Towards EU climate neutrality

Progress, policy gaps and opportunities

Chapter 9: Land use, land use change and forestry

Assessment Report 2024

European Scientific Advisory Board on Climate Change

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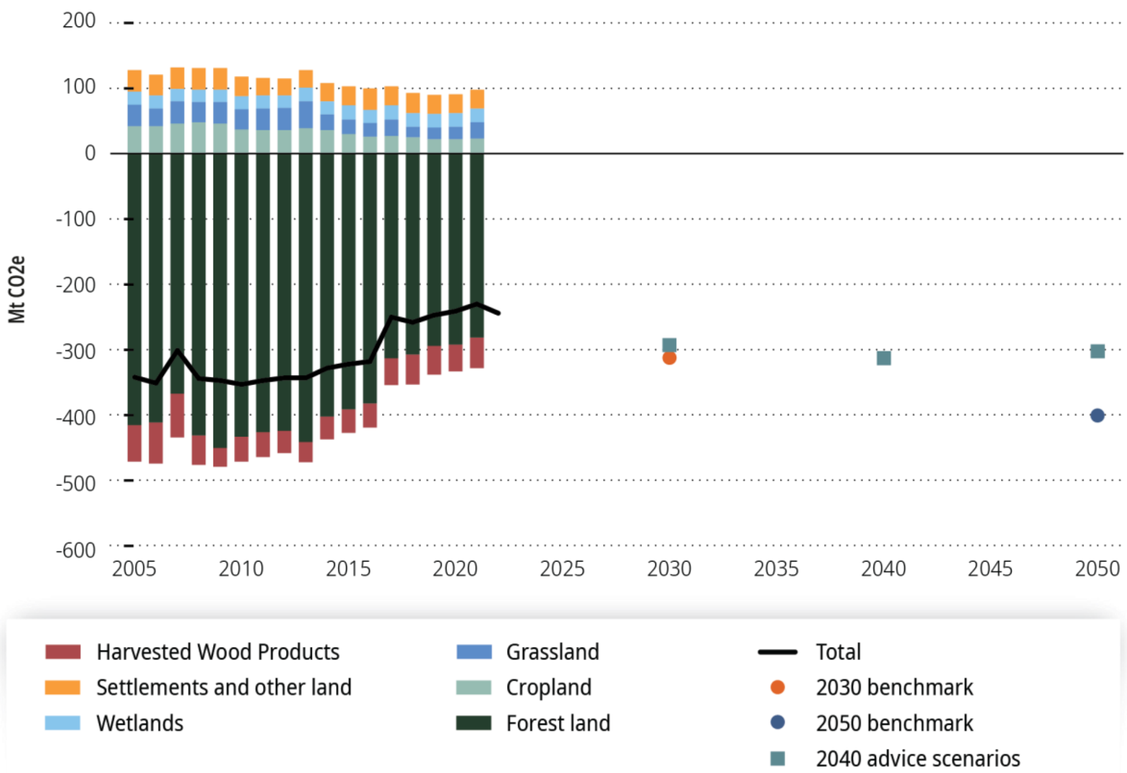
Key messages

The observed decrease in the net carbon sink in the LULUCF sector needs to be reversed to be consistent with the EU climate objectives. Several complementary options are available to achieve this.

Figure 63 displays the overall levels of emissions and removals from the LULUCF sector. The net sink in the LULUCF sector has been in decline since 2010 and was a third lower in 2021 than in 2005. The decline was predominantly caused by reduced CO_2 removals by EU forests, driven by slower forest growth, natural disturbances and increased demand for woody biomass (see indicator L6 for more details). The carbon sink has declined, removing on average 6 Mt CO_2 less every year in 2005–2022. This trend needs to be reversed so that the sink will remove on average an additional 8 Mt CO_2 each year in 2023–2030 to meet the legally binding target of 310 Mt CO_2e net removals per year by 2030, and to be consistent the European Commission scenarios underpinning the 2050 climate neutrality objective.

Figure 63 Indicator L1 – overall progress in reducing emissions (positive values) and increasing removals (negative values) in the LULUCF sector



Sources and Notes: See Figure 65 for detailed sources and notes.

The Advisory Board has explored four possible pathways to reverse the downward trend in the LULUCF sink: maintain and expand forests and wetland areas, increase the carbon sink in existing forests, reduce GHG emissions and increase removals in crop- and grasslands, and improve the resilience of ecosystems to current and projected climate change impacts. These solutions are not mutually exclusive, and a combination of all four might be required to achieve the required net removals in 2030 and beyond. The conclusions of the assessment for each pathway are summarised below.

The potential to maintain and expand the area of forests and wetlands is undermined by EU policies on agriculture and biofuels, which are driving land use for agricultural production.

Needs. Maintaining and expanding the area of forests and wetlands has substantial potential to increase the net sink in the LULUCF sector. Its potential is constrained by land availability, which is largely determined by demand for other competing land uses such as human settlements and agricultural production. More efficient spatial planning (see also Section 7.5), lower production of livestock products (which accounts for approximately 65 % of total agricultural land use), reduced food waste and lower production of biofuels made from feed and food crops are all enabling conditions that can reduce demand for these land uses and therefore increase the land available for carbon sequestration.

Gaps. Even if the total area of agricultural land in the EU has slightly decreased, several EU policies are putting upward pressure on demand for agricultural land, which undermines the potential to maintain and expand forest and wetland areas. As described in Chapter 8 'Agriculture', the current CAP continues to financially support livestock production **(policy inconsistency)**, which drives demand for land for feed production. Similarly, the CAP continues to financially support the cultivation of organic soils and marginal lands, which might be better suited to carbon sequestration **(policy inconsistency)**. The CAP does have a mandatory requirement to preserve wetlands (good agricultural and environmental condition (GAEC) 2), but over half of the EU Member States have opted to delay its implementation to 2024 or 2025. The CAP also allows support mechanisms (eco-schemes) for the restoration of wetlands, but these are used to only a limited extent by Member States **(implementation gap)**. The objectives of the Farm to Fork Strategy to reduce fertiliser use (by 20 %) and increase the share of organic farming (to 20 %) have direct local environmental benefits, but risk reducing yields and therefore increasing demand for land (either in the EU or abroad) if demand for agricultural products is not reduced in parallel **(policy gap)**. It also includes an ambitious (non-binding) objective to reduce food waste per capita by 50 % by 2030, but the proposed legal objectives under the Waste Framework Directive fall short of achieving this **(ambition gap)**. Finally, as described in Chapter 6 'Transport', EU biofuel policies continue to incentivise demand for specific biofuel types that drive demand for agricultural land **(policy inconsistency)**.

Recommendation L1. EU policies on agriculture and biofuels should better reflect the need to maintain and expand the area of forests and wetlands for carbon sequestration purposes. The upcoming revision of the CAP should reduce support for livestock production, which is a major driver of demand for agricultural land. Similarly, EU biofuel policies should cease to promote the use of biofuels with high ILUC risks, and in particular first-generation biofuels (see also Chapter 6 'Transport'). Finally, the EU should leverage its competence to support more efficient spatial planning at the (sub)national level (see also Section 7.5**Error! Reference source not found.**).

The carbon sink in EU forests is under pressure from multiple factors, including wood demand. To keep aggregate demand for biomass within sustainable limits while ensuring sufficient supply, incentives for bioenergy use should be better targeted towards end use sectors with limited other mitigation options.

Needs. The decline in the EU forest carbon sink is driven by several, interlinked factors including forest age, climate change impacts and harvesting practices (which affect carbon sequestration both in living biomass and in forest soils). There is an ongoing scientific debate on the role of EU biomass policies in driving the observed decline in the carbon sink (through increased harvesting), and the climate mitigation impact of (forest) biomass use in general. This impact strongly depends on the source and end use of forest biomass, but there is also a need to limit the aggregate demand to the sustainably available supply of forest biomass.

Gaps. Subsequent revisions of the Renewable Energy Directive have made incentives for biomass use for energy conditional on increasingly stringent sustainability criteria, minimum GHG savings thresholds and adherence to the cascading principle. Furthermore, the incentives for bioenergy use are expected to be counterbalanced by the incentive coming from the LULUCF Regulation, and Member States will have to report on the compatibility of their bioenergy policies with their targets under the LULUCF Regulation. Nevertheless, some reasons for concern remain. Firstly, specific exemptions **(ambition gap)** and monitoring and compliance issues (including fraud) **(implementation gap)** risk undermining the effectiveness of the sustainability criteria and provisions on the cascading principle under the RED III. Secondly, so far, Member States have provided insufficient information for the European Commission to assess the compatibility between projected bioenergy demand and sustainably available supply **(implementation gap)**. Furthermore, the incentives for using forest biomass for energy purposes versus maximising the LULUCF carbon sink continue to be unevenly distributed in the absence of a financial incentive for land managers to reduce emissions and increase removals in the LULUCF sector **(policy gap)** (see also Chapter 10 'Pricing emissions and rewarding removals'). Finally, the aggregate demand for biomass is currently projected to (substantially) exceed sustainably available supply. As a result, the EU risks either increasing biomass harvesting levels beyond what is sustainable (thereby undermining the LULUCF net sink) or increasing the import of biomass from regions outside the EU (thereby exporting environmental pressures to outside the EU). This risk could be mitigated by better targeting incentives for biomass use to sectors that have limited other mitigation options. However, key EU policies such as the RED III ([1]) do not differentiate incentives for bioenergy use as a function of other available mitigation options for each end use **(policy gap)**.

Recommendation L2. EU policies should better target incentives for bioenergy use towards end uses with limited mitigation options, to reduce the risk that aggregate demand will exceed sustainably available supply.

Recommendation L3. The EU should start preparations now with the view to introduce a GHG pricing instrument in the LULUCF sector, as to provide a financial incentive for forest managers to reduce emissions and increase removals. This would counterbalance current price incentives for biomass use (see also Chapter 10 'Pricing emissions and rewarding removals').

The potential of reducing CO2 emissions and emission removals in other land use categories (mainly agricultural land) remains under-addressed by EU policies.

Needs. Reducing net CO_2 emissions in non-forest land use categories (e.g. through sustainable soil carbon management practices and agroforestry) can contribute to increasing the overall LULUCF net sink, which is particularly important given the challenges in increasing the forest carbon sink. Whereas net emissions from these non-forest land use categories have reduced by 24 % compared to 2005, they have partially rebounded in recent years. To be consistent with the European Commission's scenarios that underpin the 2030 – 55 % objective, their net emissions need to be reduced by 12 % by 2030 and 75 % by 2050 compared to 2021.

Gaps. The CAP is the strongest policy driver of agricultural land use decisions. It includes both mandatory (e.g. GAECs 1 and 2 on wetland and grassland preservation) and voluntary (e.g. eco-schemes to support 'carbon farming' ([2]) and agroforestry) provisions that aim to reduce emissions from and increase

([1]) The exception is electricity-only generation, which cannot receive new or renewed support except when used in specific just-transition regions with high dependence on solid fossil fuels, as a temporary measure in outermost regions and territories, or in combination with CCS.

([2]) See (EC, 2021u) for an overview of the different practices covered under this term.

emission removals in agricultural soils. However, there are reasons for concern about the effectiveness of these measures. The mandatory requirement on the maintenance of grasslands (GAEC 1) does not prevent agricultural practices that lead to high soil carbon emissions from grasslands **(ambition gap)**. Whereas most Member States have set targets on carbon storage in soil and biomass, only eight of them included voluntary eco-schemes to incentivise carbon farming, often with low levels of ambition **(implementation gap)**. The assessment result is more positive for agroforestry, with a majority of Member States supporting it either directly or indirectly under the CAP. However, the effectiveness of these national support schemes is still suboptimal owing to their limited scope (which relates to a more general concern about the expected effectiveness of eco-schemes; see also Chapter 8 'Agriculture') **(implementation gap)**.

