Continuous Cover Forestry (CCF) certificates as climate action in Sweden Green Building Council's Net Zero Carbon Future certification system "NollCO$_2$" for new buildings

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Abstract

Forests and other woodland cover nearly half of the EU's land. They can, if managed in a sustainable way, have rich ecosystems and store carbon above and below ground. For many, forests offer a place to relax and connect with nature and they provide food, wood, and clear water. EU has in its new EU Forest Strategy for 2030 declared that forest management to preserve and restore biodiversity must be the new normal and in the EU taxonomy introduced requirements on sustainable forestry. Long-lived wooden products from sustainable forestry constitute a carbon sink, contributing to net zero future carbon buildings. Sweden Green Building Council's net zero certification system "NollCO$_2$" will therefore introduce the opportunity to classify long-lived wooden products originating from continuous cover forestry as a climate sink. This article summarizes researchers' results that show how continuous cover forestry result in increased carbon storage, increased biodiversity, and a better base for ecotourism without the reduction of economical return. The article also reasons around climate actions to reach net zero balance and the concept of net zero.

1. Introduction

1.1 The New EU Forest Strategy for 2030

In July 2021, the European Commission adopted its communication on the new EU forest strategy for 2030 (European Parliament, 2022). The new strategy shall contribute to the biodiversity and climate neutrality goals in the EU Green Deal and the EU Biodiversity strategy for 2030. The strategy aims to improve the quantity and quality of EU forests, reversing negative trends and adapting EU forests to the new conditions, weather extremes and high uncertainty brought about by climate change (European Parliament, 2022). The 2020 State of Europe's Forests report concluded that, on average, the condition of European forests is deteriorating (Forest Europe growing life, 2020) . Sweden, unlike most of the EU countries, reported a net decrease in forest area between 2010-2020 and a much lower number, 74,4%, of forest available for wood supply as a proportion of growing stock (FAW) compared to EU's average of 83,3 %. One reason is the high damage (9,4%) reported by Sweden, caused by windstorms and heavy snow, fires, insects and diseases, wildlife damage and other causes. Due to the high damage and its forestry practice, Sweden had in 2010-2020 an extreme high felling rate to net annual increment (94%) compared to the average in Europe (73%). The result of the high felling rate is that Sweden had the highest marketed roundwood volume in Europe 2013-2017. The quality of the roundwood is low as most of the trees are young at the felling date, and only 20% of a harvested tree in Sweden is turned into a wooden product and 80% is turned into short lived products and bioenergy (Sveaskog, 2017). Consequently, the wood industry has a lower contribution (0,6%) to Sweden's gross domestic product than the pulp and paper industry which contributes with 1% (Forest Europe growing life, 2020).

1.2 EU taxonomy requirements on sustainable forestry

The EU taxonomy is a classification system for sustainable economic activities. It establishes a list of environmentally sustainable economic activities and play an important role helping the EU scale up sustainable investment and implement the European green deal. In the Annex I of the EU taxonomy, EU states that the activity "forestry", to claim that it is sustainable, must perform a climate benefit analysis that demonstrates that the net balance of GHG emissions and removals generated by the activity over a period of 30 years after the beginning of the activity is lower than a baseline, corresponding to the balance of GHG emissions and removals over a period of 30 years starting at the beginning of the activity, associated to the business-as-usual practices that would have occurred on the involved area in the absence of the activity (EU commission, 2021). Other criteria on the sustainable forestry includes a forest management plan, a permanence guarantee and a regular external audit ensuring the criteria are fulfilled.

1.3 Carbon stores in forests

Sweden's forests are part of the boreal forests, high latitude forests, that contain around 25% of global terrestrial carbon stores – mostly in their soils (Quideau, 2021) . Carbon stocks in boreal forests are estimated at 471 gigatons – close to 25% of the total amount of carbon stored in terrestrial ecosystems worldwide. Boreal forest carbon stocks consist of a complex mixture of carbon pools, with more than 85% of carbon being stored in the soil rather than the vegetation according to Quideau. This is a higher number of carbon stored in soil than the European average of 61,8%. The Forest Europe Growing life report from 2020 presents an illustration of the forest carbon pools in Europe, see Figure 1.

The carbon stores are affected by climate change, forest management practices, and how the harvested trees are used. In its forest strategy for 2030, EU envisions that the harvested trees should be used for long-lived wooden products enabling the construction sector to go from a source of greenhouse gas emissions into a carbon sink.

