 27**: up to 2.9°C, and 1.07°C on average (Marando et al., 2022)

Marando et al., (2022): In this EU-wide study, the ecosystem service of microclimate regulation has been assessed in 601 EU-27 cities through a model which simulates the temperature difference between a baseline and a no-vegetation scenario. It has been shown that European green infrastructure cools the temperature by 1.07°C on average, and that a 10% increase in urban vegetation reduces the temperature by an average of 0.6°C. The temperature regulation is mostly dependent on the amount of vegetation inside a city, as well as by canopy transpiration. Furthermore, in almost 40% of the countries, more than half of the residing population does not benefit from the microclimate regulation service provided by urban vegetation

> Quaranta et al (2021)
>
> 35% of the EU's urban surface (>26,000 km2) would avoid up to 55.8 Mtons/year CO2e, reduce energy demand for cooling buildings by 92 TWh per year, with a net present value (NPV) of more than €364 bn.
>
> It would decrease summer temperature by 2.5–6 °C, with mitigation of the urban heat island effect estimated to have a NPV of €221bn over 40 years.

[34] https://www.fs.usda.gov/detail/r9/home/?cid=STELPRD3832558

[35] Healthy environment, healthy lives: How the environment influences health and well-being in Europe EEA Report No 21/2019

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| Horvathova et al (2021)<br><br>Urban cooling from street trees in Prague, Czech Republic: present value of benefits €4362 - 9163 per hectare; benefits exceed costs after 30 years at 3% discount rate. |

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| Venter et al (2019)<br><br>Oslo, Norway: Cooling effects of urban trees - If each city tree was replaced by the most common non-tree cover in its neighbourhood, the area of Oslo exceeding a 30°C health risk threshold during the summer would increase from 23 to 29%. Each tree in the city currently mitigates additional heat exposure of one heat sensitive person by one day. |

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| Marando et al., (2019) Rome, Italy: it has been shown that a large peri-urban forest, an urban forest, and a tree lined road reduce summer temperatures by 2.8 °C, 3 °C and 1.3°C, respectively. Furthermore, the cooling effect extends by an average distance equal to 170, 100 and 30 meters, respectively. |

**Climate mitigation:**

**Urban trees can play an important role in climate mitigation**

A mature urban tree is capable to absorb around 90 kg of carbon per year, and as a consequence contribute to mitigate climate change (McPherson et al (1994)**.**

The tree canopy cover targets (taking a conservative estimate of 1,500 trees per hectare) represent around 300 million trees in towns, cities and suburbs by 2030 (so more than 10% of the EU wide 3 billion tree target) and a total of nearly 4.8 billion by 2050 , distributed over more that 32 million hectares of land. This would represent a significant step towards the climate mitigation objectives.

Studies have also demonstrated clearly that green roofs and walls can make buildings significantly warmer in winter (up to 4.5°C), as well as and cooler in summer, which represents significant energy savings for heating and cooling

**Health and well-being**:

**Urban trees and green and blue spaces provide multiple benefits for mental health and well-being, for recreation, as well as the ability to reduce levels of pollution significantly.**

**European residents of areas with the most greenery were 3 times as likely to be physically active and 40% less likely to be overweight or obese, than those living in the least green**

**settings.** People are happier when living in urban areas with large amounts of greenspaces, showing lower mental distress levels and higher wellbeing (life satisfaction) levels.

Living in or close to green areas can reduce mental stress and increase life satisfaction. Pregnant women living more than 300 meters away from green spaces have higher blood pressure compared to those who live closer.

| Kwon et al (2021) |
| --- |
| 90 global cities in 60 developed countries, covering 179,168 km² and 230 million people: Correlation between urban green space (UGS, based on high-resolution satellite imagery), happiness and GDP. Urban green space and GDP are correlated with a nation's happiness level. Strongest correlation between UGS and happiness is in wealthiest countries. |

| Vivid Economics (2017) |
| --- |
| Green space in London, UK Recreation, mental and physical health, residential property, carbon and temperature: Gross capital value of benefits of £91.3 bn (€107bn), with largest values for residential property (61%), recreation (19%), physical health (12%) and mental health (7%). Each £1 spent on public parks delivers £27 in benefits to Londoners. |

| WHO Regional Office for Europe (2016) |
| --- |

Urban green spaces, such as parks, playgrounds, and residential greenery, can promote mental and physical health, and reduce morbidity and mortality in urban residents by providing psychological relaxation and stress alleviation, stimulating social cohesion, supporting physical activity, and reducing exposure to air pollutants, noise and excessive heat.

European Environment Agency briefing (2022) 'Access to nature in European cities': *Parks, urban forests, tree-lined streets and riverbanks support urban well-being by providing space for rest, relaxation and exercise and keeping temperatures down. But not everyone across Europe enjoys equal access to green spaces in cities.* This briefing reviews the evidence of socio-economic and demographic inequalities in access to the health benefits derived from urban green and blue spaces across Europe.

**Pollution of air and water:**

**Green infrastructure has also been shown to help improve the quality of air and water and can reduce the volume of pollutants entering water courses.**

Trees and vegetation are able to intercept large volumes of rain through their canopies and roots, which reduces urban flood risk, and in **addition particulate levels on tree-lined streets can be up to 60% lower than those without trees**. In a study carried out in 10 Italian metropolitan cities (Manes et al. 2016), it has been shown that urban and peri-urban forests exert a remarkable role in ameliorating urban air quality, removing an amount of some air pollutant (tropospheric Ozone and particulate matter) equal to 37,164 tons in one year, with a relative monetary benefit (due to avoided impacts to human health, ecosystems and materials) equal to 344 million USD/year.

*Examples of cases reported at the NWRM platform:*

Permeable surfaces, Swales, Filter Strips, Detention Basins and Retention Ponds Oslo, Norway[36]: Increase in water storage 230 m3/ha:

- o 60 % reduction pollution Phosphorus (P)
- o 40 % reduction pollution Nitrogen (N)
- o 80% reduction Total Suspended Solid (TSS)
- o 65 % reduction pollution Copper (Cu)
- o 45 % reduction pollution Zinc (Zn)

Permeable surfaces, Swales, Filter Strips, Soakaways Detention Basins, Retention Ponds, and Infiltration basins, Utrecht, Netherlands[37]:

- Retained water 2,200,000 m3/year
- Increase water storage 1,000 m3/ha
- 80 % reduction pollution Phosphorus (P)
- 50% reduction Total Suspended Solid (TSS)
- Potential for recreational activities in the water courses that will be created

**Noise control:** Grass surfacing reduces noise by up to **3 decibels** compared to concrete paving, while planting vegetation 10 metres wide can reduce noise from traffic and other sources by 3-8 decibels, more effectively than man made barriers.

**Property value:** This benefit varies widely, but is often discussed. Various assessments show that **residential property can increase in value due to the proximity to green space, by up to 15-25%.** Properties on tree-lined streets have been shown in some multi-city studies to be valued on average at up to 30% more than those on streets without trees.

**Further case study examples of benefits exceeding costs for urban trees and green spaces**

[36] http://nwrm.eu/case-study/sustainable-stormwater-management-and-green-infrastructure-fornebu-norway
[37] http://nwrm.eu/case-study/leidsche-rijn-sustainable-urban-development-netherlands

Greening 35% of the EU's urban surface would generate net benefits worth €364 bn through reduced cost of cooling and €221bn through reduced urban heat island effect, as well as absorbing 17.5% of urban run-off (Quaranta et al., 2021).

Benefits of planting and maintaining urban street trees in Prague, Czechia, exceed the costs over 30 years, in terms of cooling alone, even before other benefits for climate, air quality and biodiversity are considered (Horvathova et al, 2021)

Benefits of urban street trees in California, US, are 5.8x costs (McPherson et al., 2015, 2016)

Benefits of urban street trees in New York, US, are 5.5x costs (Peper et al., 2007)

Each £1 spent on public parks in London, UK, delivers £27 in benefits through recreation, mental and physical health, residential property, carbon and temperature regulation (Vivid Economics (2017)

Investment of £5.5 billion in the UK would deliver £200 billion in physical health and wellbeing benefits for disadvantaged communities, a benefit: cost ratio of 36 in terms of health benefits alone. It would create 40,000 temporary jobs in construction and 6,300 ongoing jobs in maintenance, and benefit active travel, biodiversity, carbon capture and air quality (Vivid Economics and Barton Wilmore, 2020).

Sustainable urban drainage systems have 50% lower capital costs and 20-25% lower annual maintenance costs than traditional drainage systems (SNH, 2014).

According to the 2030 BiodiverCities report (Jan 2022), by 2030 **nearly half (44%) of the GDP of cities will be at risk due to the loss of biodiversity**. They say that to avoid an economic collapse, nature-based solutions are needed. The report says that spending €520 billion on developing green infrastructure, along with related actions aimed at freeing up land, could create 59 million jobs, including 21 million dedicated to the restoration and protection of ecosystems. According to the report, nature-based solutions are not only better for the climate and biodiversity (with an **average value-added of 28%**) but they are also more efficient from an economic point of view compared to conventional engineering solutions (by **50% on average**).

## 8.5 Synthesis

### Table VIII-3: Overview table assessing options on EU impact assessment criteria urban ecosystems

| | Option 1 | Option 2 | Option 3 | Conclusions |
|---|---|---|---|---|
| Feasibility / | Likely to be effective | Feasibile and | This option has partly | Integration of urban |

| | | | | |
|---|---|---|---|---|
| effectiveness | in some respects to halt urban sprawl, prevent soil sealing and in turn protect semi-natural and forest areas in and around urban spaces. Would not encourage the greening of existing and new buildings stock or other infrastructure. Could encourage the building of permeable car parking.<br>In terms of feasibility, this option could have social and economic costs (preventing certain types of urban development) that lie outside the specified objectives of this nature restoration proposal. | effective action for restoration.<br>Increasing green infrastructure (GI) can contribute to biodiversity and other ecosystem services, as well as improved ecological connectivity between urban and peri-urban areas. Important and effective for adapting to the impacts of of climate change – a specified objective of the biodiversity strategy nature restoration plan. | been merged with option 2.<br>Proportionate targets for tree canopy cover are considered feasible. The 10% minimum tree cover by 2050 for all city, towns and suburbs LAUs is considered as both feasible and effective as a minimum level to which all LAUs with high density of population should reach to ensure at least some support for biodiversity and climate change adaptation objectives. | green space components in existing urban structures and increasing space for nature and tree cover, considering ecological principles, will create a resilient and networked "city ecosystem" capable of generating a substantial range of social, environmental and economic benefits for urban citizens, whilst also providing protection against the effects of climate change. In terms of feasibility, the options selected are in line with the availability of brownfield land, the turnover and 'greening' renovation of building stock, and the restoration and enhancing of abandoned agricultural land around urban centres. |
| Efficiency | This measure is not considered an efficient option for meeting the objectives of the biodiversity strategy as it would have too many additional implications for how and where urban development would take place (rather than focusing on urban 'greening') | Many cities are relatively green but can benefit from increased efforts in improving the quality of existing public green spaces restoring ecological functions and ecosystem services benefits. | The structure, in terms of the number, density, sizes and species composition, health and spatial configuration of street trees, largely determines the benefits. This requires good growing conditions for new and existing trees and to ensure diversity of native tree species composition. | Increasing urban green and blue infrastructure, including tree cover, are realistic targets for most cities, with emphasis on public green spaces, ensuring accessibility for all citizens and embedding them in existing and new urban development plans, which has proved effective as more and more European cities are developing urban green infrastructure strategies and integrate nature in their master planning. |

| | | | | |
|---|---|---|---|---|
| | | | | Options 2 and 3 offer a very efficient way to deliver multiple services for biodiversity, climate change mitigation and adaptation, air and water filtration (contributing to the meeting of waste water treatment objectives by reducing flood water) as well as supporting the commitment to plant 3 billion trees |
| Coherence | Coherent with the European Commission's Roadmap to a Resource Efficient Europe aims for a 'no net land take by 2050'. This means that land recycling and densification rates must show an increasing trend, which would result in a direct contribution to reducing net land take. | Full coherence with EU environmental policies and climate goals. Potential to make substantial contributions to climate adaptation and mitigation, as well as health and wellbeing objectives, Also supports, SDGs, adaptation strategy, sustainable city policy. | Full coherence with EU environmental policies and climate goals. As part of the EU Climate Pact, the EU is further pledging support to local communities, organisations and citizens who are committed to new tree-planting initiatives.<br><br>Full coherence with SDG (15 and 11). | Options 2 and 3 have multiple links to, and positive impacts on, a wide range of EU and international commitments and policies. |
| Proportionality | Built-up areas have been mainly enlarged at the expense of agricultural land. Progressive soil sealing will take place in urban areas considering the urban growth trends, however this option is considered disproportionate in terms of delivering urban ecosystem objectives. | Proportionate and in line with the importance of improving biodiversity and associated ecosystem services and reducing the harmful impacts of urbanisation and habitat fragmentation across Europe as well as restoring the connection between people and nature.<br><br>Given the widespread benefits seen in terms of urban cooling, flood protection and physical and mental well-being, combined | See option 2 + the pattern of decreasing tree cover and leading to loss of environmental benefits and increased environmental issues of this very valuable form of urban green. | Even small areas of vegetation can have a positive impact upon biodiversity, and urban biodiversity needs to be managed by considering the functions of tree and plant species and their role in delivering key ecosystem services. |

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| | | with enhancing biodiversity protection this option is considered proportionate given the achievable level of target and time frame proposed. | | |

It is proposed that 2021 will serve as a practical reference starting year, with the setting of goals for both 2030, 2040 and 2050.

