Evaluation of delivery pathways for the 2050 target for woodland and trees outside of woodland

Technical report

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10F Printing House Yard
Hackney Road
London E2 7PR

+44 (0) 20 7580 5383
eftec@eftec.co.uk
eftec.co.uk

This document has been prepared for Office for Environmental Protection by:

Economics for the Environment Consultancy Ltd (eftec)
10F Printing House Yard
Hackney Road, London
E2 7PR
www.eftec.co.uk

Project team:

Angus Beattie
Emma Thomas
Russell Drummond
Daniel Maynard (UCL)

Reviewer

Ian Dickie and Ece Ozdemiroglu

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Executive summary

Purpose

The Government target to increase England's tree canopy and woodland cover to at least 16.5% of land by 2050 (henceforth the "2050 woodland target") is central to achieving several environmental, economic, and social objectives, including climate change mitigation, species recovery, rural economic growth, and public wellbeing. The target can be delivered through a range of planting and management pathways, which may differ in their delivery of such benefits and overall societal value. This project aimed to identify, quantify, and value such pathways to test their synergies, trade-offs, and co-benefits. The results provide evidence on the long-term impacts of meeting the 2050 woodland target and illustrate how planting and management choices could influence progress towards specific objectives and increased societal welfare.

Approach

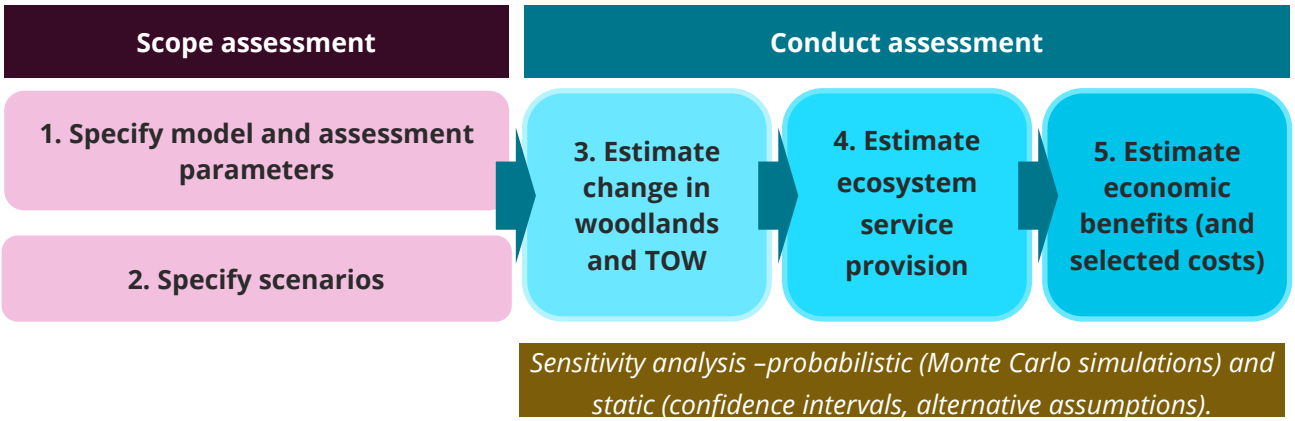


Figure ES1: Overview of the project approach

This project had five main aspects (summarised in Figure ES1):

- Conducted a literature review to determine the parameters needed to model woodland and trees outside of woodland (TOW) in England between 2025 and 2100.
- Defined five feasible combinations of planting and management inputs (scenarios) for woodland and TOW occurring from 2025 to 2050. These scenarios were developed by taking current trends and practices and modifying them to produce evidence on the future of woodlands in England (e.g., what are the consequences of focussing more on conifer planting?) All scenarios were defined across planting rates, planting by woodland types, and management. Further, all scenarios (except 'maintain existing woodland') were defined to meet the 2050 woodland target in line with the Defra delivery plan (Defra, 2025d), but differed in how that was accomplished. The scenarios were:
  - **Maintain existing woodland –** no new planting or change in management practices.
  - **Reach target with increase of current trends and practices –** the 2050 woodland target is met by increasing the planting of woodland types in proportion to current trends. The proportion of woodland in management is assumed to continue near current estimates.

