Information on LULUCF actions by Sweden

Final Report 2020

This information on LULUCF actions by Sweden responds the request set out in article 10 of Decision [529/2013/EU] on Land-Use, Land-Use Change and Forestry.

Contents

1. Background

This information on LULUCF actions by Sweden responds the request set out in article 10 of Decision [529/2013/EU] on Land-Use, Land-Use Change and Forestry.

In this report Sweden submits to the Commission information on the progress in the implementation of LULUCF actions. The information in this report builds on Sweden's initial report on LULUCF actions from 30th June 2014 and on Sweden's first progress report 2016. Sweden also provides information on emissions and removals reported to the Kyoto protocol and the EU.

Detailed information on emissions and removals from LULUCF-activities will be reported to the EU on 15th January 2021. Sweden will submit the National Inventory Report 2021 to the UNFCCC in April 2021. New projections of removals and emissions will be reported to the EU in March 2021.

Sweden's climate policy framework from 2017 contains new ambitious climate goals, a climate act and the establishment of a climate policy council. It states that by 2045 at the latest, Sweden is to have zero net emissions of greenhouse gases into the atmosphere and should thereafter achieve negative emissions. Supplementary measures such as enhanced removals in the LULUCF-sector, negative emissions through bio-CCS and verified emission reductions in other countries may be used to a limited extent to attain some of the goals of the climate policy framework[1] [2].

The information on LULUCF provided in this report covers the commitment period 2013-2020 solely while none of the Government's initiatives for 2021 and thereafter are presented. Henceforth, Sweden will submit information on national policies and measures and LULUCF projections by 15th March 2021, and every two years thereafter, according to article 18 of the Governance Regulation.

While official harvest statistics for Sweden is provided by the Swedish Forest Agency, all statistics regarding forest growth, harvesting and natural losses in this report are based on the National Forest Inventory for reasons of consistency.

[1] Sweden's integrated national energy and climate plan 2020

[2] The potential for supplementary measures has been investigated in "Vägen till en klimatpositiv framtid" SOU 2020:4

2. Trends in emissions and removals

2.1. Total LULUCF

The net emission removal as reported in the LULUCF sector has been quite stable in Sweden since 1990, around 37,5 Mton CO_2-eq. on average from the atmosphere every year with inter-annual variations ranging from -31,4 Mton CO_2-eq. in 1993 to -42,8 Mton CO_2-eq. in 2001. During the commitment period, 2013 to 2019, the sector has removed 36,6 Mton CO_2-eq. on average every year from the atmosphere.

The total size, variation and trend of the net removals in the LULUCF-sector are mainly affected by the carbon stock change on forest land, dominated by the variations in net removals in living biomass and the mineral soil. Harvested wood products is also a net sink, and the variations in removals in living biomass and harvested wood products depends on harvest rate. Increased harvest results in increased net removals in harvested wood product and decreased net removals in living biomass while decreased harvest results in decreased net removals in harvested wood products and increased net removals in living biomass.

The net emissions in the LULUCF sector are dominated by the net emissions from drained organics soils. All greenhouse gases together, the net emissions amounted to 10,4 Mton CO_2-eq. in 2019. The average net emissions from drained organic soils between 2013 - 2019 were 10 Mton CO_2-eq. The carbon pool dead organic matter (dead wood and litter) also constitutes a source and the emissions were an on average 3,2 Mton CO_2-eq. during the period from 1990 until 2019. The emissions in 2019 were 3,4 Mton CO_2-eq.

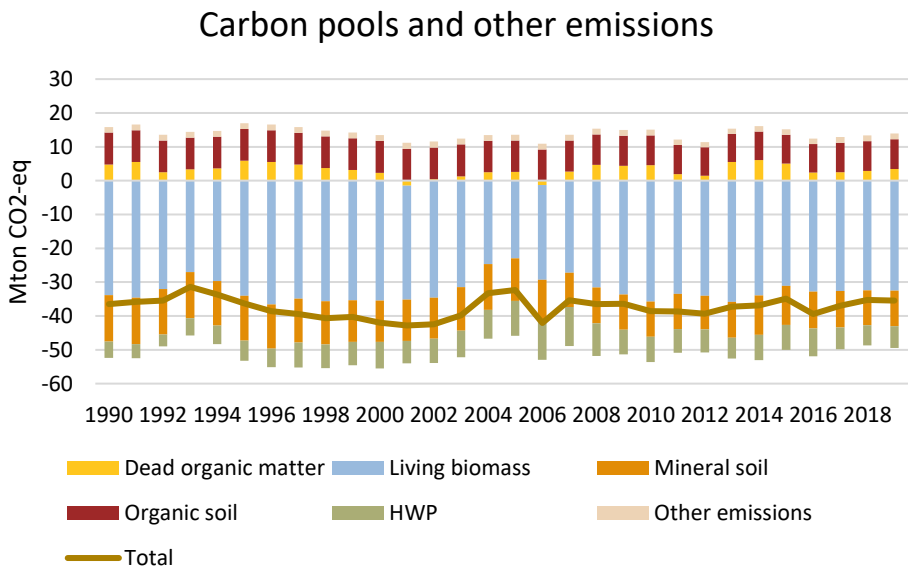

Figure 1 Total net emissions (+) and net removals (-) in the LULUCF-sector in Sweden. LULUCF carbon pools according to UNFCCC inventories.

In the figure above (Fig. 1), the net emissions (+) and net removals (-) are presented for the different carbon pools and in accordance with the reporting format under the Climate convention in order to show the development in the sector from 1990 until 2019. Other emissions are CH_4 and N_2O emissions from fertilization, biomass burning and from drainage of organic soils. Since the net emissions and net removals are showed in accordance with the reporting guidelines under UNFCCC, emissions and removals on wetlands (due to peat production) and other land (forest land converted to other land) are also included.

Calculations are made in accordance with UNFCCC-reporting guidelines and Kyoto Protocol guidelines and the methodological guidelines decided on by UNFCCC and Kyoto Protocol. Information is to be found in Sweden's National Inventory Report[3] submission 2021.

2.2. Forest management

Since 2013, Forest management has removed an average of 43,6 Mton CO_2-eq annually from the atmosphere with inter-annual variations ranging from 42,4 Mton CO_2-eq in 2015 to 45,6 Mton CO_2-eq in 2016. The net removal in 2019 was 42,9 Mton CO_2-eq and the projection for 2020 is a net removal of 41,8 Mton CO_2-eq.

