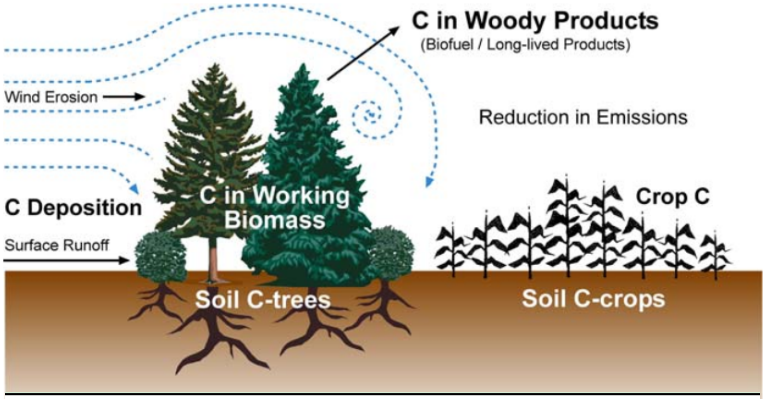
# 26. Agroforestry & the 2040 AFOLU net-zero target

***EURAF Policy Briefing 26. Gerry Lawson (EURAF), Sonja Kay (Agroscope), Michael den Herder (EFI), Paul Burgess (Cranfield University), 23.6.23. DOI 10.5281/zenodo.8075187***

*EURAF is an NGO, based in Montpellier and Brussels (Transparency Register ID of 913270437706-82). It aims "to promote the adoption of agroforestry practices across Europe by supporting efforts to develop awareness, education, research, policy making and investments which foster the use of trees on farms". It has a network of 31 affiliated entities in 23 countries.*

***This Briefing is a contribution to the DG CLIMA consultation on 2040 climate targets. It suggests that, if the EU's target of 3 billion additional trees by 2030 were planted in agroforestry systems at the density of 150 (50-400) trees/ha, with 1 million ha planted each year to 2050, that a long-term average of 192 Mt CO2 yr[1] could be sequestered during the lifetime of the plantations. This is close to the current levels of LULUCF sequestration across the EU (212 Mt CO2e in 2021). However, trees grow slowly when they are first planted and the potential contribution of these agroforestry systems would take time to develop. Taking, for example, a generic agroforestry plantation at 150 trees/ha, a rotation length of 30 years, and 1 million hectares planted per annum across Europe from 2025 to 2050: it is estimated that sequestration would be only 2 Mt CO2 in 2030, but that this would rise to 81 Mt in 2030 and 188 Mt CO2 in 2050. Agroforestry can be carried out by planting trees in lines within parcels, or in hedges, windbreaks [1] and copses at parcel boundaries. It is thought that this scale of planting is economically feasible on most of the 169 Million ha of agricultural land which exists in the Europe (EEA-39) with zero tree cover, and that any reductions in agricultural yield would be moderate, and compensated by carbon sequestration and other environmental or animal-welfare benefits. This Briefing is being sent to the Agricultural Departments of all Member States: it is hoped they take advantage of the EU's request that CAP Strategic Plans be revised to deliver on the new LULUCF targets. Agroforestry programmes are possibly the best option to achieve this.***




Major carbon sinks and sources in a field windbreak (Schoeneberger 2008)

## 1 Introduction

The revised Land Use, Land Use Change and Forestry (LULUCF) Regulation entered into law on 11th May 23. It sets a sequestration (negative emission) target of -310 million tonnes per year of $CO_2$ equivalent for the LULUCF sector by 2030. This is an increase of 16% from the estimated annual sequestration of -268 Mt $CO_{2eq}$ in the EU in the 2016-28 base years[1], and an increase of **46%** compared to the level of sequestration of -212 Mt $CO_{2eq}$ provisionally estimated for 2021 [2]. It is significantly less than the net emission of non $CO_2$ gases from agriculture: which was +382 Mt $CO_{2eq}$ in 2020 [2]. From 2025, Europe's greenhouse gas (GHG) accounting will be based on net accounting methods in the "Agriculture, Forestry and Other Land Use" sector (AFOLU). This provides integrated reporting of $CO_2$ and non-$CO_2$ emissions from the whole land sector. The Commission's initial draft of the LULUCF Regulation (July 2021) set a target of net-zero in the AFOLU sector by 2035. This target was rejected by Parliament (see EURAF Policy Briefing #17) in June 2022, but new proposals for 2040 are expected soon from the Commission[2]. It is likely that the AFOLU neutrality target will be proposed again, but this time for 2040. **EURAF**

[1] LULUCF sequestration continues to decline in the EU - in 2020 it was only -239.2 Mt $CO_2$ (UNFCCC), and the EEA estimates that it may be as low as -212 Mt CO2 in 2021.