The agriculture and LULUCF sectors are currently still excluded from the EU GHG-pricing regime, which also implies a lack of an overall financial incentive for farmers and land managers to enhance CDR **(policy gap)**. The Carbon Removal Certification Framework, which is currently under development, might create such an incentive, but only to the extent that it creates a voluntary market.

Recommendation L4. Overall, EU policies should provide stronger incentives to trigger emission reductions and removals in all land use categories, including agricultural soils. This could be achieved by making better use of the potential of the CAP, and by pricing GHG emissions and rewarding removals in the LULUCF sector (see also recommendation L3 above and Chapter 10 'Pricing emissions and rewarding removals'). The Advisory Board will publish a dedicated report on the topic of CDR in 2024, including more detailed recommendations on how they should be governed and incentivised at the EU level.

Climate adaptation is crucial to maintain and possibly even increase the net sink in the LULUCF sector. At the same time, even with increased adaptation efforts, the future of the net sink is uncertain.

Needs. The LULUCF sink is increasingly under pressure from natural disturbances, which are exacerbated by climate change, a trend that is projected to worsen in the future. This highlights the need for increased adaptation efforts, such as (in many places) shifting conifer monocultures to mixed-species or broadleaf forests. Such adaptation efforts might decrease the sink in the short term (as maladapted species are harvested) but would increase it in the future (as newly established trees grow and losses from natural disturbances are reduced). Furthermore, it highlights the need to account for uncertainty when relying on removals in the LULUCF sector to achieve overall climate objectives.

Gaps. The assumptions that underpin the LULUCF objective for 2030 did not account for the uncertain effects of climate change and related natural disturbances on the development of the sink **(policy gap)**. The European Climate Risk Assessment will include an assessment of the potential impacts of climate change on the forestry sector, which can provide a good knowledge basis for the future.

Recommendation L5. To cope with the uncertainties of climate change, the EU and its Member States should increase efforts on adaptation.

Recommendation L6. In parallel, the EU should develop a contingency strategy to manage the potential impacts of climate change on the LULUCF net sink. The contingency strategy should include an assessment of the potential development of the LULUCF sink under different climate change scenarios and explore the potential for further reductions in residual emissions or increases in technological emission removals to cope with a further decline in the LULUCF sink.

9.1 Scope and sectoral assessment framework

Scope

This chapter covers all GHG emissions and removals by the EU LULUCF sector, as reported to the UNFCCC under CRF category 4. It focuses particularly on emissions and removals by forests (afforestation, deforestation and forest management), which is by far the largest land use category in terms of net GHG removals, but also the main driver behind the observed decline in the net sink observed over the last decade (see Section 9.2 below). Emissions and GHG removals in other land use categories (crop-, grass-, wet- and peatlands) are also covered under this chapter, but in less detail. The Advisory Board will publish a separate, dedicated report on CDR in 2024, which will cover the topic in more detail, as well as the removal of CO_2 from the atmosphere through novel technologies such as BECCS and direct air carbon capture and storage (DACCS).

Emissions and removals in the LULUCF sector are governed by the LULUCF Regulation (EU, 2023j), which allocates binding targets to Member States. Each Member State will have to implement policies at the national level to achieve these objectives. If a Member State does not achieve its national objective, it can make use of several flexibilities set out in the regulation. Achieving the regulation's objective depends on policies to be defined by each Member State. The European Commission's assessment of the draft updated NECPs found that the majority of those draft updated do not show sufficient ambition and action on the LULUCF sector, with only very few Member States showing a concrete pathway to reach their national net removal targets (EC, 2023p). In aggregate, Member States' action in the sector would still lead to a gap of -40 to -50 Mt CO_2e compared to the 2030 target.

Whereas ambitious national action will be crucial for achieving the 2030 LULUCF objective, the policy consistency assessment in this chapter focuses on to what extent other EU policies facilitate or hamper the achievement of this objective.

Greenhouse gas emission reductions and removals required in the LULUCF sector to reach climate neutrality

Achieving overall climate neutrality requires a balance between anthropogenic GHG emissions ('residual emissions') and the removal of GHGs from the atmosphere. Currently, CDR in the LULUCF sector is the only available option to remove GHGs from the atmosphere at a large scale. In the future, this is expected to be complemented by CDR technologies such as BECCS and DACCS (IPCC, 2018).

The LULUCF sector in the EU is a net sink, removing 230 Mt CO_2e from the atmosphere in 2021 (EEA, 2023f). The EU has set a legally binding objective under the LULUCF Regulation to reach an annual net sink of 310 Mt CO_2 by 2030 (EU, 2023j). The impact assessment for that regulation states that, in order to achieve overall climate neutrality by 2050, net removals in the LULUCF sector should increase to 400 Mt CO_2e by 2050 (EC, 2021r). This corresponds to the 400 Mt CO_2e upper limit of the range of GHG removals in the LULUCF considered to be feasible under the Advisory Board's advice on the EU's 2040 reduction objective (ESABCC, 2023b), considering future impacts of climate change. Under those scenarios where net reductions reach 90–95 % by 2040, the LULUCF sink increases to approximately 300 Mt CO_2e by 2030, with a slight further increase by 2040 (325 Mt CO_2e), after which it levels off by 2050.

Assessment framework for the LULUCF sector

The following building blocks were identified to achieve the required net GHG removals in the LULUCF sector by 2050.

Outcomes. IPCC AR6 has identified several mitigation pathways (see mitigation levers below) that can reduce GHG emissions and increase GHG removals in forests and other ecosystems (IPCC, 2022a). Overall, these pathways aim to achieve either of the following goals, which have been selected as outcomes for the assessment in this chapter.

— **Maintain or expand the surface area of carbon-rich land use categories**, that is, land use categories with high carbon stocks or carbon sink ([3]) potential, primarily forests and wetlands.
— **Reduce emissions and increase emission removals** within each land use category.

Mitigation levers. To achieve these outcomes, five main levers were identified ([4]), which largely correspond to the main mitigation pathways included in Sections 7.4.2 and 7.4.3 of Working Group III's contribution to AR6 (IPCC, 2022a).

1. **Reducing deforestation and forest degradation** can reduce GHG emissions in the LULUCF sector on a short timescale (IPCC, 2022a). Whereas globally the highest potential lies in tropical forests, deforestation is still occurring in the EU-27 as well, causing approximately 30 Mt of CO_2e emissions each year (EEA, 2023h).
2. **Afforestation, reforestation and forest ecosystem restoration** can increase GHG emission removals. The level of emission removals per hectare is relatively low in the initial years, but then increases over time as trees start to grow. In the longer term, removals decrease again as forests reach maturity (EEA, 2023o).
3. **Avoiding conversion and degradation of wetlands and other organic soils** avoids high emissions per hectare on a short timescale, whereas **restoring** these land types can increase removals over a longer timescale (Humpenöder et al., 2020; IPCC, 2022a).
4. **Improved forest management** can increase the carbon stocks in existing managed forests, through a variety of practices such as longer rotations, less intensive harvests, continuous-cover forestry, change of species and provenances, and increasing resilience to avoid the risk of hazards (e.g. fires, windfall, pests and diseases) (IPCC, 2022a).
5. Certain agricultural practices can increase carbon sequestration on agricultural lands, both in the soil and in above-ground biomass. These include **sustainable agricultural soil management practices** (e.g. cover crops, reduced tillage, residue retention and improved water management) and **agroforestry** (the integration of woody vegetation on agricultural land used for grazing or crop production) (IPCC, 2022a; Kay et al., 2019; Sykes et al., 2020).

In addition to increasing the carbon stock in living biomass, some of the practices under levers 1, 2 and 4 can also increase carbon stocks in forest soils (see Box 5).

Enabling conditions. In addition, the following enablers were identified, which could support the various levers. This list is not exhaustive.

— The availability of land determines the potential for the expansion of land use categories with high carbon sequestration potential such as forests and wetlands (Searchinger et al., 2022b). It can be increased by **more efficient spatial planning** to reduce land take and urban sprawl (Metternicht,

([3]) A carbon stock is the total amount of carbon stored in an ecosystem, either in biomass or in soils. A carbon sink is the annual increase in the total carbon stock, in other words the amount of carbon that is removed from the atmosphere and added to the biosphere carbon stock in a certain year.

([4]) The conservation and restoration of grasslands is included as a mitigation pathway in the IPCC AR6, but not included as a mitigation lever in this chapter. This is because most of Europe's climate is suitable for forest ecosystems, which have a higher carbon sequestration potential than grasslands. Whereas reducing the conversion of grasslands to croplands can reduce emissions (and conversely the restoration of croplands to grasslands can increase removals), the conversion of crop- or grasslands to forests has an even higher GHG mitigation potential.

2018). Similarly, **reduced livestock production** (which require large amounts of land for feed production) (Leip et al., 2015) and **reduced food waste** (Philippidis et al., 2019) can reduce the area of land required for agricultural production.

— Keeping the **demand for biomass for GHG mitigation purposes** ([5]) **within sustainable limits** can support the mitigation levers in two ways. Keeping demand for woody biomass within sustainable limits avoids overharvesting of managed forests, which would lead to a decrease in the forest carbon sink (and even risking turning it into a source). Reduced demand for crops for biofuel production can reduce the land required for agricultural production, thereby increasing the land available for, for example, afforestation.
— **Price signals and financial incentives** can influence decisions on land use and land management (Kim and Langpap, 2015).
— **Enhancing climate adaptation/resilience** is key to maintaining the carbon stock and sink activity in EU forests and ecosystems, which are currently already under pressure from climate change impacts (Forzieri et al., 2022; Patacca et al., 2023). For example, the decrease in the forest carbon sink observed in recent years is partly due to natural disturbances such as pest outbreaks (bark beetles), storms and wildfires, all of which are projected to become more frequent and more intense as a result of climate change. Improving the resilience of forest and ecosystems against such disturbances can mitigate future carbon losses.