  - **Reach target with increased management –** the 2050 woodland target is met by increasing the planting of woodland types in proportion to current trends, and the proportion of woodland in management is increased (compared to the increase of current trends scenario) to meet government intentions (assumed at reaching approximately 70% of woodland by 2050).
  - **Reach target with increased conifer proportion –** the 2050 woodland target is met by planting a higher proportion of coniferous woodland than the increase of current trends scenario. Higher management rates (as per the increased management scenario) are also achieved.
  - **Reach target with increased agroforestry proportion –** the 2050 woodland target is met by using more land for agroforestry than the increase of current trends scenario. Higher management rates (as per the increased management scenario) are achieved.
- Quantified the outcomes for woodland and TOW from 2025 to 2100 (assuming no *new* actions between 2051 and 2100) using **the woodland and TOW model**, developed for this project. The model used probabilistic processes and multiple runs (Monte Carlo simulations) to predict the extent, type, age, and condition outcomes of existing and new woodland and TOW in England over the modelling period based on the scenario inputs, risks to woodlands and TOW, and natural progressions such as tree growth over time;
- Assessed the costs and benefits of each scenario, including sensitivity testing; and
- Compared how the different scenarios and pathways contribute to wider government objectives and overall net societal benefits.

Results and discussion

The overall project results are presented in Table ES1, and a more detailed economic assessment is provided in Table ES2.

The results provide evidence across the following themes:

- **Woodlands and government objectives:** Some government objectives are sensitive to whether and how the 2050 woodland target is achieved, while some depend on wider inputs and enabling factors:
  - **Habitat:** Conifer planting will not support the 2042 Wildlife Rich Habitat Target, as coniferous dominant woodland is not categorised as a wildlife-rich habitat type in England (even with other species present). Therefore, the Wildlife Rich Habitat Target is much less likely to be met by an increased conifer proportion scenario.
  - **Carbon:** The planting rate used in the scenarios between 2025 and 2050 was not fast enough to achieve the targeted net-zero 2050 contributions based on the latest Climate Change Committee (CCC) advice (Climate Change Committee, 2025). Achieving the 2050 woodland target is around 35-45% of the modelled woodland and TOW canopy cover increase in England to achieve the "balanced pathway" in the CCC's technical analysis for its advice on the seventh carbon budget (Thomson, Young and Nickerson, 2025). The planting rate would need to roughly double by 2030 to reach the net carbon sequestration of this "balanced pathway", even with a higher proportion of conifer in the increased planting rates.
  - **Timber:** The increase of current trends, increased management, and increased conifer

proportion scenarios would contribute to slightly higher timber yields by 2100. The increased conifer proportion scenario had the highest potential to realise a small increase. However, timber production also requires several enabling factors such as appropriate market dynamics (e.g., incentivising harvesting), infrastructure, and skills (there is a noted skills gap around the timber production as well as use in construction). Any significant increase in timber production would only be seen beyond the appraisal period of this study.

- **Physical outcomes of woodlands under different scenarios:** physical outcomes (e.g., average woodland age, condition, losses due to various risks) did vary somewhat by scenario:
  - **Ecological condition**: Increased management rates resulted in a greater proportion of woodlands in favourable ecological condition, but lower average woodland age by 2100. This is in part due to management being associated with woodland harvesting, resulting in the loss of older stands but higher scores on some condition indicators.
  - **Timber production:** Clear-fell harvesting was highest in the increased conifer proportion scenario. However, overall timber production was similar across all three scenarios with higher management proportions due to thinning and selective harvesting, and because most newly planted woodland would not be clear-felled before 2100.
  - There were no systematic differences across scenarios in the proportion of woodland and trees affected by risks such as pest and disease, fire, and drought. Across model runs, between 20% to 28% of woodland was modelled to be affected by one or more risks between 2025 and 2100. Variation was primarily driven by future climate outcomes and the presence of pest and diseases, rather than management or planting choices. However, all new woodland was assumed to follow the UK Forestry Standard (UKFS), and therefore be more resilient to risks. Woodland management and planting falling outside of UKFS would be likely to have lower condition and therefore more susceptibility to risk.
- **Woodlands and benefits:** All of the 2050 woodland target pathways increase the provision of ecosystem services and benefits, and the differences across pathways are minimal.
  - Consistent with the current national natural capital accounts (Office for National Statistics, 2026), the analysis shows carbon sequestration and air pollutant removal as the largest benefits. Cultural benefits of improved biodiversity provision were also observed to be a major benefit (see Table ES2).
  - The uncertainty within pathways (such as the impact of future climate change, or the confidence intervals around economic values) are much more significant than how the scenario inputs are defined.
  - Existing woodland and TOW will provide ecosystem services and benefits over the next 75 years of around £192 billion (2025 to 2100 (PV75), 2026 prices). New planting to achieve the target will provide significant additional benefits of around £35 billion (2025 to 2100 (PV75), 2026 prices).
- **Woodlands and costs:** The 2050 woodland target pathways do not have significantly different estimated costs.
- **Pathway net benefits:** Given the benefits and costs, the 2050 woodland target pathways do not have significantly different estimated net benefits.

