Evaluation of Woodland Pathways: Carbon Supplement

1. Introduction

This note provides supplementary evidence on the analysis of carbon sequestration outcomes and estimated values to the "Evaluation of delivery pathways for the 2050 target for woodland and trees outside of woodland" report (eftec, 2026).

A critical policy question addressed in the main report is to what extent different pathways to achieve the government's target to increase England's tree canopy and woodland cover to at least 16.5% of land by 2050 (henceforth the 2050 woodland target) contribute towards the government's commitment to reach net zero by 2050. This assessment was framed in comparison to the expected contributions of woodland under the Climate Change Committee's (CCC) advice on carbon budgets, and the government's own carbon budget delivery plans. That assessment was the result of three steps:

- Developing feasible scenario pathways for England to reach the 2050 woodland target;
- Modelling the state of future woodlands and trees outside woodland (TOW) under these scenarios, including the annual and cumulative woodland area; and
- Estimating annual carbon sequestration rates for different woodland types and calculating total annual carbon sequestration.

The purpose of this note is to further review the sensitivity of this analysis to the assumptions and inherent uncertainties at each of these steps and discuss their impacts on the results and conclusions of the report.

To accomplish this aim, this supplement provides more detail on the approach used in the main report and presents additional analysis undertaken to explore:

- Assessment against contribution towards reaching net zero by 2050. *How was the contribution of the modelled woodland pathway scenarios towards reaching net zero assessed?*
- The woodland area and carbon outcomes (e.g., sequestration rates and total carbon sequestered), their sensitivities, and how these influence the assessed contributions towards reaching net zero. *How sensitive is the assessment of the contribution of different pathways that achieve the 2050 woodland cover target toward government net zero commitments to different assumptions and evidence?*
- The similarities and differences in the methods and assumptions used in eftec (2026) and other carbon modelling, in particular that done by the CCC. *How does this work compare and differ from other woodland carbon modelling?*
- The implications of delaying planting against the pathways in terms of total carbon sequestration and storage contributing towards net zero. *How important is planting now versus planting later in terms of achieving net zero 2050 commitments?*

Specifically, this supplement: (i) provides more detail on the calculations used to estimated woodland carbon sequestration and associated contributions to net-zero targets; (ii) compares the different

underlying assumptions and models used by this work, the CCC balanced pathway, and the government's carbon delivery plan; (iii) provides greater interpretation of how achieving the 2050 woodland target contributes to, or falls short of, net zero objectives; and (iv) discuss the possible consequences of delayed/ slower initial planting, and the knock-on effects on achieving the 2050 woodland target, the loss of cumulative carbon sequestration, and the differences in benefit values.

2. Carbon modelling approaches and comparisons

This section describes the estimation of carbon outcomes in the eftec (2026) analysis, how woodland pathways were assessed for alignment against progress towards net zero, and some of the differences that arise from different carbon accounting models.

Carbon modelling and estimation approach

The eftec analysis estimated carbon outcomes in three stages (see Figure 1). First, the canopy cover area of woodland and TOW per year by woodland type and age was estimated using the woodland model developed for the project. Second, annual sequestration rates were applied to all woodland and TOW areas in the model (including both existing and newly planted woodland). These rates are based on the Woodland Carbon Code (WCC) (WCC, 2025) carbon calculator estimates, using the woodland profile (combination of broad species and management regime) and age, producing a total volume of annual carbon sequestration. Finally, the economic assessment applied the UK non-traded carbon values (DESNZ, 2023) to the carbon sequestered to estimate monetised benefits.