The net removal of living biomass (growth minus harvest and natural loss) under forest management is mainly affected by the changes in forest growth, harvest, natural degradation and natural hazards. In Sweden there has been a steady increase of the forest growth[4] and the total timber stock has also been growing[5]. During the commitment period, the growth has nevertheless decreased from 119,6 Mm^3 stemwood in 2013 to 114,9 Mm^3 stemwood in 2016 (the figures are presented as running 5-years means)[6]. The annual carbon loss (harvest and natural loss) was 92,7 Mm^3 stemwood in 2013, and 93,1 Mm^3 stemwood in 2016 (also presented as running 5-years means)[7]. The timber stock in the Swedish forests is increasing since the annual growth (gross removal) is larger than the annual harvest and natural losses but the growth rate has slowed down during the last years[8].

The Harvested wood product pool has constituted a net removal since 1990. The average net removal during 2013 - 2019 was 6,6 Mton CO_2-eq, with the highest net removal in 2015 and the lowest net removal in 2018. The harvested wood product pool covaries with the pool of living biomass above ground. The net removal of the

[3] Will be submitted 15 of January 2021 to the EU under Monitoring Mechanism Regulation 525/2013/EG

[4] https://skogsstatistik.slu.se/pxweb/sv/OffStat/OffStat__AllMark__Tillvaxt/AM_Tillvaxt_avverkning_fig.px/table/tableViewLayout2/

[5] https://skogsstatistik.slu.se/pxweb/sv/OffStat/OffStat__AllMark__Virkesforrad/AM_Virkesf_tot_fig.px/table/tableViewLayout2/

[6] https://skogsstatistik.slu.se/pxweb/sv/OffStat/OffStat__AllMark__Tillvaxt/AM_Tillvaxt_avverkning_fig.px/table/tableViewLayout2/

[7] https://skogsstatistik.slu.se/pxweb/sv/OffStat/OffStat__AllMark__Tillvaxt/AM_Tillvaxt_avverkning_fig.px/table/tableViewLayout2

[8] https://www.forskning.se/2020/06/01/rekordmanga-trad-dor-av-annat-an-avverkning/

harvested wood product pool is mainly governed by the level of harvest and the inflow of carbon that results from felling trees. Also, the existing carbon stock is important for the development in the pool as it affects the outflow.

The mineral soil has constituted a net removal during the whole commitment period. The annual net removal is on average 13,5 Mton CO_2-eq. The net removal is very difficult to estimate since it is a large carbon pool with very small annual changes (relative to the total carbon stock). More information can be found in Sweden's National Inventory Reports.

The net emissions from Forest management arise mainly from drained organic soils (CO_2, CH_4 and N_2O) and litter, and these have not changed to any large degree between 2013 and 2019. The annual net emissions are 6,1 Mton CO_2-eq on average, including the emissions of CH_4 and N_2O.

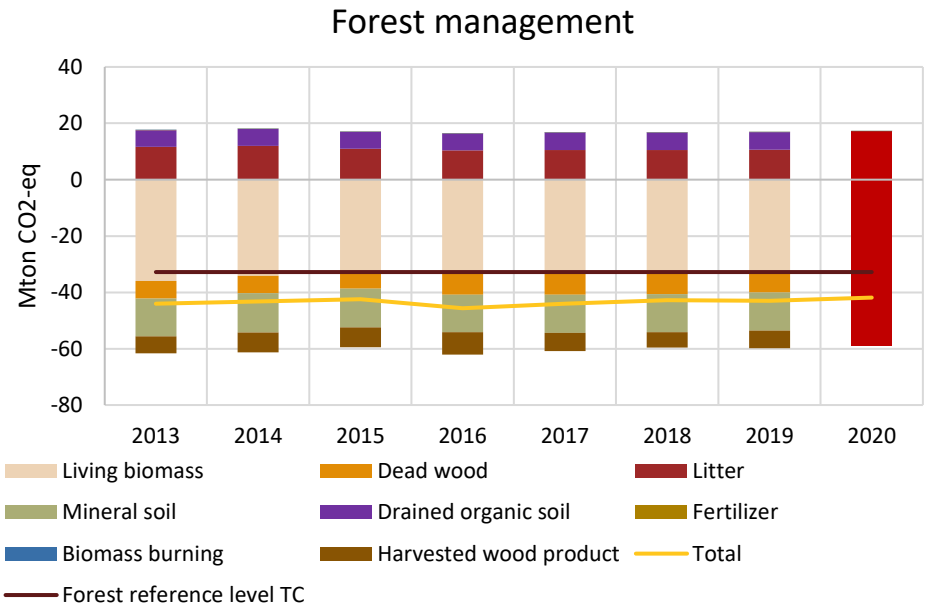

Figure 2 Forest management – reported net removals (-) and net emissions (+) during the accounting period 2013 – 2020. The figure for 2020 is a projection. The technical corrected forest reference level is also included. CO_2, CH_4 and N_2O are all included in the figures for drained organic soil.

The assumptions for the Business As Usual scenario for the forest management reference level (FMRL) can be found in Submission of information on forest management reference levels by Sweden, 2011[9]. In the scenario used to simulate the FMRL, the annual felling (harvest) is assumed to be at the level of what is regarded as sustainable in the long term, i.e. set to the highest possible harvest without decreasing the future standing stock, while assuming no harvest from areas for nature conservation and volumes not available for harvesting in production areas due to environmental legislation. The results in the scenario show that the possible harvest during the period 2010-2030 amounts to approx. 93 Mm^3 stemwood annually.

[9] Submission of information on forest management reference levels by Sweden, 2011, 25th of February

Within the scenario, the average timber stock continues to increase from 3 060 Mm^3 stemwood in 2010 to 3 307 Mm^3 stemwood in 2030.

The net removals under Forest management have been larger than the FMRL level during the whole commitment period. The difference is on average 10,7 Mton CO_2-eq annually with inter-annual variations ranging from 9,6 Mton CO_2-eq in 2015 to 12,8 Mton CO_2-eq in 2016. This difference is partly due to that the actual forest growth, harvest rate, and natural loss during the commitment period developed in a different way than assumed in the FMRL. The actual forest growth was slightly lower than in the simulation while the harvest intensity (the share of the annual growth that was annually harvested) was higher than assumed in the FMRL.

Preliminary results indicate that Sweden will account credits from forest management during the period 2013–2020 since the net removal has been larger than the forest reference level. Accounted credits from Forest Management are capped at 2,5 Mton CO_2eq. annually.

2.3. Afforestation/reforestation

Forest land constitutes 63 percent of Sweden's total land area and has been relatively stable over time. Afforestation/reforestation in Sweden is an uncommon activity and plays only a minor role compared to Forest management. Uncertainties in the calculations are quite large. The average annual sink resulting from this activity is about 1 Mton CO_2-eq. Afforestation mostly occurs on former cropland and grazing land. The area afforested annually during 2013 to 2019 was 12 000 ha on average.

Preliminary results indicate that Sweden will account credits from Afforestation/Reforestation of 1,1 Mton CO_2-eq annually during the period 2013 – 2020.