Table ES1: Comparative results by scenario for key targets and associated benefits

Result	**Maintain existing woodland** *The benefits of today's woodland, modelled over time. Assumed management achieved: ~55%*	**Reach target with increase of current trends and practices** *Achieve the target in proportion to today's planting and management. Assumed management achieved: ~55%*	**Reach target with increased management** *Achieve the target while also increasing management. Assumed management achieved: ~70%*	**Reach target with increased conifer proportion** *Achieve target by planting a higher proportion of coniferous woodland. Assumed management achieved: ~70%*	**Reach target with increased agroforestry proportion** *Achieve target through a higher proportion of agroforestry. Assumed management achieved: ~70%*
Achieves 2050 woodland target*	✗✗	✓	✓	✓	✓
Aligned with CCC's CB7 advice for a Net Zero 2050 balanced pathway	✗✗	✗	✗	✗	✗
Achievement of contribution to 2042 Wildlife Rich Habitat Target	✗	✓	✓	✗	✓
Timber in Construction Roadmap 2025, Priority theme 4	✗	◇	◇	◇	◇
Average final woodland condition	▲	▲	▲▲	▲▲	▲▲
Woodland resilience	◇	◇	◇	◇	◇
Carbon sequestration	▲	▲▲	▲▲	▲▲	▲▲
Biodiversity provision (as proxied by woodland condition)	▲	▲▲	▲▲▲	▲▲▲**	▲▲▲
Timber provision	◇	◇	▲	▲▲	▲
Total increase in net benefit	▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲

Table notes: Legend: ✗✗ = certainly off-track for target; ✗ = largely off track for target, ◇ = no change, no difference, or uncertain result, ✓ = largely on track for target, ▲ to ▲▲▲ = small, moderate, and large relative increase in provisions. * = All scenarios outside of "maintain existing woodland" were assumed in modelling to meet the target. This does not reflect the likelihood of meeting the target with current policies and practices. ** = The result that biodiversity increases under the increased conifer proportion scenarios is due, at least in part, to the use of woodland condition as a proxy. See Section 2.5 and 4.2.

Table ES2: Median costs and benefits of each scenario

Ranges in terms of smallest, median, and largest net benefits (PV75 terms in line with the model period of 2025 to 2100, £'billions)

	Maintain existing woodland	Increase of current trends	Increased management	Increased conifer proportion	Increased agroforestry proportion
Benefits	**£192 (£87 to £404)**	**£225 (£110 to £457)**	**£228 (£112 to £458)**	**£229 (£111 to £459)**	**£230 (£113 to £459)**
Carbon sequestration	£115	£128	£128	£129	£129
Timber provision	£3	£3	£4	£4	£3
Air pollutant removal	£61	£64	£64	£64	£64
Flood regulation	£10	£10	£10	£10	£10
Cultural benefits of increased biodiversity provision[1]	£3	£17	£19	£19	£20
Change in recreational opportunity[2]	£0	£4	£4	£4	£4
Water quality	£0	£0	£0	£0	£0
Costs	**£28 (£21 to £37)**	**£31 (£24 to £41)**	**£32 (£25 to £42)**	**£33 (£25 to £42)**	**£32 (£24 to £42)**
Establishment cost	£0	£1	£1	£1	£1
Restocking cost	£2	£2	£2	£2	£2
Maintenance cost	£16	£17	£18	£18	£18
Opportunity cost	£11	£11	£11	£11	£11
Net benefits	**£164 (£66 to £368)**	**£194 (£86 to £417)**	**£196 (£87 to £417)**	**£197 (£86 to £417)**	**£198 (£89 to £418)**