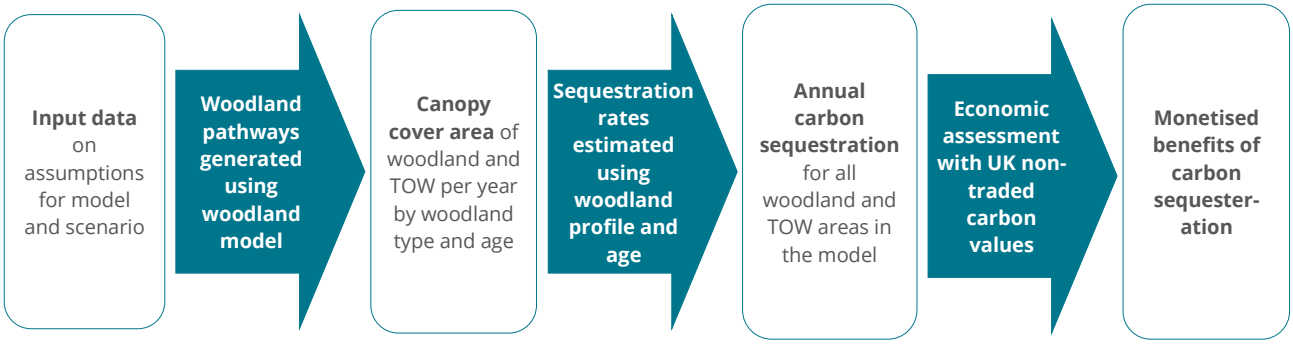


Figure 1: Overview of carbon outcome analysis in eftec (2026)

Most woodland carbon models that can be used in country-level analysis have similar broad steps to this approach, and each step is subject to assumptions and areas of uncertainty. Differences in these underlying assumptions makes comparing carbon sequestration outcomes across different work difficult (i.e., comparing the eftec work to analysis undertaken by the CCC). For example, most woodland carbon models require assumptions about tree species, management, spacing, yield class, the type of soil planted on, carbon disturbances, harvesting and thinning, carbon stored in wood products, whether risks/disturbances to woodland are included, the underlying carbon sequestration rates of different kinds of woodland, and the time scale and geographic scope included. Table 1 provides a comparison across assumptions and approaches in each model.

Table 1: Comparison of key sources for assessing contribution of woodland and TOW planting to net zero

	This project (eftec, 2026)	Seventh carbon delivery budget (CB7)[1] Land Use Emission Pathways (Thomson et al., 2025)	Latest government carbon delivery budget (CB6) (UK Government, 2025)
Description	Modelling of different pathways to achieve the 2050 woodland target and economic appraisal of the costs and benefits of those pathways	Modelling land use change contribution to achieve net zero on the "balanced pathway" by 2050, updated for CB7	Carbon savings of all current and proposed policies to achieve emission reductions up to the end of the 6th Carbon Budget (CB6) (2037)
Purpose	Overarching analysis of the costs and benefits of achieving the 2050 woodland target through different scenarios	Comparison of reaching net zero on the CCC's recommended "balanced pathway", with a business-as-usual scenario	Government delivery plan for how it aims to achieve carbon savings in the UK required for CB6
Scope of changes	Woodland and TOW creation and management	All Land Use, Land Use Change and Forestry (LULUCF)	All policies in sectors with significant carbon emissions
Geographic scope	England	UK, with some devolved administration (DA) breakdown	UK wide (some policies are England only then scaled to the UK)
Time of analysis	2025-2100 (planting up to 2050)	2025-2050	2025-2037 (underlying Energy and Emissions Projections (EEP) data extends to 2050)
Total woodland and TOW planted in England	~200,000 ha (including agroforestry and TOW)	~500,000 ha (woodland only)	~200,000 ha (including agroforestry and TOW)
Annual carbon sequestration from all woodland (Mt CO2e)	7 Mt CO2e (England, 2050)	28.0 Mt CO2e (UK wide, 2050)	n/a – not included in report
Annual carbon sequestration of newly planted woodland and TOW (MtCO2e)	0.9-2.1 MtCO2e (England, 2050)[2]	2.7 MtCO2e (England, 2050)	• Calculated as 1.0 MtCO2e (England, 2050)[3] • 0.72 MtCO2e (UK, 2037)[4]
Carbon modelling process	• Based on WCC carbon calculator, with different planting profiles, which allow differentiation of management regimes. • Includes consideration of woodland affected by risks.	• Based on profiles derived from Matthews et al. (2022). Assumes a single profile each for conifer and broadleaf.	• Based on a single profile each for conifer and broadleaf.