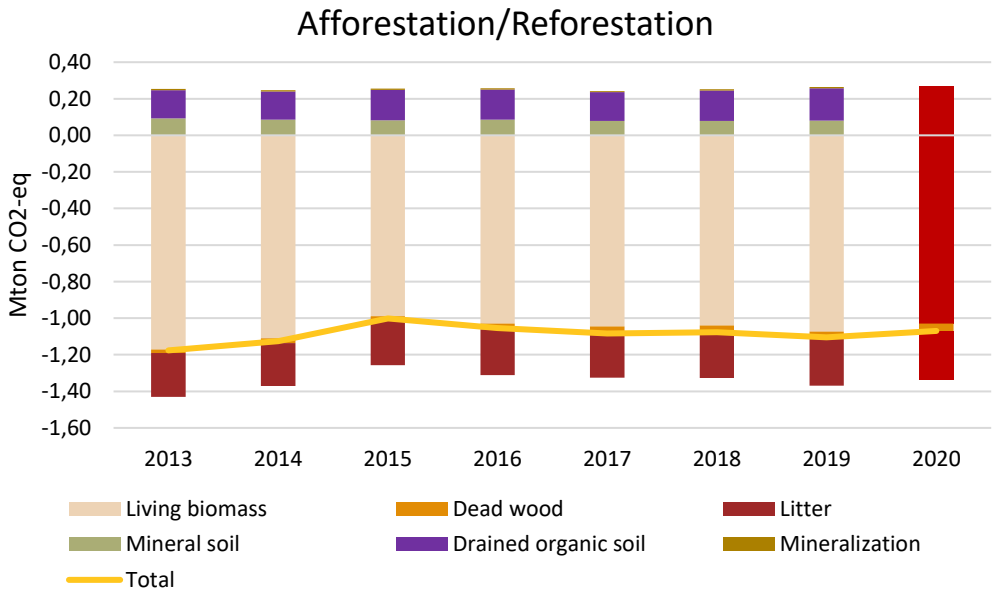

Figure 3 Afforestation, net removals (-) and net emissions (+) during the accounting period 2013-2020. The figure for 2020 is a projection.

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2.4. Deforestation

Since 2013, deforestation has resulted in an average net emission of 3,2 Mton CO_2-eq annually with inter-annual variations ranging from 2,8 Mton CO_2-eq. in 2016 to 4,3 Mton CO_2-eq. in 2015.

Deforestation is driven by construction of buildings and roads (including enlargement of the forest road network), and installations of power lines. An area of about 13 000 ha is deforested annually, mainly to settlements. The other parts are for conversion from forest land to grassland or cropland, but those activities are much less common.

Preliminary results indicate that Sweden will account debits from Deforestation of 3,3 Mton CO_2-eq. annually during the period 2013 - 2020.

The annual deforested area is around the same as the annual afforested area. However, as northern forests grow slowly, sinks from afforestation cannot fully compensate for emissions from deforestation in the short term.

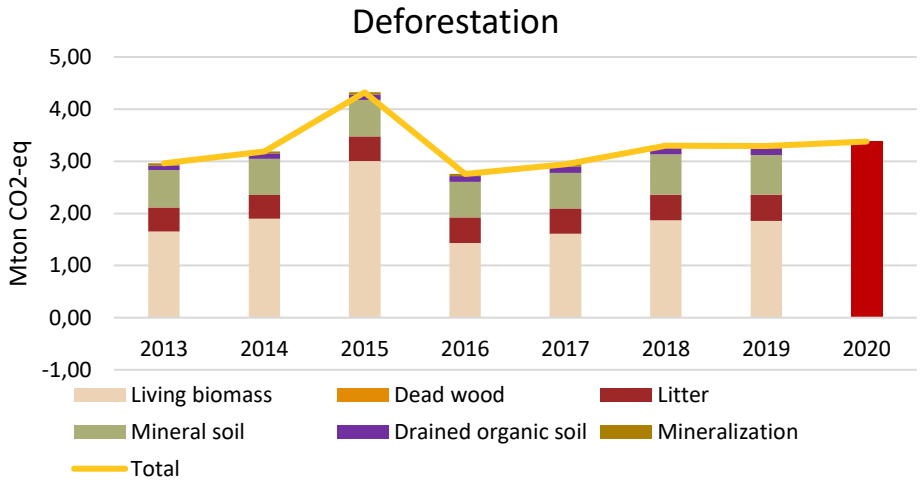

Figure 4 Deforestation, – net removals (-) and net emissions (+) during the accounting period 2013-2020. The figure for 2020 is a projection.

2.5. Cropland management

The area of cropland in Sweden is about 6 percent of the total land area. The area under Cropland management has decreased by around 250 000 ha since 1990, and one of the reasons is that agricultural land has been abandoned due to lower profitability. Most of this land has been converted to Forest land and Settlements.

The total net emissions for this activity have been 3,9 Mton CO_2-eq. on average for the period 2013 – 2019. The emissions are dominated by soil carbon losses, with the highest emissions from organic soils, with additional losses from mineral soils. The emissions from organics soils have remained largely constant during the period 2013 – 2019, while the emissions from mineral soils have increased slightly during the last years. The emissions from organics soils come from degradation of the soil carbon when exposed to oxygen during cultivation/management. The emissions

from organic soils during the period 2013 – 2019 is lower than in the base year 1990 since the area of organic soil has decreased in a rate that follows the general decrease of the total cropland area.

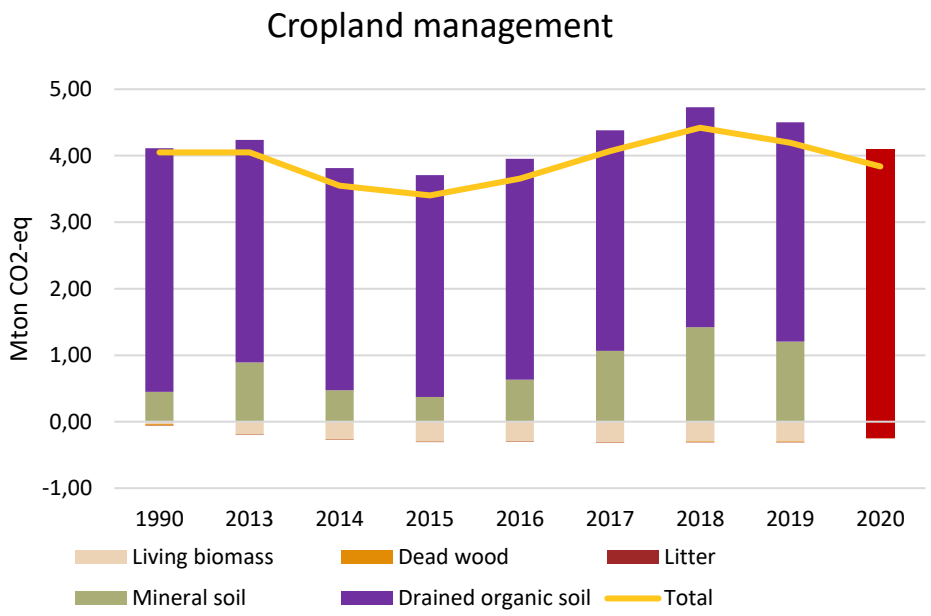

Figure 5 Cropland management, net removals (-) and net emissions (+) during the accounting period 2013-2020, the figure for 2020 is a projection.