Table notes: (1) biodiversity provision is assessed as the *change in* benefit, not the total benefit. It is also assessed using woodland condition as a proxy indicator for biodiversity
(2) recreational opportunity is assessed solely as a function of the *change* in woodland extent.
(3) for the estimated ranges for each benefit, see Section 4.2

Conclusions and next steps

The woodland and TOW modelling and economic assessment show that the benefits of achieving the woodland target overall are significantly greater than the costs. When combined with the continued benefits of existing woodland, the total future net benefits of woodland under the target are around £200 billion. These findings support previous evidence that achieving the 2050 woodland target of 16.5% woodland and canopy cover in England will result in significant benefits to society.

At the marginal and site level, the existing literature demonstrates that woodlands with different species mixes and management strategies can have benefits and costs that differ significantly in magnitude, timings, and beneficiaries. However, this project suggests that for the regional and national level analysis,

the diversity across individual woodlands results in smaller relative differences in aggregate benefit, assuming certain basic constraints are adhered to. There are three likely reasons behind this result:

- Future planting and management rates and regimes are likely to be similar to what is currently occurring based on existing practices, skills, policies (e.g., the UKFS (Forest Research, 2023)) and resources (such as nursery stocks). These factors were embedded into the scenarios through the rates of planting, management, and woodland types, and therefore the difference between the scenarios was relatively small as those inputs did not vary widely.
- The evidence available for use in modelling, biophysical, and economic assessments is not yet adequately sensitive to certain characteristics of the type and condition of woodland. While this project endeavoured to improve on the existing methods and utilise all available evidence, constraints around woodland condition data and evidence on the differences in ecosystem service provision as woodlands age, diversify in structure, or increase in biodiversity limited the types of analysis that were possible.
- Using air-pollutant removal services as an example, the evidence is sensitive to some aspects of woodlands (age up to maturity, location), but not others (type, species mix, management, condition). This means that improvements in biodiversity, structure, management, or increases in age beyond 40 years do not provide additional benefits in the way scenarios have been possible to define.

Further analysis could usefully expand this analysis for the purposes of informing OEP and policy level discussions. First, the same modelling process could be used to explore scenarios that have higher levels of differentiation between them, to see if policies to overcome current constraints might be worthwhile. Second, these scenarios could include outcomes in which the woodland target is significantly exceeded. The equivalent annual net benefit from the scenarios average £5,500 per hectare of new woodland which suggests that additional woodland could continue to generate positive net benefits despite diminishing marginal benefits or increasing marginal costs. Third, the regional and national model outputs and economic assessments could be paired with woodland level marginal analysis, to understand how the trade-offs present for any given parcel of land feed into the aggregate result and vice versa. Finally, the model could be refined to have a higher level of spatial precision to investigate the differences in location specific actions and outcomes.

Finally, it is clear from this project (as well as previous evidence) that achieving or exceeding the 2050 woodland target will have benefits greatly in excess of the costs. There is, therefore, the potential to increase the target. However, given that the current rate of planting (6,387 ha was planted in England in 2025/26) will need to increase to around 8,000 ha per year to meet the target after 2030, policy development should focus first on increasing this rate by putting appropriate measures in place.

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Glossary

This glossary is specific to this report and project; the definitions used are not intended to be universal.