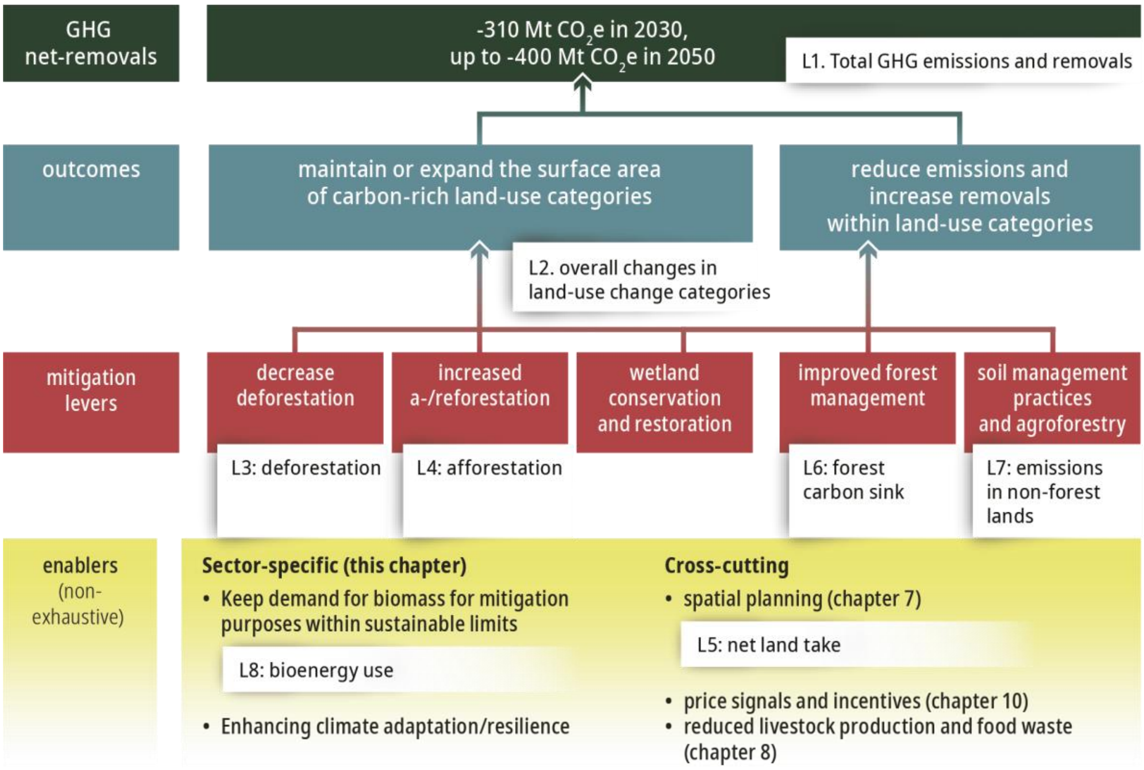
There are strong links between climate mitigation, climate adaptation, and biodiversity preservation and restoration. In most cases, there is potential for strong synergies. For example, maintaining and restoring carbon-rich ecosystems such as forests and wetlands contribute to climate mitigation, climate adaptation and biodiversity objectives. However, in some cases trade-offs might also occur; for example, rewetting afforested land might be beneficial from a nature and biodiversity perspective, but would reduce the carbon sink in the LULUCF sector. Although a detailed assessment of such potential synergies and trade-offs is beyond the scope of this report, it is important to taken them into account when developing policies affecting the LULUCF sector.

Finally, it is important to note that all land use categories are subject to carbon saturation, which means their potential to serve as a carbon sink will decrease over time and finally reach zero (EEA, 2023o). When this will occur depends on the type of land use, the point of departure and the specific measures taken to increase the carbon sink. From a policy perspective, this means that, whereas the LULUCF sector can contribute to climate neutrality by 2050, it cannot continue to offset residual emissions forever, and therefore provides only a temporary solution for residual emissions.

The assessment framework for the LULUCF sector – including the indicators selected to track progress for this sector (see white boxes) – are shown in Figure 64.

([5]) That is, demand for biomass to replace fossil fuels and feedstocks and other GHG-intensive materials.

Figure 64 Assessment framework for the LULUCF sector



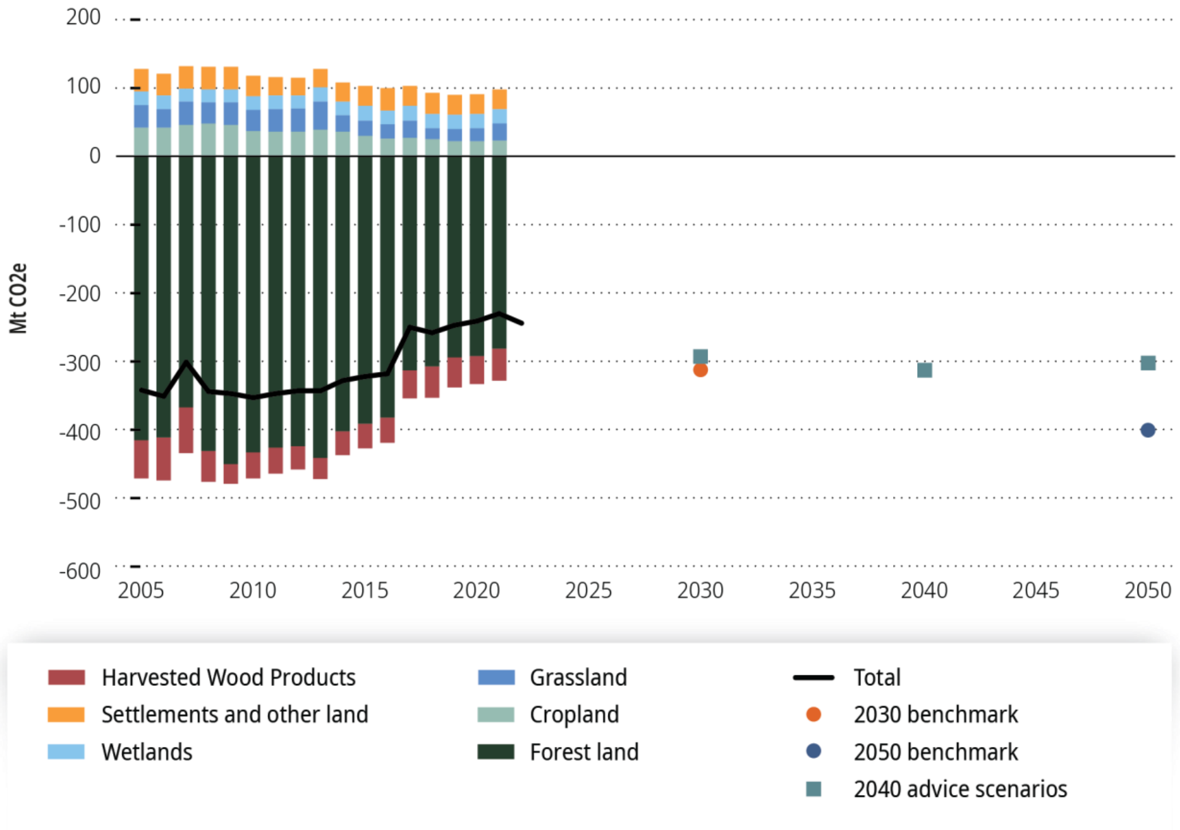
Source: Advisory Board (2024).

9.2 Emission reduction progress

As shown in Figure 65, the EU LULUCF sector is a net sink of GHG emissions, with gross emission removals in forest lands and in harvested wood products larger than the GHG emissions from other land use categories. However, after relative stability in 2005–2013, the net sink has been declining rapidly in the last 10 years, and in particular since 2016. By 2021, the total net sink had decreased by approximately one third (removing 112 Mt CO_2e less) compared to 2005. The reduction in the net sink was predominantly caused by a reduced carbon sink in EU forests (removing 134 Mt CO_2e less in 2021 than in 2005), which was driven by slower forest growth, natural disturbances and increased harvesting (see Figure 69 for more details). Proxy data for 2022 indicates a slight increase in the net sink compared to 2021.

The trend observed in the last decade would need to be reversed for the EU to meet the legally binding objective for 2030 (310 Mt CO_2e net removals). After 2030, the sink should be further increased to align with the European Commission scenarios underpinning the 2050 climate neutrality objective, and the scenarios underpinning the Advisory Board's advice on a 2040 reduction objective and the 2030–2050 GHG emission budget.

Figure 65 Indicator L1 – overall progress in reducing emissions (positive values) and increasing removals (negative values) in the LULUCF sector



Notes: Historic data from the EU GHG inventory, with 2022 data based on proxy data reported to the EEA. 2030 benchmark based on the legally binding objective under the LULUCF regulation, while 2050 benchmark based on the impact assessment accompanying the revised LULUCF regulation. 2040 advice values are based on the scenarios that underpin the Advisory Board's 2040 advice.

Sources: EU GHG inventory (EEA, 2023f), LULUCF regulation impact assessment (EC, 2021d), Advisory Board 2040 advice scenarios (ESABCC, 2023b).

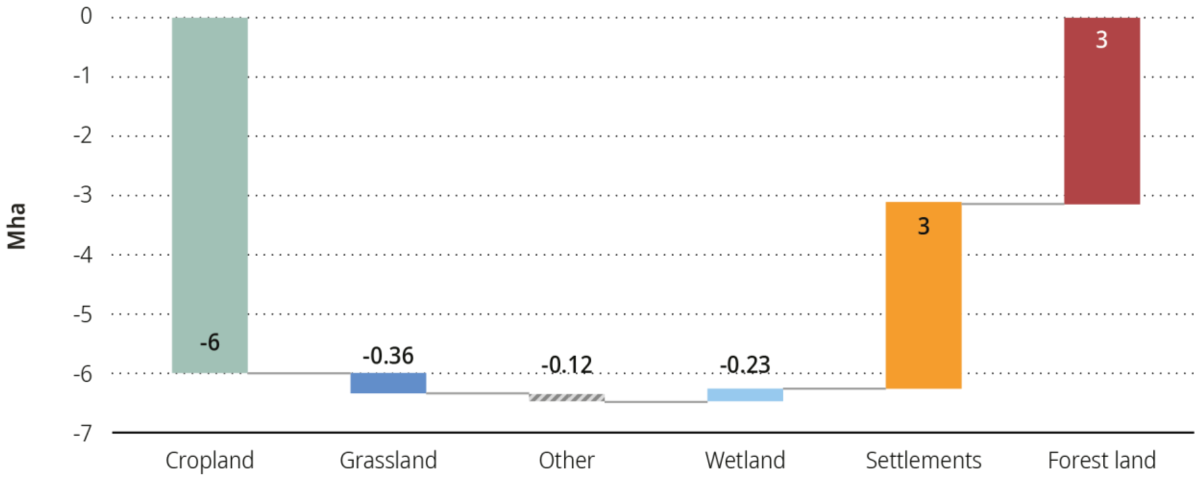
9.3 Outcome 1: maintained or expanded surface area of carbon-rich land use categories (forests and wetlands)

Progress on expanding forest and wetland areas

There have been limited changes in total area for each land use category since 2005.

As shown in Figure 66, there have been relatively limited changes in the total area for each land use category since 2005. The most noticeable change has been a decrease in cropland (– 6 million ha, or – 5 % compared to 2005) and an equal increase in settlements (+ 3 million ha, or + 13 % since 2005) and forest land (+ 3 million ha, or + 2 % compared to 2005). The area of wetlands has also increased, but to a lesser extent (+ 0.2 million ha, or + 1 % compared to 2005).

Figure 66 Indicator L2 – change in surface area per land use category (2021 compared with 2005)



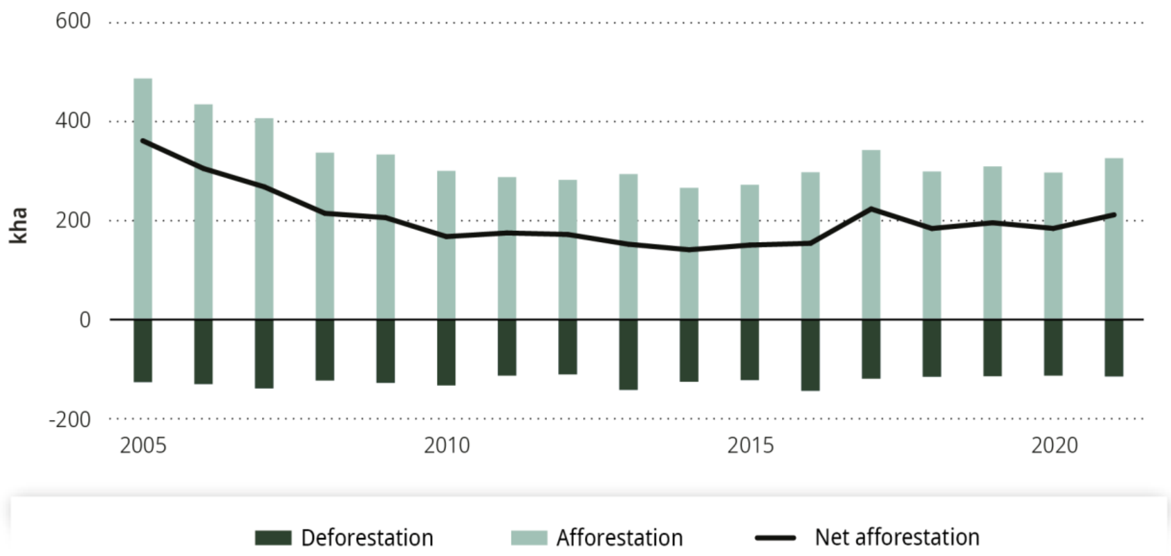
Notes: No benchmarks were found for 2030 or 2050.