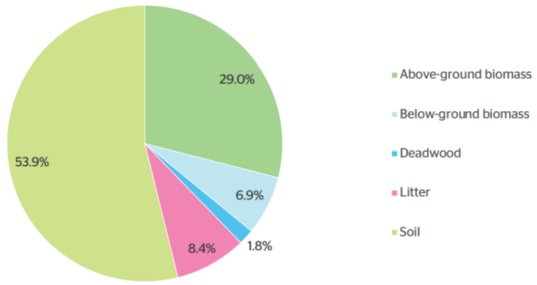

Figure 1 Proportions of forest carbon pools in Europe, 2020 [source: Forest Europe Growing life]

The idea behind this concept is that carbon stored in the harvested trees is later stored in long-lived wooden products. If the trees are turned into short-lived products and bioenergy, the carbon stored in the trees is released into the atmosphere in a few years' time before any new growth in the forest has the possibility to compensate for the removed carbon sink. To fulfil the vision in the EU forest strategy for 2030, the share of trees used for long-lived products must be much higher than the share used for short-lived products and bioenergy. This can only be achieved if the trees have such quality, in terms of age and absence of insects and disease damage, that a majority of the tree can be used for wooden products. Resilient forests withstanding fires, pests, and diseases, require, according to EU, a transition from clear-cutting forest management to close-to-nature forest management. In Germany the process of Waldumbau is used for restructuring forests for more biodiversity and climate resilience in response to disturbance events such as windstorms or insect attacks. The goal is more natural structures and life cycles with multiple species and tree ages per stand (European Parliament, 2022).

Forest management practices not only affects what products can be produced from its harvest, but also the levels of carbon stored in the soil. Research shows that clear-cutting practices, also called rotational forest management (RFM), causes large greenhouse gas emissions and that a reduction in felling rates would benefit the forest's function as a carbon sink on a 50 years scale, taking substitution effects into consideration (Skytt, Englund, & Jonsson, 2021) (Vestin, et al., 2020) (Vestin, 2017) (Lindroth, et al., 2009) (Pukkala, Carbon forestry is surprising, 2018) (Díaz-Yáñez, Pukkala, Packalen, & Peltola, 2019) (Heinonen, et al., 2017). The study by Vestin et al. measured the greenhouse gas emissions from a clear-cut forest during multiple years and arrived at a net emission rate at around 50 tCO_2e/ha for the first three years. The research study by Lindroth et al. and Pukkala shows that it may take 50 years to sequestrate back the carbon that is released from soil and biomass as a consequence of clear-felling and in CCF cutting, the lost carbon is sequestrated back in 15 years. The study by Skytt et al. arrives at the conclusion, that if future substitution effects decrease, which is a plausible and desired development, low harvest strategies are preferred in both short- and long-term time perspectives. Pukkala shows that leaving mature trees in the forest, even after they have died, is a better strategy than harvesting them when it comes to maximizing the long-term carbon balance of boreal Fennoscandian forest. His results shows that a low cutting level maximizes the carbon balance. Vestin's PhD thesis' field study showed that selective cutting forestry did not release stored soil carbon, likely since the protective vegetative layer is not removed. Díaz-Yáñez, Pukkala, Packalen, & Peltola's simulations showed that with small reductions in timber revenues, it was possible to greatly increase the multifunctionality of the landscape, especially the biodiversity indicators in the Fennoscandian countries. Heinonen et al. included all carbon pools in the IPCC guidelines (IPCC, 2000) and calculated the carbon balance as consisting of changes in living forest biomass, the soil organic matter, and wood-based products (for which increased diameter of harvested trees decreased releases). They showed that, while keeping today's cutting target for a 90-year period for the Finish forestry, the total carbon balance of forestry was the highest with a continuously low cutting level, which was lower than the forest growth rate.

1.4 Forest management practices

Forest management practices differ. Conventional forestry in boreal forests predominantly employs even-aged (rotation) forest management, where the rotation and management actions can be divided into three phases: regeneration, thinning (typically from below based on what trees are expected to grow into trees that are economically feasible to harvest) and final felling (so called clear-cutting) (Díaz-Yáñez, Pukkala, Packalen, & Peltola, 2019). Close to nature forestry (CTN) is another forest management method that has a long tradition in Europe. It seeks to ensure and combine the following benefits and functions:

- conservation of biodiversity,
- protection of soil and climate,
- production of timber and other goods, and
- amenity, recreation, and cultural aspects.