	This project (eftec, 2026)	Seventh carbon delivery budget (CB7)[1] Land Use Emission Pathways (Thomson et al., 2025)	Latest government carbon delivery budget (CB6) (UK Government, 2025)
Granularity of analysis	• Includes 12 different woodland profiles and TOW, and 9 different carbon sequestration profiles. • Underlying modelling is spatially explicit (abstraction) and probabilistic.	• Includes single broadleaf and conifer categories, with separate assumptions for agroforestry. • Underlying modelling is deterministic.	• Includes single broadleaf and conifer categories, with separate assumptions for agroforestry. • Underlying modelling is deterministic.
Spatial area for carbon analysis	• Area of canopy cover	• Total land use area	• Total land use area
Carbon accounting model	• WCC calculator (Derived from CSORT model modified with additional data from (West, 2011) and (Matthews *et al.*, 2022)	• Derived from CARBINE model	• Derived from CSORT/CARBINE model (term used interchangeably in the report)

Table notes: (1) CB7 is the 7th Carbon Budget (available here: https://www.theccc.org.uk/wp-content/uploads/2025/02/The-Seventh-Carbon-Budget.pdf)

(2) Range depends on the scenario specified and whether carbon sequestration was estimated with the eftec or CCC carbon model (see Section 3)

(3) Calculated based on apportioning carbon sequestration rate from the UK wide delivery pathway in 2050 of 2.4 $MtCO_2e$ (from the underlying source, EEP 2023-50) to England (approx. 40% planting).

(4) Calculated by aggregating: 0.63 $MtCO_2e$ from forestry policies up to end of CB6 (2037) (based on EEP 2023-50) + 0.09 $MtCO_2e$ from agroforestry + 0.004 $MtCO_2e$ from divergence from EEP projections.

Differences in carbon accounting methods

eftec (2026) estimated annual carbon sequestration rates using the Woodland Carbon Code (WCC) carbon calculator (WCC, 2025), which allowed for differentiation between both broad woodland species categories (broadleaved, coniferous, mixed) and how they are managed. It also allows inclusion of the impacts of clear fell harvesting, thinning, and restocking woodland that has been lost to risk. While not the primary purpose of the tool (which is site level carbon estimation), using it for country-level analysis has been done previously in the literature (e.g., Zellweger *et al.*, 2022).

The WCC calculator is underpinned by the CSORT carbon model (see Morison *et al.*, 2012), with additional sources for soil carbon (West, 2011), and the carbon impact of planting activities (Matthews *et al.*, 2022). There are other carbon models developed for the UK, notably CARBINE (Henshall, 2026), that form the basis of other net zero analysis (See Table 1 and Matthews *et al.*, 2022), which developed carbon sequestration rates for several different woodland profiles. The specific assumptions and woodland profiles and their associated carbon sequestration rates over time (woodland age) are not currently publicly available.

While these models provide a general approach for estimating carbon sequestration, they are predictive rather than observational (e.g., compared to actively measuring carbon flux of a woodland), and subject to criticism on their accuracy. This includes: (i) limited evidence on soil carbon values for different woodland types in different soil types (Hüblová and Frouz, 2021), (ii) an underrepresentation of the carbon accumulation of long-established woodland and large trees (Wilkes *et al.*, 2026)), and (iii) limited evidence supporting the application to estimating the carbon sequestration of TOW (Zellweger *et al.*, 2022) (which make up approximately 30% of canopy cover in England in 2022 (Forest Research, 2025)). Therefore, any application of these models or sequestration rates will be subject to uncertainty depending on the applicability of the underlying assumptions in the model and the accuracy of the evidence itself.

In Table 1 the main project's analysis (eftec, 2026) of the impact of woodland and TOW planting towards net zero is compared to two other sources of carbon modelling: the technical analysis on Land Use Emission Pathways carried out for the CCC's advice for the seventh carbon budget by Thomson, Young and Nickerson (2025), and the analysis underpinning the government's latest carbon delivery budget (CB6) (UK Government, 2025). .

At a high level, the comparison shows that:

- The scope of each piece of work differs substantially, across geographic areas, sector, time horizons, and the underlying policy question it addresses;
- Results are not directly comparable due to differences in woodland and carbon modelling; and
- Differences in results are primarily driven by the differences in scale of planting assumed.

3. Comparative assessment results

This section compares results and assumptions between eftec (2026) and the work by Thomson, Young and Nickerson (2025) for the CCC.

