Consultation on the Common Biomass Sustainability Framework

Technical Annex on carbon impacts of forest derived biomass

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Introduction

The following Technical Annex provides scientific and technical background to certain proposals contained within the consultation. It covers an identification and assessment of the carbon risks associated with the use of forest biomass feedstocks for bioenergy, as well as an assessment of feasible options to address these.

An analysis of options to make the existing sustainability criteria addressing carbon risks for forest-derived biomass more stringent was performed by Forest Research. This followed on from previous qualitative and quantitative assessments of the direct and indirect greenhouse gas (GHG) emissions associated with different types of solid and gaseous biomass (Matthews and others, 2015, Strengers and others, 2024). From the literature reviewed, the analysis identified a list of conditions that reduce the risk of forest derived biomass having a negative impact on GHG emissions, and support outcomes that result in a positive carbon balance. These conditions were compared against the breadth of sustainability criteria in current legislation to identify what risks are already addressed. This then identified where the common framework could improve on existing sustainability criteria. In particular, improvements to capture the various contexts in which forest-derived biomass can reach the bioenergy market, or to mitigate negative GHG impacts occurring if future demand for biomass were to grow. Options to make the common framework criteria more stringent and effectively mitigate against the theoretical risk that biomass use can have a negative impact on GHG emissions were considered, alongside:

- Evidence that risks or negative impacts on forest carbon could be occurring as a result of the current biomass supply.
- Practicalities of monitoring, measuring and detecting outcomes which lead to negative carbon impacts.
- Potential indicators of theoretical risk that could be monitored or included in the common framework.
- Sources of evidence, assessment methods or frameworks that would be needed to monitor or regulate risks or indicators.
- What data may be reasonable and practical for operators, scheme administrators, or other stakeholders to collect, analyse and verify.

The Department for Energy Security and Net Zero (DESNZ) has considered this technical analysis in the context of wider policy considerations such as other aspects of sustainability, ecosystem protection, economic, social impacts, biodiversity and energy security in framing the consultation.

1.1 Options analysis: Long term forest carbon stock

The consultation document outlines how current land criteria requirements relating to forest productivity and sustainable forest management, which are applied to biomass subsidised for use in the UK energy system wherever it is obtained from, can act as proxy for ensuring that long term forest carbon stocks are maintained or increased. If forest productivity is to be maintained, the amount of woody biomass (and therefore carbon) removed should be at least balanced by carbon sequestration during tree growth, hence the carbon stock should stay broadly constant.

There is an opportunity to make the criteria more stringent by explicitly requiring that the long-term forest carbon stocks are stable or increasing in the productive forest area from which the biomass is sourced. However, there are reasons, unrelated to forest management changes that could occur in response to changes in wood or wood fibre demand, such as tree age-distributions and natural disturbances, which can cause carbon stocks to fluctuate in the short term.

In the case of natural disturbances, the Sustainable Biomass Program (SBP), a certification scheme which provides assurance on legality and sustainability to purchasers, takes the approach that biomass can be sourced from areas affected if it assists with the recovery of the forest to productivity such as salvage logging to clear access routes or land for replanting, or uses material that would otherwise be lost. This would mean that the carbon 'consequence' of extracting biomass for energy use would be expected to be at least neutral, if not beneficial.

In the case of there being an uneven-aged distribution in the forest areas supplying biomass, the situation is less straightforward, and this is where the consultation is exploring how guidance could be produced to assess biomass supplies from such areas, as discussed in the next section.

1.2 Uneven-aged forest areas

Uneven-aged forests, which are the majority of managed forests globally, are formed of stands of trees at different ages. Age distribution is largely a result of historical tree planting rates, which can be influenced by various historic events, past incentives, initiatives, forest management objectives and wood product markets. Uneven-aged forests can result in forest carbon stocks rising and falling significantly over time due to varying proportions of the forest area reaching the optimal age range for sustainable harvesting at any given time. In practice, there may be periods in the development of an uneven-aged forest when carbon stocks are increasing in the forest, simply because the majority of the stands forming the forest area are relatively young, and unsuitable for harvesting. Conversely, carbon stocks could fall if a large area of a forest reaches the optimal age range for sustainable harvesting at the same time. Therefore, unevenly-aged forests could see periods of time when the carbon stock is neither stable nor increasing because the amount of standing timber volume harvested from a forest area is likely to be higher than the annual increment (annual volume growth) over a given period.