Combining these functions is expected to result in a sustainable forestry that still provides society with production of high-quality timber and other goods. Another term used for CNF is the term Continuous Cover Forestry (CCF). In continuous cover forestry, harvests are partial and artificial regeneration is not used. Thinnings are done from above (based on a tree crown's impact on the neighbouring tree crowns) and regeneration is promoted by selective cutting of single trees or tree groups. The forest structure is often un-even aged (Díaz-Yáñez, Pukkala, Packalen, & Peltola, 2019). (Tahvonen, Pukkala, Laiho, Lähde, & Niinimäki, 2010) show that the un-even aged management practice is superior to even-aged management when it comes to financial return due to differences in regeneration and harvesting costs, the interest rate, and the price differential between saw timber and pulpwood for the two management practices. (Díaz-Yáñez, Pukkala, Packalen, & Peltola, 2019) did a similar study but included impact on carbon sinks and biodiversity, climate change effects according to the model by (Seppälä, et al., 2019), and all the carbon pools listed in IPCC (IPCC, 2000). For the study's two rotational forest management practice scenarios, the two continuous cover forestry scenarios and one scenario, where cutting practice was chosen as the result of an optimization algorithm, the lowest net present value, net income, and drain was obtained for one of the rotation forest practices. The other four forest management strategies produced higher economic values with no large differences between them. If the economic impact from ecotourism and the more complicated relation between increased biodiversity and the wider economy are included in the economic analysis, the result would show even higher economic gains from continuous cover forestry. (Knoke, Stimm, Ammer, & Moog, 2005) showed that the economic risk arising from climate change impact on spruce forests, can be mitigated by having a mixture of birch and spruce. (Ahtikoski, et al., 2011) discusses the economical trade-offs between ecotourism requiring scenic landscapes and rotational forestry. Their research question "how many more tourists per annum would compensate for the loss in annual timber revenues" revealed that an increase of 444 tourists would outweigh the economic impact of the forest management transition from 100% (clear-cut) felling to 39% in the area between two top-rated tourist resorts in northern Finland.

Despite continuous cover forestry's positive impact on carbon pools and biodiversity, the higher or equal financial return of continuous cover forestry for forest owners compared to rotational forest management, the percentage of CCF differs, from over 75% in Slovenia to practically zero in Sweden, see Figure 2. Finland has started its transformation and according to the Finnish researcher Timo Pukkala, the percentage CCF is higher than indicated in Figure 2: the Forest Service uses CCF in 25% of their forest area and 17% of private forest owners use CCF in all their forests, and 43% use CCF in some tree stands (Pukkala, 2022). In the article "Continuous cover forestry in Europe: usage and the knowledge gaps and challenges to wider adoption", researchers from Scotland, Slovenia, Portugal, and Finland have analysed what limits the use of continuous cover forestry (Mason, Diaci, Carvalho, & Valkonen, 2021). Major obstacles found in their study included: little awareness of continuous cover forestry amongst forest owners, limited competence in continuous cover forestry within the forestry profession, a sawmilling sector geared to processing medium-sized logs, subsidy regimes favouring practices associated with rotational forestry management and a lack of experience in transforming plantation forests to more diverse structures.

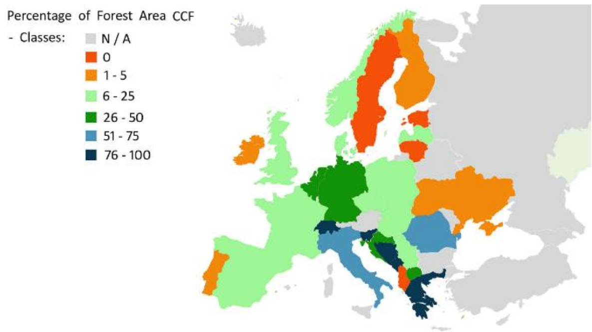

Figure 2 Percentage of forest area managed by CCF by country across Europe [source: (Mason, Diaci, Carvalho, & Valkonen, 2021)]

1.5 Green Building Councils

The first Green Building Council was founded in 1993 and the World Green Building Council (WorldGBC) was founded in 2002 by eight Green Building Councils (World Green Building Council, 2022). Since its formation, WorldGBC has grown into a global network of around 70 Green Building Councils around the world. Sweden Green Building Council (SGBC) was founded in 2009 by thirteen companies and organisations. It has kept growing since then and has today around 410 members (Sweden Green Building Council, 2022). Common for all GBCs are that they are working for a sustainable built environment, but it differs in what degree they work through certification, education, and/or advocacy. Sweden Green Building Council has its focus on certification and education.