Net zero target comparison

The main finding highlighted in eftec (2026) is that while achieving the 2050 woodland target is sufficient for the Government's current net zero pathway,[1] both are misaligned with the CCC's advised "balanced pathway". As eftec (2026) assumes the 2050 woodland target is achieved, the research can be used to assess the costs and benefits of achieving that target, but it cannot use those results as evidence about whether the target will be achieved or the importance of woodland sequestration in the wider risks and pathways towards net zero by 2050.[2] The CCC's recommended pathway provides a useful third point of comparison, giving insights which will be missed by pathways that assume the 2050 woodland cover target is achieved.

Planting and land use change comparison

Comparing the relative contributions of woodland and TOW to the net zero target using area-based assessments (either annual or cumulative area planted) can reduce the sensitivity to assumptions and is the basis of the main comparison in the eftec (2026) report. However, this simplification comes at the cost of sensitivity to some critical outcome measures (such as species mix or woodland condition). This section makes further comparisons by translating and analysing different carbon models.

The primary difference between the eftec (2026) scenarios and the CCC's balanced pathway is the area of new woodland and TOW planted by 2050 (Figure 2). The annual planting rate is similar up to 2030 for both, but then the balanced pathway ramps up significantly, resulting in the planting required for the 2050 woodland target (203,000 ha), achieving approximately 40% of the balanced pathway planting (512,000 ha).

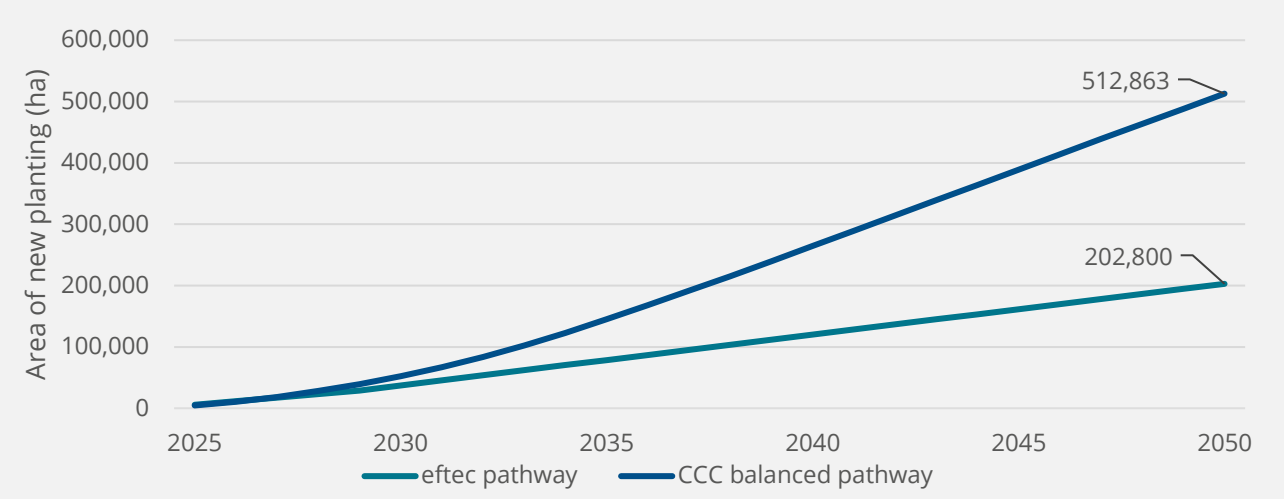


Figure 2: Total new woodland and TOW: eftec (2026) pathway and CCC (2025) balanced pathway

[1] Note that this is true more or less by definition, as the target assessed in eftec (2026) is the target used for the net zero 2050 requirements.

[2] One further consideration is whether it is feasible to assume that the other DAs will meet the assumed planting rates required to achieve net zero, given they have different woodland cover targets at differing levels of ambition.

Carbon sequestration comparison

Figure 3 shows the annual carbon sequestration rate of newly planted woodland and TOW across the scenarios in eftec (2026).[3] Differences in carbon sequestration of newly afforested area are quite similar across the scenarios, with minor differences seen between the conifer focus scenario, and the other three (see main report). This similarity of outcome is partially a result of the constraints imposed to ensure that the modelled scenarios were realistic.[4] Therefore, it is reasonable to draw comparative insights between eftec (2026) and other models using only one set of outputs (e.g., the conifer focused scenario).