[2] *On 10.11.22 both Parliament and Council agreed that "the Commission will submit a report within six months of the first global stocktake under the Paris Agreement (to be carried out in 2023), on including non-CO2 greenhouse*

**believes that agroforestry and "Trees outside Forests" (i.e. including trees in settlements) can make a crucial contribution to the net zero AFOLU target.** However, trees take a long time to grow, and **a large programme of afforestation, agroforestation and settlement-tree-planting is needed YESTERDAY.**

This Briefing is an input to the DG CLIMA consultation on an "EU Climate Target for 2040" [3]. It looks at the potential impact of the Commission's EU's Tree Billion Additional Trees initiative [4], and the timing of additional sequestration provided by these trees if they are planted on agricultural land. **The Briefing provides initial estimates for the potential contribution of agroforestry to the Commission's 2030, 2040 and 2050 AFOLU targets, and the impact of a 1 million hectares per annum emergency planting programme for agroforestry.**

## 2 How much difference can tree planting in Europe make to net emissions?

The Commission Staff Working Document which accompanied the draft LULUCF Regulation [5] suggested that the 3 billion "additional-tree" target, if distributed over around 3 million hectares and assuming a planting density of 1000 trees/ha, could potentially sequester approximately 4 Mt $CO_2$ in 2030 and 15 million tonnes $CO_2$ in 2050. This means that, for every ha of trees planted in the decade 2020-2030, the Commission expects a sink of about 4.5 t $CO_2$ $year^{-1}$ in the decade 2030-2040 (i.e. 10 years after planting) and about 7.8 t $CO_2$ $year^{-1}$ in the decade 2040-2050 (i.e. 20 years after planting).[3]

National LULUCF projections show a **decrease in the level of net removals**, with an average of 200 Mt $CO_2$eq estimated to be sequestered per year for the period 2020-2040, compared to the historical average of 300 Mt $CO_2$eq per year from 1990 to 2019 (European Commission 2021). Additional sequestration measures planned by MS in their CAP Strategic Plans are only expected to increase net removals from 2020 to 2040 by only around 3% (European Commission 2021). **Much more ambitious targets are needed**. There is therefore an urgent need for the expansion of Trees outside the Forest (ToF): both on agricultural land as agroforestry and in settlements as urban-forestry.

**Box 1 - From "Scientific advice for the determination of an EU-wide climate target and greenhouse gas budget for 2030-2050** [9]**.**

LULUCF accounted for net removals of 237 Mt $CO_2$ in 2019 and 212 Mt $CO_2$ in 2021 [2]. These values include net GHG removals from forest land (including non $CO_2$ gases) and harvested wood products (although the storage of carbon in biochar or other products is not included), and net $CO_2$ emissions from croplands, grasslands, wetlands, settlements and those due to land use change.

Filtered future scenarios considered by the Advisory Board suggest minimum 266 Mt $CO_2$ carbon removals from the land sector in 2030, and a possible 273 Mt $CO_2$ in 2040-2050. However the target for removals has already been set for 2030 in the revised LULUCF Regulation at 310 Mt $CO_2$. This will be a difficult target for Member States to achieve, but it is less than the maximum capacity reported in the EU's 2030 Climate Target Plan (425 Mt $CO_2$ from LULUCF in 2050), or in the EU's 2050 '1.5 LIFE' scenario (460 Mt $CO_2$ from LULUCF in 2050).