1.6 The concepts “net zero” and “carbon neutral”

Advancing Net Zero (ANZ) is WorldGBC’s global programme working towards total sector decarbonisation by 2050 (World Green Building Council, 2022). The ANZ vision is that by 2050, new buildings, infrastructure and renovations will have net zero embodied carbon, and all buildings, including existing buildings must be net zero operational carbon. In its guideline “Advancing Net Zero Whole Life Carbon”, WorldGBC states that

“...emission reduction efforts should be prioritised at all opportunities. However, in the immediate term, offsets are a necessary part of the transition towards total decarbonisation, or zero carbon, for the building and construction sector.” (World Green Building Council, 2021)

World GBC ANZ allows today’s net zero building to use, besides credits from carbon removal projects, also credits from carbon reduction projects to balance the residual emissions, if the projects are credible, unique, additional, and permanent, as determined via independent third party verification.

“Net zero” has however not yet been defined by any international standard. The organisation “Science Based Targets Initiative (SBTi)” uses a strict definition of “net zero”, stating that for “company net zero”, a company’s residual emissions must be reduced with 50% to 2030 and with 90-95% in 2050 compared to a base year’s level. The residual emissions are balanced to net zero in the net zero target year by carbon removals outside the company’s value chain (Science based targets, 2020). The removals can be sourced from carbon credits.

Within EU, half of the 20% residual GHG emissions in 2050 are non-CO_2 GHG emissions from agriculture according to the EU, Figure 3. The remaining non-CO_2 emissions are to be neutralized with carbon capture and storage (CCS) technology, direct air capture (DAC), and an increase of the land use and forest carbon sink. EU expects the contribution from CCS and DAC and the increase in the land use and forest carbon sink to be only a few percentages in 2050. If a project wants to claim an earlier net zero year, using the strict SBTi definition, it might experience that the availability of carbon credits for CCS and DAS is very limited, if at all available, since they are not yet commercially available at a reasonable cost.

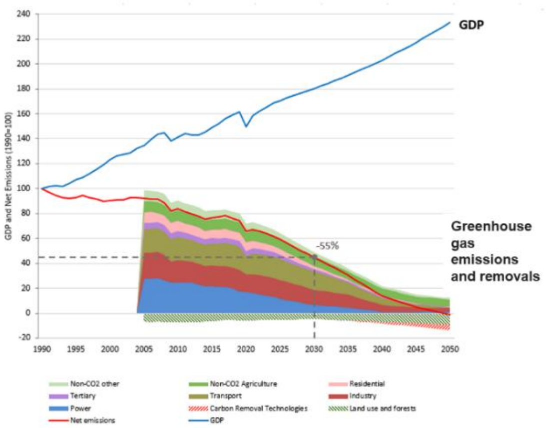

Figure 3 GHG emissions and removals forecast in EU, plotted as overlapping curves [source: EU, https://ec.europa.eu/clima/eu-action/european-green-deal/2030-climate-target-plan_sv]

The option left is to invest in carbon credits in form of increased uptake in land use and forests. Some carbon markets have chosen to develop carbon credits in the form of large scale even-aged monocultures of pine, since pine is the tree species storing the most carbon in the fastest time. But large-scale even aged monocultures of pine can cause many problems, especially if pine is not a native tree. In 2020, the Swedish Energy Agency stopped purchasing climate credits from a large scale pine plantation project in Uganda, since the project caused environmental degradation and loss of land and livelihoods for local villagers (Skydda skogen, 2020). In New Zeeland, the

Ministry for Primary Industries recently released a public discussion document proposing that from the first day of 2023, only native forest would be eligible for carbon credits, among others due to pine plantation risks from pests and fire compared with native forests (Ministry for Primary Industries, 2022).

If a project wants to stay clear from incentivising large-scale even aged pine plantations, applying a strict definition of net-zero therefore gives little possibility of net zero buildings for several decades. The strict net zero definition also does not allow the usage of contributions to societal net zero as a way of neutralizing the project's residual emissions to net zero. The regenerative effect is zero.