The contributing factors to inter-annual variations in the mineral soil emissions on Swedish arable land (approx. 2.5 million ha) mainly depend on changes in crop types (e.g., ley decreases emissions) and yields, as well as on weather conditions the specific years. The annual carbon input to mineral soils is an important driving variable, which is proportional to the yield statistics (i.e., higher yield implies higher carbon inputs). The higher emissions in 2018 and 2019 largely depends on particularly low yields in 2018 because of a severe summer drought. For example, yields for cereals and ley were 45 and 26 percent lower, compared to the last five-year average. Furthermore, there was a reduced proportion of high yielding winter sown crops grown in 2018, such as winter wheat, because of wet conditions in 2017.

Preliminary results indicate that Sweden will account credits from Cropland Management since the average net emissions 3,9 Mton CO_2-eq. during the period 2013-2020 is lower than the net emission in base year 1990 of 4,1 Mton CO_2-eq.

2.6. Grazing land management

Grazing land area in Sweden is about 1 percent of the total land area. Since 1990 until now the area under the activity grazing land management has decreased by roughly 74 kha. There have been proportionally quite large areas converted between Grassland and Cropland, and between Grassland and Forest land.

The net emissions from grazing land management are very small if compared with the emissions from cropland management or forest management. The average

net emission during the period 2013 to 2019 was 0,3 Mton CO_2-eq. The emissions arise from organic and mineral soils, while the removals come from living biomass, litter and dead wood.

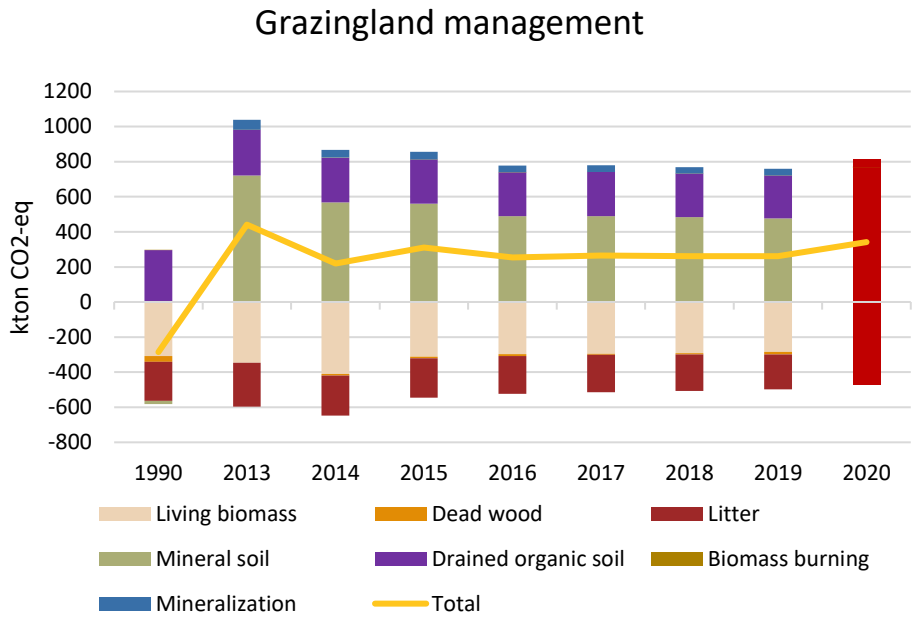

Figure 6 Grazing land management, net removals (-) and net emissions (+) during the accounting period, the figure for 2020 is a projection.

Preliminary results indicate that Sweden will account debits from Grazing land management since the average net emissions 0,3 Mton CO_2-eq. during the period 2013-2020 is higher than in the base year 1990 where the activity constituted a sink of -0,3 Mton CO_2-eq.

3. Preliminary accounting

Preliminary results indicate that Sweden will report accounted total net debits from LULUCF of 0,7 Mton CO_2-eq. for the commitment period 2013 to 2020 despite that the LULUCF activities in total resulted in net removals of 36,6 Mton CO_2-eq. annually on average. Accounting results for 2020 is based on a projection mainly using trend extrapolation. Forest management, Afforestation/Reforestation and Cropland management are expected to generate credits while Deforestation and Grazing land management are expected to generate debits. Accounted credits from Forest Management are capped, 2,5 Mton CO_2-eq. annually. Therefore, debits from Deforestation and Grazing land management cannot be fully compensated by credits from Forest Management.

This result is associated with much uncertainty both due to methodology and annual variation. Since the LULUCF sector is not part of the EU and member states' climate commitment for 2020, credits or debits under LULUCF decision will not be taken into account for the achievement of the commitments under EU climate legislation. However, the LULUCF sector is a part of the commitment under the Kyoto Protocol, and Sweden as a Party will account for Afforestation/Reforestation, Deforestation and Forest management but not Cropland management and Grazing land management. The final results for the LULUCF accounting under EU LULUCF decision and under the Kyoto Protocol will be reported in 2022. Sweden does not include wetland management or rewetting under the LULUCF decision. However, this will be recorded under the LULUCF Regulation. The climate effect from rewetting is nevertheless shown in section 6.2.6.

Table 1. Preliminary results of LULUCF-accounting during the commitment period 2013-2020, credits (-) and debits (+) [Mt CO2-eq.]. Year 2020 is based on projection. Accounted credits from Forest Management are capped by 2,5 Mton CO_2-eq. annually. For Forest Management the most recent technical correction of forest reference level was applied.

	PRELIMINARY ACCOUNTED CREDITS (-) AND DEBITS (+) [MT CO2-EQ.]	
	Total 2013-2020	**Annual**
AFFORESTATION/REFORESTATION	-8,7	-1,1
DEFORESTATION	26,1	3,3
FOREST MANAGEMENT	-20,2 (capped)	-2,5 (capped)
CROPLAND MANAGEMENT	-1,2	-0,2
GRAZING LAND MANAGEMENT	4,6	0,6
SUM	**0,7**	**0,1**

4. Projections for emissions and removals for the accounting period

Projection of the last accounting year, 2020, are included in the figures above. Sweden will submit new scenarios for the LULUCF-sector on the 15:th of March 2021 and in accordance with the Governance regulation 2018/1999. A table with all figures in total for Afforestation/Reforestation, Deforestation, Forest management, Cropland management and Grazing land management are presented in appendix I.