One scenario has estimated up to 667 Mt $CO_2$ of biogenic carbon removals in the EU by 2050 [10], 2019), but others are more conservative: [11] estimates up to 441 Mt $CO_2$, while [8] give a range of 100 to 400 Mt $CO_2$ taking into account future impacts of climate change (including droughts, wildfires, storms, pests [12]

Calculations on carbon sequestration in the EU Staff Working Document [5], accompanying the 3 Billion Additional Trees target, assume that trees will be planted at 1000 trees per ha and will cover 3 million hectares in total, with 300,000 ha of planting taking place annually from 2021-2030 (i.e. over the ten years of the pledge). However, agroforestry would be planted less densely at (50)-150-400 trees per hectare. The yield of carbon per individual tree will be significantly greater than in conventional forestry, with less loss of carbon through thinning operations, and continued sequestration of carbon in the pasture or climate-sensitive farming operations beneath the trees.

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*gas emissions from agriculture in the scope of the regulation and the setting of post-2030 targets for the land-use sector"*

*[3] These figures came from IIASA [6] and from the JRC. For the JRC, the net annual increment was attributed to young forests (i.e. less than 40 years old) according to a large database of growth curves collected at European level [7,8] The resulting total annual volume increment was further converted to annual carbon removals by assuming an average wood density equal to 0.50 t m-3, an average biomass expansion factor equal to 1.2 and an average carbon content equal to 0.5. The resulting values do not account for carbon stock change on dead wood, litter and soil, since these pools are directly affected from the land use preceding the afforestation.*