According to ISO 14021:2017, "carbon neutral" refers to a product that has a carbon footprint of zero or a product with a carbon footprint that has been offset (Swedish Standards Institute, 2017). Offsetting is, according to ISO 14021:2017, "a mechanism for compensating for the carbon footprint of a product through the prevention of the release of, reduction in, or removal of, and equivalent amount of GHG emissions in a process outside the boundary of the product system".

1.7 "NollCO$_2$" certification

Sweden Green building Council (SGBC) joined the ANZ programme in 2017 and within its framework, started the development of a net zero certification scheme for new buildings called "NollCO$_2$" following the ANZ net zero principles. As Sweden Green Building Council's certification scheme "NollCO$_2$" is part of the World GBC initiative ANZ, "NollCO$_2$" adhere to the ANZ definitions. "NollCO$_2$" therefore allows for emissions reductions as well as emission removals outside the system boundary to contribute to the net zero balance. The "NollCO$_2$" system consists of criteria for reducing whole life carbon impact in line with the sector level 1.5° pathway and includes regenerative climate actions for contributing with carbon reductions and removals to the society outside the project system boundary, to balance the project's residual emissions to net zero, see Figure 4 (Sweden Green Building Council, 2020).

In "NollCO$_2$", B1-B7, are balanced to net zero on a yearly basis while A1-A5 and C1-C4 are balanced, earliest at the date of certification and latest in 2045, to net zero. To reduce carbon impact, "NollCO$_2$" has set a project specific carbon limit for the modules A1-A3 and a static carbon limit for the modules A4-A5 and an energy performance limit for B6. The reduction limit is in the range of 30% of the residual emissions. "NollCO$_2$" requires the climate impact of the building and its building elements to be calculated according to the standards SS EN 15978 and SS EN 15804. The "NollCO$_2$" unit for the climate impact of a building element is kgCO$_2$e per kg building element. The climate impact of a transportation building element has the unit kgCO$_2$e per ton transported goods and km (tkm). The unit for climate impact of the building is kgCO$_2$e per m^2 gross area. The expected building service life is a 50-year span after the building is put into operation, as defined by the Swedish National Board of Housing, Building and Planning in the building code for climate declarations of new buildings. "NollCO$_2$" includes the full life cycle A-C according to EN 15978 and all building elements above and below ground level, see NollCO$_2$ manual 1.0 (Sweden Green Building Council, 2020).

1.8 "NollCO$_2$" climate actions

Early in the "NollCO$_2$" development, it was clear that the "NollCO$_2$" pilot projects wanted to balance their residual emissions by reducing or removing emissions in Sweden and was not invested in buying offsets in countries far away. The discussions resulted in that "NollCO$_2$" introduced national climate actions with the same requirements as for offset programs on additionality, permanence, measurability, traceability, and exclusivity. It was decided that the climate actions must be initiated and funded by the "NollCO$_2$" project or the organisations behind the "NollCO$_2$" project to guarantee additionality. Unlike conditions for offsets, the funding organisation is allowed to profit financially from the "NollCO$_2$" climate actions. Installing renewable electricity production was selected as one climate action. Performing energy efficiency renovations in existing buildings was chosen as another. The renewable electricity production can be installed on- or offsite but must be installed within the Nord Pool electricity market (https://www.nordpoolgroup.com), as this market was the basis for the carbon credit calculation. The energy efficiency renovation should result either in 30% improvement in energy performance or in energy performance class C, in line with the EU taxonomy requirements on building renovation projects.

The "NollCO$_2$ foundation framework", available in Swedish at SGBC.se, presents calculations, done according to the GHG Protocol (https://ghgprotocol.org/), resulting in climate credits for the two climate actions (Sweden Green Building Council, 2020).

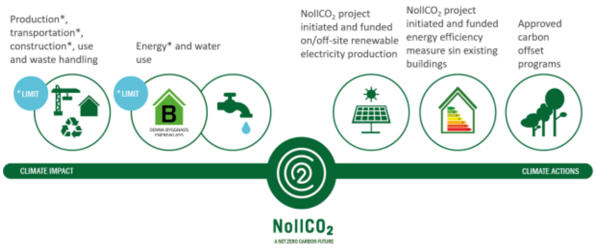

*Figure 4 "NollCO$_2$" model. *= Limit value [source: SGBC]*

2. Introduction of CCF certificate

In the 1.0 version, "NollCO$_2$" did not include any national climate action for using long-lived wooden products in the building. “NollCO$_2$” was aware of the problems discussed in section 1.1-1.3 in this article and the inclusion was postponed. With the knowledge now available, “NollCO$_2$” has decided to include national certificates from using long lived wooden products from continuous cover forestry as a carbon uptake climate action.