The ratio between forest increment (the growth of the forest) and the rate of harvesting (the removal of material from the forest), sometimes called the growth-drain ratio, is a possible indicator of sustainable forest harvesting. A growth-drain ratio greater than or equal to 1 could indicate sustainable harvesting rates, while a ratio less than 1 could imply over-harvesting. However, the issue with uneven-aged forests illustrates the limitations of this approach. For example, if the majority of stands forming a forest area have reached the optimal age range for sustainable harvesting then the growth-drain ratio would be below 1. This situation could continue for some years, until the rate of growth exceeds the harvesting rate once again and the growth-drain ratio would be back above 1. The time required for this to occur would depend on a combination of factors, including the tree age distribution of the forest, tree growth rates and the area of forest under assessment (noting that the common framework consultation proposes that forest biomass cannot be sourced from areas that have undergone deforestation). Figure 1 and 2 compare the growth to drain ratio and the average tree age along with the losses of carbon from harvesting and the removals of carbon from the atmosphere between an even aged forest and a hypothetical uneven aged forest.

Figure 1(a) Carbon removals and harvest from an established even aged forest harvested continually at a rate giving a growth to drain ratio of 1

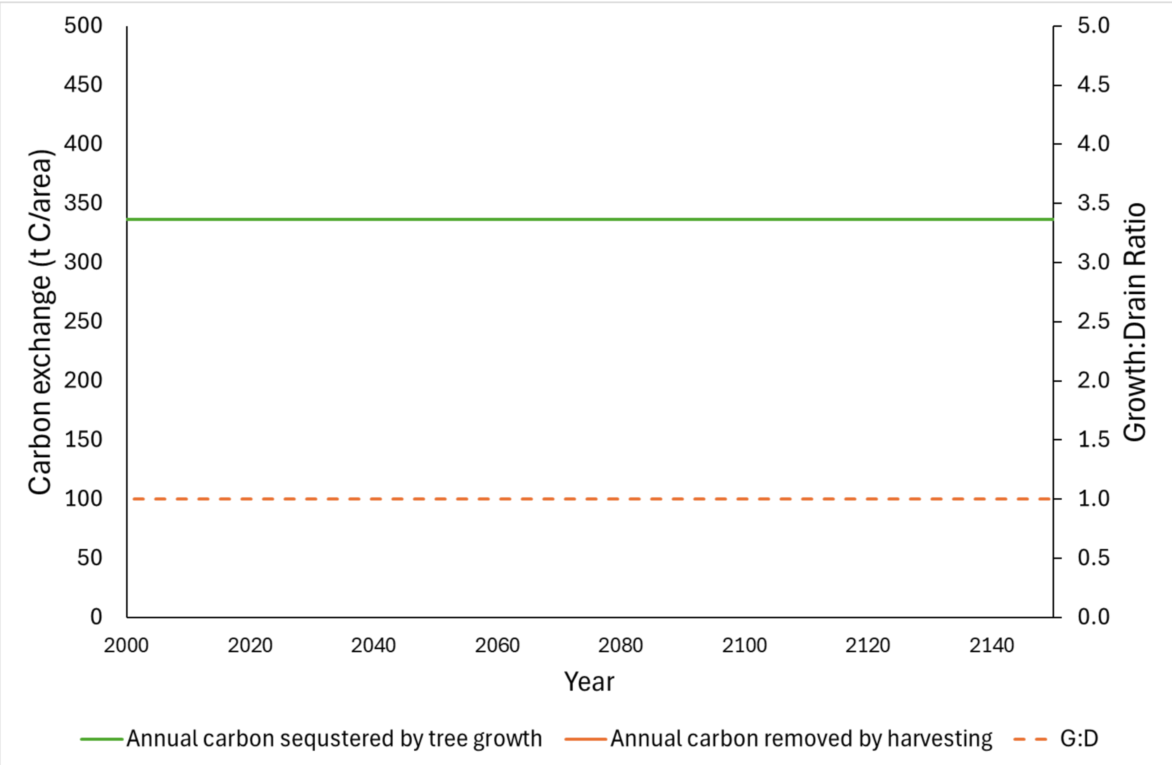

Figure 1(b) Average age of trees in an even aged sitka spruce stand harvested with a growth to drain ratio of 1

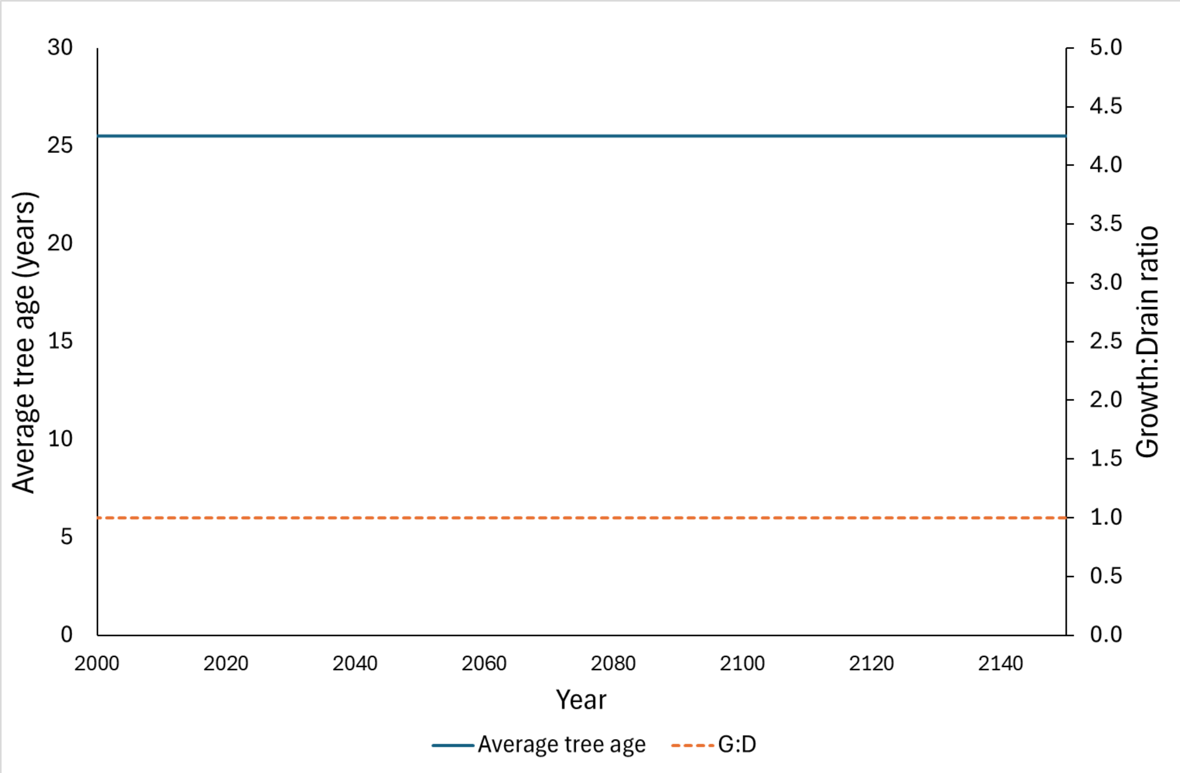

Figure 1(a) illustrates the exchange in tree carbon stocks in a hypothetical 100-hectare woodland consisting of 100 1-hectare stands of Sikta spruce (YC 12) with an even age distribution, managed with no thinning and clearfelling on a 50-year rotation. The figure shows annual carbon sequestration in tree growth and carbon removal (or 'losses') by harvesting. In this example, sequestration and losses are the same, therefore the growth-drain ratio= 1. Carbon exchanges in deadwood, litter, soil and wood products are not considered in this example. Figure 1(b) shows the average age of trees in the stand (unchanging at 25.5. years in this example) vs. growth-drain ratio.