Word or term	Abbreviation or shortening	Definition (and source)
Agri-environment scheme	AES	Schemes offering financial incentives to farmers and land managers for specific actions relating to environmental protection and improvement
Continuous Cover Forestry	CCF	Forest management approach that harvests timber without clear-felling, trying to create more diverse woodland structure and species composition.
England Woodland Creation Offer	EWCO	Forestry Commission grant scheme for creating and managing new woodlands
Forestry Commission	FC	UK non-ministerial department responsible for "increasing the value of woodlands to society and the environment"
Interim Woodland and TOW target by 2030	2030 interim woodland target	The target to increase England's tree canopy and woodland cover by 0.33% of land area by December 2030 from the 2022 baseline of 14.9% equivalent to a net increase of 43,000 hectares.
National Forest Inventory	NFI	An ongoing programme by Forest Research which provides national scale data on the size, distribution, composition and condition of UK forests and woodlands. It includes the annual NFI woodland dataset, the TOW map, and bespoke reports and analysis.
Pathway		The way the state of woodland changes over time in a scenario, which allows modelling of the resulting impacts on society within a cost-benefit analysis structure.
Present value	PV	Value of future stream of benefits/costs, discounted using a social time preference rate.
Quantity of woodland and TOW		The extent or area of woodland and TOW, typically measured in hectares (ha). For TOW, the area is typically measured by canopy cover, or in some cases assumed stocking densities.
Scenario		A specific set of actions to achieve the 2050 woodland target, including planting (afforestation) and the management of new and existing woodlands.
Silvicultural system		"The process of tending, harvesting and regenerating a forest." (Forest Research definition).
State of woodland and TOW		An overarching term to describe the quantity and characteristics of woodland and TOW.
Tree		A plant with at least one woody stem and that can be expected to achieve a height of at least 5 metres (Forestry Commission definition).
Tree canopy and woodland cover		The area, or percentage of land area, in England that has canopy cover from woodlands or TOW. This includes land that has been planted but has yet to achieve the canopy cover percentage.
Trees outside woodland	TOW	Any trees that are not included in the overall woodland statistics due to being too small or narrow an area

Word or term	Abbreviation or shortening	Definition (and source)
Woodland		Contiguous areas of trees that have at least 20% canopy cover and are at least 0.5 ha in size with a minimum width of 20 m (NFI definition). Note that energy forestry is explicitly not included as woodland
Woodland and TOW		All woodland and trees outside of woodland (TOW) that will count towards the 2050 woodland target
Woodland and trees outside of woodland (TOW) target by 2050	2050 woodland target	The statutory target to achieve 16.5% woodland and TOW cover in England by 31 December 2050.
Woodland Condition Assessment	WCA	A standardised approach to assess the ecological condition of a woodland in the UK, based on 15 indicators of woodland condition.
Woodland profile		A description of several characteristics (age, dominant species type, management, and condition) of woodland and TOW, particularly those characteristics that are useful to the assessment framework and modelling

1. Introduction

The delivery of the target to increase England's tree canopy and woodland cover to at least 16.5% of all land by 2050 (henceforth called the "2050 woodland target") is a critical outcome for the achievement of multiple environmental, social, and economic objectives. These include legislative targets on species recovery and climate change, social objectives on economic growth in rural communities, and the health and wellbeing of people. There is flexibility in how the 2050 woodland target can be achieved, however, and the delivery pathway could matter in terms of the range of objectives met and the overall societal welfare provided. By modelling and predicting the outcomes of a range of potential pathways, this project enables a better understanding of the synergies and trade-offs within and between each pathway, and the scale of benefits and costs associated with them.

1.1 Background and context

Woodland and trees outside of woodland (TOW) are important to several government targets (Table 1.1)[1], including legally binding ones for carbon, biodiversity, and economic sectors. The targets cover measures including woodland creation, management, monitoring, and protection, and relate to a wide range of benefits including carbon sequestration, biodiversity provision, timber output, recreational use and access, flood mitigation, water quality improvements, air quality improvement, and urban cooling. This is a recognition of the wide-ranging benefits that woodlands and trees outside of woodland (TOW) provide to people, and the importance of woodland and TOW to achieving a variety of wider objectives in support of social welfare.

The measures to achieve these targets will come with trade-offs and opportunity costs, however, and understanding those is critical to undertaking appropriate measures to meet the targets in an efficient manner. Choices around location, tree species mix, and management regimes will impact the value to society of any given woodland, and in turn which and how well that woodland supports the various government targets. There is evidence on some of these trade-offs at the micro scale. For example, there is significant evidence that woodlands with higher intensity management that provide timber and meet economic objectives may support less biodiversity and come at the cost of amenity and recreational potential (eftec, 2025; Felton *et al,* 2024; Sing *et al.* 2018). Similarly, woodlands that achieve the highest levels of biodiversity may not be profitable for private landowners unless subsidised through grant schemes. However, there is limited evidence on these trade-offs at the macro and strategic scale in terms of how woodland creation and management choices aggregate across regional and national scales over time.