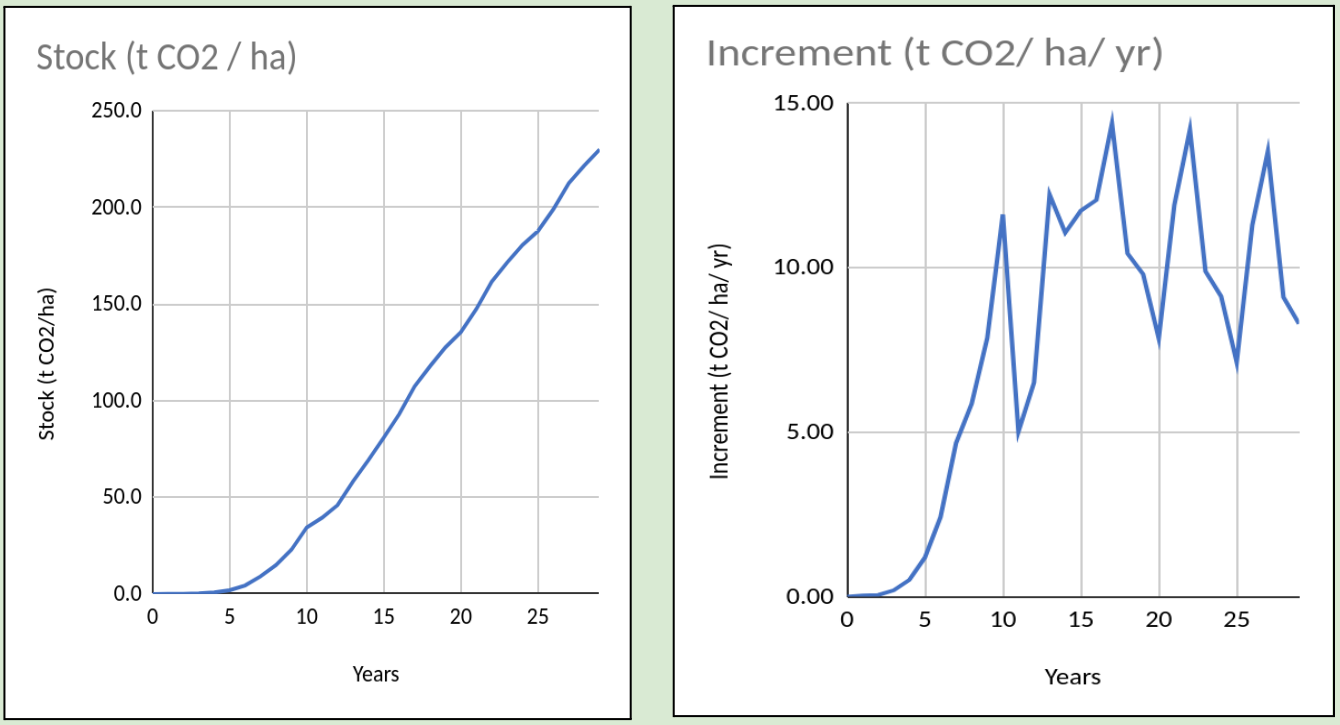


***Figure 1:*** *The predicted rate of sequestration of carbon dioxide for a poplar agroforestry system (156 trees ha-1) managed on a 30 year rotation using calibration data described by [13], comprising above- and below-ground biomass, but not soil carbon. The variation in increment between years is due to modelled weather changes. Poplar is used as an example, but the spacing, species-provenance-clone and management would be adapted to local soil and climate conditions.*

EURAF Policy Briefing #8 reports on a wide range of European and Global literature, and shows that the total productivity of an agroforestry plantations ranges from 3.37-26.8 t $CO_2$/ha/yr. A recent study for the UK Woodland Trust, by Cranfield University [14], modelled sequestration rates by the trees in two agroforestry systems (156-400 trees/ha) and predicted sequestration of 6 to 18 t $CO_2$/ha/yr over 30-40 years. Taking data for poplar planted at 156 trees/ha and harvested after 30 years, using typical weather patterns for the English East Midlands, the model predicted an average annual biomass sequestration of **7.7 t $CO_2$ $ha^{-1}yr^{-1}$** over the rotation (Figure 1). Extrapolating this rate to the whole of Europe, and assuming that **one million hectares of agroforestry could be planted annually** from 2025 to 2050, indicates that this annual planting for 25 years could eventually provide **192 Mt $CO_2$ $yr^{-1}$**. The species-provenance-clone used and the spacing and management would be adapted to local climate and soil conditions and the management priorities of farmers.

At a time when pressures are increasing to harvest greater proportions of forests for bioenergy and the bioeconomy, this contribution from agroforestry could be very useful in the long-term emissions-neutrality planning of Member States. **However,** it will take some time for this sequestration to be implemented, since **:** a) the full area of 25 million hectares is accumulated over a 25-year period; b) the volume and carbon-content of a plantation typically follows a "S-shaped" (e.g. Logistic, Gomperz, Richards etc) curve, with growth being slow in early years, reaching maximum growth at middle age and declining as the trees become old and suffer excessive competition.

Modelled growth in **Figure 1** shows little slowing down in annual increment up to year 30: largely because agroforestry trees are planted at wide spacing, with lower branch pruning, and with little tree-to-tree competition. More carbon is likely to be sequestered if the stand is managed on a longer rotation, and it may be that the optimum rotation for carbon sequestration is longer than it is for economic-yield. Nevertheless, we assumed a 30-year rotation and **Figure 2** shows the probable schedule of accumulation of carbon in the above- and below-ground trees over the extended period to 2100, and with annual planting of 1 million ha/year assumed to occur between 2025 and 2050. The likely contribution by 2030 is predicted to be only 2 Mt $CO_2$, but by 2040 it will rise to 81 Mt $CO_2$, and in 2050 to 188 Mt $CO_2$. These data relate only to $CO_2$, although agroforestry potentially brings benefits in reducing $N_2O$ emissions [15].