5. Potential to limit or reduce emissions and to maintain or increase removals

An analysis of the potential to limit or reduce emissions and to maintain or increase removals has been reported previously in Sweden's initial report on LULUCF actions from 30th June 2014.

6. Agricultural land

6.1. List of appropriate measures in order to pursue the mitigation potential on agricultural land

Emissions and removals of biogenic carbon dioxide from agricultural land are reported in the LULUCF sector. Other emissions from agricultural land, such as emissions of methane from enteric fermentation and nitrous oxide from the use of fertilizers in the field, are reported within the agricultural sector. Fossil energy use within the agricultural sector is reported in the energy sector, but biomass from agricultural land can replace fossil fuels and reduce emissions in the energy sector. The removals and emissions of biogenic carbon dioxide on agricultural land depend on the land use itself and on measures that take place on agricultural land. Most measures affecting LULUCF emissions and removals are not primarily designed to reduce LULUCF emissions and therefore the effect on LULUCF emissions can be considered secondary. One example is support for willow coppice production where the primary target is an increased production of biofuels but where the measure also leads to an increase in soil carbon.

Policy measures that will contribute to reducing emissions and to maintain or increase removals in the LULUCF-sector include:

1. Increased carbon sequestration due to changes in land-use.
2. Increased carbon sequestration due to changes in management practices on existing land.
3. Measures to reduce greenhouse gas emissions from organic soils.

6.2. Policies for implementing measures to pursue the mitigation potential in agricultural land

6.2.1. Measures within the Common Agricultural Policy (Pillar I)

To get green direct payment support, 5 percent of a farmer's agricultural land needs to be designated as Ecological Focus Areas (EFAs). EFAs include flowering fallow, catch crops, willow coppice and ley sown into the main crop. All these measures increase carbon sequestration in the soil. Willow coppice can also be used as biofuel and therefore contribute to the substitution of fossil fuels in other sectors.

In order to receive payment through the green direct payment scheme within the EU Common Agricultural Programme there is a national condition stating that permanent grasslands (here defined as all pastures and hay meadows as well as arable land with pasture cultivation or fallow that has not been included in the crop rotation on the farm for 5 years or more) are not allowed to decrease by more than 5 percent annually compared to a reference level measured as a quota of permanent grassland divided by the total area of agricultural land. Sweden has had a growing quota since

its introduction, except for 2019 when the quota decreased slightly. However, the negative change was not due to the fact that the actual permanent grasslands decreased in Sweden, but to the measurement method being developed this year and becoming somewhat more accurate.

Two of the cross-compliance requirements within Pillar I are related to soil carbon content. To receive a payment under the Basic Payment Scheme Swedish farmers are not allowed to burn stubble (GAEC 6). Burning stubble removes organic carbon from the soil. GAEC 4 includes a ban on bare soil for 50 to 60 percent of cropland at the farm level during autumn or spring. This ban includes large farms within a large area of Sweden's agricultural land.

6.2.2. Agri-environmental payment and Agri- environmental and climate measures (AECM) within the Common Agricultural Policy (Pillar II)

Within the Rural Development Program 2014-2020 there is an agri-environmental payment for ley with a five-year commitment period in some parts of the country, and as ley production may increase soil carbon content this support has a potential to increase carbon storage in soils. In other parts of the country this payment is replaced by compensation support. The area receiving any of these supports including support from the previous program period (2007-2013) has decreased from around 909 000 to 698 000 ha between 2013 and 2019. The total area of ley during the same period has decreased from 1 138 000 to 1 105 000 ha.

Further there are agri-environmental payments for catch crops, pastures and meadows. The area of catch crops receiving support or being included as an EFA has increased from 115 000 to 123 000 ha between 2013 and 2019. The total area of pastures and meadows has increased from 443 000 ha in 2013 to 461 000 ha in 2019.

In the Rural Development Program 2014–2020 there is an agri- environmental and climate measure (AECM) for the rewetting of agricultural soils and support could also be given for management of wetlands. The main purpose of the support is to promote biodiversity and reduce nutrient leakage and, consequently, the wetlands can be established on mineral soils as well as organic soils. Rewetting of organic soils will reduce emissions.

6.2.3. Investment support within the Common Agricultural Policy (Pillar II)

Within the Swedish Rural Development Programme there is investment support to farmers who wish to plant perennial coppice crops including willow, hybrid aspen and poplar on cropland. The area receiving investment support or being included as an EFA has decreased from 4 200 to 2 200 ha between 2015 and 2019 and the total area has decreased from 12 700 to 8 900 between 2013 and 2019. Growing perennial bioenergy crops on agricultural land previously used for annual crops can increase carbon storage in the soil and biomass and the biomass grown can be used to replace fossil fuels but there is a decreased interest in Sweden for growing perennial bioenergy crops.

6.2.4. Advice for farmers

The Swedish Board of Agriculture works with information and knowledge transfer to farmers. Within the Rural Development Program financed counselling "Focus on Nutrients[10]" there are modules that directly or indirectly relate to increasing soil organic content of the soil as well as modules addressing excessive fertilization etc. One module, named "Soil carbon content and fertility" particularly is aimed at enhancing soil properties and thus also increasing soil carbon. The module focuses on improving soil health and yield and is based on a tool for calculating the effects of cropping systems and other measures (catch crops, straw removal, adding manure) on soil carbon content.

6.2.5. Other government initiatives

There have been several government initiatives to create wetlands on cropland, but not explicitly for the purpose of climate mitigation or adaptation. One exception is the LONA-project, which expressedly gives funding to wetland restoration as a climate mitigation strategy. However, wetland creation for purposes of nutrient retention, increased water quality and biodiversity, have been funded through the LOVA (Lokala vattenvårdsprojekt) and LONA (Lokala Naturvårdssatsningen). When these wetlands are located on organic soils, they reduce emissions from the soil.

In most parts of southern and central Sweden, where most of the agricultural land is found, there is a general ban on draining organic soils. This includes measures to increase the capacity of existing land drainage. Besides the prohibition against new land drainage in the south of Sweden, new or increased land drainage requires a permit in the whole country. Exemptions from this ban can be granted. Historically, organic soils were drained for agriculture production but with the current regulations, virtually no organic soils are drained for agricultural use.

In accordance with the Nitrate Directive farmers in parts of southern Sweden are obliged not to leave soil bare during autumn or winter on a large fraction of their cropland. This contributes to carbon sequestration. The Nitrate Directive also regulates the use of fertilizer on agricultural land.