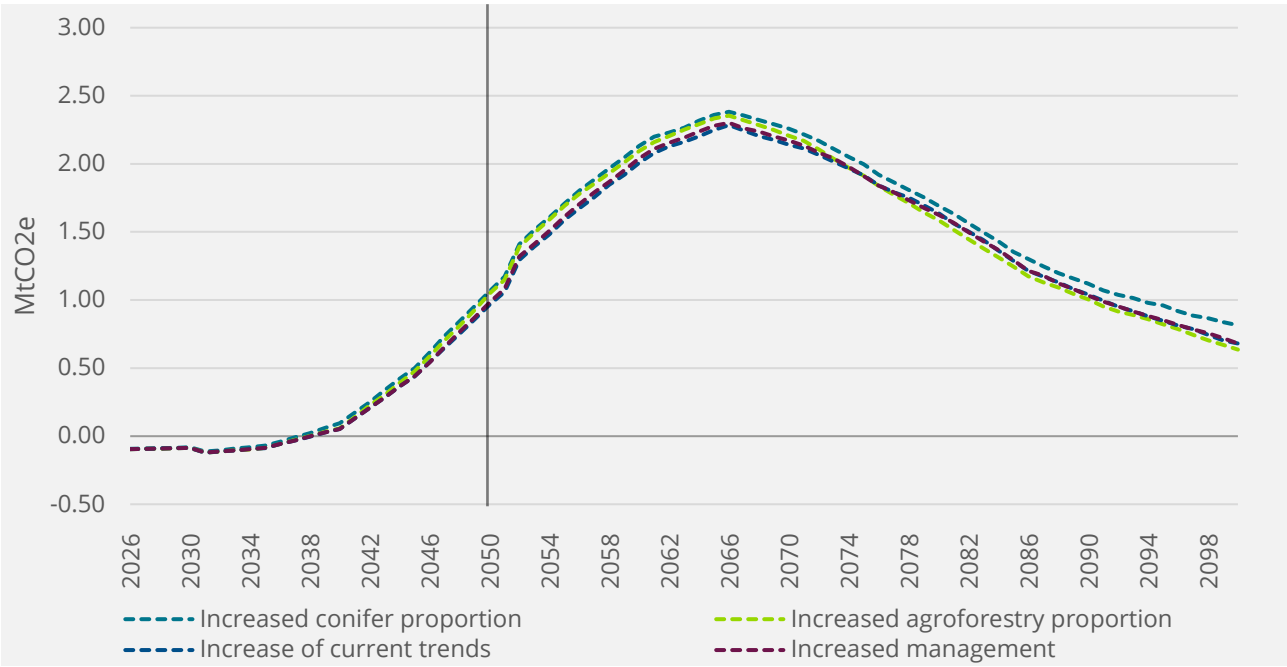


Figure 3: Comparison of annual carbon sequestration across eftec modelled scenarios.
Note: line indicates 2050 when net zero must be achieved

While a full like-for-like comparison of the modelling approaches was not possible, the eftec (2026) scenarios (increase of current trends and increased conifer proportion) were modelled using the CCC carbon model for newly planted woodland (CCC, per. comm). Implementing this required making several simplifying assumptions to reconcile the two models. Figure 4 shows the estimated annual carbon sequestration rates across five variations:

- The CCC scenario assumptions using the CCC carbon model;
- The eftec conifer focus scenario using both the CCC model and the eftec carbon model; and
- The eftec current planting trends scenario using both the CCC and eftec carbon model.

The modelling of these five variations allows two comparisons for sensitivity testing: (i) the differences in the scenarios and (ii) the differences in models.

In terms of the differences in scenarios, the CCC modelling estimates that by 2050 the CCC balanced pathway will sequester 2.7 MtCO2e per year (excluding agroforestry), compared to 2.1 MtCO2e per year for the eftec conifer focus scenario and 1.7 MtCO2e per year for the eftec continuation of current trends

[3] See eftec (2026) for the scenario details and woodland and TOW carbon sequestration rate assumptions
[4] For example, relatively small differences in planting rates by species mix and assumed adherence to UKFS,

scenario (both eftec scenarios include agroforestry). These differences highlight the impact of the less ambitious planting rates in the 2050 woodland target pathways when compared with the CCC balanced pathway.