2.1 Climate benefit analysis

The soil carbon emissions from continuous cover forestry thinning from the top is sequestrated back in 15 years and the re-growth of forest volume is equal or higher than the harvested volume in the time frame 30 years. The stored soil carbon increases in continuous cover forestry, also in mature forests, is expected to neutralize the burning of 20% of the harvested volume as bioenergy or waste handling of pulp and paper products. Therefore, continuous cover forestry does fulfil the EU taxonomy criteria regarding climate benefit analysis.

2.2 Permanence

The continuous cover forestry for which the CCF certificate is issued is under a contractual guarantee ensuring that it will remain a forest, and is, as the term implies, continuous. The requirement on permanence of sustainable forestry in the EU taxonomy is therefore fulfilled.

2.3 Management plan and audits

The organization that issues certificates from continuous cover forestry needs to establish that the forest owner follows a forest management plan that meets the organization's criteria for sustainable continuous cover forestry and allows the organisation to do regular audits. The certificate program can support CCF forest owners or forest owners who transition to CCF. The CCF forests included in the certificate program are listed where the certificates are ordered. The certificate must contain coordinates to the CCF forest from which the certificates origin. An independent third party auditor checks that the issuing organisation and the forest owners do not deviate from the requirements. SGBC reserves the right to approve from which organizations CCF certificates can be purchased. A list of these organisations will be published on SGBC.se>NollCO$_2$.

2.4 Long-lived

Long-lived implies that the expected service life of the wooden product is longer than or equal to the EU taxonomy’s carbon balance time frame of 30 years. In a “NollCO$_2$” project, a wooden product is therefore considered to be long-lived if it belongs to a BSAB category with an expected service life longer than or equal to 30 years, see Table 1. “NollCO$_2$” will only allow a maximum amount of CCF certificates corresponding to the maximum amount of long-lived wooden products in the building, as a balancing climate action. This to ensure that the carbon sink has a lifetime of at least 30 years.

Table 1 Expected service life of building elements, construction products and building service systems, from EU Level(s) according to its BSAB 96 building element category.

Building elements, construction products and building service systems	Expected service life
BSAB 15S Basic constructions for houses, BSAB 27 Bearing structure in house frame BSAB 49B House shaft	60 years
BSAB 43 Internal components for room construction (non-load bearing), BSAB 45 House extensions (non-load-bearing stairs)	30 years
BSAB 41 Climate-separating components and extensions in roofs and floor joists BSAB 42 Climate-separation components and extensions in the outer wall (non-load bearing) BSAB 45 Exterior house additions (balconies, walkways)	30 years (35 years for glass façade elements, 10 years for outer paint layers)
BSAB 44 Internal surface layers	10 years
BSAB 46 Room extensions (permanently installed)	10 years
BSAB 52B Tap water system	25 years
BSAB 53B Wastewater system	25 years
BSAB 54B Water extinguishing system	30 years
BSAB 55 Cooling system	15 years
BSAB 56B Hot water system	20 years
BSAB 57 Air handling system (air handling unit/AHU) BSAB 57 Air handling system (other)	20 years 30 years
BSAB 61 Sewer system	30 years
BSAB 63 Electric power system (except for BSAB 63. FF/FE/FG/FH)	30 years
BSAB 63FF/FE/FG/FH Lighting and illumination systems	15 years
BSAB 64 Telecommunication system	15 years
BSAB 71 Lift system BSAB 73 Escalator system and roller ramp system	20 years

2.5 Carbon sequestered in sustainable long-lived wood products

The carbon sequestered per kilogram long lived wooden product from a sustainable forestry is derived from BS EN 16449 as:

$$S_{CO_2} = \frac{44}{12} \times cf \times \frac{1}{1+\frac{\omega}{100}}$$

where

S_{CO_2} = carbon sequestered, per kilogram of product, from the atmosphere (kgCO_2/kg)

cf = carbon fraction of woody biomass (oven dry mass) (assume 50% in the absence of product specific information)

ω = moisture content (assume 12% in the absence of product specific information)

The carbon molar mass is 12 and the oxygen molar mass is 16, which gives that carbon dioxide weight is 44/12 times the carbon weight.