6.2.6. Rewetting of drained organic soils on cropland

Since 1990, the Swedish state has funded the rewetting of more than 3500 ha of drained organic soils for purposes such as nutrient retention and biodiversity from different initiatives, including LBP (Landsbygdsprogrammet). Data of rewetting efforts from the period 1990 to 2019 vary in quality, and the total area is likely underestimated. A vast majority of wetlands reported in the utilized database are located on agricultural land (3412 ha), with a total emission reduction of ca 689 kton CO_2-eq. over the period 1990 to 2019, where each wetland is estimated to contribute with emission reductions for 20 years. In the year 2019, the annual emission reduction was ca 68 kton CO_2-eq. Despite the possible underestimation of rewetted

[10] Greppa näringen

area, the overall emission reduction may be overestimated as these wetlands have not been created for climate mitigation purposes. Some of these wetlands have likely been created by removing layers of soil prior to rewetting.

The emission factor for rewetted cropland is 21 ton CO_2-eq. per ha and year, which represents a net emission reduction. An hectare drained organic soil on cropland is estimated to release 30.4 ton CO_2-eq. per year, whereas an hectare rewetted soil is estimated to release only 9.3 ton CO_2-eq. per year, mostly in the form of methane[11]. These emissions factors include nitrous oxide, which is otherwise reported within the agricultural sector.

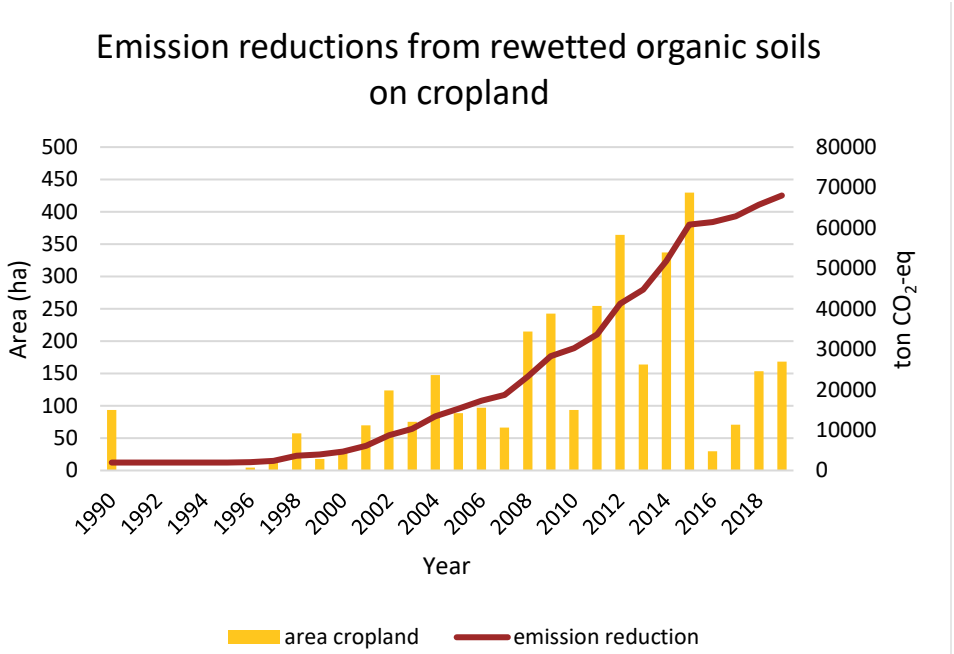

Figure 7 Rewetting of drained organic soils on cropland. Areas are given each year. The accumulated emission reduction from soils is calculated based on the wetland area and associated emission factors.[12] Each wetland counts toward reductions for 20 years after rewetting.

Counting from the year 2013, a total area of 1352 ha has been rewetted on cropland. If earlier rewetting efforts are excluded completely from the analysis, the total accumulated emission reduction amounts to 129 kton CO_2-eq. between 2013-2019. The annual emission reduction for 2019 then amounts to ca 21 kton CO_2-eq.

[11] SOU 2020:4

[12] SOU 2020:4

7. Forest land

7.1. List of appropriate measures to pursue mitigation potential in forest land

The following policy measures can have other main purposes but will also contribute to reducing economy-wide emissions and maintaining or increasing removals.

1. Replacing greenhouse gas intensive materials with materials from forest biomass.
2. Replacing fossil energy with bioenergy, mainly from harvesting residues and residues from forest industries.
3. Increasing sustainable biomass growth through improved forest management, such as improved breeding material, improved reforestation practices, fertilization used with precaution, continued afforestation and enhancing the carbon stock in forest soils through changes in silvicultural systems and protection and restoration of ecosystems, for example peatlands.
4. Avoiding forestry methods which increase greenhouse gas emissions from forest soils, such as drainage, and in other respects adapting forest management to reduce the risk of future emissions as the climate changes.
5. Increasing the amount of carbon stored in harvested wood products.

The last three measures are LULUCF actions primarily influencing carbon sequestration in the LULUCF sector, while the first two measures are LULUCF actions that will reduce emissions in other sectors.

7.2. Policies for implementing measures to pursue the mitigation potential in forest land

7.2.1. Policies to replace fossil fuels by bioenergy

The general carbon tax that was introduced already in 1991 has effectively helped to reduce fossil fuel use, especially in the heat sector. Bioenergy has steadily increased and in 2018 bioenergy use was 141 TWh, of which over 70 percent are forest sector residues. In district heating and industry, carbon taxes as well as other policies and measures have spurred growth in biomass use. From 2003, the green electricity certificate system made it favourable to switch fuels, from fossil fuels to biomass, in existing combined heat and power plants, and in forest industries producing their own power. In the transport sector, several policies and measures have supported bio-fuel powered vehicles and increased the share of more efficient diesel vehicles for road transport. The greenhouse gas reduction mandate for gasoline and diesel has in the last couple of years contributed to considerably increase the use of biofuels in the transportation sector.

7.2.2. Forest policy and the Forest Act

The Swedish Forestry Act (as of 1993) has two overarching, equal objectives: support production and protect the environment.

The production objective means that forests and forest lands should be used effectively and responsibly so they produce sustainable yields. The direction of forest production should be given flexibility in the use of what the forests produce.

The environmental objective means that the natural productive capacity of forest land should be preserved. Biodiversity and genetic variation in forests should be secured. Forests should be managed in a manner that enables naturally occurring plant and animal species to survive in natural conditions and in viable populations. Threatened species and habitats should be protected. Cultural heritage assets of forests and their aesthetic and social values should be safeguarded.

Under the current Forestry Act, production subsidies are abolished, and forest owners have considerable freedom and responsibility to independently conduct long-term sustainable forest management. The regulations concerning timber production cover the notification of felling, the lowest age for felling, requirements for reforestation, guidelines for thinning, and measures to limit damage to soil, water and biodiversity. These regulations indirectly promote storage of carbon. Examples of regulations concerning nature conservation and cultural heritage include not disturbing important biotopes, buffer zones and arable land, and leaving older trees and dead wood in situ which often indirectly promote storage of carbon. Special regulations apply to certain types of forests, such as subalpine forests and deciduous forests.