Source: EU CRF tables (EEA, 2023h)

Net afforestation declined in 2005–2010 and has remained relatively stable since, driven by declining afforestation in combination with stable deforestation.

Whereas the total surface of forest land has increased since 2005, the rate at which it increased (the net afforestation rate) declined in 2005–2010 as a result of decreasing afforestation and stable deforestation, as shown in Figure 67. Both afforestation and deforestation have been relatively stable since.

Figure 67 Indicators L3 and L4 – afforestation and deforestation in the EU



Notes: No benchmarks were found for 2030 or 2050

Source: EU CRF tables (EEA, 2023h)

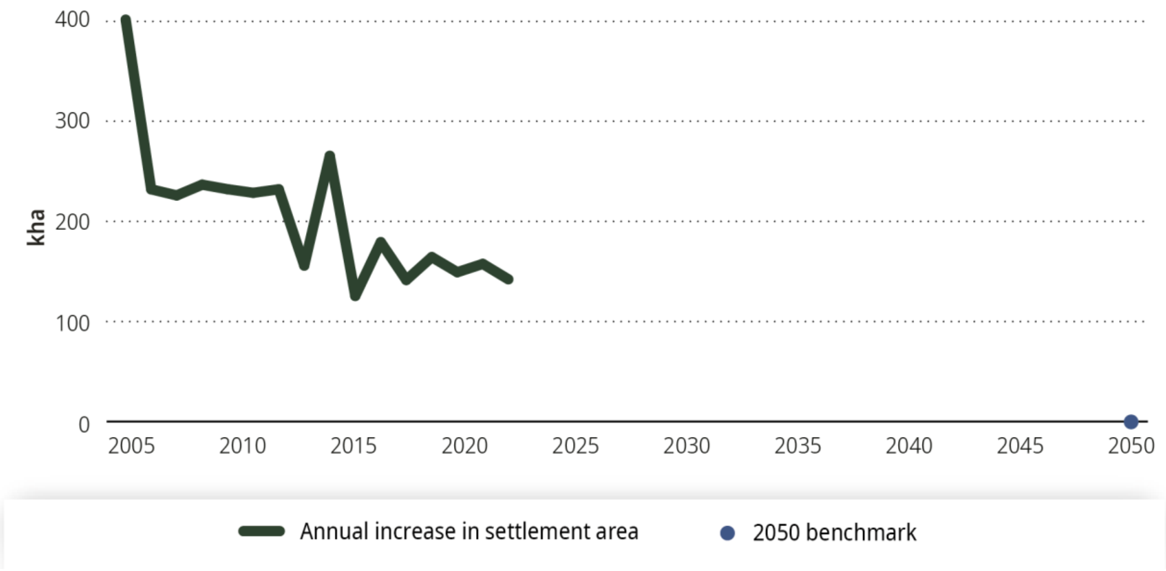
The EU Biodiversity Strategy includes a pledge to plant 3 billion additional trees by 2030, for which a roadmap was included under the Forest Strategy (EC, 2021n, 2020e). To achieve this objective, the EU would need to plant on average 333 million additional trees per year in 2022–2030. However, 2 years after the pledge only 12.5 million additional trees have been reported as planted, which is far below the required rate (EEA, forthcoming). The Advisory Board has not been able to assess whether this low figure is due to lack of planting or lack of reporting. Furthermore, even if the objective is achieved, it will only make a modest contribution to the LULUCF sink, generating 15 Mt CO_2e of additional removals by 2050 (Korosuo et al., 2023).

A faster reduction of deforestation would be a quick win to increase the LULUCF carbon sink in the short term, whereas increased afforestation increases the carbon sink gradually over time, as it takes time for young forests to sequester carbon (Korosuo et al., 2023). About half of the deforestation observed in 2005–2021 is driven by the expansion of settlements (EEA, 2023h). Decreasing net land take (see indicator L5) could therefore be expected to contribute to decreasing deforestation.

The decrease in net land take for settlements has slowed down in recent years.

As shown in Figure 68, the total surface of settlement area increased by 13 % in 2005–2021, but the rate at which it did so fell between 2005 and 2017 (EEA, 2023h). However, since then the rate has been relatively stable. The downward trend over the longer term needs to be continued to put the EU on track towards achieving no net land take by 2050, in accordance with the ambition of the 7th Environmental Action Programme (EU, 2013a). An even faster decrease could support the overall LULUCF objective by reducing deforestation (see indicator L4 in Figure 67) and increase the surface land available for carbon sequestration.

Figure 68 Indicator L5 – annual increase in settlement area (as proxy for net land take)



Sources: EU CRF Tables (EEA, 2023h) (historic), 7th Environment Action Programme (EU, 2013a) (benchmark)

Consistency of EU policies

EU policies are driving land use for agricultural production, thereby reducing the potential for maintaining and expanding forests and wetlands.

Section 9.1 identified several enabling conditions that could reduce the demand for land for settlements and agricultural production, thereby reducing pressure on carbon-rich land use categories and increasing the amount of land available for their expansion.

Whereas spatial planning is predominantly a (sub)national competence, there are some areas where EU policies can facilitate more efficient spatial planning, which could, among other effects, reduce land demand for human settlements. These are further discussed in Section 7.5.

The EU has more competences in other areas such as agriculture, transport and energy, which could be used to limit land for agricultural production (including for biofuel crops) and therefore increase the amount of land available for carbon sequestration. However, as further detailed below, there are some EU policies in these policy domains that put upward pressure on land demand for agricultural production.

For example, livestock production is particularly land-intensive: animal feed accounts for 61 % of the EU's total cereal production (EEA, 2023o), and livestock systems (including feed production) occupy around 65 % of total agricultural land (or 28 % of the EU's total land surface) (Leip et al., 2015). Reducing livestock production would not only reduce emissions directly (less GHG emissions from enteric fermentation and manure) and indirectly (less fertiliser use for feed crop production) but could also free up substantial amounts of land that could be used for carbon sequestration (e.g. afforestation). However, there are few EU policies in place that aim to reduce demand for livestock products, and the current CAP continues to financially support livestock production (see also Chapter 8 'Agriculture').

The CAP does include a number of provisions to maintain and increase the area of grass-, wet- and peatlands (EU, 2021d). Firstly, the minimum environmental requirements under the CAP include the mandatory requirement to maintain permanent grassland (GAEC 1) and the protection of wet- and peatlands (GAEC 2). Secondly, Member States can (financially) support the rewetting of wet- and peatlands, and the establishment, maintenance and extensive use of grasslands, through eco-schemes and agri-environmental measures. However, there are several elements of the CAP that undermine its effectiveness at expanding or even maintaining the area of carbon-rich land use categories. Firstly, the overall approach of the CAP is to provide payments per hectare of land cultivated. This approach incentivises farmers to continue to cultivate organic soils, which causes high CO_2 emissions, and to cultivate less productive land, which might be more suitable for afforestation and the restoration of grasslands and wetlands (EEA, 2022h). Furthermore, the majority of EU Member States have chosen to delay the implementation of GAEC 2 (on the conservation of peatlands) to 2024 or 2025 (EC, 2022aa). Finally, some peatland-rich Member States have not included any voluntary support schemes for rewetting peatlands, and in those that have done so the schemes are not expected to lead to substantial changes in land management practices (Birdlife Europe and EEB, 2022; Midler et al., 2023).

As further described in Chapter 8 'Agriculture', the Farm to Fork Strategy includes a range of objectives to reduce local environmental pressures from agricultural production, such as increasing the share of organic farming and reducing the use of mineral fertilisers. However, whereas such measures can reduce environmental impacts (including GHG emissions) locally, they are also expected to result in lower yields (JRC, 2021b). Therefore, unless they are complemented by policies to reduce demand for agricultural products (which are largely missing regarding reduced livestock consumption; see Chapter 8 'Agriculture'), they risk increasing overall land demand for agricultural production either in the EU or abroad.

Finally, EU policies in the domain of transport fuels continue to incentivise the demand for (and therefore production of) crop-based biofuels, which contribute further to land demand for agricultural production (see also Section 6.4, under 'Lever: fuel switches', and Section 8.5, under 'Lever: minimise demand for biofuel crops').

Even if there has been a slight decline in the total area of croplands in the EU (– 5 % since 2005; see Figure 66), the abovementioned policies put upward pressure on the area of land required for agricultural production. Changes to these policies could reduce this pressure, freeing up larger areas of land available for carbon sequestration through afforestation/reforestation and wetland restoration.

9.4 Outcome 2: reduced emissions / increased removals within land use categories

Progress on increasing removals in EU forests

Despite the increasing forest area, the net carbon sink in EU forests is declining. The decline needs to be reversed to be consistent with the scenarios underpinning the EU climate objectives.