Using the default values, S_{CO_2} equals 1,83.

The "NollCO_2" projects can also use the "GWP-biogenic" value as a sequestered carbon value if the EPD for the long-lived wooden product is done according to the standard EN 15804+A2.

In Germany, which has widespread CCF forestry, approximately 50% of the harvested volume became long lived wooden products (Profft, Mund, & Detlef, 2009). The "NollCO_2" project therefore needs to purchase CCF certificates for two times the volume of the long lived wooden products for which they want to claim a carbon sequestration.

At the end of life of the long lived wooden products, the year is 2052 and after. At that time, EU and Sweden must have net zero emissions and energy generation plants burning wood waste have carbon uptake systems. The waste treatment of the long-lived wooden products is therefore assumed to produce zero biogenic carbon emissions.

2.6 Verification

The "NollCO_2" project needs to show a copy of their CCF certificates bought from an, by SGBC, approved, issuing organisation.

3. Discussion

With the introduction of national CCF certificates, the "NollCO_2" project can strive for a strict net zero using national carbon uptake measures. A project of 8000 m^2 gross area and residual 350 $kgCO_2e/m^2$ gross area would need CCF certificates for 5600 m^3, since the volume long-lived wooden products from sustainable forestry need to sequester 8000*365 $kgCO_2e$ (assuming dry wood density is 465 kg/m^3):

$$\frac{8000 \times 365}{465 \times 1{,}83} = 2800\ m^3$$

4. Conclusions

This article has summarized the researchers' results related to even aged rotational forestry management (RFM) and continuous cover forestry (CCF). From the summary the conclusion was drawn that continuous cover forestry can contribute to climate mitigation according to the requirements in the EU taxonomy. Therefore, the long-lived wooden products in a "NollCO_2" project can be included as carbon sinks if the project can prove they originate from CCF forestry by buying CCF certificates. Since Sweden Green building council work for social and economic sustainability as well as for ecological sustainability, the researchers' results are encouraging as they show that continuous cover forestry does not only contribute to increased carbon storage but also to increased biodiversity and a better base for ecotourism. This without the reduction of economical return for the forest owner. However, the hurdles for the transformation to continuous cover forestry, as described by (Mason, Diaci, Carvalho, & Valkonen, 2021) , must be tackled by the appropriate government organisations.

5. Acknowledgements

The continuous development of "NollCO_2" cannot be done without the help of the "NollCO_2" pilot projects, the Sweden Green Building Council's drive to push for a science- and standards-based certification system, and all the experts and members of the Sweden Green Building Council participating in discussions contributing to the system. The World Green Building Council's network "Advancing Net zero" is also a valuable support and discussion partner.

References

Ahtikoski, A., Tuulentie, S., Hallikainen, V., Nivala, V., Vatanen, E., Tyrväinen, L., & Salminen, H. (2011). Potential Trade-Offs Between Nature-Based Tourism and Forestry, a Case Study in Northern Finland. *Forests, 2*, 894-912. doi:doi:10.3390/f2040894

Díaz-Yáñez, O., Pukkala, T., Packalen, P., & Peltola, H. (2019). Multifunctional comparison of different management strategies in boreal forests. *Forestry*. doi:10.1093/forestry/cpz053

EU commission. (2021). *Commission Delegated Regulation (EU) 2021/2139.* EUR-Lex. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R2139

European Parliament. (2022). *New EU forest startegy for 2030.* Retrieved from Think Tank European parliament: https://www.europarl.europa.eu/thinktank/en/document/EPRS_ATA(2022)698936

European Parliament. (2022). *Think Tank European Parliament.* Retrieved from At a glance: https://www.europarl.europa.eu/RegData/etudes/ATAG/2022/698936/EPRS_ATA(2022)698936_EN.pdf

Forest Europe growing life. (2020). *State of Europe's Forests 2020.* https://foresteurope.org: UNECE, Food and Agriculture Organization of the United Nations.

Heinonen, T., Pukkala, T., Mehtätalo, L., Asikainen, A., Kangas, J., & Peltola, H. (2017, July). Scenario analyses for the effects of harvesting intensity on development of forest resources, timber supply, carbon balance and biodiversity of Finnish forestry. *Forest Policy and Economics, 80*, 80-98. doi:https://doi.org/10.1016/j.forpol.2017.03.011

IPCC. (2000). In: Watson, R., Noble, I.R., Bolin, B., Ravindranath, N.H., Verardo, D.J., Dokken, D.J. (Eds.), Land use, Land-use Change, and Forestry: A Special Report. Cambridge University Press, Cambridge, UK.