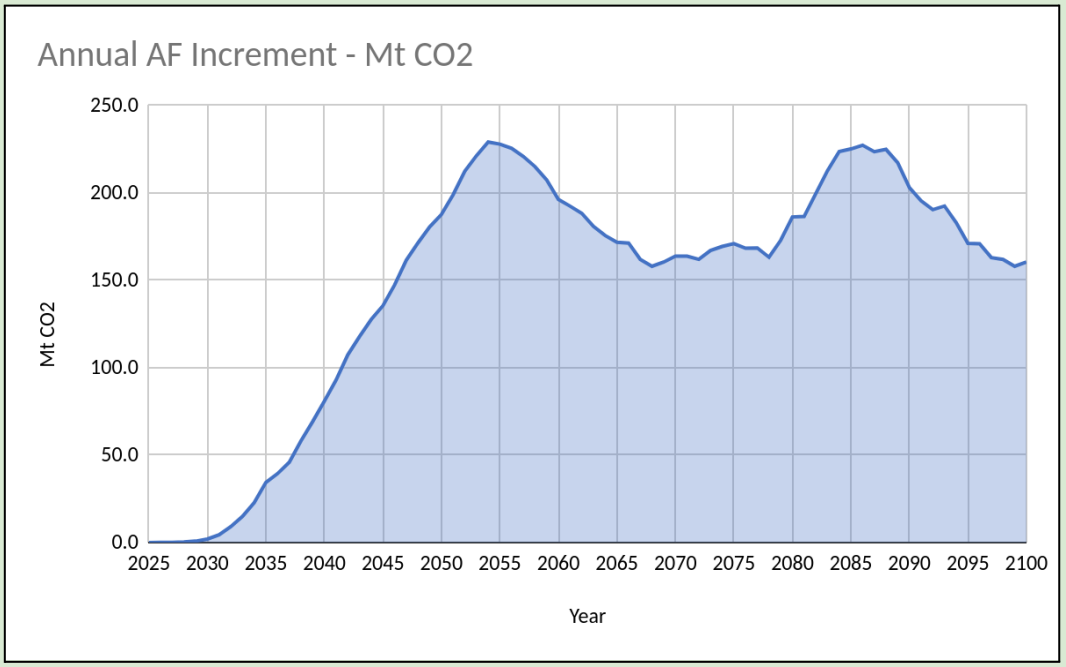


***Figure 2*** *Potential sequestration in a generic agroforestry plantation (poplar 156 trees/ha), managed on a 30-year rotation, with 1 million hectares planted annually between 2025 and 2050. Yield predictions and calibration of the Yield-SAFE model were made according to [13] for the UK - East Midlands - using* ***current*** *weather patterns.*

The following section considers whether there is sufficient agricultural land for conversion to agroforestry at the rate of 1 million hectares per year for the next 25 years.

## 3 Land availability for agroforestry

Den Herder et al (2000) (EURAF Policy Briefing #2) suggested targeting the Commission's proposed 3 billion "additional" trees primarily on land "outside forests" - i.e. agroforestry and settlement-tree-planting. They used the Copernicus Tree Cover Density 2015 product[4], and the Corine Land Cover 2018 database (to provide an "agricultural" overlay) to identify areas of agricultural land which have very low existing tree cover (Table 1). They also overlaid Natura 2000/ Ramsar databases to exclude protected areas. They then looked at the extent of agricultural areas with "zero tree cover" across the wider Europe (EEA-39). These tree-deserts were recommended as priority areas for tree planting because they are usually associated with high values of environmental-stress indices such as those related to erosion, nutrient loads in water courses, soil moisture deficits, and low levels of landscape or functional biodiversity, so agroforestry would bring additional ecosystem services. Such a planting would also help address the "Earth Commission" initiative of having 20-25% of each 1 km$^2$ under semi-natural or natural vegetation [16], and the Biodiversity Strategy target of 10% "high diversity landscape features" by 2030 [17][5].

***Table 1****. Area (km$^2$) of agricultural land with 0%, <1%, <2%, <5%, <10% tree cover for the year 2015 (EEA-39).*

| Tree cover<br>Corine class | 0% | <1% | <2% | <5% | <10% | Total area (km2) |
|---|---|---|---|---|---|---|
| 211 Non-irrigated arable land | 962,804 | 969,374 | 982,468 | 1,013,740 | 1,039,933 | 1,212,620 |
| 212 Permanently irrigated land | 93,809 | 94,725 | 95,773 | 97,808 | 99,852 | 109,331 |
| 213 Rice fields | 6,012 | 6,045 | 6,103 | 6,235 | 6,355 | 8,210 |
| 231 Pastures | 248,130 | 250,396 | 257,926 | 276,927 | 296,912 | 428,720 |
| 244 Agroforestry | 4,478 | 5,824 | 6,645 | 8,493 | 11,179 | 33,083 |
| 2 All agricultural areas | 1,686,407 | 1,709,746 | 1,749,513 | 1,843,090 | 1,945,852 | 2,445,287 |

[4] **Tree Cover Density** data is provided by CORINE in a range from 0-100% for the 2012 and 2015 reference years. The data is available as raster data in European projection (EPSG: 3035) with 20m and 100m resolution. For our assessment we used the data with 100m resolution as we were interested in large areas with little or no tree cover. For our assessment we first constructed a map showing tree cover density in "agricultural areas". We then examined different thresholds for "no or very low tree cover" (0%, <1%, <2%, < 5%, <10%).