The comparison of estimated planting rates between the CCC carbon model and the eftec carbon model shows significantly different shapes of annual sequestration and total sequestration by 2050 (1 MtCO2e compared with 1.7-2.1 MtCO2e). Some of these differences are explained by:

- Differences in underlying assumptions (e.g. growth rate, sequestration profile over time);
- Differences in assumed woodland types and management (the CCC model that all newly planted woodland is managed, and therefore will generally have higher sequestration rates);
- Consideration of woodland affected by risk, leading to lost carbon and requires replanting (the eftec model includes these effects, the CCC model does not); and
- Differences in the incorporation of agroforestry and TOW.

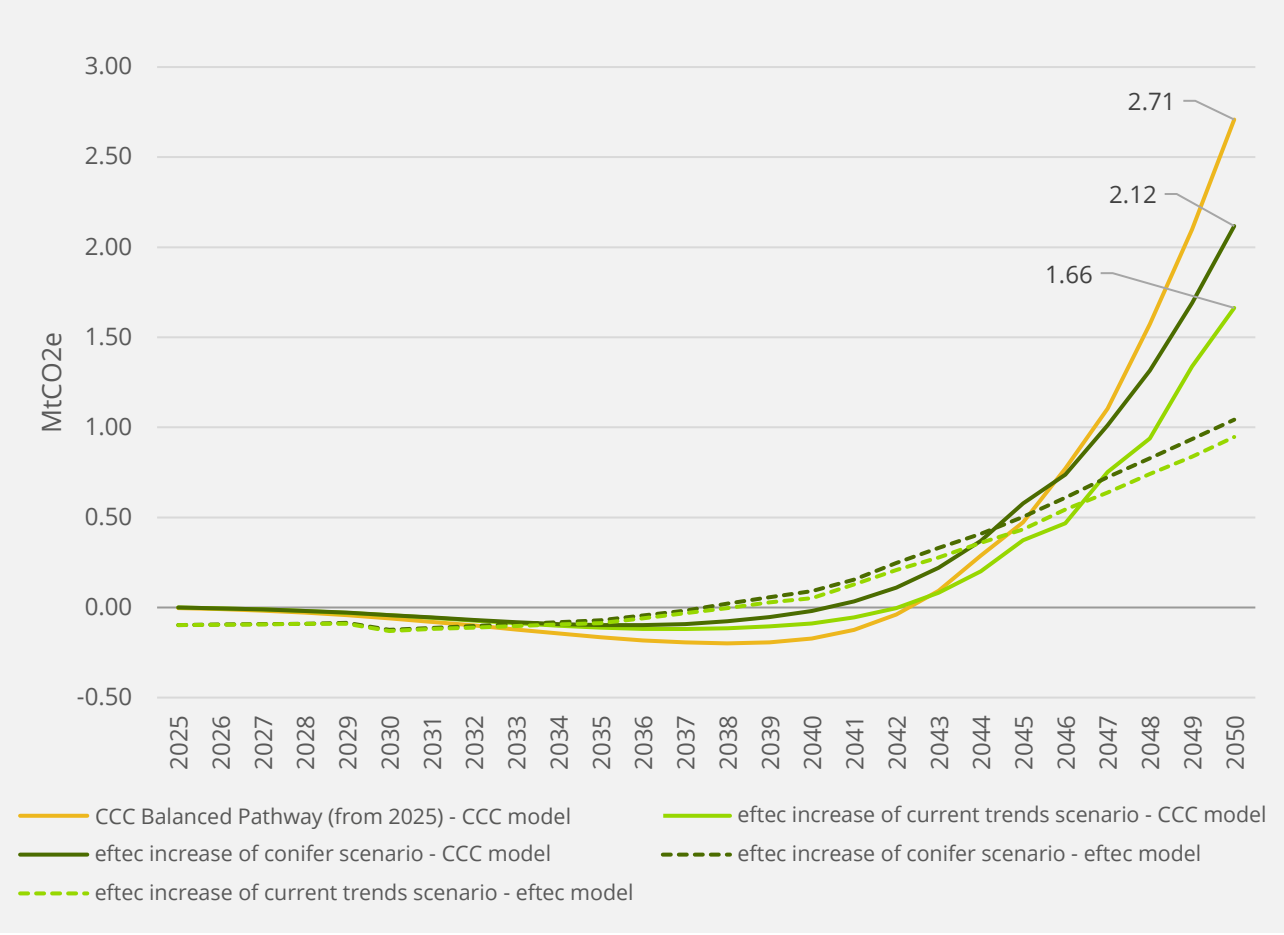


Figure 4: Total carbon sequestration from 2025 to 2050 from newly planted woodland across carbon models and scenarios

Overall, this analysis confirms that lower woodland planting rates will lead to real, material differences in annual carbon sequestration by 2050. This in turn will impact the achievement of net zero and limit the potential policy mixes that can reach the target. The analysis also suggests that the incorporation of elements such as annual loss to risk and uncertainty in management may lead to lower overall estimates of carbon sequestration, both in terms of total amount and highest annual amount achieved.