Sustainable forest management influences carbon dioxide removals and emissions in various ways, through the production of renewable raw materials that can replace fossil fuels and materials that generate emissions of greenhouse gases while maintaining or increasing carbon stocks in biomass, soils and harvested wood products. A long-term sustainable forest growth is needed to meet demand for renewable bio-based products. At the same time, it is important that environmental goals are reached and long-term carbon sinks are preserved.

7.2.3. Environmental code

The Swedish Environmental Code is a coordinated, broad and strict environmental legislation aimed at promoting sustainable development so that present and future generations can live in a good, healthy environment. For example, the Code contains regulations on land drainage. In central parts of the southern Swedish highlands and north of the Limes norrlandicus (the biogeographical boundary of northern Sweden), drainage – defined as drainage intending to permanently improve the suitability of a property for a certain purpose – may only be undertaken with a permit. In the rest of the country, and on sites specifically protected under the RAMSAR Convention, such schemes are prohibited. Protection and restoration of peatlands with high carbon stocks can reduce emissions of carbon dioxide to the atmosphere.

7.2.4. Provisions on nature reserves and habitat protection in the environmental code and nature conservation agreements

High biodiversity often is linked to older forests. Conservation efforts (site protection, nature conservation agreements and voluntary set-aside of land) not only preserve biodiversity, but also positively impact carbon stocks in forest biomass and soil carbon, by allowing them to be maintained or to continue to increase until growth and decomposing rates stabilize. Protected forest ecosystems, in areas where natural disturbances like forest fires are rare, have a capacity to sequester carbon, even long after a conservation measure is implemented. There are milestone targets for 2020 for the conservation and protection of areas containing both wetlands and forest land. Since felling in protected areas is restricted, the carbon stocks in biomass and soil will, in most cases, be larger than in productive forest land managed for wood supply. Such non-managed forests do not contribute to renewable materials for climate mitigation in other sectors.

7.2.5. The Swedish National Forest Program

The supply of sustainable biomass from Swedish forests has an important role to play in the continued transition to a fossil free society. In 2015 the Government initiated a comprehensive dialogue with stakeholders within the Swedish National Forest Program. In 2018, the Government adopted a strategy for Sweden's National Forest Programme, followed by an action plan with specific measures. The action plan will be updated in dialogue with interested parties. The core of the National Forest Programme is the broad dialogue on the role forests play to ensure a sustainable society and a growing bioeconomy. The program contributes to Sweden's climate mitigation efforts by establishing goals and actions plans to increase the national supply of bio-based alternatives.

The strategy for the National Forest Programme focuses on objectives for five main areas:

- Sustainable forest management with greater climate benefits
- Multiple uses of forest resources for more jobs and sustainable growth throughout the country
- World-class innovation and processed forest products
- Sustainable use and conservation of forests as a profile issue in Sweden's international cooperation
- A knowledge leap to ensure the sustainable use and conservation of forests

7.2.6. Examples of Government support, advise, and training

As part of an earlier government initiative, the 'Forest Kingdom' initiative, the Government allocated SEK 10 million each year during 2012–2015 to strengthen governmental advice and training for increased production and to promote environmental awareness in order to increase the uptake of carbon. The Swedish Forest Agency also provided information to forest owners on how climate change

will affect their forests. Furthermore, the Swedish Forest Agency offered guidance adapted to the owners' specific holdings on how to best manage their forests in light of climate change with the owners' own specific goals for their forestry activities in mind.

The Swedish Forest Agency issued a report in 2016 on the effects of climate change on forests and the need for climate change adaptation in forest management. In line with ordinance 2018:1428 on state authorities work with climate change adaptation, Swedish Forest Agency presented an analysis of the vulnerability of forests and forestry to climate change in 2019[13], put forward impact objectives and suggested adaption measures after consulting stakeholders. The objectives aim at maintaining a profitable forestry with an evenly spread wood delivery over time, while avoiding increased negative effects on other societal values and facilitating improved possibilities to climate adaptation for reindeer herding. Risks and suitable policy responses were analysed, e.g. the increased risk of drought and the importance of tree selection adapted to the local habitat,

In a collaborative process the Swedish Forest Agency worked together with representatives of the Swedish forest sector to determine common positions on increased forest production in line with a sustainable and diversified forestry. The aim was to produce a list of actions to be pursued by the state and other Swedish actors to promote an increased production of forestry products in Sweden. The result was presented in a report in January 2020[14]. Increased forest growth will often increase carbon sequestration and carbon stocks.

Furthermore, the Swedish Forest Agency published a report in 2020 on the carbon balance of forests and the climate[15], as a chapter in their series on forest management. The series compiles current knowledge on forest management and is written by prominent researchers in each scientific area, to be used as textbooks at universities, by professionals in forestry operations, adjacent business activities and forest owners. The report provides detailed descriptions of the national circumstances of forest carbon balance, including the contribution of the Swedish forests and forest products to climate change mitigation.

The ordinance (2010:1879)[16] on subsidies for certain activities in forestry enables forest owners to apply for financial support[17] for forestry measures to improve natural and cultural values. Actions include establishment of shallow wetlands, establishment of forests of broad-leaved trees on abandoned agricultural lands, plantations to establish transitional zones between forest and agricultural land, and

[13] www.skogsstyrelsen.se/globalassets/om-oss/publikationer/2019/rapport-2019-23-klimatanpassning-av-skogen-och-skogsbruket.pdf

[14] www.skogsstyrelsen.se/globalassets/om-oss/publikationer/2019/rapport-2019-24-skogsskotsel-med-nya-mojligheter.pdf

[15] www.skogsstyrelsen.se/mer-om-skog/skogsskotselserien/skog-och-klimat/

[16] Förordning (2010:1879) om stöd till vissa åtgärder inom skogsbruket

[17] During 2013-2019 an average of 23.2 Million SEK per year was provided to support these measures, encompassing on average 3846 ha per year.

afforestation of certain broad-leaved trees (elm, ash, common hornbeam, common beach, oak, wild cherry, small-leaved linden, Norway maple). Afforestation of broad-leaved trees on abandoned agricultural land contribute to carbon sequestration[18].