Figure 2(a) Illustration of the effect of a synthetic uneven age distribution on the carbon sequestered by a forest and the carbon lost from the forest through harvesting and the resulting growth to drain ratio

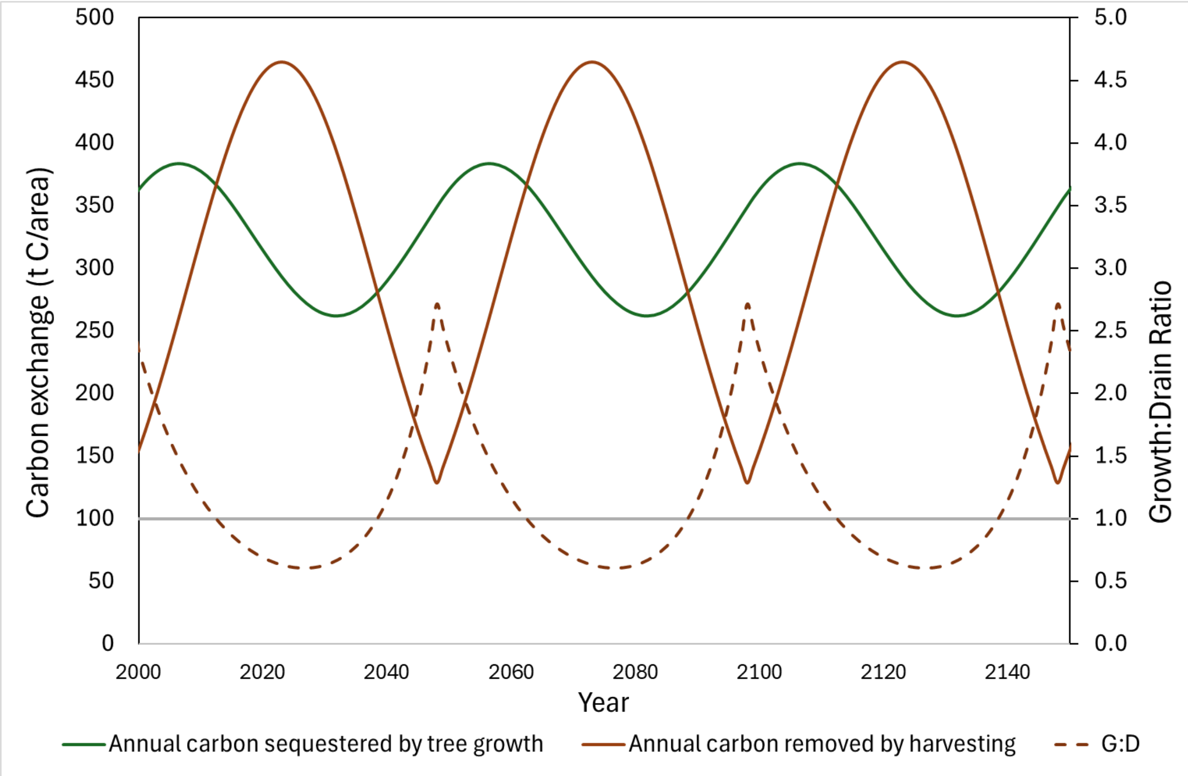

Figure 2(b) shows the average age of trees in the stand vs. growth-drain ratio

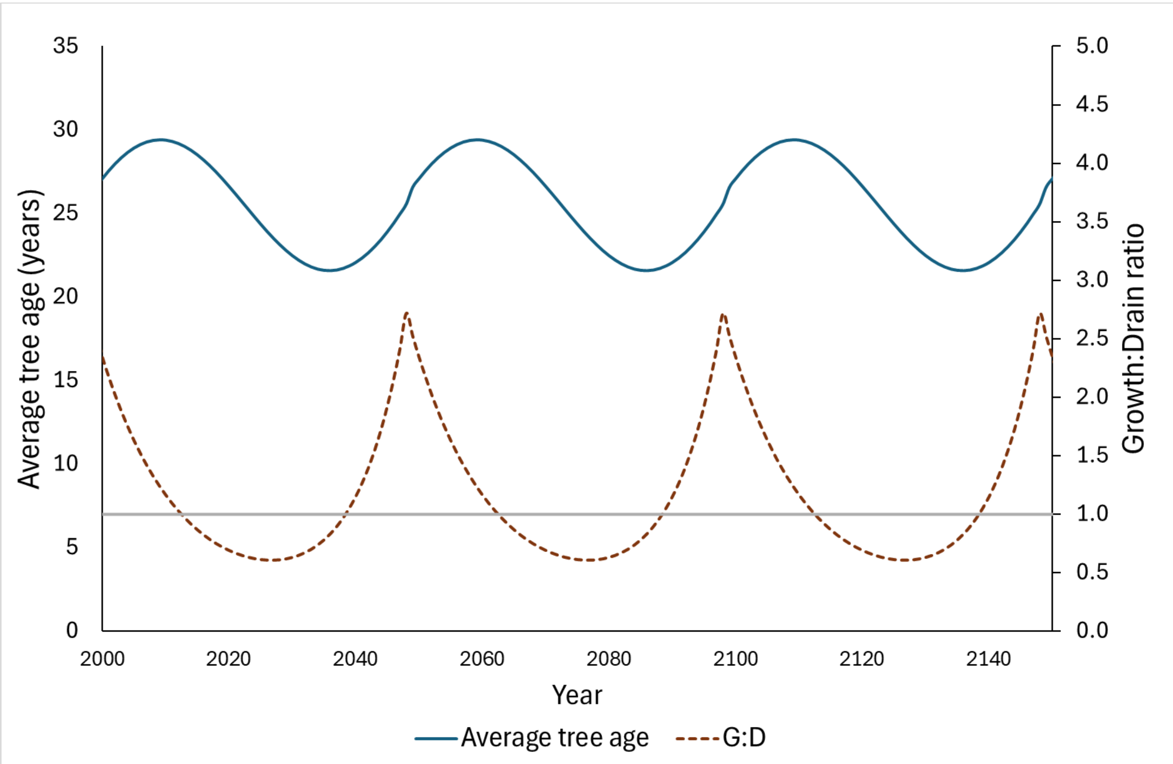

Figure 2(a) Shows the exchange in tree carbon stocks in a hypothetical 100-hectare woodland consisting of 100 1-hectare stands of Sikta spruce (YC 12) with an uneven age distribution, managed with no thinning and clearfelling on a 50-year rotation. Compared to Figure 1, there are periods of time when a larger proportion of the forest area reaches the rotation age, and therefore a greater proportion of carbon is removed by harvesting than is sequestered via the growth of the younger parts of the stand. As a result, the growth-drain ratio drops below 1 during these periods. Conversely, as the stand is restocked and becomes proportionally younger, harvest rates naturally decline (fewer mature stands reaching rotation age) and the growth-drain ratio increases above 1. Carbon exchanges in deadwood, litter, soil and wood products are not shown. Figure 2(b) shows the average age of trees in the stand vs. growth-drain ratio, illustrating how the growth-drain ratio increases during periods when the average age of the trees in the woodland is increasing, and decreases during periods when the average age of the trees is decreasing, because a relatively greater proportion of stands are reaching maturity and are being harvested.