[5] Although current amendments (June 23) in Parliament on the Nature Restoration Law have removed all significant mentions of this target.

Den Herder et al. show that 169 million ha of European agricultural land[6] has 0% tree cover, with 171 million ha having less than 1% and 194 million ha less than 10% tree cover. Only 20% of the European agricultural area has more than 10% tree cover. 84.5% of non-irrigated arable land (Class 2.1.1) has zero tree cover, and only 9.3% of this land has more than 10% tree cover (Table1).

***Table 2.*** *Percentage of total agricultural land[7] with 0%, <1%, <2%, <5%, <10% and >10% tree cover for 2015 (EEA-39).*

| Tree cover<br>Corine class | 0% | <1% | <2% | <5% | <10% | >10% |
|---|---|---|---|---|---|---|
| 211 Non-irrigated arable land | 84.5 | 85.0 | 86.2 | 88.9 | 91.7 | 9.3 |
| 212 Permanently irrigated land | 88.6 | 89.4 | 90.4 | 92.4 | 94.3 | 5.7 |
| 213 Rice fields | 89.6 | 90.1 | 91.0 | 93.0 | 94.8 | 5.2 |
| 231 Pastures | 65.5 | 66.1 | 68.1 | 73.1 | 78.4 | 22.6 |
| 244 Agroforestry | 13.5 | 17.6 | 20.1 | 25.6 | 33.8 | **66.2** |
| 2 All agricultural areas | 68.8 | 69.8 | 71.4 | 75.2 | 79.4 | 20.6 |

Table 2 also shows that 34% of agroforestry land, as identified in the CORINE database, has tree crown densities below 10%. This identifies a need for the regeneration and management of traditional agroforestry systems, in addition to the planting of new areas.

***Table 3.*** *Calculated "Priority" and "Possible" areas for agroforestry to be planted or regenerated before 2030, using the methodology of [18] (including UK but excluding Croatia). Planting densities assume a selective thinning rate of 3-4:1 to reach final stocking.*

| Scenario | Agroforestry System | Calculated Area (ha) | Planting Density/ha | Total trees (billion) |
|---|---|---|---|---|
| **Priority Areas** (4-5 environmental threats) | Silvoarable | 9,959,142 | 200 | 1.99 |
| | Silvopastoral | 2,844,592 | 400 | 1.14 |
| | **Total** | | | **3.13** |
| **Possible Areas** (1 environmental threat) | Silvoarable | 95,890,000 | 200 | 19.18 |
| | Silvopastoral | 24,000,000 | 400 | 9.60 |
| | **Total** | | | **28.78** |

For agroforestry plantings, even with high quality planting material, the final stocking is always lower than the initial density of seedlings. Thus there is a need to plant 3-4 times more trees than the final stocking. Policy Briefing #2 suggested that a planting density of around 200 trees/ha was needed in silvoarable systems and 400 trees/ha in silvopastoral systems. Thus taking the "Priority Area", with 4-5 environmental threats, identified by Kay et al 2019 (totalling 9.96 million ha of cropland and 2.84 million ha of grassland) this represents a total of 3.13 billion additional trees! This closely matches the "additional tree" planting target of the Commission in the Biodiversity Strategy 2030 [17]. If the "Potential Area" for planting (with 1 environmental threat) were considered, this target converts to 28.8 billion trees.

Den Herder et al. presented a traffic-light map of agricultural land with very low tree cover (**Figure 3**), and suggested that the priority should be for these red areas to turn green as soon as possible. This Policy Briefing gives a spatial priority strategy to achieve this, and estimates the proportion of agricultural land which requires to be planted to achieve climate neutrality in the land sector by 2030 - assuming that the net GHG balance of forest land remains static at -310 M tonnes CO2 equivalent (Mt $CO_2e$).