*For all the options, Copernicus data are already fully available for setting and monitoring these targets for all LAUs. The Copernicus Land Monitoring Service provides geographical information on land cover and its changes, land use, vegetation state, water cycle and Earth's surface energy variables to a broad range of users in Europe and across the World in the field of environmental terrestrial applications.*

Conclusions

**Table VIII-4: Summary**

| Issue | Details / best estimates |
|---|---|
| *Tree cover and/or other urban green has a significant and meaningful beneficial impact on **biodiversity**, particularly if part of a wider green-infrastructure urban greening plan.* | Minimum threshold estimate 10-30% green cover |
| *Increasing tree cover and/or urban green has a very significant and measurable impact on **flood prevention**.* | 5% increase in green cover: 2-2.5% runoff reduction. *(multiple studies)*<br><br>NBS 50% lower capital cost + 20-25% lower maintenance |
| *Tree cover and/or other vegetation cover has been demonstrated to have a very marked impact on **urban temperatures** in the surrounding areas.* | 10% increase in urban vegetation: temperature reduction ~ 0.6°C *(multiple studies)* |
| *Urban trees can play an important role in **climate mitigation*** | One tree: 90kgs $CO^2$ per year.<br>Cooling in summer and heat retention in winter can have important energy benefits/ |
| *Urban trees and green and blue spaces provide multiple benefits for **mental health and well-being**, for recreation.* | Strong evidence from multiple studies linking health and well-being to levels of, and proximity to, green space in urban settings. |

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|---|---|
| | Mostly not quantified in monetary terms. One study puts ratio of cost to benefits of public parks at 1:27 |
| *Green infrastructure has also been shown to help improve the* ***quality of air and water*** *and can* ***reduce the volume of pollutants*** *entering water courses.* | Particulate levels on tree-lined streets can be up to 60% lower than those without trees.<br><br>Permeable surfaces / natural water retention: 50-80% reduction in pollution to rivers. |
| *Significant* ***noise reduction*** *from vegetated surfaces* | 3-8 decibels locally |

The levels of targets proposed have been selected so as to be realistic, and achievable within the bounds of existing urban planning process. They are not only fully in line with EU and international objectives, but they will also do not need to be restricting for urban development, but rather help with steering it to be greener progressively over time. In relation to overall levels of urban green space, starting with ‘no net-loss’ but giving until 2030 to achieve this basic, common-sense, target will allow for some flexibility in approach. It should be borne in mind that urban development can be ‘green’ and can enhance the local environment if undertaken with due attention of urban ecosystem condition, such as by using, green roofs, permeable ‘green’ parking lots, focused tree/hedge planting and incorporation of biodiversity supporting features. Alternatively, or additionally, brownfield/abandoned sites can also be restored elsewhere in compensation. This impact assessment has shown there is potential for such land to significantly contribute to the targets proposed. Thus no-net loss of urban green is considered as a realistic and simple baseline for protecting, and later restoring, urban ecosystems. Having this target will provide a focus for urban planning process, steering them to help achieve the objectives of the biodiversity strategy.

The idea of the targets, and the levels to which they are set is to ensure that the amounts of green space and tree coverage become an integral part of the urban planning process, and that the reach good levels in terms of providing healthy urban ecosystems, by 2050. They can be achieved by restoring degraded and industrial land, greening new developments over time as they are built or replaced (i.e. industrial buildings, housing, retail, local authority builds including hospitals and schools) using options such as tree planting, (including tree-lining streets) green roofs, new green spaces, as well as other “multifunctional” green infrastructure, such as new green mobility lanes or by creation of new parks and woodlands in urban fringes.

In terms of the tree canopy cover targets these are considered as an important sub-set of urban green overall, (so the same arguments apply), but with a very high biodiversity and climate mitigation and adaptation value. It is vital that any urban greening targets ensure the provision, protection and increasing of tree canopy cover in EU urban ecosystems. There is significant capacity within all LAUs for the provision of some increase in tree canopy cover, so the aim of this target is to start moving in the right direction, in line with the planting of 3 billion trees commitment made under the Green Deal. The target for an absolute minimum of 10% tree canopy cover in the LAUs will help to ensure a minimum level of urban ecosystem restoration is undertaken, and support key climate change mitigation and adaptation objectives, in turn supporting air and water pollution objectives.

For 2050 achievable increases in the targets have been proposed that continue the restoration at a similar pace post 2030 and 2040, but over the following decades. Again, they have been set at a relatively low levels per year, to stimulate better urban planning processes, rather than to restrict growth / development.

Overall, there is good evidence related to the costs and benefits of increasing urban green space, albeit almost all in case study form. These demonstrate convincingly a wide range of positive benefits coming from increasing and maintaining higher levels of urban green space. Due to the wide variation, however, in many aspects of the studies, such as the (climate/locations/type of urban space), and the (often limited) parameters being investigated (pollution, energy, water runoff, health and well-being, climate mitigation etc) it is not possible to monetize some of these benefits in a generalized manner. Indeed, the high number of multiple co-benefits provided by using nature-based solutions to urban challenges tends to mean often the full benefits of urban green space and tree cover are underestimated. So, while it has not been possible to undertake a traditional cost/benefit analysis, as can be done on single issues, evidence points to the clear net positive values of halting the loss of, and then restoring green urban spaces.

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*Data used for the calculations*:

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Degree of Urbanisation: https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/population-distribution-demography/degurba

GHS Settlement Model grid: settlement layers generated by porting in the GHSL framework the degree of urbanisation model adopted by EUROSTAT that combines the population and built-up grids in each four epochs.

Dataset: Pesaresi, Martino; Florczyk, Aneta; Schiavina, Marcello; Melchiorri, Michele; Maffenini, Luca (2019): GHS settlement grid, updated and refined REGIO model 2014 in application to GHS-BUILT R2018A and GHS-POP R2019A, multitemporal (1975-1990-2000-2015), R2019A. European Commission, Joint Research Centre (JRC) DOI: 10.2905/42E8BE89-54FF-464E-BE7B-BF9E64DA5218 PID: http://data.europa.eu/89h/42e8be89-54ff-464e-be7b-bf9e64da5218

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# 9. Soils

Given that the new "*EU Soil Strategy for 2030 - Reaping the benefits of healthy soils for people, food, nature and climate*" COM/2021/699 final, published in November 2021 is announcing a dedicated legislative proposal on soil health by 2023, no overarching soil target is being proposed in the nature restoration law but one of the target options from this chapter (Rewetting drained organic soils) is being retained and integrated in the Commission proposal under the agro-ecosystem targets because of its high importance for nature and biodiversity as well as its high urgency.

## 6.1 Scope

Soils are generally referred to as being mineral or organic. **Organic soil** has in general a 40cm or thicker surface layer of organic material and 20 % or more soil organic carbon (SOC) %[38]. **Mineral soils** are all other soils that do not satisfy these criteria.

**Soil organic matter (SOM)** refers to all the organic components of soil in different stages of breakdown including living plants and animals and dead organic matter. SOM is essential for soil ecosystem processes - water storage, nutrient cycling, soil fertility and pollutant filtering - linked to soil structure and soil health, crop productivity, soil structure, drought resilience, reduced erosion risk.

**Soil organic carbon (SOC)** as the measurable component of SOM is one of the main indicators of soil health. SOC has crucial role for climate change mitigation - EU soils hold around 75 billion tons of carbon, more than in vegetation and air combined[39]. Most SOC stocks are in organic soils in Northern Europe[40]. Lowest concentrations are around the Mediterranean, parts of France, Germany, and some eastern European countries[41]. SOC content is highest in wetland soils, followed by forest & grassland soils, with lowest SOC content in cropland and sparsely vegetated areas.

## 6.2 Problem, current trends and ecosystem-specific baseline

Soil restoration is urgently needed as soils provide the main foundation for life on Earth, both above and below ground, yet soil condition is deteriorating in the EU where around 60-70% of soils are estimated to be unhealthy. SOC is a key indicator for soil health as it plays a crucial role in soil biological, chemical and physical processes which underline the delivery of all soil

[38]Based on the World Reference Base definition of Histosols (see main fiche for full definition).

[39] Gobin, A., Campling, P., Janssen, L., Desmet, N., van Delden, H., Hurkens, J., Lavelle, P., Berman, S. (2011). Soil organic matter management across the EU – best practices, constraints and trade-offs, Final Report for the European Commission's DG Environment, September 2011.

[40]Schils, R, Kuikman, P, Liski, J, Van Oijen, M, Smith, P, Webb, J, Alm, J, Somogyi, Z, Van der Akker, J, Billett, M, Emmett, B, Evans, C, Lindner, M, Palosuo, T, Bellamy, P, Jandl, R and Hiederer, R (2008) Review of Existing Information on the Interrelations between Soil and Climate Change (CLIMSOIL final report). Contract number 070307/2007/486157/SER/B1, European Commission, Brussels.

[41]de Brogniez, D., Ballabio, C., Stevens, A., Jones, R.J.A., Montanarella, L. and van Wesemael, B. (2015), A map of the topsoil organic carbon content of Europe generated by a generalized additive model. Eur J Soil Sci, 66: 121-134. https://doi.org/10.1111/ejss.12193.

ecosystem services including carbon sequestration, soil fertility, and hazard risk mitigation. A range of pressures threaten both organic and mineral soils driving their SOC below critically low levels, including land management choices/changes, reclamation and drainage of organic soils, soil erosion, peat extraction, soil sealing, and climate change.

**Mineral soils:** Around 45 % of EU mineral soils have low or very low SOC and 1.5 % have extremely low SOC levels with lowest levels in Southern Europe[42] and arable soils[43,44,45]. Overall, EU SOC stocks in mineral soils have not changed significantly in the past decade, due to limited land cover change and plateauing of stocks towards a carbon input-output equilibrium that is below optimal levels. Despite this aggregate trend, key regional hotspots are experiencing notable SOC decreases in the Mediterranean and central-eastern Europe. Most areas at risk of critically low and decreasing SOC are on arable land, with decreases of 2.5 % in SOC concentrations reported in cropland from 2009-2015. Grasslands likely have an overall stable or slightly increasing SOC stocks. Trends in forest soil stocks are uncertain but generally acting as a sink. The largest SOC declines from 2009-2015, of 11 % on average, were reported for areas converted from grassland to cropland.

**Organic soils:** Organic soils, mostly former peatlands drained for agriculture, forestry and peat extraction are a particularly important source of greenhouse gas emissions. An estimated 45 000 – 55 000 km² of organic soil have been drained for agricultural use and are currently losing disproportionate volumes of carbon[46]. Those soils, an estimated 3% of all EU agricultural land, are responsible for about 25% of agricultural greenhouse gas emissions[47]. In the EU, drained peatlands emit around 220 Mt $CO_2$ every year[48], making the EU the third largest emitter from peatland (behind Indonesia and Russia) worldwide[49]. Within the EU, Germany is the biggest emitter, responsible for 47 Mt $CO_2e$[50].

**In this assessment, organic soils meeting the definition given above are referred to as peatlands, even if they are under agricultural use as grassland or cropland. The scope is**

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[42] Jones, A, Panagos, P, Barcelo, S, Bouraoui, F, Bosco, C, Dewitte, O, Gardi, C, Erhard, M, Hervás, J, Hiederer, R, Jeffery, S, Lükewille, A, Marno, L, Montanarella, L, Olazábal, C, Petersen, J-E, Penizek, V, Strassburger, T, Tóth, G, Van Den Eeckhaut, M, Van Liedekerke, M, Verheijen, F, Viestova, E and Yigini, Y (2012) The State of Soil in Europe. A contribution of the JRC to the European Environment Agency's Environment State and Outlook Report - SOER 2010, Publications Office of the European Union, Luxembourg.

[43] Costantini, E., Antichi, D., Almagro, M., Hedlund, K., Sarno, G. and Virto, I., 2020. Local adaptation strategies to increase or maintain soil organic carbon content under arable farming in Europe: Inspirational ideas for setting operational groups within the European innovation partnership. Journal of Rural Studies, 79, pp.102-115.

[44] Maes et al (2020) Mapping and Assessment of Ecosystems and their Services: An EU wide ecosystem assessment in support of the EU biodiversity strategy. EUR 30161 EN, European Commission, Brussels.

[45] Jones, A, et al (2012) The State of Soil in Europe.