The variations in growth-drain ratio described above are related mainly to the age distribution of the forests, rather than indicating varying periods of sustainable and non-sustainable harvesting. Hence, periods in which harvesting exceeds increment in forests with an uneven age distribution can still align with sustainable forest management for timber production, particularly in situations where the age distribution is largely a result of historical tree planting rates, which can be influenced by various historic events, past incentives, initiatives, forest management objectives and wood product markets. In the UK, trees have often been planted in periods of woodland replacement following over-harvesting during the Napoleonic and twentieth century wars. The resulting age structure leads to substantial fluctuations over periods of decades in projected removals as generations of trees, that are managed for timber, mature (Thomson, 2024). Similar issues affect forests in other wood product markets, such as the SE USA, where historic agricultural economic changes can lead to forest expansion either as an alternative income source for landowners, or following land abandonment, natural regeneration leading to uneven age structures being not uncommon at a forest catchment scale.

Alternatively, there could be situations where forest growth exceeds the harvesting rate, but the rate of harvesting is being increased, so that a greater proportion of the growth is being extracted. In these situations, the growth-drain ratio would be greater than 1, so that the greater intensity of harvesting would not be registered by considering this metric in this simple way.

While noting the above complexities, one possible approach to addressing carbon issues arising from biomass sourcing could involve a requirement for operators to limit biomass supply to only sourcing from regions or countries where the forests display a growth-drain-ratio that is greater than 1 during a given monitoring period. Operators could use resources available in national forest inventories that are publicly reported to identify areas where the growth-drain ratio is becoming “unfavourable” (at risk of going below 1), which would mean that these areas cannot be sourced from. This would, however, be potentially disruptive to the forest sector and forest industries and could ultimately lead to worse environmental outcomes such as reduced forest carbon removals, alongside potential energy security implications. Given that bioenergy feedstocks are not the primary output of the forest sector, and that the evidence shows that it is sourced as a co-product of conventional forestry activity (Cowie and others, 2021, Dale, Kline, and others, 2017, Rodriguez Franco, 2022), this option may be felt by some to be unduly constraining, and it is difficult to determine, given the limited fraction of the economic value of harvest from bioenergy, whether forest management activities may change as a result.

In summary, the growth-drain ratio is a helpful indicator of sustainable forest management but has limitations when applied in uneven-aged forest areas (which is the most likely situation encountered in practice). Therefore, it would be beneficial if further guidance could be provided to operators and the forest industry on how to measure the carbon impact of sourcing biomass from uneven-aged forest areas, which the consultation has sought views on. One aspect concerns determining the area of assessment. When comparing harvest with increment in a simple way, it may be difficult to clearly define the area of forest to be included when calculating the increment. Depending on the scale of assessment, and the types of forest areas that are included or excluded from calculations, there could be some instances where the effects of intensified harvesting or forest degradation are masked by growth in natural or less intensively managed forest areas. Alternatively, harvesting may be purposefully restricted to forest areas that are managed more intensively, and to protect other forest areas from harvesting, which may or may not be related to carbon objectives. Therefore, government needs to gather evidence about which forest areas are appropriate to include in an assessment, such as including some or all of forests in a sourcing area that are not actively under management for wood production, or non-harvested timberland, or a proportion of it. Other decisions, such as the timescales over which assessments should be done, or how often they should be performed, are also needed for the common framework.

There are emerging views in the forest sector that monitoring and managing the growth-drain ratio may not fully mitigate the risks that the sourcing of forest-derived biomass could have on GHG emissions. A situation as described earlier, with increased harvest but below the forest increment can lead to a carbon debt being associated with the harvesting of additional biomass. Changes in management such as an intensification of harvesting in an area of forest could occur if there are sufficient incentives that meet the objectives of forest landowners, which could be influenced by external factors, such as bioenergy policies without sustainability safeguards or increased demand from markets. These negative impacts would not be addressed by simply maintaining a growth-drain ratio greater than 1.