[6] EEA-39 - Including EFTA members and EU Candidate States (inc. Turkey). This map will be replaced with EU-27

[7] The "**agricultural areas**" for this purpose excludes: vineyards (221), fruit trees and bushes (222), olive groves (223), complex cultivation patterns (242), land principally occupied by agriculture with significant areas of natural vegetation (243). The analysis will be repeated in 2024 using the new CLC+ dataset and higher resolution data, but with the same land cover classes.

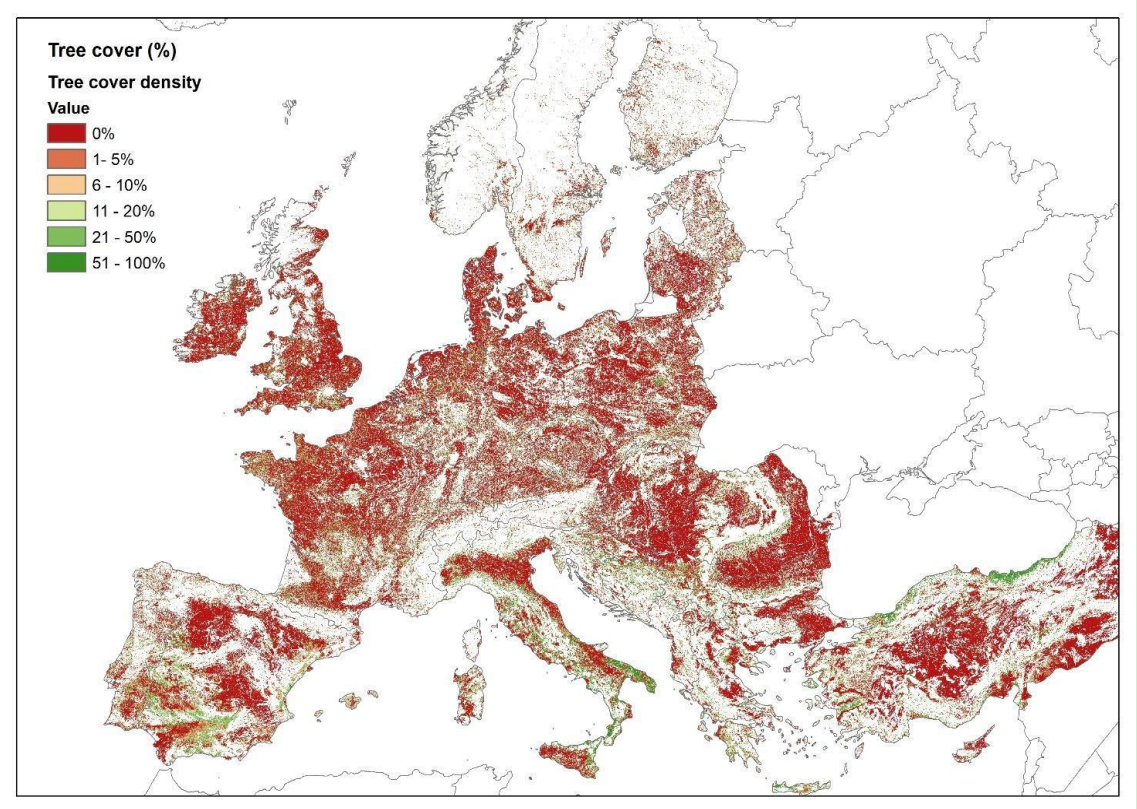


***Figure 3**. Priority planting areas, where tree cover density (% tree cover) on agricultural land is particularly low. Source: Copernicus tree cover density 2015.*

## 4 Future additions to this Briefing

EURAF is working on a fuller version of this Briefing (September 2023) which will also include:

- whether MS include ToF in their current LULUCF inventories for cropland and grassland;
- MS plans for forest and agroforest expansion (hopefully from national Energy and Climate Plans)
- latest estimates of the current area of Trees Outside Forests in the EU
- estimates of GHG loss due to forest fires, and potential role of silvopastoralism in limiting this - particularly in view of the "**flexibility margin**" for natural disasters included in the LULUCF Regulation
- accounting methods used in the major carbon farming certification schemes used in Europe
- improved estimates of potential carbon sequestration by trees outside forests in the EU by 2030, 2040 and 2050.

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