Knoke, T., Stimm, B., Ammer, C., & Moog, M. (2005). Mixed forests reconsidered: A forest economics contribution on an ecological concept. *Forest Ecology and Management, 213*, 102-116.

Lindroth, A., Lagergren, F., Grelle, A., Klemedtsson, L., Langvalls, O., Weslien, P., & Tuulik, J. (2009). Storms can cause Europe-wide reduction in forest carbon sink. *Global Change Biology*, 346-355.

Mason, W., Diaci, J., Carvalho, J., & Valkonen, S. (2021). Continuous cover forestry in Europe: usage and the knowledge gaps and challenges to wider adoption. *Forestry: An International Journal of Forest Research*, 1-12.

Ministry for Primary Industries. (2022). Retrieved from Managing exotic afforestation incentives by changing the forestry settings in the NZ Emissions Trading Scheme: https://www.mpi.govt.nz/consultations/managing-exotic-afforestation-incentives

Profft, I., Mund, M., & Detlef, S. E. (2009). Forest management and carbon sequestration in wood products. *European Journal of Forest Research*.

Pukkala, T. (2018). Carbon forestry is surprising. *Forest Ecosystems, 5*(11). doi:10.1186/s40663-018-0131-5

Pukkala, T. (2022). mejl conversation, University of Eastern Finland,UEF, School of Forest Sciences.

Quideau, S. (2021). *Investigating Carbon Storage and Stability in Boreal Forest Soils.* Canada: University of Alberta.

Science based targets. (2020). *FOUNDATIONS FOR SCIENCE-BASED NET-ZERO TARGET SETTING IN THE CORPORATE SECTOR.*

Seppälä, J., Heinonen, T., Pukkala, T., Kilpeläinen, A., Mattila, T., & Myllyviita, T. (2019). Effect of increased wood harvesting and utilization on required greenhouse gas displacement factors of wood-based products and fuels. *Journal of Environmental Management, 247*, 580-587.

Skydda skogen. (2020). *Skydda skogen*. Retrieved from Swedish Energy Agency stops funding carbon offset project in Uganda: https://skyddaskogen.se/swedish-energy-agency-stops-climate-compensating-in-uganda/?lang=en

Skytt, T., Englund, G., & Jonsson, B.-G. (2021). Climate mitigation forestry—temporal trade-offs. *Environmental Research Letters 16*.

Sveaskog. (2017). *Skogsbruk, på ren svenska: Allt du behöver veta om det svenska hållbara skogsbruket - på bara sju minuter.*

Sweden Green Building Council. (2020). *NollCO2 - A NET ZERO CARBON FUTURE - MANUAL 1.0.* Stockholm: SGBC.

Sweden Green Building Council. (2020). *NollCO2 1.0 Ramverk.* Sweden Green Building Council. Retrieved from www.sgbc.se

Sweden Green Building Council. (2022, April). *Om oss*. Retrieved from https://www.sgbc.se/om-oss/

Swedish Standards Institute. (2017). *Svensk standard SS-EN ISO 14021:2017. Environmental labels and declarations - Self-declared environmental claims (Type II environmental labelling).* Swedish Standards Institute.

Tahvonen, O., Pukkala, T., Laiho, O., Lähde, E., & Niinimäki, S. (2010). Optimal management of uneven-aged Norway spruce stands. *Forest Ecology and Management, 260*, 106-115.

Vestin, P. (2017). *Lund University, Faculty of Science, Department of Physical Geography and Ecosystem Science*.

Vestin, P., Mölder, M., Kljun, N., Cai, Z., Hasan, A., Holst, J., . . . Lindroth, A. (2020). Impacts of Clear-Cutting of a Boreal Forest on Carbon Dioxide, Methane and Nitrous Oxide Fluxes. *Forests*.

World Green Building Council. (2021). *Advancing Net Zero Whole Life Carbon.*

World Green Building Council. (2022, April). *About us*. Retrieved from https://www.worldgbc.org/our-story

World Green Building Council. (2022, April). *Advancing Net Zero*. Retrieved from https://www.worldgbc.org/advancing-net-zero