Therefore, given the limitations to using the growth-to-drain ratio, another approach could be to instead define a baseline for comparing the development of forest carbon stocks between scenarios where biomass is or is not derived from a forest area. Strengers and others (2024) identified four possible options for selecting a baseline for assessing forest carbon balances. Two of these approaches are commonly applied in assessments of the impacts of forest management on carbon stocks, and these are explored here:

- Determining whether there have been impacts on the development of forest carbon stocks because changes in forest management have occurred over time, influenced by biomass markets, and

- Comparing sourcing forest biomass with a hypothetical situation in which forests are not managed or harvested but remain intact and continue accumulating carbon stocks.

1.2.1 Changes in management

An indicator of carbon risk could be one that characterises whether changes in forest management have occurred, and whether those changes have, or could, lead to a lower level of long-term carbon stock. Some examples include situations such as:

• Issue A: Shortening rotations within areas of the same forest type, which is likely to have significant impacts on forest carbon stocks (Strengers and others, 2024) but evidence suggests is unlikely to occur as forest owners seek to maximise timber returns (Ricardo 2016).

• Issue B: Increasing the quantity of biomass extracted from a forest area, for example by introducing thinning to areas previously unthinned, or taking more volume/biomass in an individual thinning event compared to pre-existing amounts removed in thinnings. In this case, the long term carbon impacts could be more complex as thinning can have positive and negative impacts on long term carbon stocks, depending on a range of factors including the timescale and scope of assessment, thinning intensity (Mäkipää and others, 2023, Zhang and others, 2024), and potential mitigation effects against natural disturbances (particularly drought and fire (Davis and others, 2024, Moreau and others, 2022, Shive and others, 2024, Sorensen and others, 2011). Good thinning practice aims to encourage tree growth in stands to produce sawlog-grade timber, which can eventually mitigate some or all of the negative carbon impacts of thinning through long-term retention of carbon in wood products and the displacement of more GHG intensive products (Bravo-Oviedo and others, 2015, Matthews, and others, 2015). Thinning should usually increase the economic value of a stand (Kerr & Haufe, 2011) providing an incentive to retain forest land (Favero and others, 2023). It can also provide other benefits such as removing invasive tree species or supporting the growth of ground vegetation and shrubs to enhance stand structural diversity. Therefore, changes in thinning could be related to other management objectives such as improving biodiversity, resilience and ecosystem services but be enabled by rewards for achieving biodiversity objectives or sales of the thinnings which are typically low quality small roundwood.

• Issue C: Increased extraction of wood harvesting residues, where these would otherwise have been left to decompose in the forest, and where decay rates are slow (for example, multiple decades). However, this is likely to be too difficult to evidence as it would be difficult to verify quantities removed, or identify changes in removal rates, or place limits on the size of residues that can be removed. The current sustainability criteria already require operators to meet principles of sustainable forest management, residue management being one of the principal activities taking place under this (Titus and others, 2021), therefore any actions that would either be a) a deviation from recommended practice or b) potentially having a detrimental impact on to soil health or forest productivity are already covered and should be detected under the existing sustainability criteria. Soil carbon and deadwood surveys will, over time, identify changes but are themselves uncertain, may not have historic data, and do not identify the impact of specific consignments.

There are some ways to identify whether the changes in management such as those illustrated above have occurred:

- Collecting data on the average age of harvested trees received at mills or from harvest inventories in given regions. This could indicate issues relating to issue A and extreme cases of issue B.

- Monitoring the age distribution of the forested area to detect shifts in average age, after considering impacts of uneven ages of stands forming the forest areas. Another option could involve monitoring the rate of change of the fraction of harvested fibre relative to the standing forest inventory. These approaches could indicate issues relating to issue A and extreme cases of issue B.

- Predicting changes, such as by collecting data from forest management plans regarding landowner's intentions for rotation lengths, management objectives, species selection, compared to the previous rotation.

- Benchmarking - as above but comparing against benchmarks for typical rotation lengths or harvest levels in given regions that are co-developed with the forest sector.