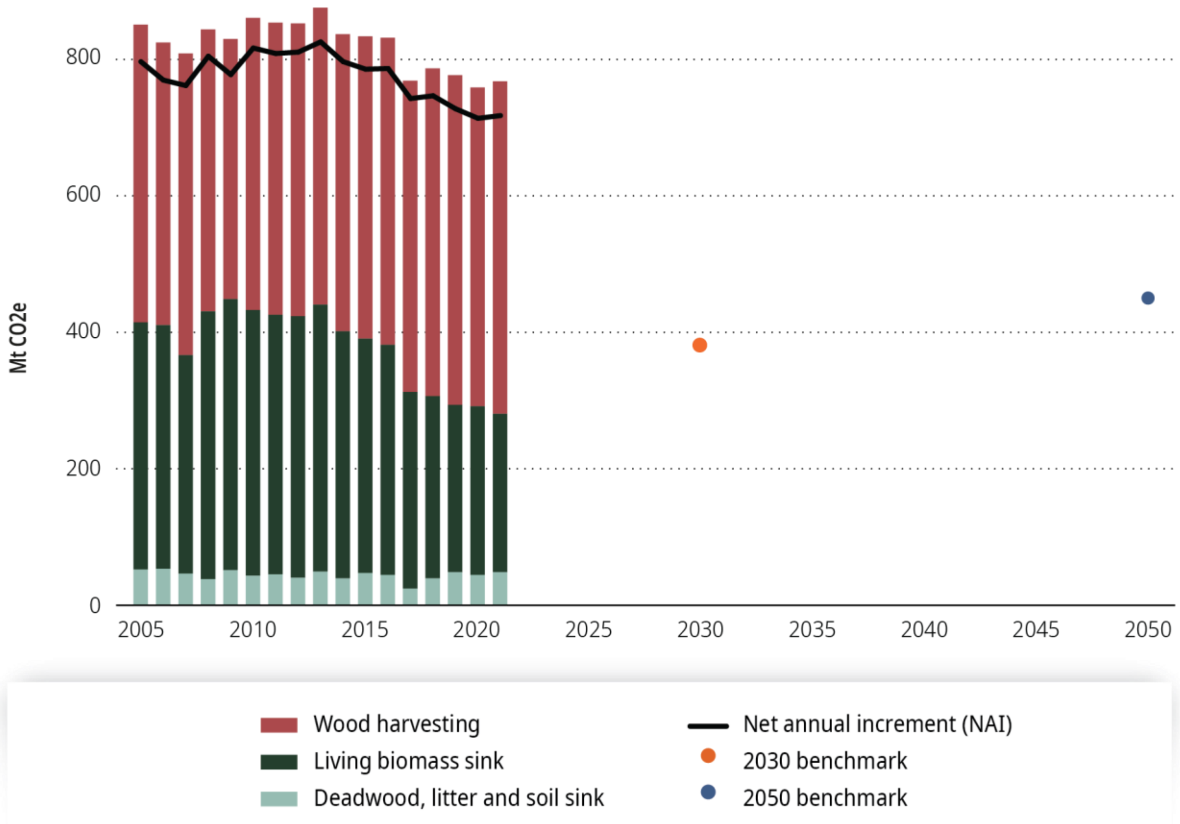
Despite the net afforestation occurring in the EU (see indicators L3 and L4 in Figure 67), the forest carbon sink has been declining rapidly, primarily because of a slowing down of the annual growth in living biomass which accounts for > 80 % of the total forest carbon sink (see Figure 69). In the last 5 years, the net carbon sink in forests declined by on average 8 Mt CO_2e per year. This trend would need to be reversed to be consistent with the scenarios underpinning the EU climate objectives. Under the MIX scenario of the Climate Target Plan, the forest carbon sink would need to increase to 380 Mt CO_2e by 2030 and 450 Mt CO_2e by 2050.

Box 5 The role of forest soils in the carbon sink and stock

As shown in Figure 69, growth in living biomass accounts for the large majority (between 80 % and 90 % in 2005–2021) of the total forest carbon sink, with deadwood, litter and soils accounting for the remaining 10–20 %. However, forest soils represent the largest carbon stock in forests, with a total carbon content estimated to be 2.5 times larger than the carbon stock in tree biomass (see footnote 3 for the difference between the carbon sink and the carbon stock) (De Vos et al., 2015). Furthermore, the role of forest soils as a carbon sink and stock can be further increased through forest management practices.

The French National Research Institute for Agriculture, Food and Environment launched a study (Augusto and Boča, 2022) to identify the characteristics of forests that would optimise carbon sequestration in soils. It found that it is important to have a significant amount of tree biomass in forests, which would produce a lot of debris (leaves, needles and dead roots) that contributes to the carbon stock in the soil. Furthermore, forests made up of a mixture of two species can store more carbon than forests with a single species, provided that the mixed forests grow faster than the single-species ones. But it is the characteristics of the dominant tree species in combination with the climate zone and soil type that most control the capacity of forests to store carbon in soils. Even though some questions remain to be further explored in more detail, the results of the study show that encouraging a significant biomass of trees, through extensive management or a mixture of species, is a practice that should be encouraged provided that the environmental risks to which the forest is exposed are carefully assessed (fires, drought, etc.). Above all, it is important to choose the species of trees carefully, favouring species ecologically adapted to the climate and soil of the region where they are planted.

Figure 69 Indicator L6 – changes in the forest carbon sink



Notes: Wood harvesting data converted from m[3] to Mt CO_2e based on standard conversion factors. The Net Annual Increment was approximated as the sum of the forest carbon sink and wood harvesting. 2030 and 2050 benchmarks are based on the MIX scenario from the Climate Target Plan impact assessment.

Sources: EU GHG inventory (EEA, 2023h). FAO Statistics on Forestry Production and Trade (2020), Climate Target Plan impact assessment (EC, 2020s) (Figure 10).

The decline in the forest carbon sink is driven by multiple, interlinked drivers, including forest age, biomass demand and climate change impacts.

Forests have long production cycles (from 15 to more than 250 years), which means that changes in the forest sink over a few years could be (but are not necessarily) compatible with long-term sustainable forest management. The observed decline in the carbon sink in the last 10 years is caused by several underlying trends, including a slowdown in net afforestation (see indicators L3 and L4 in Figure 67 above), a decrease in gross annual increment (that is, forest biomass growth before taking into account natural mortality and harvesting), increased mortality (worsened by natural disturbances) and increased harvesting (Korosuo et al., 2023). This is also illustrated in Figure 69, which shows a declining net annual increment (NAI) ([6]) since 2013, and an increase in wood harvesting. These trends are driven by multiple, interlinked drivers.

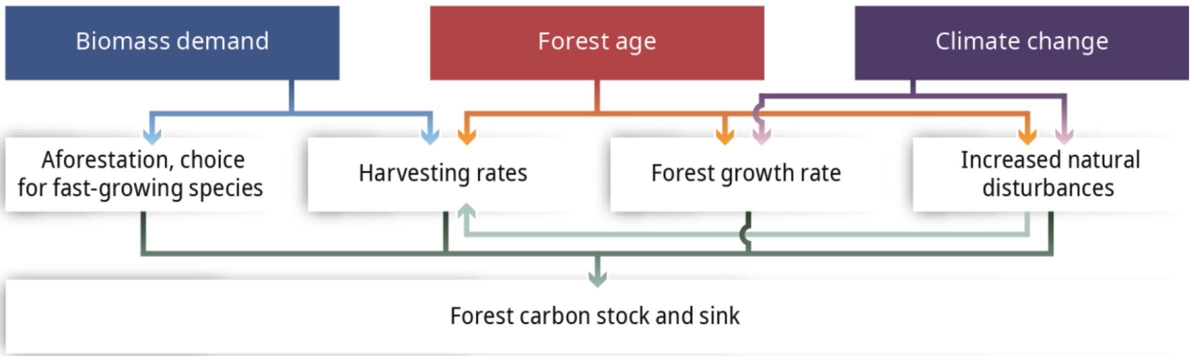
([6]) The NAI is defined as the gross annual increment (gross forest growth) minus the natural mortality. Part of the NAI is harvested; the remaining biomass growth represents the net carbon sink. See Figure 2 in (Korosuo et al., 2023) for more details. Natural disturbances have an impact on both natural mortality (e.g. if a tree is burned in a wildfire) and harvesting

— **Forest age** determines the forest growth rate (EEA, 2023o). Trees grow slowly when they are young, resulting in a small annual carbon sink. The growth rate then accelerates as they grow older (which increases the carbon sink), after which it starts to slow down again as the tree reaches maturity. As a result, the average age of a forest determines the forest growth rate and consequently the carbon sink. Furthermore, forest age also influences harvesting rates, as forest managers are likely to harvest trees when they reach a certain size. Finally, forests with older trees are also more vulnerable to natural disturbances, which could result in carbon stock losses and related emissions both directly and indirectly (see Figure 70). As forests in the EU do not have even age structures, there will be fluctuations in the carbon stock and sink, even if management and growth conditions are unchanged.

— **Biomass demand** is a driver of harvesting rates (De Oliveira Garcia et al., 2018), and increased biomass demand could therefore lead to a net decrease in the forest carbon sink and even a net decrease in the carbon stock (in which case it would result in net emissions). On the other hand, it is argued by some that biomass demand could also incentivise afforestation and forest management practices that improve forest productivity, which would increase the carbon sink (Berndes et al., 2022), although other research found no or only weak evidence to support this claim (Giuntoli and Searle, 2019). It is also suggested that biomass supply could be increased through forest management practices without affecting long-term carbon storage (Gylling et al., 2023) but, again, the aggregate effect necessarily depends on the specifics.

— **Climate change** is expected to increase the frequency and intensity of natural disturbances that undermine the sink potential of EU forests either directly (increased mortality) or indirectly (increased sanitary or salvage logging) (Korosuo et al., 2023; Seidl et al., 2017). Forest management practices to adapt forests to projected climate change impacts can increase resilience against such disturbances but might require increased harvesting in the shorter term (see also Section 9.5 for more details).

Figure 70 Overview of drivers affecting the forest carbon sink and carbon stock



Source: Advisory Board (2024).

Increasing the forest carbon sink is possible only by reducing the share of the NAI that is harvested, either by increasing the NAI more than the increase in harvested woody biomass or by decreasing harvesting compared with the NAI. This would require more effort than the traditional concept of sustainable forest management, which is understood as ensuring that harvesting does not exceed the NAI (Korosuo et al., 2023).

(when a tree is cut for sanitary or salvage purposes). There is an inverse correlation between natural mortality and harvesting, as the non-harvesting of trees will eventually increase natural mortality and vice versa. In its assessment, the Advisory Board has assumed a constant natural mortality for simplicity.

Consistency of EU policies with the aim of increasing the forest carbon sink

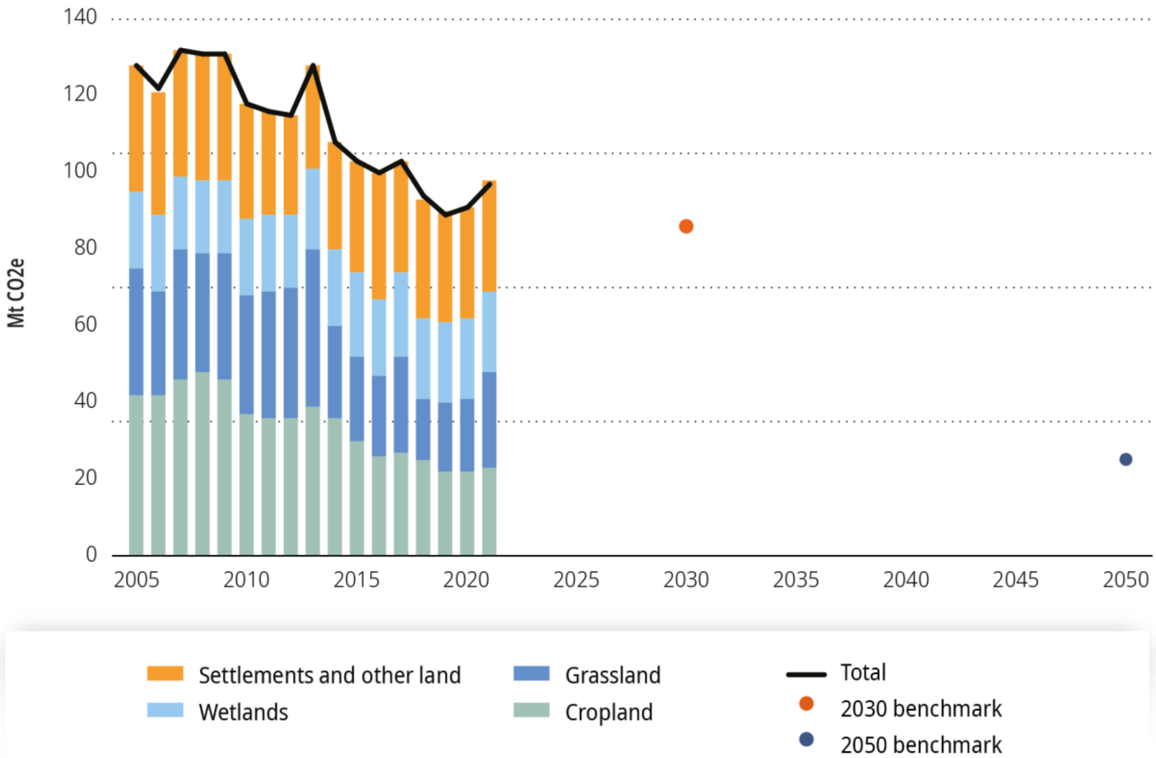
The observed decrease in the forest carbon sink has been linked to EU bioenergy policies and the increasing occurrence of natural disturbances, exacerbated by climate change. These topics – including the role of EU policies – are assessed in more detail in Section 9.5 below, as they are relevant to the overall LULUCF sector.