4. Implications of delays in planting

The comparison of the models and scenarios invites a specific question on the consequences that later or earlier afforestation of a given plot of land can have on both government targets and societal welfare. Regardless of the pathway, significant afforestation actions will be needed to achieve the 2050 woodland target, and the planting rate is likely to have a large impact on the overall sequestration and benefits achieved.

An indicative assessment of the size of the impact from a delay in plantings has been undertaken by modelling the cumulative carbon sequestration of a single hectare of woodland planted in different years between now (2026) and the 2040s. This has been done for what is likely to be the most planted woodland type in England, lightly managed broadleaf, and the most common productive conifer type (medium rotation conifer). Figure 5 and Figure 6 show these modelled sequestration pathways.

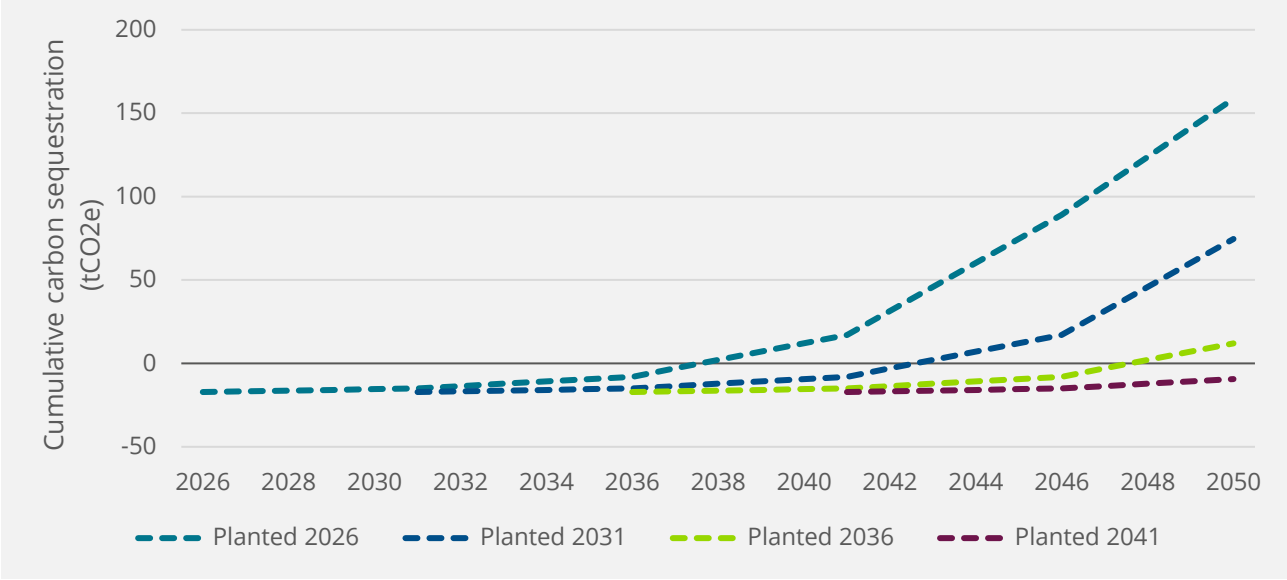


Figure 5: Cumulative carbon sequestration over time of planting a hectare of lightly managed broadleaf woodland in different years