There are challenges to using approaches such as those identified above, because relevant data, such as the mean age of trees and forest management are not routinely captured in national forest statistics, or data may be limited by the level of granularity available reported, such as for forest age-class distributions. There is an absence of evidence of what relevant data is or could be collected routinely to demonstrate this risk. If data on variables such as mean age of harvested trees cannot be collected, then alternatively data could be collected on rotation lengths in managed forests within the biomass supply area.

More complex monitoring options, which may be expected to control for possible (including less likely) carbon outcomes, are likely to have significant regulatory challenges associated with their adoption. There is no definitive evidence of the extent to which the bioenergy market influences changes in forest management. Some assessments have suggested impacts have been neutral or positive (in carbon terms), in terms of how forests are managed in areas around pellet mills (Aguilar and others, 2020, 2022, Dale, Parish, and others, 2017), or that there can be GHG benefits from handling low value biomass that was previously discarded (Lamers and others, 2014). However, although some might propose that there is only a low risk that the biomass industry has caused changes in forest management leading to negative carbon impacts, definitive evidence for determining this for current, and particularly future biomass demand, is limited (Ricardo 2016), while modelling of the carbon impact of these risks show they may be substantial were they to be realised (for example DECC 2014). Therefore, there is a need to develop ways to collect data to support compliance with the sustainability criteria. This includes understanding the impact of changes on long term carbon stocks of forests: on first principles, if management changes are occurring that have a negative impact on the development of forest carbon stocks, then there is undoubtedly a carbon debt occurring in the affected areas. However, the time taken for this to be "repaid" strictly depends on a number of factors which must be considered, including:

- What would have occurred in the absence of the change – the counterfactual option where management is not changing, which is unverifiable.

- The alternative fate of the biomass - where it is expected that the primary driver for harvest activities is timber procurement and the biomass sector makes use of lower value woody material where it cannot be sold more profitably.

- What impacts could happen externally to the forest, such as in the wood product pool and substitution of wood products.

Therefore, explicitly determining the forest carbon impact of a change in forest management could become complex, and there may be other related carbon impacts (positive and negative) that occur outside of the forest. There may be other wider environmental drivers of changes in management, for example, to meet biodiversity objectives, or to manage pests and disease outbreaks, which must be met but which can lead to a negative impact on carbon. Considering these complexities, the consultation seeks input from stakeholders on the benefits, challenges and limitations of seeking additional evidence on the management of forests where biomass is supplied from.

1.2.2 The ‘no management’ reference case

Some researchers propose that a scenario in which forests should always be compared against the baseline option of leaving forests unharvested, assuming the trees would grow on and reach maximum carbon stocks for that site, sometimes omitting consideration of disturbances from diseases, fires or storms (Helin and others, 2013, Hudiburg and others, 2019, Moomaw and others, 2019, Peng and others, 2023). This assumption of ‘no harvesting’, however, is often not the appropriate choice of an alternative scenario, for example when assessing forest areas that are already under established management for wood supply. There is evidence that the current biomass supply predominantly originates from managed forest areas (Dale, Parish and others, 2017, Cowie and others, 2021, Rodriguez Franco, 2022, Bull and others, 2022, Dale, Kline, and others, 2017, Kittler and others, 2020 North and others, 2021, Parish and others, 2017), therefore it would be inappropriate to adopt a ‘no harvesting’ baseline as part of a general methodology, otherwise it would lead to misleading results (Strengers and others, 2024, Vance, 2018). Comparisons of managed forests with an alternative ‘no harvesting’ scenario do not alter the fact that, intrinsically, forests can be managed to produce various forest products, including for bioenergy, and this can be an effective approach for supplying the bioeconomy and achieving climate mitigation, provided that appropriate forest management practices are applied (Strengers and others, 2024). We therefore do not recommend the ‘no harvest’ reference case for the use of biomass. A more accurate approach is to identify the greenhouse gas emission impact caused by changes in the way forests are managed to meet the aim of producing forest products, and additionally to identify how these impacts, if any, can be attributed to forest-derived biomass for bioenergy in addition to those caused by the production of biomass for other long-lived purposes such as timber for construction. The consultation seeks views on how this can be achieved efficiently.

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