Progress on reducing emissions and increasing removals in other land use categories

Net emissions are decreasing, but the pace needs to double beyond 2030.

Although forests make up the largest share of the LULUCF sector, reducing net emissions in other land use categories can contribute to enhancing the overall sink. Between 2005 and 2021, net GHG emissions in these other land use categories decreased by 24 %, as shown in Figure 71. This was mainly achieved by reductions of soil carbon emissions in croplands (– 46 %, – 19 Mt CO_2e), grasslands (– 23 %, – 8 Mt CO_2e) and settlements (– 14 %, – 5 Mt CO_2e), whereas emissions from wetlands increased slightly (+ 5 %, + 1 Mt CO_2e). However, reported data show a rebound in emissions in recent years. The average pace of reductions in the last 5 years (1.5 Mt CO_2e) would need to be maintained until 2030, and then double (to 3 Mt CO_2e per year) to be consistent with the European Commission scenarios underpinning the EU climate objectives.

Figure 71 Indicator L7 – net GHG emissions in non-forest land use categories



Notes: 2030 and 2050 benchmarks are based on the MIX scenario from the Climate Target Plan impact assessment.

Sources: EU GHG inventory (EEA, 2023h), Climate Target Plan impact assessment (EC, 2020s) (Figure 10).

Consistency of EU policies with the aim of reducing emissions from other land use categories

The EU has few policies to incentivise carbon sequestration in crop- and grasslands.

Whereas there are several agricultural practices to enhance carbon sequestration in crop- and grasslands, there are currently only a few EU policies to incentivise this. The CAP does allow Member

States to support such measures under eco-schemes, but only eight Member States have chosen to do so (EC, 2022aa). Furthermore, permanent grasslands are defined in such a way that the mandatory requirement on the maintenance of permanent grasslands (GAEC 1) does not prevent ploughing and tilling, which are agricultural practices that lead to high soil carbon emissions from grasslands. Regarding agroforestry, some positive policy developments can be observed compared with the pre-2020 CAP. From 2007 to 2020, direct payments under the CAP were conditional on a maximum tree density (50 trees/ha in 2007–2013, 100 trees/ha in 2014–2020), which incentivised farmers to remove trees from arable land in order to receive such payments. This condition was removed in the CAP after 2020, which is positive for the promotion of agroforestry (Mosquera-Losada et al., 2023). Furthermore, the amount of national support schemes for agroforestry under the CAP has also increased. In 2007–2013, only five Member States supported agroforestry under the CAP, which increased slightly to eight Member States in 2014–2020. Under the latest CAP, 17 Member States have included eco-schemes to support agroforestry in their CSPs, either directly (4 Member States) or indirectly through support for landscape features (13 Member States), making it one of the most widely employed schemes (Buratti-Donham et al., 2023). Nevertheless, some room for improvement remains, as the national support schemes do not cover all types of agroforestry or support all phases (preservation of traditional systems, implementation of new systems and management of those new systems) (Buratti-Donham et al., 2023; Mosquera-Losada et al., 2023).

Furthermore, there is currently no (financial) incentive at the EU level for the agriculture and LULUCF sectors to enhance CDR. The European Commission recently took initiatives to start addressing this gap, including a proposal for a Union certification framework for carbon removals (EC, 2022w), and steps to explore the possibility of establishing a mandatory, separate emissions trading system for GHG emissions and removals in the land sector (EC, 2023bd). Both initiatives are described in more detail in Section 10.6.

The Advisory Board’s upcoming report on CDR will provide a more detailed assessment and policy recommendations to enhance CDR, including in agricultural soils.

9.5 Enabling conditions

Keep biomass demand within sustainable limits

Biomass use can be an important mitigation lever, but can also have a negative impact on ecosystems, including on the net sink in the LULUCF sector.

According to IPCC AR6 (IPCC, 2022g), biomass has the potential to be a high-value and large-scale mitigation option, and could be particularly valuable for sectors with limited alternatives to fossil fuels (e.g. aviation, energy-intensive industry), for the production of chemicals and other products, and, potentially, in CDR by means of BECCS or biochar. However, the long-term role of bioenergy in low-carbon energy systems is uncertain because of sustainability concerns about traditional biomass and first-generation biofuels – which can have far-reaching impacts on food production, forestry, water use, land use and overall ecosystems – and cost-effectiveness concerns about more advanced biofuels.

In line with the IPCC guidelines for GHG inventories (IPCC, 2006), when biomass is harvested this is counted as an emission under the LULUCF sector. When the harvested biomass is then combusted for energy purposes, it is ‘zero-rated’, meaning that it is assigned an emission factor of zero, although biogenic GHG emissions are still reported as a memo item. This means that, whereas bioenergy can contribute to GHG emissions in other sectors, it can at the same time undermine the sink in the LULUCF sector (and thus achievement of the LULUCF objective). This is less of a risk when the harvested biomass is used as a material instead of being combusted (in which case it is reported as a sink under the harvested wood product” category) or when bioenergy is combined with CCS (BECCS, in which case it should be accounted as a removal under CRF category I.C).

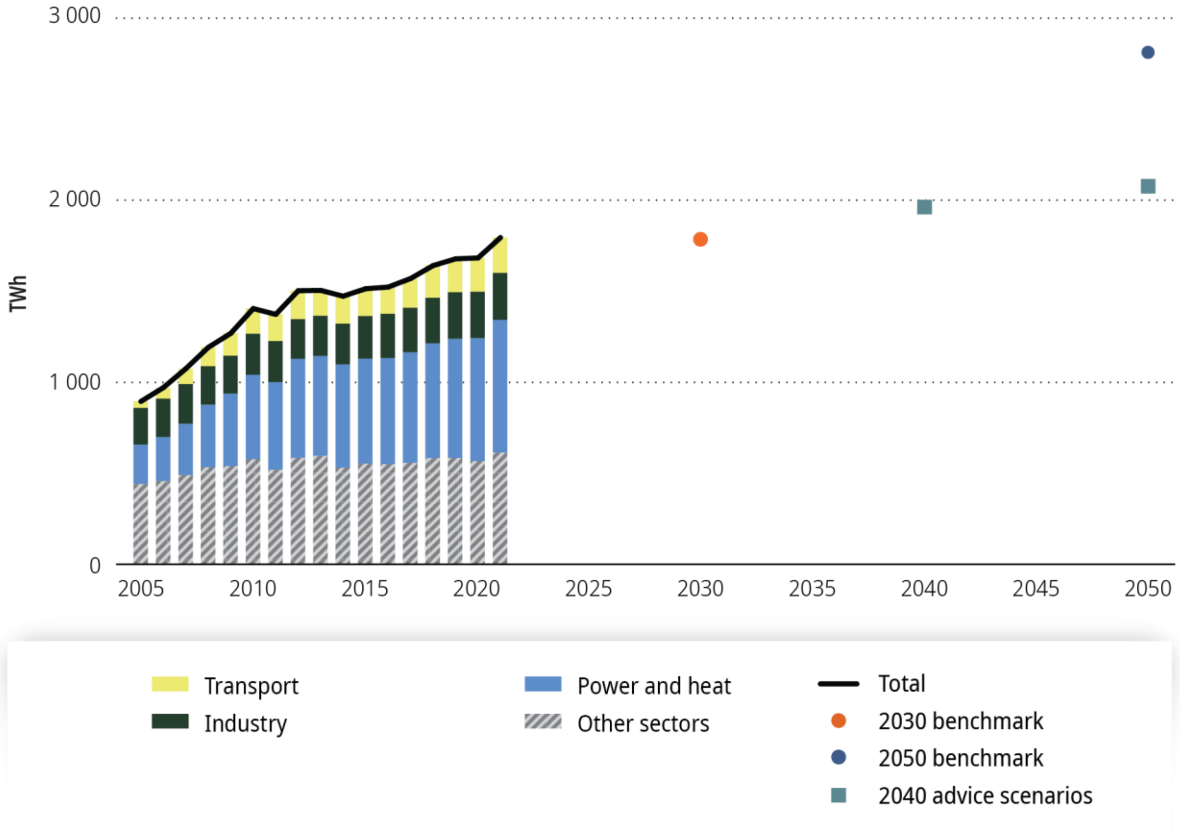
Bioenergy use in the EU has doubled since 2005 and is projected to more than double again by 2050 under the European Commission’s decarbonisation scenarios.

The EU started to promote the use of biofuels in the electricity and transport sectors in the early 2000s (EU, 2001, 2003), and has continued to do so under the renewable energy directives, the EU ETS and the ESR.

Since 2005, bioenergy use has doubled from about 900 TWh in 2005 to 1 800 TWh in 2021 (see Figure 72). This was mainly driven by increased use for electricity and heat production (+ 512 TWh) and in ‘other sectors’ (mainly building heating, + 178 TWh), followed by the transport (+ 158 TWh) and industry sectors (+ 55 TWh). Based on the most recent data (2021), it is mainly used as input for electricity and heat production (41 %), followed by building heating (34 %), transport (14 %) and industry (11 %). Bioenergy is the main source of all renewable energy in the EU, accounting for 59 % of all renewable energy use in 2021 (EC, 2023bh).

As shown in Figure 72, the European Commission’s scenarios underpinning the EU climate objectives assumed that bioenergy use could increase by 10 % between 2015 and 2030. However, in reality this increase was already exceeded in 2021. After 2030, the scenarios assumed, bioenergy use would again increase substantially, to double by 2050 compared with 2030, driven mainly by increased use in the power and heat sector combined with CCS (about 500 TWh more than in 2021) and in the transport sector (about 325 TWh more than in 2021, mainly for aviation and maritime transport). The total bioenergy use by 2050 under the European Commission’s scenarios (> 2 800 TWh) would exceed the 20 EJ (or 2 500 TWh) ‘ high feasibility’ threshold used for the Advisory Board’s advice on the 2040 target (which is based on the High availability scenario from Ruiz et al (2019)).

Figure 72 Indicator L8 - bioenergy use



Notes: Historic data refers to final energy use in the industry, transport and other sectors, and transformation input for the power and heat sector. The "other sectors" is primarily dominated by residential buildings (ca. 85% of "other sectors'" bioenergy use in 2021), but also includes the tertiary and agriculture sector. 2030 and 2050 benchmarks are based on the MIX scenario of the Climate Target Plan impact assessment. 2040 advice range refers to the average bioenergy use in the scenarios which underpin the Advisory Board's advice for a 90-95% emissions reduction by 2040.