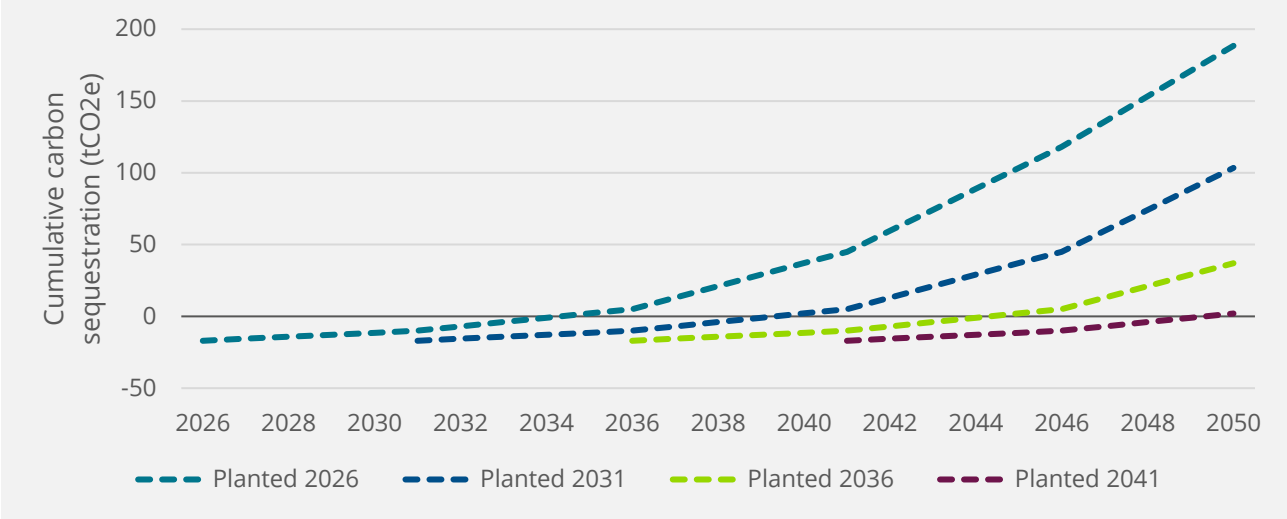


Figure 6: Cumulative carbon sequestration over time of planting a hectare of medium rotation conifer woodland in different years

Using the eftec carbon model and assumptions, lightly managed broadleaf becomes a net carbon sink after 12 years and medium rotation conifer after nine years. This suggests that any planting done after 2035 is likely to make very little contribution towards achieving net zero by 2050, and planting after 2040 may actually be a net source of carbon in the context of that target. Therefore, any significant delay in increasing planting rates will have a critical impact on the net zero target overall, even if the 2050 woodland canopy target is met through afforestation beyond that date. This does not mean that planting should stop after this point, as the benefits of woodland continue after 2050, and further carbon sequestration will be needed to ensure the UK remains at a sustainable level of carbon emissions after 2050.

5. Discussion

Overall, this note has investigated the contribution of the 2050 woodland target towards the net zero 2050 target and conducted a comparison of eftec (2026) with analysis undertaken by the CCC (Thomson, Young and Nickerson 2025) and the UK Government (2025). This comparison highlights that there are multiple ways to model woodland planting and growth over time, and different ways to estimate the carbon sequestered by woodland, particularly at a national scale.

Determining the modelling difference and its influence on results can make direct comparisons of the modelling (and hence the predicted contributions to targets) difficult. Therefore, there is methodological and policy value in making the underlying carbon sequestration analysis more transparent and having wider access to carbon modelling tools based on the latest research. This would allow for easier comparison across research and different national scale afforestation scenarios, and hence better informed and nuanced policy debate in this area.

However, this assessment was able to make several comparisons, and this analysis supports the general findings of eftec (2026), mainly that the current pathway towards achieving the 2050 woodland target is not in line with the CCC balanced pathway, and that more and earlier planting will provide much more benefit in terms of carbon sequestration between now and 2050. There are clear and significant differences in carbon outcomes between the CCC's balanced pathway and the 2050 woodland target delivery plan, with the CCC's advice placing more emphasis on woodland planting as a contribution to reach net zero by 2050. Further, while there are uncertainties in the carbon outcomes for newly created woodland and TOW, the evidence of carbon sequestration is more established for afforestation and land use change than many other policies that are suggested to contribute significantly to net zero, especially those that are speculative or require unproven technologies (at the scale needed for net zero). Given the window to increase planting rates as a means of contributing towards net zero by 2050 is closing, and that other methods of achieving net zero also carry significant risks, eftec (2026), the CCC advice, and this supplement provide evidence in support of upscaling planting as soon as possible.

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