[46] Tanneberger, F, Tegetmeyer, C., Busse, S., Barthelmes, A. and 55 others (2017) The peatland map of Europe. Mires and Peat No 19 (22), 1-17. (Online: http://www.mires-and-peat.net/pages/volumes/map19/map1922.php). Schils, R, Kuikman, P, Liski, J, Van Oijen, M, Smith, P, Webb, J, Alm, J, Somogyi, Z, Van der Akker, J, Billett, M, Emmett, B, Evans, C, Lindner, M, Palosuo, T, Bellamy, P, Jandl, R and Hiederer, R (2008) Review of Existing Information on the Interrelations between Soil and Climate Change (CLIMSOIL final report). Contract number 070307/2007/486157/SER/B1, European Commission, Brussels.

[47] O'Brolchain, Niall & Peters, Jan & Tanneberger, Franziska. (2020). CAP Policy Brief Peatlands in the new European Union Version 4.8.

[48] Tanneberger, F, Appulo, L, Ewert, S, Lakner, S, Ó Brolcháin, N, Peters, J and Wichtmann, W (2021) The power of nature-based solutions: how peatlands can help us to achieve key EU sustainability objectives. *Advanced Sustainable Systems* No 5 (1).

[49] Joosten, H and Clarke, D (2009) *The global peatland CO2 picture. Peatland status and drainage related emissions in all countries of the world*. Wetlands International. https://www.wetlands.org/publications/the-global-peatland-co2-picture/

[50] UBA (2019) Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2019. National Inventory Report for the German Greenhouse Gas Inventory 1990–2017, German Environment Agency, Dessau, 945 pp.

**therefore wider than the Annex I peatland habitats referred to in the EU Habitats Directive.**

The pressures on peat soils in the EU are closely linked to drainage. A key pressure on mineral soils in the EU is soil erosion.

**Degradation of peatlands from drainage: problems**

Besides greenhouse gas emissions, the continued draining of peatlands as well as other changes in their hydrological functioning often in combination with conversion from wetland to pasture or pasture to cropland, managed burning and over-grazing, afforestation and/or intensified forestry practices have led to different degrees of ecological degradation, impacting all kinds of wetland habitat types and species. Consequently, most mire-related habitat types in the EU are on the red list[51] and are in unfavourable conservation status[52]. The number of characteristic fauna and flora species of these habitats in that red list is high and accounts for a major part of the total biodiversity loss in the EU.

Degraded peatlands cause also other environmental problems as they lose their capacity to control floods by storing water, their capacity to clean water. The risks of peatland fires and soil erosion, subsidence, and landslides increase as peatlands dry out. **Soil erosion:** SOC loss and soil erosion are tightly linked and should be addressed together. 24 % of EU area is threatened by unsustainable erosion (over 2 t/ha/year) and 5.2 % is exposed to severe erosion (over 10 t/ha/year). Arable land has the highest mean soil erosion rate (2.67 t/ha/year), and 6.6 % of EU agricultural area (7.2 % of cropland and 4.5 % of grasslands) is affected by moderate to severe water erosion. Soil erosion is highest in the Mediterranean region: Italy, Spain, Greece, Cyprus and Slovenia.

**Baseline scenario:** In the absence of additional legally binding soil restoration targets, the current mineral and organic soil degradation trends in the EU are assumed to continue to 2030:

- Mineral soils will continue experiencing low SOC levels on 45% of EU area. Stable trends in aggregate SOC levels are expected to 2030 with some differences across regions and land-uses. Arable land will continue experiencing critically low SOC on a considerable proportion of its area (2.6%) with regional hotspots and, despite a likely overall equilibrium between SOC gains and losses, important declines will continue in high-risk arable areas. Permanent grasslands will likely continue experiencing modest increases in SOC. Forests will continue acting as a sink.
- All currently degraded (drained) organic soils will continue to lose carbon to 2030 and there will be no further significant drainage of undrained organic soils.

[51]Janssen, J A M, Rodwell, J S, García Criado, M, Gubbay, S, Haynes, T, Nieto, A, Sanders, N, Landucci, F, Loidi, J, Ssymank, A, Tahvanainen, T, Valderrabano, M, Acosta, A T R, Aronsson, M, Arts, G, Attorre, F, Bergmeier, E, Bjlsma, R-J, Bioret, F, Bita-Nicolae, C, Biurrun, I, Calix, M, Capelo, J, Čarni, A, Chytry, M, Dengler, J, Dimopoulos, P, Essl, F, Gardfjell, H, Gigante, D, Giusso del Galdo, G, Hájek, M, Jansen, F, Jansen, J, Kapfer, J, Mickolajczak, A, Molina, J A, Molnár, Z, Paternoster, D, Piernik, A, Poulin, B, Renaux, B, Schaminée, J H J, Šumberová, K, Toivonen, H, Tonteri, T, Tsiripidis, I, Tzonev, R and Valachovič, M (2016) European Red List of Habitats. Part 2. Terrestrial and freshwater habitats. European Commission, Luxembourg: Publications Office of the European Union.

[52] EEA (2020) State of Nature in the EU: Results from reporting under the nature directives 2013-2018. EEA Report No 10/2020, European Environment Agency, Copenhagen.

- Current trends of soil erosion will continue until 2030 (decrease of 0.4 % in soil erosion rate).

There is uncertainty around this baseline due to unpredictable impacts from climate change, shifts in the political landscape and increased demand for bio-resources. Changes in the next 2023-2027 CAP funding period might improve SOC management, but this will ultimately depend on implementation at the Member State level. SOC trends under climate change are challenging to predict, but declines are expected at least in some southern regions and in cropland.

The largest potential for SOC stock improvement is on degraded agricultural land as these areas are not saturated for SOC. For managed soils under permanent grassland, forestry, and for all organic soils, the main goal is to maintain current SOC stocks and reverse losses. Many of the measures needed to enhance SOC can also decrease erosion risk and vice-versa. Addressing soil erosion therefore helps maintain and improve SOC levels.

## 6.3 Target options screened in/out

**Proposed overarching target:** ***Improve SOC in soils under all land uses and reverse current losses on agricultural mineral soil, towards an annual growth rate of 0.4 % in EU soil carbon stocks.***

On all organic soils the aim is to preserve the high carbon stocks and to halt current losses. On mineral soils the aim is to maintain or improve carbon stocks under land uses where SOC is generally accumulating (permanent grasslands, forests and other semi-natural ecosystems), and to enhance stocks under arable land and permanent cropland with critically low and decreasing SOC stocks at a set annual growth rate.

The goal of a 0.4% annual growth rates follows the proposed 4 per 1000 initiative presented at COP 21 which the EU is expected to join as announced under the new EU Soil Strategy. This is the rate of additional soil carbon storage needed to compensate for emissions and keep global warming under 2ºC. Organic soils are excluded from the quantitative target as there are uncertainties around their additional storage potential. The stronger focus on agricultural land is because currently available data shows it has the greatest SOC stock increase potential and low SOC risk, especially in the southern regions of Europe.

Four **complementary options** to reaching this target were identified:

**Option 1**: ***Restoring and rewetting drained organic soils (drained peatlands) under agricultural use (both grassland and cropland) which are currently losing carbon (appr. 52 000km²).***

Rewetting to different degrees and with different subsequent land uses and management, is the most effective method to stop greenhouse gas emissions from agricultural land, to avoid future loss of SOC stocks on organic soils and to stop and reverse biodiversity loss, in particular as concerns wetland habitats and their species. This option proposes the gradual rewetting of drained organic soil (drained peatland) area under cropland or grassland which is currently losing carbon (52 000 km², less than 1% of EU land) with milestones by 2030, 2040 and 2050. It refers to restoration measures that would most typically include measures such as conversion from cropland to permanent grassland, raising of the water-table, fallowing and extensive grazing and it refers also in particular to rewetting, which is understood as full rewetting in the meaning of 'wet' in the water table depth classes based on IPCC (2014): 'dry'= deep drained = mean annual water table lower than 30 cm below soil surface, 'moist' = shallow-drained = mean annual water table at ~30 cm below soil surface, 'wet'= undrained/rewetted = mean annual water table at the soil surface. The wording of the target suggested is as follows:

***For drained peatlands under agricultural use, Member States shall put in place, without delay, restoration measures, including rewetting, on at least:***

a) ***30% of such areas by 2030 of which at least a quarter is rewetted***
b) ***50% of such areas by 2040 of which at least half is rewetted, and***
c) ***70% of such areas by 2050 of which at least half is rewetted.***

Restoring and rewetting drained peatlands under agricultural use will affect Member States to different degrees (see Table IX-1). The Member States by far the most affected in proportional terms are Netherlands and Finland where organic soils constitute more than 10% of their agricultural land followed by Germany, Ireland, Latvia and Estonia. In terms of absolute surface Germany and Poland are the MS with the biggest areas of organic soils followed by the Netherlands, Ireland and Finland. Given that rewetting is likely to trigger conversion of land-use (for example to paludicultural use) and takes time and effort to prepare and implement, the suggestion is to include as part of the target-milestones a rather low percentage of rewetting by 2030 (7,5%) which would still mean substantial areas to be rewetted for Germany and Poland followed by Netherlands, Ireland and Finland.

The percentages of the target are inspired by two publications from Germany and Netherlands scientific bodies that are both proposing targets on the matter:

1. *"Towards net zero $CO_2$ in 2050: An emission reduction pathway for organic soils in Germany"*[53] is a scientific study from 2021 setting out two pathways to carbon neutrality in Germany. The first pathway is slower and goes from dry to moist and then to wet conditions over time, while the second targets directly at wet conditions. The more gradual pathway requires the following interim (2030, 2040) and ultimate (2050) milestones:
    - Cropland use stopped and all Cropland converted to Grassland by 2030;
    - Water tables raised to the soil surface on 15% /60%/ 100% of all Grassland;

[53] http://www.mires-and-peat.net/pages/volumes/map27/map2705.php : Towards net zero CO2 in 2050: An emission reduction pathway for organic soils in Germany by Franziska Tanneberger et al,

The end-result in 2050 is the same for both pathways, namely a near to 100% rewetting of organic soils, whereby the study considers that most of this area would be used for paludiculture (including grazing). The percentages proposed now for the EU target are somewhat lower than the ones suggested in the study, setting a target for both grassland and cropland together, leaving it to Member States how to approach the target and divide it between grassland and cropland. We argue this by the focus of the restoration law on the win-win approach with biodiversity gains, where not only the sheer surface under restoration measures and rewetted but also the location of the rewetted areas and the quality of the restoration measures play an important role.

2. *"Stop Land Subsidence in peat meadow areas"*[54] is a publication of the Dutch Advisory Council on Environment and Infrastructure of September 2020 and recommends targets capable of stopping land subsidence in the 'Green Heart' of NL: It suggests an indicative target to achieve 70% less land subsidence in rural peatlands by 2050 with an interim target of 50% by 2030. To counter land subsidence in peat meadow areas, the groundwater level needs to rise. While the target is not area-based, it is recommended to take an area based approach with zoning whereby some exceptions should be possible where the target cannot be reached (e.g. for areas with thin peat layer and little subsidence the target would be disproportional).

   The Council argues that continuing to increase drainage of peat-meadows is no longer acceptable, because:

   - drainage leads to reduced water quality, a deterioration in the quality of the natural environment and greater safety risks.
   - drained peat produces high $CO_2$ emissions, while the Dutch $CO_2$ emissions must be drastically reduced over the next 30 years (for the Netherlands by 95% compared with 1990 levels)
   - if policy remains unchanged, the costs of water management in peat meadow areas will continue to rise.

**Table IX-1 MS where drained peatlands (organic soils) under agricultural use constitute more than 1% of their agricultural land (sources: national UNFCCC reporting, and Martin and Couwenberg 2021)**

| MS | Grassland on organic soil (in km²) | Cropland on organic soil (in km²) | Total agricultural area (in km²) | Total organic soil (in km²) | % of agricultural land on organic soil | Rewetting target options in km² | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **7,5%** | **25%** | **35%** | **50%** | **70%** |
| **1. NL** | 2774,0 | 608,0 | 22916,5 | 3382 | 14,8 | 254 | 845 | 1184 | 1691 | 2366 |
| **2. FI** | 669,1 | 2625,2 | 27333,1 | 3294 | 12,1 | 247 | 824 | 1153 | 1648 | 2310 |
| **3. DE** | 9704,8 | 3421,4 | 194287,1 | 13126 | 6,8 | 984 | 3281 | 4594 | 6563 | 9184 |
| **4. IE** | 3329,3 | 0 | 49361,9 | 3329 | 6,7 | 250 | 832 | 1165 | 1664 | 2324 |

[54] https://www.rli.nl/sites/default/files/advisery_report_stop_land_subsidence_in_peat_meadow_areas.pdf: Stop Land Subsidence in peat meadow areas – The Green Heart Area as an example"  Council for the Environment and Infrastructure, September 2020

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5. | LV | 796,9 | 786,3 | 24993,4 | 1583 | 6,3 | 119 | 396 | 554 | 791 | 1106 |
| 6. | EE | 480,3 | 283,9 | 12786,8 | 764 | 6,0 | 57 | 191 | 268 | 382 | 532 |
| 7. | DK | 516,2 | 1274,3 | 32339,6 | 1791 | 5,5 | 134 | 448 | 627 | 896 | 1246 |
| 8. | PL | 7616,9 | 1601,0 | 180942,8 | 9218 | 5,1 | 691 | 2304 | 3226 | 4608 | 6454 |
| 9. | SE | 277,2 | 1370,1 | 33071,7 | 1647 | 5,0 | 123 | 412 | 576 | 824 | 1148 |
| 10. | LT | 686,0 | 640,0 | 35640,2 | 1326 | 3,7 | 99 | 331 | 464 | 662 | 924 |

Depending on socioeconomic and ecological context, fully rewetted organic soils can either be[55]:

- Taken out of productive use (e.g. through land purchase/acquisition or compensation) and reverted to fallow land or restored to near-natural status and placed under conservation.
- Converted to alternative sustainable land uses such as
  - Agricultural production of biomass crops using paludiculture on arable land with high water table,
  - Extensive grazing on grassland established on organic soil with water table raised to soil level or above during winter and lowered to up to 30 cm below during spring or summer grazing (provided capillary action within soil maintains soil saturation).