Finally, while there is significant focus on new planting, 90% of the woodland and TOW necessary for the 2050 woodland target already exist. This means that choices on the management of existing woodland have significant potential for contributing to wider targets and increasing the benefits of woodland and TOW. Indeed, management choices on existing woodland is the only way to influence outcomes like timber provision in the near term. Therefore, the assessment of the costs and benefits of the future of woodland

[1] A more detailed review of the targets in Table 1.1 can be found in Appendix 1, including relevant government and forestry sector strategic plans such as the Forestry Commission Strategy 2023-2028 (Forestry Commission, 2023b) and The National Wood Strategy (Barnes and Leitch, 2023). The assessment of these targets and plans helps to understand the priorities for these organisations, what relevant data was available and inform how the different scenarios should be modelled based on likely future actions and stakeholder priorities.

and TOW must adequately consider both new planting and the management of existing woodland and TOW.

Table 1.1: Main Government targets woodland and TOW creation and management will impact

Target or policy	Detail	Likely contribution of woodland & TOW
Long term targets		
2050 Woodland Target	16.5% of all land in England is covered by woodland and TOW by 2050 (Environment Act 2021)	Essential – planting woodlands and TOW defines the target
Net Zero 2050	The UK will be a net zero carbon emitter by 2050 (Climate Change Act 2008)	Partial – woodland is a small (but important) part of UK carbon budgets
2042 Species Abundance Target	10% increase in species abundance by 2042 (Environment Act 2021)	Essential – many of the species in England depend on forest habitats
2042 Wildlife Rich Habitat Targets	Restore or create 500,000 ha of wildlife rich habitat outside protected areas (Environment Act 2021)	Essential – trees and TOW are included in these targets
Interim targets		
2030 Woodland Target	Increase England's tree canopy and woodland cover by 0.33% of land area by December 2030 from the 2022 baseline of 14.9% (Equivalent to a net increase of 43,000 hectares) (Environment Act 2021)	Essential – planting woodlands and TOW defines the target
2030 Species Abundance Target	Halt decline in species abundance by 2030 (Environment Act 2021)	Essential – many of the species in England depend on forest habitats
2030 wildlife rich habitat targets	62% of the statutory woodland target is expected to contribute to the statutory wildlife-rich habitat target (EIP25)	Partial – While there are other methods to reach the target, increase in tree cover is expected to form a significant part of reaching the target
Other commitments		
Timber in construction roadmap 2025	Increase in timber production - no specific target is set but linked to several targets	Partial to essential – directly linked to woodland, but there may be other supply chain constraints for using domestic timber
Other EIP25 Targets	Various targets in the EIP25, many are not legally binding	Mixed – some targets will be impacted, others are dependent on other factors

Source: EIP 2025 (Defra, 2025a)

1.2 Objectives

This project identifies, quantifies, and values the multiple benefits from woodlands in the context of trade-offs and synergies across multiple targets. The objectives necessary to that aim were to:

- Define a likely or feasible set of woodland creation and management scenarios that would achieve the 2050 woodland target in different ways (e.g., by varying management choices);
- Estimate likely woodland and tree extent and condition outcomes for each scenario over a time period that adequately captures the costs and benefits of those actions (e.g., from 2025 to 2100);
- Appraise the costs and benefits to society of the actions and outcomes for each scenario; and

- Assess the differences in how each scenario's pathway to the 2050 woodland target met (or did not meet) wider government objectives and the scale of the net benefits to people and society.

In doing so, this research produces evidence to help understand the potential long-term impacts of meeting the 2050 woodland target through different pathways (e.g., different national profiles of woodland creation and management). This evidence illustrates how choices about woodland and tree planting and management will influence progress towards objectives and overall societal welfare and shapes recommendations on combinations of planting and management appropriate to different objectives and certain benefits.

1.3 Approach overview

The overall project approach is set out in Figure 1.1. This project began with the assumption that the 2050 woodland target will be met, but that there are a variety of different pathways to achieving the target that will have different physical and economic outcomes. The research therefore required modelling different combinations of planting and management actions (scenarios) to understand the impacts on the aggregate profile and condition of trees and woodlands by 2050 and as far into the future as 2100. These modelled future states were then assessed across a variety of services provided (physical flows) and associated costs and benefits (using the Enabling a Natural Capital Approach (ENCA)) (Defra, 2026b) to estimate the net benefit to society, as well as how each pathway contributed to government targets (see Section 5).