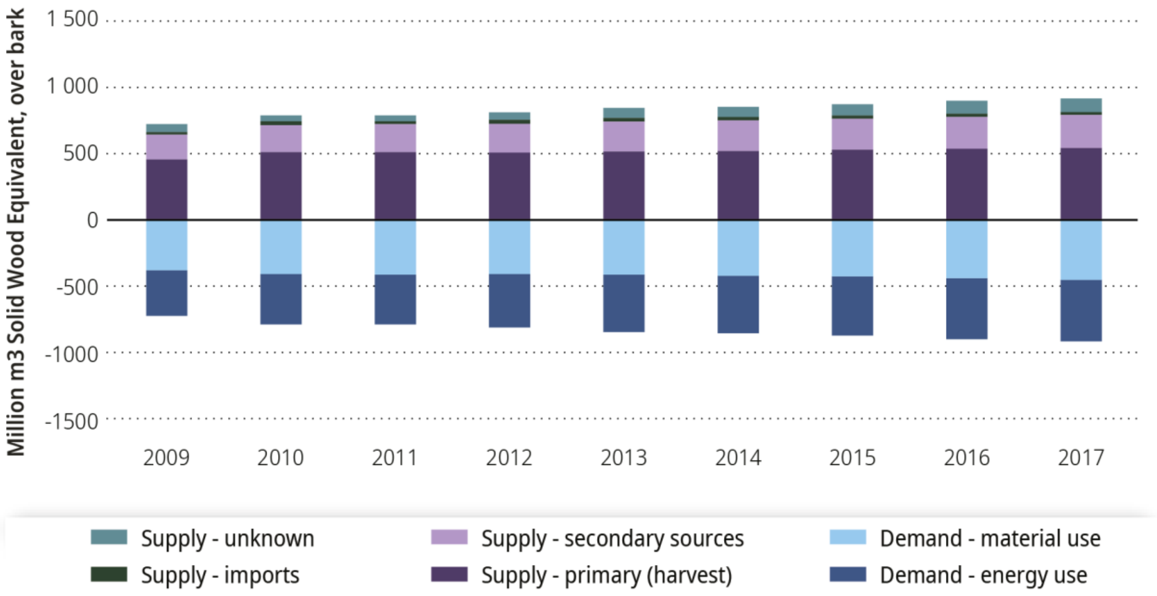
Sources: Eurostat energy balances (2023b), Climate Target Plan impact assessment (EC, 2020s) (Figure 77), Advisory Board 2040 advice scenarios (ESABCC, 2023b).

The increase in bioenergy contributed to an increase in forest biomass demand. At least 45 % of the increased forest biomass demand was met by increased harvesting.

The JRC has published data on woody biomass supply and demand for 2009 until 2017 (JRC, 2022b), which is shown in Figure 73. In that period, demand for woody biomass increased by more than 25 % (193 million m^3), primarily owing to an increase in demand for energy use (121 million m^3). At least 45 % of the increased demand in 2009–2017 was met by increased harvesting, with another 22 % being met through additional supply from unknown sources (which could also include harvesting). Only one third of the additional demand is known to have been met from additional secondary supply, which includes residues from wood-processing industries and post-consumer wood. The available data therefore shows a correlation between increased demand for woody biomass – primarily for energy purposes – and an increase in harvesting, which in its turn has contributed to the reduction of the forest carbon sink (see indicator L6 in Figure 69).

Whereas the JRC data covers only the period up to 2017, UN FAO data indicates that harvesting continued to increase, with volumes 8 % higher in 2021 than in 2017 (FAO, 2020). Similarly, Eurostat data indicates that the consumption of solid primary biofuels have increased with an additional 13 % by 2021 compared to 2017 (Eurostat, 2023b).

Figure 73 Supply (shown as positive values) and demand (shown as negative values) for woody biomass



Source: Wood Resource Balances (JRC, 2022b)

The scientific debate on the consistency of EU bioenergy policies with the EU's overall climate objectives is ongoing.

There is an ongoing debate about the role of EU biomass policies in driving the observed decline in the LULUCF carbon sink (in particular in the forest carbon sink), and the mitigation impact of bioenergy in general. The most critical voices within the scientific community (see e.g. EASAC 2017; Blattert et al. 2023; Norton et al. 2019; Searchinger et al. 2022; Brack 2017) argue that the promotion of bioenergy by EU policies is the main culprit of the decreasing carbon sink and will put the EU climate targets for 2030 and 2050 out of reach. They argue that the use of primary woody biomass for energy production often increases atmospheric GHG concentrations in the short to medium term, and it can take up to decades or even centuries before it has a net mitigation effect. Finally, they have also warned that the promotion of bioenergy puts the EU biodiversity targets at risk. They have therefore called for a halt to policy support for the use of bioenergy from primary woody biomass, including stepping away from the zero-rating approach for bioenergy.

On the other side of the debate, there are scientific researchers who are more supportive of the promotion of bioenergy (see e.g. Berndes, Cowie, and Pelkmans 2022; Berndes et al. 2016). They emphasise that, in many cases, bioenergy can already make a substantial net contribution to climate mitigation in the short term and will continue to be necessary for the EU to achieve its climate objectives for 2030 and 2050. Their main arguments are that bioenergy often uses waste streams from value chains that use biomass as material in which carbon is stored for a longer time (e.g. sawnwood, pulp and paper). Furthermore, they point out that forest management has a greater climate benefit than forest conservation, as regular harvesting and replanting of trees contributes to maintaining the forest carbon sink in the longer term, whereas the sink would saturate over time under the conservation approach. Related to this, they argue it is more appropriate to assess the mitigation impacts of forest harvesting at the landscape level instead of at the level of a specific forest stand, as under sustainable management practices it is appropriate to harvest specific forests stands when the trees reach maturity. Furthermore, they counter-argue that bioenergy use is in fact not zero-rated in GHG inventories, as the emissions are counted in the LULUCF sector, and that counting emissions at the point of combustion would therefore result in double counting. Finally, harvesting might also be appropriate from a climate adaptation perspective, for example to replace maladapted species, to reduce the amount of biomass at risk of being lost in natural disturbances or to remove wood after such disturbances (Korosuo et al., 2023).

It is highly likely that a trade-off is needed between, on the one hand, maintaining/increasing forest harvesting and biomass supply and, on the other, maintaining/increasing the forest carbon sink.

In an ideal world, the EU would be able to increase the net emissions sink in forests, while maintaining or even increasing current harvesting levels to supply other sectors with forest biomass to substitute for fossil fuels and other GHG-intensive materials. This would require the NAI in EU forests to outpace the increase in harvesting levels (see indicator L6). However, current forest management practices are projected to increase harvesting while decreasing the NAI (both of which are driven by ageing forests), and as a result the forest carbon sink is projected to decrease to 240 Mt CO_2 in 2030 and 207 Mt CO_2 in 2050 (Korosuo et al., 2023; Pilli et al., 2022). It is therefore highly unlikely that the EU can achieve its LULUCF objectives for 2030 and 2050 without major and immediate changes to current forest management practices.

There are several options possible to increase the NAI, including decreasing deforestation, increasing afforestation, specific management practices to increase gross annual increment and increasing the resilience of forests against natural disturbances. However, the impact of these options will only materialise over decades, with only modest impacts in the timeframe up to 2050. Reducing harvesting is therefore one of the rare options to maintain or increase forest carbon sinks in the short to medium term. However, this also has its downsides, as forest biomass supply supports mitigation in other sectors, allows stronger forest growth in the future and might be required in the context of climate adaptation (JRC, 2021a; Korosuo et al., 2023).

It is therefore highly likely that the EU will have to make a trade-off between maintaining/increasing current harvesting levels and maintaining/increasing the forest carbon sink. The first option would increase biomass supply to other sectors, increase the forest carbon sink in the longer term (provided that harvested trees are replanted) and possibly also contribute to climate adaptation (if harvested trees are replaced with better-adapted species). However, it might also cause the EU to miss its 2030 LULUCF target, result in a smaller sink in 2050 and undermine the EU's biodiversity objectives. The second option would enhance the carbon sink in the short to medium term and is also preferable from a biodiversity perspective. However, it would reduce the carbon sink in the longer term (as the forest carbon stock saturates) and would reduce domestic supply to other end use sectors. In certain cases, it might also make forests more vulnerable to natural disturbances. The different options are also likely to have different socioeconomic impacts, which would need to be taken into consideration, but these have not been assessed within the scope of this report.

Recent literature suggests that, in the short to medium term, limiting harvesting is a more effective climate change mitigation action than increasing harvests to produce more bioenergy and wood-based materials (partly because wood is currently mainly used in short-lived products such as packaging and paper) (JRC, 2021a; Korosuo et al., 2023). The climate benefit of biomass use can be strengthened if wood is used in longer-lived products such as construction materials, which would diversify the income stream and increase the harvested wood products sink in the LULUCF sector. Nevertheless, even for such uses, the majority of studies conclude that within a short to medium time frame (up to 2050) the mitigation potential provided by the material substitution effect is unlikely to compensate for the reduction of the carbon sink in forests affected by increased harvesting (JRC, 2021a).

The EU has taken steps to mitigate the potential adverse impacts of bioenergy, but concerns remain. In particular, there is a high risk that biomass demand (driven by EU policies) will exceed sustainably available supply.

The EU strives to address the potential adverse impacts of bioenergy production, for example through sustainability criteria and minimum GHG emissions savings for biomass set out in Renewable Energy Directive in 2009, which became increasingly stringent under the RED II and the RED III. Only biomass use that adheres to these criteria can contribute to the EU's renewable energy objectives and be eligible for financial support mechanisms (including the exemption from surrendering allowances under the EU ETS). The RED III has further strengthened this sustainability framework, by expanding it to more (smaller) installations, by excluding biomass from areas that were previously old-growth forests, and by excluding biomass harvested in a way that exceeds maximum thresholds for large clear-cuts. Although this sustainability framework is certainly useful to prevent the worst adverse impacts of biomass use, its overall effectiveness remains uncertain because of monitoring and compliance issues, including risks of fraud (Mai-Moulin et al., 2021; Mather-Gratton et al., 2021; Sikkema et al., 2021). Furthermore, as described in more detail in Chapter 6 'Transport', despite this framework, EU policies continue to promote certain types of biofuels that have a high risk of negative spillover effects.

In addition to the sustainability criteria framework, the RED III also requires Member States to design support mechanisms for bioenergy in line with the cascading principle and prohibits direct financial support for the use of specific, high-value wood types for bioenergy production. However, several implicit and explicit exemptions from these rules (e.g. the possibility of continuing to provide non-direct financial support such as tax cuts for the use of high-value wood for energy production) risk undermining their effectiveness.

The RED III also aims to improve the consistency of the EU's bioenergy policies and the objective of the LULUCF Regulation to increase the carbon sink. It does so by introducing a requirement for Member States to ensure that the domestic production of biomass for energy is consistent with their targets under the LULUCF Regulation. To this end, Member States need to assess in their NECPs the compatibility of overall projected forest biomass energy use with their respective targets under the LULUCF Regulation, and a description of the national measures and policies put in place to ensure compatibility with those targets. Member States are also required to report on those policies and measures in their biennial national energy and climate progress reports submitted under the Governance Regulation. These provisions are generally a step in the right direction to improve the consistency between the RED III and the LULUCF Regulation, but their effectiveness will depend on implementation by Member States. The European Commission's 2023 Bioenergy sustainability report (EC, 2023bh) – a biennial requirement under the Governance Regulation – found that so far Member States have not provided sufficiently granular information to allow a comprehensive insight on projected bioenergy demand and sustainably available supply. Similarly, the assessment of the draft updated NECPs found that most of them don't include information on the domestic supply of forest biomass for energy purposes, nor the projected use of forest biomass for energy purposes in 2021-2030 (EC, 2023p).