Unlike increases in carbon stocks which can take years to happen following management changes, avoided losses from rewetting result in immediate improvements. Therefore, the option aiming to rewet drained organic soils, and thus avoid their current emissions, can and must be pursued urgently.

**Option 2**: ***Focus on conserving and increasing SOC in mineral soil under arable land and permanent cropland and avoid the conversion of grassland to arable land to reverse current losses with an annual growth rate of 0.4%.***

Carbon stocks in EU-27 agricultural soils are estimated to be around 13,350 Mt C (or 48,950 Mt $CO_2$eq) in the top 0-30 cm. An estimated annual carbon input increase of around 0.66 ± 0.23 MgC[56][57] would be needed to achieve a growth rate of 0.4%. A review of European studies assessing the feasibility of increasing carbon stocks in agricultural SOC stocks revealed that achieving the overarching target of 0.4% target across the EU is currently very difficult to reach in technical and economic terms. Despite this, there is a clear scope and even clearer need to reduce and reverse SOC losses on agricultural land. Therefore, while the 0.4% target is a good aspirational target which will be supported by the EU's participation in the 4per1000 initiative, in the context of a legally binding instrument for restoration we suggest a more realistic target

[55] Buschmann, C., Röder, N., Berglund, K., Berglund, Ö., Lærke, P., Maddison, M., Mander, Ü., Myllys, M., Osterburg, B. and van den Akker, J., 2020. Perspectives on agriculturally used drained peat soils: Comparison of the socioeconomic and ecological business environments of six European regions. Land Use Policy, 90, p.104181.

[56] Bruni, E., Guenet, B., Huang, Y., Clivot, H., Virto, I., Farina, R., Kätterer, T., Ciais, P., Martin, M., and Chenu, C.: Additional carbon inputs to reach a 4 per 1000 objective in Europe: feasibility and projected impacts of climate change based on Century simulations of long-term arable experiments, Biogeosciences Discuss. [preprint], https://doi.org/10.5194/bg-2020-489, in review, 2021.

[57] NB The Bruni et al 2021 study highlights that the SOC CENTURY model used might overestimate the effects of additional inputs on SOC stocks.

which aims to maintain and increase SOC in mineral soil under agricultural land to achieve an increase of 404 Mt$CO_2$eq in EU stocks by 2030 (up to 30cm) against the BAU baseline.

A cumulative increase of 404 Mt$CO_2$eq by 2030 in EU SOC stocks in mineral top soils (up to 30cm) corresponds to an annual growth rate of 0.09 % in the soil carbon stocks in mineral top soil, starting from 2024. This target could technically be achieved with the application of best management practices, excluding the conversion to grassland, on all EU arable land. Here, it is extended to all agricultural land, including permanent grassland and permanent cropland, giving more flexibility on how it can be achieved. On permanent grassland, there is less scope to enhance stocks and the main goal is to maintain current ones, particularly by avoiding their conversion to arable land. However, in some cases, they could contribute to the target as changes in grassland management can increase stocks. Permanent cropland represents a small fraction (3%) of EU agricultural land. However, changes in their management could contribute to increasing SOC stocks particularly in regions with a higher share of permanent crops.

Local carbon sequestration potentials will vary across the EU as they depend on soil and climate variables. This target is set at the EU level allowing for variation in MS contributions. Practices which increase SOC stocks should be implemented following regional guidance adapted to local contexts. The permanent conversion of arable land to grassland is particularly relevant as well as the maintenance of grassland and banning of ploughing on permanent grassland. Measures on arable land include improved crop rotations, residue management, cover cropping, agroforestry, and organic farming.

This proposed target is deemed technically realistic and likely implementable for agricultural soils. Its implementation may require substantially changed policy and economic environment for farmers and would have significant societal benefits. The feasibility of the target should be further assessed to determine what changes in management are needed and where to achieve it using more regionalized alternative management scenarios and whether the subsequent stock changes are measurable by 2030. SOC stock changes can take several years after restoration has started, and it takes at least 5 (up to 20) years for SOC to stabilize. The proposed SOC enhancement target is based on modelling which showed the annual stock growth rate that would be achievable to 2050 by applying SOC management practices on all arable land in 2014. Since stock growth rates will decrease over time as a new equilibrium is reached, this growth rate is deemed realistic up to 2030. Another option to consider is to implement action-based targets based on the measures expected to deliver the necessary SOC improvement by 2030 so that progress can be measured before stock changes respond to management change. In addition, soil carbon sequestration potentials should be assessed beyond 2030 to determine a realistic target towards 2050.

The feasibility of setting a similar target on other managed soils (particularly for forest soils) should also be evaluated.

**Option 3:** Decrease soil erosion by water on soils under agricultural use and decreasing the area of agricultural soils with severe erosion levels (over 10 t/ha/year)

Stopping unsustainable soil erosion could be a useful indicator of progress towards SOC improvement, with focus on erosion by water as the pressure with the largest magnitude, spatial extent, and measurability. Most practices that enhance SOC content also reduce soil erosion such as cover crops, buffer strip and grassland conversion. Other measures also have clear benefits for erosion reduction include contour cropping and ploughing, terracing, reduced and zero tillage, measures to reduce soil compaction and other water management practices such as earth banks, lined water banks and water retention areas. However, there is limited evidence for measurable increases in SOC for these. Following the same reasoning as under Option 2, the focus is on decreasing erosion in soils under agricultural use.

This target should be further evaluated to determine measurable milestones to be reached by 2030, 2040 and 2050.

**Option 4**: Focus on improving SOC in mineral soils under forestry and rewetting drained organic soils under forestry (73 000 km²).

Sampling and data for forests SOC is currently insufficient to propose a target to reduce SOC losses from managed forest land. However, a coherent EU level monitoring framework and methodology for measuring SOC content and stock is being developed and there are ongoing discussions to support Member States by improved sampling. The feasibility of proposing a legally binding target for mineral soils under forestry should be re-evaluated once these systems are in place. This is particularly urgent as increased moves towards a bio-economy might increase pressures on forests by increasing harvesting rates and thus possibly increasing loss from managed forest soils. The feasibility of a target for rewetting organic soils under forestry could not be evaluated. The carbon gains from rewetting forest soils are uncertain as many of the soils are only partly drained and thus losing carbon at a lower rate compared to agricultural soils. Nevertheless, organic soils drained for forestry are an important source of carbon emissions.

**Table IX-2 Summary table screened target options**

| Target option | Screened in/out for assessment | Key reason(s) for screening in/out |
|---|---|---|
| Restoring and rewetting organic soils under agricultural use | Screened in | Feasible conversion measures demonstrated in pilot projects. High biodiversity benefit and at the same time most important measure for overall carbon benefit. |
| Conserve and increase SOC in cropland and avoid the conversion of grassland to arable land to reverse current losses with an annual growth rate of 0.4% | Screened in but modified to: Achieve a cumulative increase of 404 MtCO2eq by 2030 in EU SOC stocks in mineral topsoils (up to 30cm) under agricultural land. | Feasible and currently economic measures available on cropland and grassland. Annual growth rate of 0.4% not considered feasible in many regions. |
| Decrease soil erosion (and stop unsustainable soil erosion) | Screened in | Feasible and effective measures available. Measurable. |
| Improve SOC in mineral soils under forestry and rewet drained organic soils under forestry | Screened out | Not currently sufficient data to assess feasibility and effectiveness. |

## 6.4 Impacts of assessed target options – qualitative overview

A full quantitative assessment of the impacts of meeting restoration targets for soils is not possible at this stage, because insufficient data are available to quantify the extent of measures required and hence their benefits and costs. To carry out a full quantitative impact assessment of achieving SOC targets in relation to the expected baseline to 2030, more detailed work is needed to (1) further develop specific targets, (2) determine what measures are needed where to estimate the applicable area for the different soil management measures proposed based on overall degradation extent, and (3) collect and synthesize data on the costs and benefits of SOC restoration measures across European regions. Here, the likely costs and benefits of each option are qualitatively assessed and, where possible, illustrative per hectare values are presented based on existing studies[58].

**Option 1:** ***Focus on rewetting drained organic soils (drained peatlands) under agricultural use (both grassland and cropland) and losing carbon (52,000 km²).***

**Stakeholders affected**: While society benefits from organic soil restoring and rewetting trough a wide range of environmental benefits (emission reduction, less flooding risk, cleaner water, etc.), the costs are directly borne by land managers. Similarly, land managers obtain profits from drained peatlands, while there are externalized costs for society. Individual land managers will most likely have to adapt and change agricultural practice after rewetting and might suffer losses to different extents from rewetting and compensation schemes should be considered.

**Agricultural use after full rewetting**: Paludiculture ('palus' – latin for 'swamp') allows the productive use of rewetted peatland in ways that preserve the peat body, thereby stops subsidence and minimises emissions.

In contrast to drainage-based agriculture, paludiculture cultivates crops that are adapted to high water levels, such as reed, cattail, black alder and peat mosses. The aboveground biomass is harvested and the belowground biomass can form new peat. It can have a higher value both financially and ecologically. Using a variety of established techniques, the products of paludiculture can be processed to use as insulation and construction materials, growing media and bio-refinery products as well as for livestock fodder and for fuel. Innovative products, including, cosmetics, medicinal and food products, are under development.

Large-scale implementation of paludiculture, however, requires agricultural policies to set explicit incentives that ensure that it becomes advantageous for landowners to rewet drained agricultural peatlands and subsequently to maintain them as wetlands. To stop carbon emissions it is essential that the ground water levels in rewetted peatlands are much more close to the ground surface for most of the year (target level: +20 to -20 cm). Also grazing with traditional commercial cattle breeds is becoming increasingly difficult under these circumstances because of the detrimental trampling effects that destroy the peat layer and bring oxygen in the soil.

[58] Buschmann, C., Röder, N., Berglund, K., Berglund, Ö., Lærke, P., Maddison, M., Mander, Ü., Myllys, M., Osterburg, B. and van den Akker, J., 2020. Perspectives on agriculturally used drained peat soils: Comparison of the socioeconomic and ecological business environments of six European regions. Land Use Policy, 90, p.104181.

Paludiculture implies a transition to new agricultural practices and the use of new adapted machinery, which can be enabled and promoted through agro-environmental schemes.

**Costs:** include upfront investments to implement restoration measures, maintenance costs, and transaction costs. Available data on upfront and maintenance rewetting costs is currently anecdotal. Indicative ranges for upfront costs of €235-11,750/ha restored (with average costs from €955/ha - 4,735 €/ha) for one-off costs and €29-470/ha/year for maintenance costs. These large ranges reflect cost variation due to differences in ongoing management, degree of degradation, peatland type, and other ecological and socio-economic variables. Rewetting soil which is currently under productive land uses can come at a considerable opportunity cost. On average in Europe, they are estimated to be around €525/ha/year. This is an illustrative value as costs are context dependent with higher costs associated with organic arable soils under highly productive use, and lower costs with soils which support low level grazing. Organic soils represent a high proportion of arable land in some countries (e.g. Netherlands, Finland and Germany) where rewetting will consequently have a larger socio-economic impact. At the EU level however, agriculture on organic soil represents only around 1% of cropland and 4% of grassland (EU-15) meaning overall costs from lost productivity on these soils will be small relative to their climate and biodiversity benefits. Depending on the socioeconomic and ecological context of a given site, losses can be compensated through land purchase/acquisition and acquisition or by incentivising the establishment of alternative land uses such as paludiculture or extensive grazing.