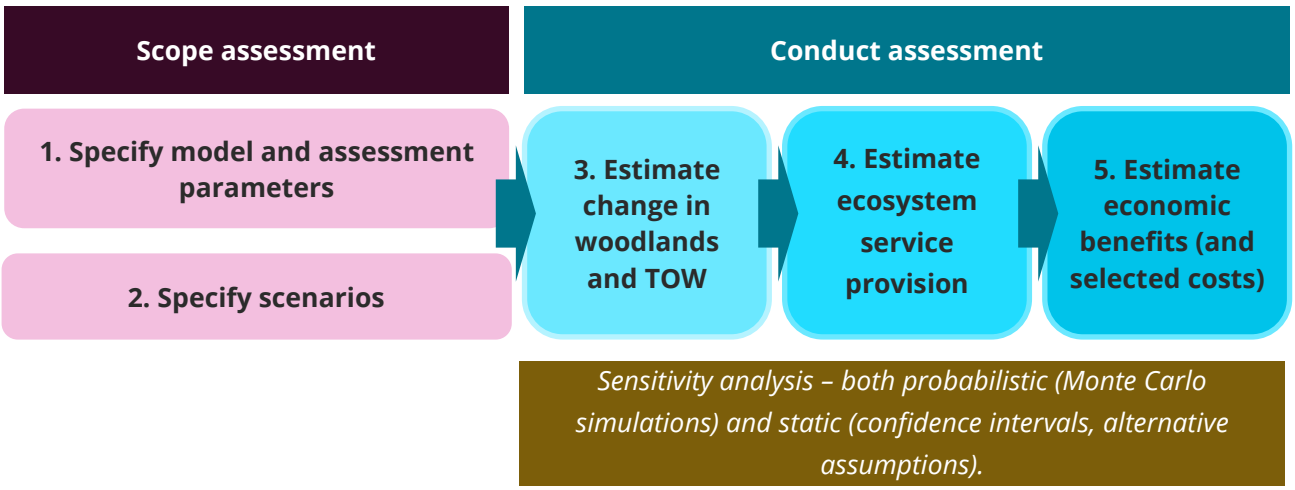


Figure 1.1: Overview of the project approach

Challenges

The central challenges to the approach were in estimating the changes in the extent and condition of woodlands and TOW. First, while there is significant data on woodlands in England, the baseline in terms of the current condition and management of English woodland and TOW is still difficult to define, as there are large gaps in the data collected (see Section 2). Second, the impact of risks and management on future woodland condition is uncertain and correlated with current woodland condition, and there are large gaps around how risks to woodland are likely to change in the face of climate change. Third, woodland management and the impacts of risks are co-dependent, such that management choice may change risk profiles, and future risk profiles may change management choices.

There were also challenges in estimating ecosystem service provision and economic benefits. While these steps were less dynamic than estimating the change in the physical state of woodland and TOW, there are several gaps in the literature such as how the benefits of woodlands change with type, condition, or age.

1.4 Report structure

The rest of the report is structured as follows:

- **Section 2: Evidence review** summarises the evidence used to develop the approach and inform the assessment. This includes the main relevant targets included as goals for modelling the scenarios, an overview of the main risks to woodlands and trees, evidence on woodland and tree management outcomes, and woodland ecosystem services and benefits.
- **Section 3: Approach** describes the modelling and assessment approach, including the modelling frameworks, implementations, and details on the key parameters. It also includes descriptions of the scenarios used in the modelling and how those scenarios are translated into the modelled planting and management actions.
- **Section 4: Results** presents the outputs from the woodland and TOW modelling and economic assessment.
- **Section 5: Discussion** draws comparisons across the results to develop policy relevant insights and recommendations based on the results.
- **Section 6: Conclusion** gives an overall assessment of the project outputs.