Actions to reduce forest damages have gained increased attention over the accounting period. Spruce bark beetle, increased forest browsing and multiple damages on pine forests have called for intensified efforts. In light of this development, the government commissioned the Swedish Forest Agency to enhance their capacity building and management of forest damages, with a special focus on limiting the spread of spruce bark beetle, including in protected areas managed by the Swedish Forest Agency.[19]

7.2.7. Rewetting of drained organic soils on forest land

Since 1990, the Swedish state has funded the rewetting of more than 3500 ha of drained organic soils for purposes such as nutrient retention and biodiversity. Data of rewetting efforts from the period 1990 to 2019 vary in quality, and the total area of forest land (150 ha) is likely underestimated. Rewetting of much larger areas on forest land have been funded and reported, but they have not been registered into the utilized database. The reported total area gives an accumulated emission reduction of ca 9,5 kton over the period 1990 to 2019, where each wetland is estimated to contribute with emission reductions for 20 years. In the year 2019, the annual emission reduction was ca 1,3 kton CO_2-eq.

The emission factors for rewetted forest land, 8.6 ton CO_2-eq. in the temperate zone and 1.9 to 2.7 ton CO_2-eq. in the boreal zone, represent net emission reductions.[20] Uncertain areas which could not be clearly categorized as either forest land or cropland were represented by the forest land emission factor in the temperate zone, firstly because they were all located in the temperate zone, and secondly as to not overestimate the emission reduction by assigning the emission factor for cropland.

[18] The area where new forests with broad-leaved trees were established encompassed 601 ha between the years 2013-2019.

[19] https://www.skogsstyrelsen.se/om-oss/var-verksamhet/regeringsuppdrag/bekampning-av-skogsskador/

[20] SOU 2020:4

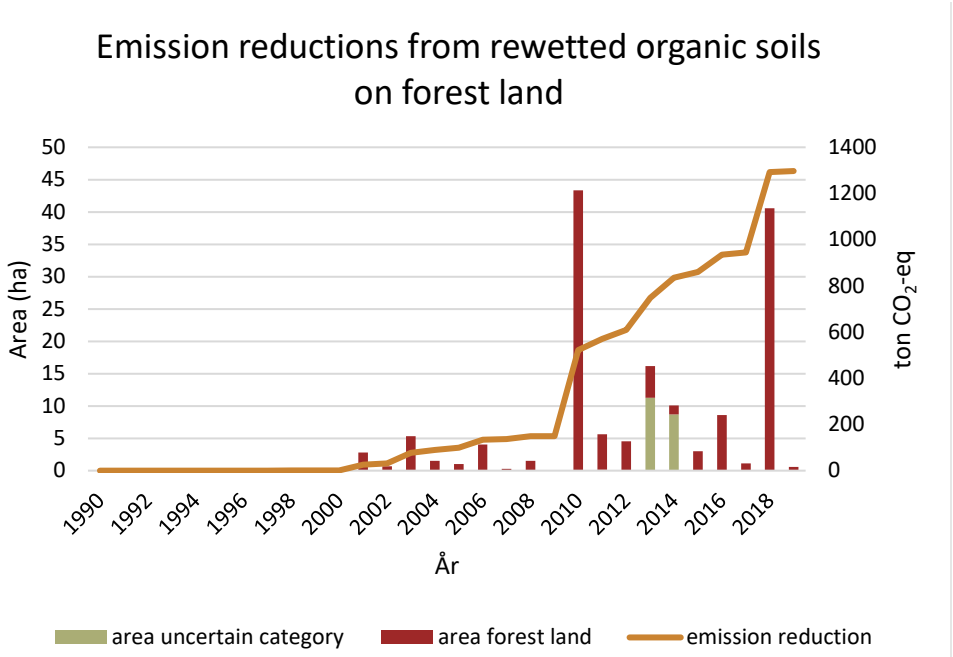

Figure 8 Rewetting of drained organic soils on forest land financed by the Swedish state. Areas are given each year. The accumulated emission reduction from soils (CO_2, CH_4 and N_2O) is calculated based on the wetland area and associated emission factors.[21] Each wetland counts toward reductions for 20 years after rewetting.

Counting from the year 2013, a total area of 80 ha has been rewetted on forest land. If earlier rewetting efforts are excluded completely from the analysis, the total accumulated emission reduction amounts to 2,7 kton CO_2-eq. between 2013-2019. The annual emission reduction for 2019 then amounts to ca. 0.7 kton CO_2-eq.

[21] SOU 2020:4

Appendix

Trends in net emissions (+) and net removals (-) 1990 – 2019 and projection for 2020.

Year	**Afforestation/ Reforestation** Totalt kton CO_2-eq.	**Deforestation** Totalt kton CO_2-eq.	**Forest management** Totalt kton CO_2-eq.	**Cropland management** Total kton CO_2-eq.	**Grazing land management** Total kton CO_2-eq.
1990	18,29	2386,04	-42837,09	4051,74	-285,65
1991	7,02	2223,41	-42202,23	4007,79	-229,51
1992	-3,79	1221,96	-41277,76	4064,77	-227,21
1993	-14,78	3385,61	-38697,80	3928,37	-230,66
1994	-68,88	1575,81	-39692,32	4269,53	-296,55
1995	-61,51	2348,23	-43079,59	4172,26	-293,56
1996	-75,94	1901,29	-44964,14	4222,34	-231,17
1997	-88,52	2592,08	-46400,63	4287,73	-220,69
1998	-187,88	2425,97	-47739,67	4488,62	-246,29
1999	-233,35	1880,29	-47032,44	4750,46	-265,23
2000	-264,09	2587,56	-49423,88	4779,74	-238,21
2001	-286,53	1960,01	-49635,24	4629,16	-227,35
2002	-296,91	1729,68	-48979,77	4693,75	-211,44
2003	-336,38	2569,04	-47145,24	4596,53	-174,91
2004	-475,45	3048,47	-40240,32	4469,42	-230,85
2005	-560,17	1553,71	-37797,53	4088,20	34,07
2006	-696,19	1847,83	-47864,71	3900,99	-76,20
2007	-779,17	3093,40	-42279,13	3838,06	538,05
2008	-854,40	2882,16	-42750,34	3419,13	593,45
2009	-1053,34	3729,50	-43027,91	3356,77	625,56
2010	-1056,34	3911,76	-45436,68	3669,17	577,75
2011	-1104,06	2986,55	-45004,32	3782,24	512,49
2012	-1178,07	3051,35	-45956,15	4188,56	572,42
2013	-1176,00	2961,57	-44017,51	4048,57	441,03
2014	-1125,15	3189,86	-43194,96	3548,41	219,80
2015	-1001,43	4321,76	-42410,19	3402,68	310,32
2016	-1054,45	2756,37	-45631,49	3654,94	253,23
2017	-1084,17	2940,00	-44053,32	4069,72	264,55
2018	-1076,08	3301,16	-42802,51	4420,47	261,89
2019	-1104,60	3293,81	-42949,84	4196,20	261,16
2020 (projection)	*-1068,82*	*3381,89*	*-41857,34*	*3839,92*	*341,87*