**Benefits:** High climate change mitigation and adaptation benefits are expected from rewetting. Rewetting drained agricultural soils can lead to decreases in emissions of around 20 $tCO_2eq$/ha/year which if applied to the 52000 km² estimated, would lead to 104 Mt of avoided $CO_2$ emissions per year. Using an estimated social cost of carbon of €100/$tCO_2eq$, this would result in potential benefits of up to €2000/ha/year. Other studies looking at the GHG mitigation and carbon stocking potential of rewetting agricultural organic soils range from 3.4 – 22.8 t $CO_2eq$/ha/year, equivalent to €340-€2724/ha/year. Besides these climate benefits rewetting will bring significant biodiversity benefits as well. The re-establishment of wetlands, also if cultivated via paludiculture can be beneficial to the occurrence of a wide range of wetland habitat types and to many bird species including herons, storks, swans, geese, ducks, harriers, crakes and rails, cranes, waders, meadow birds, snipes, warblers of which many are endangered in the EU. In addition, aquatic and semi-aquatic mammals, amphibians, reptiles invertebrates and particular fish species (including many species protected under the Habitats Directive) can benefit. Wetland-restoration and paludiculture can also facilitate the connectivity of wetland areas and their species populations in the EU. Moreover, rewetting creates benefits for water quality, flood risk mitigation, drought risk mitigation and socio-economic benefits from paludiculture and tourism.. Moreover, rewetting ensures the long-term sustainability of production on organic soil (e.g. via paludiculture and extensive grazing) as it avoids subsidence and the eventual complete degradation of soil. Quantifying these benefits is challenging but they are considerable. Studies estimating the value of multiple ecosystem services benefits after rewetting estimated median value of €1045 per hectare per year (from €164-€4895).

**Cost-benefit assessment:** Rewetting organic soils is a cost-effective measure to reduce greenhouse gas emissions, more so than increasing SOC on mineral soils. Climate benefits are the most straightforward to quantitatively estimate. Taking the illustrative per hectare cost and benefit estimates outlined above, we calculate it would take around 6 years for the carbon benefits of restoration to outweigh costs. Another approach is to use estimates of costs per avoided tonne of $CO_2$ which range from €7-85 and €27-105 when considering opportunity cost. Considering the social cost of carbon is estimated at around €100 per tonne and solely considering climate change mitigation, the benefits of implementing this option outweigh costs. The ratio between benefits, including biodiversity benefits and costs is expected to be considerably larger when also considering other ecosystem service, including tourism and socio-economic benefits which are challenging to quantify.

**Option 2**: ***Achieve a cumulative increase of 404 MtCO$_2$eq by 2030 in EU SOC stocks in mineral topsoils (up to 30cm) under agricultural land.***

**Stakeholders affected:** The measures considered under this option mainly target cropland. Stakeholders affected are primarily land managers responsible for implementing the measures which include arable farmers, but also most livestock farmers through measures for fodder crops, temporary and permanent grassland that is regularly refreshed.

**Costs:** Cost estimates from studies assessing the implementation of SOC conservation measures vary widely as studies follow different methodologies, include different soil management measures, and are based on regions with different pedo-climatic and socioeconomic contexts. Typically, values range from €100 to 1000 /ha/year with an average of around €280/ha/year.

**Benefits:** Inaction on SOC decline costs the EU €3.4-5.6 billion every year[59]. Addressing SOC decline can avoid these large costs while delivering a range of additional on-site and off-site benefits. This target will deliver climate change mitigation benefits through increasing carbon sequestration in EU-27 agricultural land by 404 MtCO$_2$eq by 2030 (equivalent to 0.31 tCO$_2$eq/ha/year). Applying a carbon value of €100 per $tCO_2$ equivalent, this would result in an economic benefit of around €40.4 billion from 2022-2030 and €31/ha/year. For specific measures, carbon stock increases range from 730 and 630 kgC/ha/year in the case of converting arable to grassland and implementing agroforestry practices respectively, to more modest increases between 15 and 30 kgC/ha/year in the case of grazing management, planting hedges, straw incorporation, and applying exogenous organic materials (EOMs).

Other key benefits include biodiversity benefits by enhancing above and below ground habitat health, and increased crop yields, reduced erosion and increased water retention leading to increased resilience of agricultural production, natural hazard risk mitigation and food security. In addition, improved soil health that can benefit plant health and thus improve resilience towards droughts and increasing pests. These all lead to considerable climate adaptation benefits which may even outweigh the mitigation benefits of enhanced SOC[60, 61]. In addition, measures can also reduce costs to farmers as they reduce input costs by, for example, reducing pesticide and fertilizer use.

[59] European Commission (2006a) Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of Regions – Impact Assessment of the Thematic Strategy on Soil Protection. SEC(2006)620 (http://ec.europa.eu/environment/archives/soil/pdf/SEC_2006_620.pdf)

[60] Powlson, D. S., A. P. Whitmore, K. W. T. Goulding (2011) Soil carbon sequestration to mitigate climate change: A critical re-examination to identify the true and the false. European Journal of Soil Science, vol. 62, no. 1, pp. 42–55.

[61] Amundson, R. and Biardeau, L. (2018) Opinion: Soil carbon sequestration is an elusive climate mitigation tool. Proceedings of the National Academy of Sciences of the United States of America, vol. 115, no. 46, pp. 11652–11656.

There is a very high variation in estimated monetary benefits from SOC enhancement. A recent meta-review found soil protection measures deliver benefits ranging from €0 to €3440/ha/yr (average €93/ha/yr)[62]. Another study found overall on-site benefits from SOC conservation and enhancement on agroecosystems have been estimated at €2.1bn/yr over 20 years in the EU-25.

**Cost-benefit assessment:** Currently available information is not sufficient to provide a reliable estimate of the cost benefit ratio of SOC management as there is a wide variation in cost and benefit estimates across regions and restoration methods. Studies comparing potential costs and benefits from key SOC enhancing measures reveal no generalisations can be made across regions and practices yet, in many cases, benefits outweigh costs, especially for low-cost measures such as including legumes in rotations. Some measures can result in a net cost to farmers which, with the right incentives, can be minimised. These costs will likely mostly happen over the first couple of years, and, with time, benefits might outweigh costs. Measures to improve SOC are crucial to maintaining productive capacity and are therefore vital for agricultural resilience and sustainability in the long-term.

There is a wide variation in estimates of the costs and benefits of SOC restoration due to heterogeneity between sites in pedo-climatic, management and socio-economic variables. Since extrapolating per hectare values across regions will not yield accurate cost estimates, this assessment did not attempt to calculate the cost-effectiveness of the option at the EU level. Similarly, more information is needed on what measure is needed where. Further assessments should address these gaps.

**Option 3:** ***Focus on decreasing soil erosion*.**

**Stakeholders affected**: As in option 3, measures are primarily on cropland and therefore affect arable farmers.

**Costs:** The measures evaluated under this option include those with evidence for decreased soil erosion but not SOC enhancement. Water management options such as buffer strips are typically low-cost. Contour ploughing and water management is considered cost-effective but not applicable to many areas while the cost-effectiveness of reduced or zero- tillage practices is highly context dependent.

**Benefits:** In addition to likely enhancing SOC, reducing soil erosion will generally improve soil health and structure and contribute to maintaining soil fertility and crop yields, decreasing water runoff leading to higher water quality and decreasing flood risk and off-site effects and costs of soil erosion. The evaluation in support of the EU soil thematic strategy calculated overall yearly on-site benefits of around €500 million from soil erosion control.

**Cost-benefit assessment:** Measures to decrease soil erosion in farmlands can be cost-effective but, in some cases, they can result in an initial net cost to farmer due to short-term loss of income from reduced maximum yield potential on the field per year. However, these costs might be outweighed by benefits in the mid-term (3 – 4 years) such as increased drought resilience.

[62] Tepes, A, Galarraga, I, Markandya, A and Sánchez, M J S (2021) Costs and benefits of soil protection and sustainable land management practices in selected European countries: Towards multidisciplinary insights. Science of the Total Environment No 756, 143925.

For all options, additional costs can be expected from planning, enforcement, administration, advice and training, research, communications, and monitoring. Most of these costs are likely to be small compared to the costs from soil protection, restoration, and management measures. Monitoring might involve considerable costs as current systems have to be scaled up and some methods such as in-field SOC monitoring can be time and resource intensive. These impacts will mostly affect national and regional authorities, relevant environmental organisations as well as land managers involved in monitoring.

Quantified estimates of soil protection costs and benefits at the EU level are currently limited by a lack of data, uncertainties in extrapolation of values across regions, heterogeneity of approaches and methodological and conceptual difficulties in calculating the monetary value of benefits from ecosystem services. Very few studies assess individual SOC conservation measures separately.

**Table IX-3: Summary of the expected types of costs of achieving restoration targets for soils and, where available, estimates of the range of the cost per hectare restored.**

| Option | Types of costs involved | Main costs | Potential magnitude range (EUR/ha) |
|---|---|---|---|
| **Option 1: Rewetting organic soils** | Upfront investments to implement restoration measures | Materials for drainage closure and other restoration works. Transport of materials, especially where helicopters are required. Installation of water-control structures and impermeable bunds. Salaries and equipment of contractors | Variable (€955/ha - 4,735 €/ha) |
| | Maintenance costs | Management to maintain water table level. | Variable (€29-470/ha /year) |
| | Administrative and transaction costs | Costs of administering programmes and schemes e.g. agri-environmental schemes | Low |
| | Opportunity costs | Opportunity costs of changing agricultural practice and production, compensation for the reduction or removal of land from productive agricultural use.<br>Land acquisition of rewetted land taken out of productive use can be taken as proxies of these costs. | Potentially high for individual farmers but low for the EU as a whole considering the low proportion of EU agriculture on organic soils |
| **Option 2: Agricultural soils** | Upfront investments and maintenance costs related to restoration measures | Highest costs associated with conversion of arable to grassland and the implementation of new farming systems such as agroforestry. Some measures result in maintenance costs e.g. EOM or cover crops. | Variable (€100-1 000 /ha/year) |
| | Administrative and transaction costs | Costs of administering programmes and schemes e.g. eco-schemes | Low |
| | Opportunity costs | Crop rotation changes might sometimes decrease productivity. Increase in grassland can reduce productive land and related income. Payments to farmers needed to compensate these. | Low- medium |
| **Option 3: Soil erosion** | Upfront investments and maintenance costs | Semi-permanent and permanent structures require the largest investments (e.g. from £32/ha for buffer strips to £670/ha for shelterbelts). For measures only relevant to erosion, terracing is the most expensive. Costs | Variable (€34-1 000 /ha/year) |

| | | | |
|---|---|---|---|
| | | will vary geographically with areas with highest erosion requiring higher investment. | |
| | Maintenance costs | High for terracing | Variable (€0-227 /ha/year) |

**Table IX-4: Summary of qualitative benefits from Soil Ecosystem Restoration. Insufficient information to estimate accurate monetary benefits at this stage.**

| Option | Types of benefits involved | Main benefits | Potential magnitude) |
|---|---|---|---|
| **Option 1: Rewetting organic soils** | Climate change mitigation | Rewetting peatland soils in grassland and arable systems nearly completely avoids an average of 7.5 t SOC /ha/yr. | Very high (around €2000/ha/year based on price of €100/t$CO_2$eq or €340-€2724/ha/ year based on literature) |
| | Biodiversity | Restored wetlands will result in significant biodiversity benefits given that wetlands are the ecosystem that has lost enormous surfaces in the past decades in the EU and is in urgent need for restoration. | High to very high |
| | Other ecosystem services | Flood risk mitigation and water quality control | High in flood prone areas |
| | Socio-economic | Benefits from sustainable uses of rewetted land - paludiculture, wet grassland grazed by water buffalo | Low/ moderate |
| **Option 2: Agricultural soils** | Climate change mitigation | Increased SOC increases carbon storage in soils. High benefits from conversion of cropland to other land uses and for agroforestry. | €31/ha/year |
| | Biodiversity | Increased soil quality leading to enhancement of soil processes needed to sustain above and below ground biodiversity. Improved habitat stability and resilience. | Unknown |
| | Other ecosystem services | Increased water quality and quantity management,<br>Flood risk mitigation,<br>Erosion control,<br>Potential cultural services including recreation and tourism and preservation of archaeological sites (uncertain) | High<br>High<br>High<br>Low/ unknown<br><br>In total: € 0-3440 /ha/yr (average €93 /ha/yr) |
| | Socio-economic | Increased crop yields and productivity and potential direct payments from carbon farming schemes to farmers. | Potentially high |
| **Option 3: Soil erosion** | Climate change mitigation | Contribute to reduced losses in SOC. | Medium |
| | Biodiversity | Increased soil quality will benefit below and above ground biodiversity | Unknown |
| | Other ecosystem services | Increased soil fertility, reduced flood risk, increased water retention and quality | High |
| | Socio-economic | Increased crop yields and productivity | Potentially high |

Source: see soil impact assessment fiche for references and evidence used

## 6.5 Synthesis

Overall, there are strong arguments for soil restoration targets addressing the protection of SOC stocks in organic soils and their maintenance and enhancement on mineral soils under agricultural usage and soils threatened by water erosion. Even though ecosystem accounting is currently not sufficiently developed to fully quantify costs and benefits across the EU, the proposed targets are expected to deliver large benefits for climate action, biodiversity and other associated ecosystem services. Overall, there is a strong socioeconomic argument for implementing soil restoration targets due to the high value of their co-benefits, win-wins with biodiversity gains and avoided costs. A global assessment on land degradation neutrality found that, across biomes, the benefits of restoration are up to 10 times higher than the costs. For

Europe specifically, benefits of action against land degradation were found to outweigh costs by a factor of 6 in Western Europe and a factor of 6.5 in Eastern Europe over a 30-year horizon. However, further assessment is needed to determine EU wide targets that can be met in an economically attractive way.