Furthermore, there continues to be an uneven distribution of incentives for the different possible uses of forest biomass. The current EU policy framework provides a direct, financial benefit for certain private actors to use bioenergy (e.g. operators that are exempted from surrendering allowances under the EU ETS or benefiting from national biomass support schemes). However, in the absence of an emission-pricing mechanism in the LULUCF sector (see also Section 10.6), the financial cost of the biomass use (in the form of a reduced carbon sink) is solely at the expense of the Member State. As a result, the climate benefit of bioenergy use is privatized, whereas the climate cost (in the form of a reduced carbon sink) is socialised.

Finally, the EU policy framework on bioenergy does not consider its potential impact on the aggregate demand for biomass compared with the sustainably available supply. Some researchers have questioned the feasibility of the European Commission's scenarios with regard to potential sustainable biomass supply (Searchinger et al., 2022a), and several assessments have cautioned that biomass demand – driven by climate and energy policies – is projected to exceed sustainably available domestic supply (EEA, 2023o; Material Economics, 2021). This could result in three outcomes, each of which is to be avoided:

— the EU would harvest more biomass than is sustainable, with negative impacts on, among other things, biodiversity and the LULUCF net sink;
— the EU would not be able to meet demand for biomass, and therefore specific sectors with limited alternative mitigation options would risk being unable to reduce their GHG emissions enough to be compatible with the overall climate neutrality target;
— the EU would meet the increased demand by substantial increases in biomass imports, thereby exporting environmental pressures (including GHG emissions) associated with biomass production.

To avoid these outcomes, the aggregate demand for biomass needs to stay within ecological boundaries, while ensuring that end uses with limited mitigation options have sufficient access to sustainably sourced biomass to decarbonise by 2050 at the latest. This could be achieved by targeting incentives for bioenergy towards end uses that have limited other mitigation options, and by promoting the efficient and circular use of biomass overall. However, EU policies do little to target bioenergy towards demand centres with limited alternatives to fossil fuels (Malico et al., 2019). Whereas the RED III (EU, 2023f) does prioritise material use over biomass use for energy, regarding end uses it only excludes (new or renewed) support for electricity-only installations. It does not further differentiate between end uses based on the availability of other renewable energy or climate mitigation options. A better-targeted use of biomass could be achieved by putting a price on emissions in the LULUCF sector at a level similar to the carbon prices in other sectors (the EU ETS and the EU ETS 2). This would create an incentive to use biomass where its value is highest, that is, where it is hardest to replace.

Enhance climate adaptation

Climate change is projected to undermine the LULUCF sink by increasing the frequency and intensity of natural disturbances.

Research has found that – despite strong interannual variation – natural disturbances are increasingly damaging EU forests ([7]), thereby undermining their climate mitigation potential (Forzieri et al., 2022; Patacca et al., 2023; Seidl et al., 2017; Senf and Seidl, 2020). There is growing evidence that climate change is one of the underlying drivers of this trend and is expected to worsen it in the future (Forzieri et al., 2022; Patacca et al., 2023); there is some evidence that climate change has increased maximum wind speeds during extreme wind events, and models predict that such events will occur more frequently in the future. Whereas improved fire suppression policies have reduced damages from forest fires in recent decades, climate change is expected to increase the intensity and frequency of extreme fire events. Finally, climate change is increasing the damage expected from bark beetle outbreaks, both by increasing the bark beetle population and by reducing the resistance of trees to beetle infestations (e.g.

([7]) Expressed as volume of forest biomass loss per year.

due to droughts). Further increases in disturbance-caused mortality risk further undermining the net sink in EU forests and could even transform them into a net source of emissions.

Whereas climate change is expected to increase the frequency and intensity of natural disturbances, it might also improve carbon sequestration in some regions and forest types through warming and CO_2 fertilisation (Forzieri et al., 2022). The overall impact is expected to be mainly negative in arid and temperate forests (southern and central Europe) whereas it might be overall positive for boreal forests (northern Europe). Pilli et al. (2022) expect climate change to lead to an overall increase in forest growth in broadleaved forests (in particular in northern European regions) and an overall decrease in coniferous forests, but concludes that the overall impact of climate change on the aggregate EU forest sink is highly uncertain and could be either positive or negative. For example, assuming continuation of current management practices, the EU forest carbon sink could range between 100 and 400 Mt CO_2e by 2050 (compared to 280 Mt CO_2e in 2021) depending on climate change impacts.

Forests' resilience can be enhanced by changing forest management practices, but, even then, the future of the LULUCF net sink remains uncertain.

The findings above highlight the need for climate adaptation efforts to safeguard the net sink in the LULUCF sector. Several forest management options exist that could improve the resilience of EU forests against climate change impacts. One recommended option is to shift from conifer monocultures to mixed forests and broadleaved species. Such practices might decrease the LULUCF sink in the shorter term (as maladapted tree species are harvested, to be replaced by more resilient species) but would enhance the sink over the longer term (as the newly planted trees grow and future losses from natural disturbances are reduced (Korosuo et al., 2023). However, even if improved forest management practices can increase the mitigation potential and resilience of EU forests, their effect might still be outpaced by increased damage caused by natural disturbances (Patacca et al., 2023).

The importance of climate adaptation – but also of accounting for uncertainty induced by climate change – is illustrated by the sudden drop in the forest carbon sink in the late 2010s, which was driven by natural disturbances, among other causes ([8]). In its impact assessment regarding the revised LULUCF Regulation (EC, 2021r), the European Commission had assumed that the LULUCF net sink could be maintained at the average 2016–2018 level (268 Mt CO_2e) until 2030 without substantial additional efforts. Moreover, it assumed around 40 Mt CO_2 of additional removals could be achieved through a range of relatively inexpensive near-term actions including improved forest management and set-aside of organic soils, which formed the basis for the 310 Mt CO_2e objective. Whereas the impact assessment acknowledged the potential exacerbation of natural disturbances by climate change and biodiversity loss, it did not account for this in its scenarios that underpinned the proposed objective. Since the assumptions were made, net removals in the LULUCF sector have dropped drastically, to only 230 Mt CO_2e in 2021. As a result, the additional effort required has almost doubled (from 42 Mt assumed in 2021 to 80 Mt CO_2e today).

This highlights the need to account for the uncertainties from climate change when setting climate reduction objectives for the LULUCF sector. This could be based on the European Climate Risk Assessment, which is currently under development and expected to be published in spring 2024.

([8]) Pattaca et al. (2023) estimate that the loss of forest biomass due to natural disturbances was on average 50 million m^3/yr in 2010–2015, and then started to increase to on average 100 million m^3/yr in 2018–2020, mainly due to increased extreme wind events and bark beetle outbreaks. Based on standard conversion factors (between 0.8 and 1 t CO_2 per tonne of forest biomass, depending on the tree species), this would have decreased the forest sink by 40–50 Mt CO_2e in 2018–2020 compared to 2010–2015. According to the EU GHG inventory, the total forest carbon sink decreased from on average 420 Mt CO_2e/yr in 2010–2015 to on average 300 Mt CO_2e/yr in 2018–2020. Natural disturbances would thus be responsible for a large minority (33–40 %) of the decrease in the carbon sink.

Furthermore, it shows that the > 400 Mt CO_2e net removals by 2050 under the European Commission's scenarios might not be achievable. In that case, more technological removals of emissions or further reductions in residual emissions will be required to achieve overall climate neutrality.

9.6 Summary tables

Table 14 Progress summary - LULUCF

Indicator	Reference period	Historical progress	Required up to 2030	Required in 2031–2050
L1: GHG emissions and removals ([a])	2005–2022	+ 6 Mt CO_2e/yr	– 8 Mt CO_2e/yr	– 5 Mt CO_2e/yr
L2: land-use changes				
L2a: forests	2005–2021	+ 194 kha/yr	No benchmark	No benchmark
L2b: wetlands	2005–2021	Stable	No benchmark	No benchmark
L3: deforestation	2017–2021	– 3 kha/yr	No benchmark	No benchmark
L4: afforestation	2017–2021	– 4 kha/yr	No benchmark	No benchmark
L5: net land take	2017–2021	Stable	No benchmark	– 5 kha/yr
L6: forest carbon sink ([a])	2017–2021	+ 8 Mt CO_2e/yr	– 11 Mt CO_2e/yr	– 4 Mt CO_2/yr
L7: emissions in non-forest lands ([a])	2017–2021	– 1.5 Mt CO_2e/yr	– 1.3 Mt CO_2e/yr	– 3.1 Mt CO_2e/yr
L8: bioenergy use ([b])	2017–2021	+ 56 TWh/yr	Stable/no further increase	+ 52 TWh/yr

Legend

On track	The required change ([c]) is ≤ 1.
Almost on track	The required change ([c]) is between 1 and 1.5.
Somewhat off track	The required change ([c]) is between 1.5 and 2.
Considerably off track	The required change ([c]) is ≥ 2.
Wrong direction	The required change ([c]) is < 0.

([a]) Positive values represent an increase in emissions or a reduction in removals. Negative values represent a decrease in emissions or an increase in removals.

([b]) Given the expected adverse impacts if bioenergy use exceeds sustainably available supply, indicator L8 is considered to be on track if bioenergy use remains below a linear trajectory to the benchmark values, and off track if it risks exceeding that linear trajectory.

([c]) See Section 2.2 for more details on how the required change is calculated.

Table 15 Policy consistency summary – LULUCF

Policy inconsistencies	– EU policies (CAP support for livestock production and the cultivation of organic soils and marginal lands, EU biofuel policies) put upward pressure on the demand for agricultural land, reducing land available for afforestation/reforestation and wetland restoration.
Policy gaps	– The objectives of the Farm to Fork Strategy to reduce fertiliser use (– 20 %) and increase the share of organic farming (to 20 %) have direct local environmental benefits, but risk reducing yields and therefore increasing demand for land (either in the EU or abroad) if demand for agricultural products is not reduced in parallel. – Agriculture and LULUCF are currently still excluded from the EU carbon-pricing regime. Therefore there is no EU-wide (financial) incentive for farmers and land managers to reduce GHG emissions and enhance CDR. It also implies that the incentives for using forest biomass for energy purposes versus maximising the LULUCF carbon sink continue to be unevenly distributed between private and public actors. – There is a genuine risk that aggregate biomass demand will exceed sustainably available supply. Key EU policies such as the RED III do not target incentives for bioenergy towards end uses that have limited alternative mitigation options. – The assumptions that underpin the LULUCF objective for 2030 did not account for the uncertainty of the effects of climate change and related natural disturbances on changes in the sink.
Ambition gaps	– Specific exemptions risk undermining the effectiveness of the sustainability criteria and provisions on the cascading principle under the RED III. – Under the CAP, the mandatory requirement on the maintenance of grasslands (GAEC 1) does not prevent agricultural practices that lead to high soil carbon emissions from grasslands
Implementation gaps	– So far, Member States have provided insufficient information in their NECPs and national energy and climate progress reports to assess the compatibility between projected bioenergy demand and sustainably available supply. – The CAP does include a mandatory requirement to preserve wetlands (GAEC 2), but over half of EU Member States have opted to delay its implementation to 2024 or 2025. It allows support mechanisms (eco-schemes) for the restoration of wetlands, but these are used to only a limited extent by Member States. Similarly, whereas most Member States have set targets for carbon storage in soil and biomass, voluntary eco-schemes to incentivise carbon farming have been implemented by few Member States, often with low levels of ambition. – Monitoring and compliance issues (including fraud) risk undermining the effectiveness of the sustainability criteria and provisions on the cascading principle under the RED III.

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