Restoring and fully rewetting organic soils is the target option developed the most as it delivers besides high climate benefits the strongest biodiversity gains and is particularly urgent. Also some of the countries most affected like the Netherlands and Germany have already (or are in the stage of developing) ambitious rewetting programmes, projects and targets. Studies and pilot projects in arable regions demonstrate their feasibility and cost-effectiveness.

Enhancing and maintaining EU SOC stocks in mineral soils under agricultural use by 404 $MtCO_2eq$ by 2030 also has clear benefits for climate mitigation and adaptation as well as food security and ecosystem health. Reducing unsustainable soil erosion is expected to contribute to safeguarding soil carbon and restoring soil health and avoiding significant costs from natural hazards associated with climate change.

Action on organic soils would be required mainly from Member States in northern and western Europe (Netherlands, Germany, Poland, Finland, Ireland,…); action on soil erosion from MS with soil erosion hotspots (e.g. the Mediterranean region, Bavaria, Slovakia.). An overall target on SOC would require a package of actions primarily focused on arable land, most of which are well-established actions. Although feasibility, effectiveness, efficiency, and proportionality of specific measures is highly context specific and would have to be assessed at a regional level, reaching a SOC target at the EU level would achieve improvements in soil health which are indispensable for future sustainable land use and food production.

Monitoring and reporting systems are available and can be improved to work better for a quantified soil target. The LUCAS soil monitoring programme initiated in 2009 offers a harmonized, regular EU-wide approach to assess SOC and provides data for MS which do not have their own soil monitoring system. The LULUCF regulation provides annual reports about emissions from organic and mineral managed soils. Importantly, the feasibility and potential of restoration targets on forest soils should be re-evaluated in future considering ongoing work to improve monitoring and reporting framework for EU forest soils. The need for improved monitoring for SOC is further justified due to the relevance of SOC as an indicator for a variety of other EU and international policies.

Further work should focus on developing the proposed targets, determining what measures are needed where, assessing the feasibility of expanding its scope to including other ecosystems (particularly forests), and other dimensions of soil health. This would include projects, research and collaborations to improve understanding and assess the potential of setting targets for soil biodiversity, compaction, contamination (point source and diffuse), sealing and salinization.

**Table IX-4: Overview table assessing options on EU impact assessment criteria**

| Criterion | Organic soils | SOC in agricultural soils | Soil erosion |
|---|---|---|---|
| **Feasibility / effectiveness** | High on feasibility and effectiveness. The particular strong win-win situation with climate & biodiversity is already triggering the relevant measures which will need upscaling Monitoring the increases of SOC | High feasibility. Builds on various political and environmental objectives. Agricultural practices are sufficiently known to guide implementation. Carbon sequestration is currently | Moderate feasibility. Funding for addressing erosion in UAA is already available within CAP. Need for region specific guidance on most appropriate |

| | | | |
|---|---|---|---|
| | on organic soils builds on MS's experiences for LULUCF reporting, and the discussions on the CAP reform. The diverse and numerous experiences with wetland restoration (e.g. LIFE) show the effectiveness of the approach. | mapped by all MS and can build on current national submissions for the LULUCF sector to the European inventory and LUCAS soil survey. To be effective, stock increases need to be preserved long-term. | measures. Hotspots should be identified and prioritised. |
| **Efficiency** | Considered to be one of the most cost-effective measures to reduce greenhouse-gas emissions and at the same time boost biodiversity, particularly if rewetting is done on a large scale. | No generalisations can be made across regions and practices yet, in many cases, benefits outweigh costs, especially for low-cost measures such as including legumes in rotations. Some measures can result in a net cost to farmers which, with the right incentives, can be minimised. | Measures to decrease soil erosion in farmlands can be cost-effective but, in some cases, they can result in net costs to farmers for which they should be compensated. |
| **Coherence** | High coherence with EU climate goals.<br>Also, high coherence with biodiversity objectives as re-wetting can lead to restoration (and in some cases recreation) of habitats protected under Annex 1 of the EU Habitats Directive and will in nearly all cases benefit a range of declining species. Farm incomes might be affected depending on the national implementation of the rewetting target (i.e. via mandatory regulations or voluntary agri-environment measures) and depending on the national CAP measures & payments. In the long-term impacts on farm income would be positive due to greater sustainability of production. | High coherence with EU climate goals and ambitions for new soil strategy outlined under the EU biodiversity strategy for 2030. SOC is a proposed CAP impact indicator. Impacts on farm income are like those under option 1 with even higher long-term positive benefits due to increased yield from increased SOC and soil health. | High coherence with CAP objectives, farm to fork objectives and zero pollution action plan objectives. Coherence with climate adaptation goals as it increases disaster risk resilience to floods and landslides while improving food security. Impacts on farm income are like those under option 2 with possible short-term losses likely offset by long-term productivity gains from improved soil health. |
| **Proportionality** | This target is proportionate as in the EU agriculture on organic soil represents a small fraction of agricultural land (around 3%) meaning overall costs will be lower than their potentially huge climate and wider ecosystem benefits.<br>Protecting organic soils supports and further stimulates efforts already established by many MS, through their national programming, funding and legislations in soil protection, sustainable land management, | The option is deemed proportionate as it will involve targeted regional measures to address gradually a significant problem which threatens the future sustainability of land use and food production. Costs and benefits mainly on arable land and highest in Mediterranean region | Overall, the target is deemed proportionate as it will target areas with greatest problems and will address a big problem in a proportionate way. Effort heavily skewed to Mediterranean countries |

| | | | |
|---|---|---|---|
| | nature protection, and climate change. | | |
| **Conclusion** | **Include as a target** | **Do not include now, consider further in a possible second stage (or possibly considered in the announced soil health legislation)** | **Consider further as a possible second stage target (will require further assessment) or possibly considered in the announced soil health legislation.** |

# 10. Pollinators

## 10.1 Scope

Wild pollinators include all flower-visiting species that contribute to the transfer of pollen, excluding managed species such as the honeybee (*Apis mellifera*). In Europe, wild pollinators are principally insects, such as bees, hoverflies, butterflies, and moths. The EU has a high diversity of pollinator species - 2,000 species of bees, around 1000 species of hoverflies, almost 500 species of butterflies, and almost 1,000 species of hoverflies plus thousands of species of moths, flies, wasps, beetles and other insects which act as pollinators. [63]

Wild pollinator habitat is treated as all natural, semi-natural and artificial habitat that provides suitable food (flowers), shelter, nesting, and overwintering sites.

This species target fully complements the targets for agro-ecosystems, heath and scrub, forests, wetlands, and the urban green spaces. It relies on some of the assessment done under those ecosystems.

## 10.2 Problem, current trends and ecosystem-specific baseline

**Pollinator populations**

Wild pollinator communities are indicators of ecosystem health and react quickly to environmental change. Wild bees indicate small-scale habitat diversity as they interact with the landscape in a complex life cycle, within a radius of a few hundred metres. Butterflies react quickly to change, in response to micro-climate and other factors as well as vegetation. Moths and some butterfly species are indicators for structurally diverse forests (mosaics with diverse forest edges, open habitats, mature canopies of native tree species). Many hoverfly species are indicators of conservation management because their larvae are restricted to specialised niches, such as particular types of rotting wood or tree species on which they feed on aphids or other insects.

84 % of the crops grown in Europe benefit at least partly from animal pollination[64], including fruits, vegetables, nuts, oil crops, pulses and legumes, crops grown for fibre or fuel or for animal food. Over 78 % of wild plants in the EU rely on pollinating insects, [65] including many medicinal plants. Without pollinators, these plants would disappear resulting in the cascading loss of biodiversity and ecosystem services, such as biological pest control or decomposition provided by some hoverfly larvae[66].

While the full magnitude of the decline is still not fully understood, the existing data clearly points to an alarming loss of pollinators in the EU: the EU Red List of Bees[67] shows that one in

[63] Potts et al., (2020) Proposal for an EU Pollinator Monitoring Scheme.
[64] Williams, I.H. (1994) The dependence of crop production within the European Union on pollination by honeybees.
[65] Ollerton et al., (2011). How many flowering plants are pollinated by animals?
[66] Hatt et al., (2017) Pest regulation and support of natural enemies in agriculture: Experimental evidence of within field wildflower strips.
[67] Nieto et al., (2014) European Red List of Bees. Publication Office of the European Union, Luxembourg.

three bee and butterfly species are declining, while one in ten are on the verge of extinction; the Grassland Butterfly Indicator shows a loss of 25 % of abundance in EU countries from 1990-2018[68]. Data at regional level shows decline of other pollinators within the general decline of insects, for example long-term monitoring in Germany shows significant declines in arthropods in grasslands and forests[69], and a 77 % decline in insect flying biomass in protected areas.[70]

The main pressures on pollinators are land-use change, intensive agricultural management and pesticide use, environmental pollution, invasive alien species, and climate change.[71]

The baseline assessment to 2030 suggests that the main pressures will continue, though impacts of pesticide use are expected to decline if objectives to reduce the risks and use of harmful pesticides and to increase the area under organic farming will be achieved. If the historical trend in the European grassland butterfly indicator continues, it would likely decline by 23% by 2030. It is not possible to extrapolate trends in other pollinators, but declines are expected to continue on agricultural land, particularly on high nature value farmland. Climate change combined with fragmentation limiting migratory routes will lead to extinctions in the southern and northern edges of ranges and in alpine species, whilst driving the expansion of some species to colonise new areas.

Crop pollination: There is evidence of current pollination deficits in crops associated with low abundance of pollinators; JRC estimated 50% of crop demanding crops in the EU are in pollinator deficient areas [72].

The INCA project developed a set of ecosystem accounts including crop pollination. Vallecillo et al, [73] estimated that in 2012 pollination contributed EUR 4.517 billion (estimated value in 1019: EUR 4.977 billion) in to the value of agricultural production in the EU, corresponding to 2 810 EUR per $km^2$. An estimated 51% of the area with pollinator dependent crops had a low pollination potential. The pollination gap of 51% is projected to widen since pollination potential slightly erodes (-1% per 10 years) whereas demand for pollination is increasing with 5% per 10 years. In the absence of restoration, the pollination gap is therefore expected to increase, assuming the demand from pollination dependent crops remains the same for the next decade (NB demand will probably increase as the area of pollination dependent crops increases with increasing use of legumes, changing demand, and changing opportunities due to climate change). The study therefore suggests that restoration of pollinator habitats has the potential to double the benefits from pollination.

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[68] In the EU27, 5 of the 17 species in the indicator show a moderate decline, 6 are stable, and one species shows a moderate increase (*Anthocharis cardamines*). The trends for the remaining species are uncertain. Ref: (Van Swaay et al, 2020).

[69] Seibold et al., (2019) Arthropod decline in grasslands and forests is associated with landscape-level drivers.

[70] Hallmann et al., (2017) More than 75 percent decline over 27 years in total flying insect biomass in protected areas.

[71] IPBES (2016) The assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production.

[72] Vallecillo et al., (2018) Ecosystem services accounting Part I Outdoor recreation and crop pollination. JRC Technical Reports.

[73] Vallecillo et al., (2018) Ecosystem services accounting Part I Outdoor recreation and crop pollination. JRC Technical Reports.

Major knowledge gaps on pollinators still exist across taxa and geographical regions in Europe as noted by Potts et al [74], which pose barriers to the development and implementation of effective management and policy responses to conserve the EU's pollinators and secure sustainable and resilient pollination services.

## 10.3 Target options screened in/out

Options for targets are:

1) **To achieve good condition[75] of pollinator species protected by the EU Habitats Directive**
The EU Habitats Directive lists 52 pollinator species in the annexes. These species are all Lepidoptera (butterflies and moths). The directive does not protect any Hymenoptera or Diptera, the most prominent pollinator groups including the most important pollinators of crops. This target would therefore only address a very small component of the pollinator community consisted of thousands of species, and only species that are relatively rare or restricted in occurrence. It therefore has low relevance to the overall aim of restoring pollinators and will not deliver the benefits that come from healthy pollinator populations.

2) **To achieve good condition of pollinator habitats protected by the EU Habitats Directive**
The EU Habitats Directive Annex I habitat types significant for wild pollinators include the semi-natural grasslands (particularly calcareous and hay meadows), most heaths (notably dry heaths) and scrub, many coastal grasslands and scrub, most wetlands and screes, and forest habitats with a high proportion of open and/or moderately disturbed habitat.[76] These habitats are associated with high species richness of pollinators, and their restoration is likely to increase pollinator species diversity and abundance. [77] However, these habitats are largely absent in more intensively managed landscapes (farmland and forest) and in urban areas. The target would therefore not cover actions addressing pollinator decline in the wider landscape[78].

3) **To reverse decline in pollinator populations.**
This target requires sufficient increases in pollinator-friendly habitat in all landscapes, and particularly Annex I grasslands, heaths and wetlands, and agro-ecosystems. It

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[74] Potts et al., (2020) Proposal for an EU Pollinator Monitoring Scheme.

[75] Good condition refers to species population, habitat, and range. This is a component of favourable conservation status (as defined in the EU Habitats Directive), which also includes the future prospects of the species (estimates of future threats, long-term viability of habitat, etc).

[76] Kudrnovsky et al., (2020) Report for a list of Annex I habitat types important for Pollinators. ETC/BD Technical paper 1/2020, Report to the EEA.

[77] Olmeda et al., (eds) (2019) EU Habitat Action Plan to maintain and restore to favourable conservation status the habitat type 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (FestucoBrometalia) (*important orchid sites) ; Olmeda et al., (eds) (2020) EU Habitat Action Plan to Maintain and Restore to Favourable Conservation Status the Habitat Type 4030 European Dry Heaths.

[78] Although the Habitats Directive requires periodic surveying and reporting on the condition of the habitats, no EU Member State currently surveys pollinators as an indicator of condition and there are no systematic surveys of pollinator species in these habitats. Thus, it is not currently possible to verify that the pollinator decline is reversed. The EU pollinator monitoring scheme aims to have systematic surveying in place by 2024.

also requires actions to reduce pressures, notably to reduce pesticide use and nitrogen inputs (reduce fertilizer and decrease deposition). Achieving this restoration would ensure the restoration of the critical structural and functional role that pollinators play across different terrestrial ecosystems, and especially in agroecosystems. Expert estimates indicate that restoration of pollinator habitat on at least 10% of farmland will be the minimum needed to maintain the most common wild pollinator species. [79]

Actions for pollinators on intensively managed farmland include[80]:

- Maintenance / creation of boundary features (e.g. ditches, banks, hedges and trees) with flowering shrubs & vegetation & nesting/breeding/shelter/hibernation niches;
- Creation of buffer strips / margins (e.g. along watercourses, by hedges, field corners) without pesticide & fertilizer drift;
- Planted strips for pollinators (flowering seed mixes), fallow (whole field / zones);
- Reduced pesticide use (including insecticides, herbicides, and fungicides), & adoption of IPM, reduced fertilizer use, organic management, tolerance of weeds;
- Late and/or lenient and/or delayed cutting and grazing of grassland, reduction in livestock densities, staggered cutting, extensification;
- Recreation of grassland from arable land, reseeding of impoverished grassland, halting reseeding of permanent grassland;
- Agro-forestry, planting flowering trees/shrubs on grassland, in hedges & field edges
- Diversification of crops (in space – diversity of crops in fields - and in time – crop rotations).

Current knowledge gaps can only be addressed through a large-scale standardized monitoring scheme. [81] It will therefore be necessary to establish and maintain monitoring and reporting of pollinator populations across the EU. Systematic pollinator monitoring will enable setting of a baseline and building of policy indicators of biodiversity at national and EU level, thereby helping improve the effectiveness of EU policies supporting land management and restoration, notably the CAP, regional funding, and protected area management. The Commission and Member States have already started working on a technical proposal for the EU pollinator monitoring scheme[82].

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[79] Dicks et al., (2015) How much flower-rich habitat is enough for wild pollinators? Answering a key policy question with incomplete knowledge; Martin et al., (2019) The interplay of landscape composition and configuration: new pathways to manage functional biodiversity and agroecosystem services across Europe.

[80] Based on IPBES 2016 Table SPM1. Includes actions of England rural development programme farm wildlife package (pollinator subpackage).

[81] Harvey et al., (2020) International scientists formulate a roadmap for insect conservation and recovery.

[82] Potts, S G, Dauber, J, Hochkirch, A, Oteman, B, Roy, D, Ahnre, K, Biesmeijer, K, Breeze, T, Carvell, C, Ferreira, C, Fitzpatrick, Ú, Isaac, N, Kuussaari, M, Ljubomirov, T, Maes, J, Ngo, H, Pardo, A, Polce, C, Quaranta, M, Settele, J, Sorg, M, Stefanescu, C and Vujic, A (2020) Proposal for an EU Pollinator Monitoring Scheme. EUR 30416 EN, Publications Office of the European Union, Luxembourg. ISBN 978-92-76-23859-1, doi:10.2760/881843, JRC122225.

https://ec.europa.eu/jrc/en/publication/proposal-eu-pollinator-monitoring-scheme

**Table X-1 Summary table screened target options**

| Target option | Screened in/out for assessment | Key reason(s) for screening in/out |
|---|---|---|
| To achieve good condition of pollinator species protected by the EU Habitats Directive | Screened out because of limited relevance and limited benefits compared to the other options | Insufficient scope to lead to recovery of pollinator populations |
| To achieve good condition of pollinator habitats protected by the EU Habitats Directive | Screened out because out because its scope does not cover intensively managed landscapes, in particular farmland, where such habitats are largely absent. | Insufficient scope to lead to recovery of all pollinator populations, though many rare and declining species likely to benefit |
| To reverse decline in pollinator populations | Screened in as directly relevant, feasible, and enforceable, including the roll out of EU wide pollinator monitoring. | Directly addresses target and includes establishment of EU wide monitoring programme to inform and improve targeting and actions |

## 10.4 Impacts of assessed target options

A full quantitative assessment of the costs and benefits of reversing pollinator declines is not possible at this stage, because insufficient data are available to allow the type and extent of measures required to meet this target to be quantified across the EU. Furthermore, much of the action required for pollinators would be delivered through other costed targets for semi-natural habitats (steppe, heathland and scrub; forests; wetlands) as well as for grasslands and agro-ecosystems. It is important that the costs of these actions are not double counted, and the additional costs of measures needed to reverse pollinator declines may be modest. This section therefore includes an assessment of the specific costs of implementing a monitoring programme for pollinators, to complement measures costed for other ecosystems. The benefits of meeting pollinator targets are also discussed, and examples of their value are given.

Stakeholders likely to be impacted by the targets include:

- Landowners and managers including farmers, foresters, green space & protected area managers, other landowners including public authorities and private business. These land managers will bear costs of planning and carrying out habitat restoration and maintenance to benefit pollinators, but will also gain benefits (pollination, biological control of pests, improved image and public awareness and appreciation). Some management changes will decrease overall management costs (e.g. by reducing frequency of cutting/mowing and weed control activities, replacing management intensive horticultural/planted vegetation with native vegetation).
- Wider public – owners of gardens, users of green spaces. No additional costs expected & cultural and wellbeing benefits from changed management and reductions in pesticide use.

https://publications.jrc.ec.europa.eu/repository/handle/JRC122225

- Species experts and volunteer citizen scientists – benefit from paid work opportunities or opportunities for voluntary action.

Stakeholders who are likely to benefit from the targets include:

- Farmers and the whole biomass supply chain benefit from the sustainable provision of animal-pollinated crops and associated benefits of pollinators.
- Society and economy benefit from healthy ecosystems dependent on the diversity of wild animal-pollinated plants. The benefits are numerous ecosystem functions and services provided by those ecosystems, including resilience to climate change and provision of regulating services.
- Beekeepers (from the additional flower resources available).
- Owners of gardens, users of green spaces, and society will benefit from the non-market values of pollinators – cultural, aesthetic, wellbeing.
- Businesses and enterprises can benefit from enhanced reputation and biodiversity friendly status through their sustainability reporting, publicity, customer relations, as well as improving staff wellbeing through introducing more nature to premises.

**Costs**

Costs were estimated based on the costs of restoring Annex I habitats, the costs of the England farmland wildlife package for pollinators, and the costs of the EU pollinator monitoring scheme.

The ecosystem restoration costed in this impact assessment will contribute to reversing pollinator declines, especially the completion of all necessary restoration measures on 15,093 km2 of Annex I grasslands[83], 2096 km2 of Annex I heath and scrub[84], and up to 122,240 km2 of Annex I wetlands by 2030[85]. The costs of this restoration are not quantified for the pollinator target as they are not additional. The costs of actions for pollinators on intensively managed farmland are largely overlapping with actions for farmland birds. These are estimated at €436,866,785 - €686,578,412 to 2030 for scheme agreements on the minimum and maximum proportion of the agricultural area (min pasture = 13%, max = 23%. Min arable = 31%, max = 47%) that would be required to increase in the wildlife populations by 10% by 2030[86]. Each scheme agreement provides 10% of wildlife beneficial habitat (including agriculturally productive habitats) on the area covered by the agreement. See agroecosystem fiche for details.

**Total additional costs to 2030 for pollinator monitoring are estimated at: €144.25 million (minimum monitoring) - €154 million (full monitoring)[87].**

[83] 30% of estimated 47,909 km2 that would be in not good condition in 2030 in the baseline scenario plus at least 2,400 km2 that needs to be recreated (see agro-ecosystem fiche for details)

[84] 30% of estimated 6,586 km2 that would be in not good condition in 2030 in the baseline scenario plus at least 400 km2 that needs to be recreated (see heath and scrub fiche for details)

[85] 30% of estimated 40,800 km2 that would be in not good condition in 2030 in the baseline scenario (see wetlands fiche for details)

[86] On a total agro-ecosystem area of 2,096,616 km2 (according to Corine Land Cover data in 2018)

[87] Taken from EU PoMS proposal at https://ec.europa.eu/jrc/en/publication/proposal-eu-pollinator-monitoring-scheme

Additional costs to 2030 for restoration of pollinator habitat in forests, urban areas, and coasts could not be estimated.

Costs of reducing pressures could not be quantified but are mostly contained in the costs of implementing existing EU legislation. The baseline scenario assumes that pesticide pressures on pollinators will decrease[88], that nitrogen deposition will continue to decline, and fertilizer use will decrease[89]. The invasive alien species regulation will increasingly catalyse action to prevent and control IAS that affect pollinators. However, in the absence of targeted policy drivers for pollinator conservation, progress is expected to be slow, and it is not possible with current knowledge to estimate whether this will have a significant influence on current rates of decline.

**Table X-2: Other costs to meet target of restoring pollinator populations**

Source: (Potts et al, 2020), agro-ecosystem assessment.[90]

| Action | Total annual cost | Total over period |
|---|---|---|
| Minimum viable scheme for pollinator monitoring | €13.3 million per year | €133 million to 2030 |
| Moth module | €1.1 million per year | €11 million to 2030 |
| Rare and threatened species monitoring module | €250,000 to €1.0 million per year | €0.25-10 million to 2030 |
| **Total additional costs over 10 years** | | **€144.25-154 million to 2030** |

**Table X-3: Qualitative overview of benefits from pollinators**

| Benefit | Evidence of value | Potential to increase with restoration |
|---|---|---|
| Crop pollination | Pollination of almost all fruits, vegetables, herbs and nuts, oil crops (notably oilseed rape), pulses (beans, peas, lentils, etc), cotton, flax, feed and forage plants (notably all the protein rich and nitrogen-fixing legumes – beans, peas, clovers, alfalfa, vetches, lupins, etc). Crops grown for fibre or fuel: oilseed rape, cotton, flax, certain tree species, linseed, and other industrial crops. Crops grown for animal food, including beans, peas, alfalfa, lupins, sunflower, oilseed rape, used in feed for cattle, sheep, poultry and pigs, and farmed fish food. Medicinal herbs used in the food industry, including basil, sage, rosemary, thyme, coriander, cumin, dill, sage. | High for most crops in response to targeted measures that reduce current deficits & meet increasing demand (potential trade-offs or interactions with fertiliser use and pesticide use). |

88 As a result of increasing organic farming area, future bans or withdrawals of active substances with particularly harmful effects, increased member state ambition in national action plans, and possibly a requirement for national reduction targets in a revised Sustainable Use of Pesticides Directive.

89 As a result of further progress under the national emissions ceiling directive and other policy drivers on nitrogen pollution, and the Farm to Fork Strategy target to reduce fertiliser use.

90 Potts et al., (2020) Proposal for an EU Pollinator Monitoring Scheme.

| | | |
|---|---|---|
| | Benefits for food security and associated benefits for human health. | |
| Pollination of wild plants | Over 85% of non-crop plants rely on pollinating insects. Pollinators are therefore essential for the supply of most of the ecosystem services that rely on natural vegetation, particularly nutrient regulation from nitrogen-fixing plants (highly pollinator dependent). Wild plants supply fruits, seeds, shelter and other resources to wide range of other biodiversity including birds, mammals and insects. Also, many animal-pollinated wild plants are collected for their medicinal properties and used in the pharmaceutical industry.<br>Significant associated benefits for ecosystem services derived from healthy plant communities, including, but not limited to provision of habitat for wildlife, soil fertility, water quality, flood regulation, and C sequestration. | High for most species in response to restoration. |
| Natural biological control and decomposition of organic matter | Aphidophagous hoverfly larvae known to predate aphids on cereal crops, predatory wasps. Hoverfly larvae role in decomposer community. Evidence from scientific research. | Potential for increase in response to restoration and reduced pesticide use. |
| Cultural, aesthetic, spiritual benefits from pollinators | Prominence of bees, butterflies, and the larger and more conspicuous pollinator species in culture, art, people's appreciation of nature, etc. Pollinators are amongst the most visible and attractive manifestations of nature particularly in urban settings. Evidenced by size of public concern about pollinator decline (also present in public with low level of knowledge about nature), e.g. participation in national and EU public consultations and citizens initiatives. | Potentially huge significance of pollinators as 'flagships' of insect protection and visible attractive signs of nature particularly for urban populations. |
| Other socio-economic benefits | Benefits for recreation and tourism of restored habitats and pollinator species.<br>Opportunities for employment and income from restoration works.<br>Benefits for beekeepers from additional flowers available for honeybees | Increase in value directly connected to restoration actions. |

**Relative significance of benefits from pollinator populations**

It is not possible to calculate the overall benefits provided by pollinators or the additional benefits of restoration of populations, but just the value of crop pollination greatly exceeds the costs of restoration, as estimated:

The monetary **benefit of crop pollination** by wild pollinators was estimated to be worth €4.517 billion in 2012.[91]

[91]Vallecillo et al., (2018) Ecosystem services accounting Part I Outdoor recreation and crop pollination. JRC Technical Reports. Crop pollination by wild bees and honeybees across Europe was estimated at 14.6 [±3.3] billion EUR annually between 1991 and 2009 (Leonhardt et al, 2013). This corresponded to an average value of insect pollination of 6948 EUR per km2 of agricultural area.

The overall benefits provided by wild pollinators are much larger than the crop pollination benefits that can be monetized, as the wider benefits derive from pollination of non-crop vegetation and the ecosystem services that provides, and the presence of the pollinators themselves.

## 10.5 Synthesis

The assessment has demonstrated that the additional costs associated with the pollinator target (monitoring and actions on intensively managed farmland) are much lower than the monetised benefits of crop pollination by wild pollinators, without taking account of the substantial additional benefits that cannot be monetised. These costs (€154M) are estimated at around 3% of the annual benefits of animal pollination (€4517M), though given the additional benefits this is likely to be <1%. It is not possible to say to what exact extent these benefits would be lost by 2030 if no action is taken, but the assessment shows that through the restoration of pollinator habitats it will be possible to mitigate a considerable loss.

The pollinator target is feasible, as well-established restoration actions are available, and measurable, as the work on a pollinator monitoring mechanism is already under way. The costs of action in agro-ecosystems are far below the monetary benefits obtained from crop pollination, without even fully accounting for all benefits provided by pollinators. It is currently not possible to calculate the costs of the necessary restoration action needed in forests, urban areas, and other ecosystems, due to the knowledge gaps, but most actions are either low-cost or cost saving (e.g. due to reduced management such as less frequent cutting of grassland areas) or are associated with adoption of management systems that bring other biodiversity benefits (coppicing, forest edge diversification, increasing native flowering plants).

Actions to reverse pollinator declines synergise with, add value to, and complement the restoration of agro-ecosystems, heath, and scrub, forests, wetlands, and urban green spaces. The pollinator target would go further than the ecosystem targets, because restoring habitat condition will not automatically deliver for pollinator populations, as 1) pollinators are very rarely monitored as an indicator of habitat condition, so habitats may reach good status in terms of vegetation composition but key pollinators are still absent (e.g. due to impacts of chemicals), and 2) pollinators require landscape scale habitat mosaics and combinations of different habitats that do not always result from restoration that is measured by improvement in condition of one habitat or ecosystem type.

**Table X-4: Overview table assessing options on EU impact assessment criteria**

| | Habitats Directive pollinator species | Annex I habitats | Reverse decline in pollinator populations |
|---|---|---|---|
| Feasibility / effectiveness | Feasibility varies according to species and required habitat. Not effective at restoring pollinator populations as a whole (as Annex includes only a tiny proportion of all pollinators). | High feasibility and potential for restoration. Restoration is highly effective for biodiversity, and contributes to other ecosystem services, but will not deliver recovery of pollinator populations | High feasibility (as measures already established under the CAP) and effective if measures are taken on 10% of all farmland |

| | | | |
|---|---|---|---|
| | | outside these habitats. Re-creation of new habitat is limited by the availability of suitable sites. | |
| Efficiency | Targeted measures deliver population increases of most species; benefits for other pollinators limited to species in the same habitat. | Restoration of habitats important for pollinators benefits rare species and abundance of commoner species. But may not meet species requirements for landscape diversity. | Measures on farmland are generally low cost. Some opportunity cost on arable land of increases in grassland, legumes, and fallow in crop rotations. |
| Coherence | Full coherence with EU environmental policies as already an objective of the EU Habitats Directive to reach favourable conservation status. | Full coherence with EU environmental policies as already an objective of the EU Habitats Directive to reach favourable conservation status. Potential to also make contributions to other ecosystem services from grasslands, heaths etc. | Full coherence with EU environmental policies (as other options) and meets global obligations to protect pollinators. |
| Proportionality | Proportionate to the very high importance of the species for biodiversity conservation and as indicators of habitats of conservation value. | Proportionate to the high importance of the habitats for biodiversity and associated ecosystem services. | Proportionate to the benefits provided by pollinator populations. |
| **Conclusions** | **Not recommended as target** | **Not recommended as target** | **Include as a target, with high priority** |

## 11. Cost estimates for different speeds of restoration

**Table XI-1: Overview of cost estimates for targets options on the restoration, re-creation and maintenance of Annex I habitat (in MEUR)**

Please note: 1) Figures are presented as Present Value of the sum of annual costs, discounted at an annual rate of 4%, which explains why scenario B comes out more costly in net terms since a bigger share of cost is borne in the short term. Caution should be taken, since nature restoration generally actually becomes more costly over time if postponed, which was not factored in the cost estimates; 2) Marine ecosystems, urban ecosystems, soil ecosystems and pollinators were not included in this table since no area-based targets to restore or re-create Annex I habitat were screened in (urban, soils), or only partly (marine). For marine it was not possible to make a reliable cost estimate due to data gaps both on the extent of measures required and costs; 3) Maintenance is included in the calculations to ensure no deterioration; 4) The grand totals are slightly lower than those in the summaries of the thematic IA's since the latter include maintenance costs up to 2070, in line with the requirement of no-deterioration until the cut-off date for this assessment.

## Scenario A: 15-40-100 % by 2030-40-50

| Target | | Costs for 15 % by 2030 (present value, MEUR) | +Costs for 30 % by 2040 (present value, MEUR) | +Costs for 90 % by 2050 (present value, MEUR) | Total Costs for 15 % by 2030, 40 % by 2040, 100 % by 2050 (present value, MEUR) | Grand total Cost 2030-2050 (present value, MEUR) |
|---|---|---|---|---|---|---|
| **Ecosystem** | Cost Category | | | | | |
| **Peatlands** | Restoration | 436 | 501 | 677 | 1 614 | 4 204 |
| | Re-creation | 103 | 118 | 160 | 381 | |
| | Maintenance | 959 | 742 | 508 | 2 209 | |
| **Marshlands** | Restoration | 58 | 68 | 90 | 216 | 2 931 |
| | Re-creation | 3 | 3 | 4 | 10 | |
| | Maintenance | 1 167 | 908 | 630 | 2 705 | |
| **Forests** | Restoration | 5 874 | 6 753 | 9 124 | 21 751 | 44 352 |
| | Re-creation | 187 | 214 | 290 | 691 | |
| | Maintenance | 9 532 | 7 352 | 5 026 | 21 910 | |
| **Heathland and scrub** | Restoration | 71 | 118 | 235 | 424 | 7 218 |
| | Re-creation | 25 | 30 | 34 | 89 | |
| | Maintenance | 2 066 | 2 309 | 2 330 | 6 705 | |
| **Grasslands** | Restoration | 1 080 | 1 241 | 1 677 | 3 998 | 22 346 |
| | Re-creation | 976 | 714 | 489 | 2 179 | |
| | Maintenance | 7 020 | 5 428 | 3 721 | 16 169 | |
| **Rivers, lakes and alluvial habitats** | Restoration | 8 236 | 9 468 | 12 793 | 30 497 | 34 082 |
| | Re-creation | 22 | 25 | 34 | 81 | |
| | Maintenance | 1 397 | 1 177 | 930 | 3 504 | |
| **Coastal wetlands** | Restoration | 1 145 | 1 317 | 1 780 | 4 242 | 4 974 |
| | Re-creation | 22 | 26 | 35 | 83 | |
| | Maintenance | 284 | 218 | 147 | 649 | |
| **TOTAL** | | **40 663** | **38 730** | **40 714** | **120 107** | |

| Average annual | 4 518 | 3 873 | 4 071 | |
|---|---|---|---|---|

**Scenario B: 30-60-100 % by 2030-40-50**

| Target | | Costs for 30 % by 2030 (present value, MEUR) | +Costs for 60 % by 2040 (present value, MEUR) | +Costs for 90 % by 2050 (present value, MEUR) | Total Costs for 30 % by 2030, 60 % by 2040, 90 % by 2050 (present value, MEUR) | Grand total Cost 2030-2050 (present value, MEUR) |
|---|---|---|---|---|---|---|
| **Ecosystem** | Cost Category | | | | | |
| **Peatlands** | Restoration | 872 | 601 | 406 | 1 880 | 4 543 |
| | Re-creation | 206 | 141 | 96 | 443 | |
| | Maintenance | 959 | 748 | 514 | 2 221 | |
| **Marshlands** | Restoration | 116 | 80 | 54 | 250 | 2 994 |
| | Re-creation | 5 | 4 | 3 | 12 | |
| | Maintenance | 1 167 | 923 | 642 | 2 732 | |
| **Forests** | Restoration | 11 748 | 8 104 | 5 474 | 25 326 | 53 476 |
| | Re-creation | 373 | 257 | 174 | 804 | |
| | Maintenance | 11 901 | 9 190 | 6 255 | 27 347 | |
| **Heathland and scrub** | Restoration | 141 | 141 | 141 | 423 | 7 247 |
| | Re-creation | 29 | 30 | 30 | 89 | |
| | Maintenance | 2 066 | 2 322 | 2 347 | 6 735 | |
| **Grasslands** | Restoration | 2 160 | 1 428 | 1 006 | 4 594 | 23 008 |
| | Re-creation | 987 | 715 | 485 | 2 186 | |
| | Maintenance | 7 020 | 5 476 | 3 731 | 16 227 | |
| **Rivers, lakes and alluvial** | Restoration | 16 472 | 11 362 | 7 676 | 35 510 | 39 061 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **habitats** | Re-creation | 22 | 15 | 10 | 47 | |
| | Maintenance | 1 397 | 1 177 | 930 | 3 504 | |
| **Coastal wetlands** | Restoration | 2 292 | 1 581 | 1 068 | 4 941 | 5 687 |
| | Re-creation | 45 | 31 | 21 | 97 | |
| | Maintenance | 284 | 218 | 147 | 649 | |
| **TOTAL** | | **60 262** | **44 544** | **31 210** | **136 016** | |
| **Average annual** | | **6 696** | **4 454** | **3 121** | | |

**Table XI-2 Benefit to cost ratios for Annex I habitat targets for Scenario A and B**

| Ecosystem type | Benefit to cost ratio (Costs for Scenario A: 15 % by 2030, 40 % by 2040, 100 % by 2050) | Benefit to cost ratio (Costs for Scenario B: 30 % by 2030, 60 % by 2040, 100 % by 2050) |
|---|---|---|
| **Inland wetlands (for peatland only)** | 7.1<br>(2.2 if carbon only) | 8.3<br>(2.5 if carbon only) |
| **Forests** | 4.1<br>(0.1 if for carbon only*) | 4.1<br>(0.1 if for carbon only*) |
| **Heathland and scrub** | 7.9<br>(1.3 if carbon only) | 9.2<br>(1.5 if carbon only) |
| **Agro-ecosystems** | 8.6<br>(0.6 if carbon only) | 9.2<br>(0,7 if carbon only) |
| **Rivers, lakes and alluvial habitats** | 24 | 26 |
| **Coastal wetlands** | 35.3<br>(0.2 if carbon only) | 38.1<br>(0.2 if carbon only) |
| **Median cost-benefit ratio between ecosystem types** | 7.9 | 8.8 |

= most conservative estimate only based on reduced felling intensity (see section 3.4 above)