The report is also supported by several appendices:

- **Appendix 1: Relevant targets assessment**
- **Appendix 2: Risks to woodlands and TOW**
- **Appendix 3: Woodland model specification**
- **Appendix 4: Simulation parameters**
- **Appendix 5: Model outputs**
- **Appendix 6: Benefit valuation**
- **Appendix 7: Costs**
- **Appendix 8: Economic appraisal results**
- **Appendix 9: Regional level results**

2. Evidence review

This section reviews the evidence and data used to inform the project approach and implementation. It starts with a summary of the key findings. The detailed evidence review is then separated into six sub-sections: (i) summary of evidence; (ii) evidence on the current types, condition, and management of woodland in England; (iii) potential risks and wider impacts to woodland and TOW both now and in the future; (iv) management, propagation, and growth of woodlands and trees; (v) benefits of woodland and TOW; and (vi) costs of planting and maintaining woodland and TOW.

2.1 Summary

The evidence review focused on understanding the current condition and extent of woodland and TOW, and how future changes to that condition and extent could be modelled and quantified:

- **Current condition and extent of woodland and TOW**: the evidence available is relatively complete across some dimensions (e.g., extent, general species mix), but not others (e.g., current management). This provided a high-level starting point for the modelling, but some informed assumptions were necessary across the areas with less complete data. More data is available for woodlands than TOW.
- **Risks to woodlands and TOW:** potential risks include fire, windthrow, drought, flood, pests and diseases, frost, and development and affect different woodland types differently. While the annual total impact of risks to woodlands in England is relatively small, they are a necessary component of the model as risks are expected to increase with climate change and the small impacts add up over long time horizons. There is sufficient evidence to model these risks, and existing research has done so. However, there are still several areas of uncertainty to address in developing the modelling approach. There is limited evidence on risks to TOW and how they vary relative to woodland.
- **Woodland and TOW planting and management:** detailed evidence on planting and management is mixed – with far less evidence on TOW. There is national level data on historical planting trends. There are many different activities that can constitute woodland management, which result in very different management regimes and forest profiles. Likewise, key stages for newly planted woodland are known in detail for specific species (with more limited evidence for other species).
- **Assessing woodland condition:** this is assessed using 15 indicators (Woodland Condition Assessment (WCA)). Outcomes vary by specific factors to each site, broad type, and age of woodland. There is no comparable approach for TOW.
- **Benefits and costs of woodland and TOW:** the benefits of woodland and TOW are well-established, although the quality of the economic value evidence varies across benefits. Some benefits vary spatially, making it difficult to assess at a national scale. There are multiple ways to estimate standardised costs for woodland planting, maintenance, and opportunity costs. Benefits and costs vary with extent, condition, type, location, and management.

Understanding and modelling the progression of woodland and TOW over time requires the inclusion of each of these elements, linking them to one another, and factoring in outside influences such as climate change, current practices, and policy incentives. The modelling, within the scope of this project, has taken account of all these factors as much as feasible.

2.2 Current woodland cover, type, and management

A summary of the state of woodlands and TOW can be seen in Table 2.1. The National Forest Inventory (NFI) woodland map includes woodland areas over 0.5 hectares with a minimum 20% canopy cover and provides a good estimate of current woodland cover. Data on TOW comes from the TOW mapping project (Hunter *et al.*, 2025). As of 2022, total canopy cover (as defined by the target) is estimated at 14.9% of total land area, of which 10.2% is woodland, 4.5% is TOW, and 0.2% are orchards (Forest Research, 2025d). Data on woodlands is available over time, and woodlands in England have been gradually increasing as a proportion of land area since the 1920s (Forest Research, 2025d). Recent annual data is available in a format that can be further mapped to regional and local levels (using a Geographical Information System (GIS)).

Table 2.1: Overview of current woodland and TOW in England

Aspect	Current state	Data year	Recent trends	Other notes
Overall woodland and tree cover	14.9% of land cover (10.2% woodland, 4.5% TOW, 0.2% orchards)	2022 (Forest Research, 2025d)	Increasing (average rate of 5,000 ha / 0.4% of woodlands per year for the last five years)	Canopy cover estimates are expected to be updated every five years. NFI data on woodland is available annually (latest 2024)
Woodland types	73% broadleaf 22% conifer 5% mixed	2024 (Forestry Commission, 2025d)	Recent woodland planting has predominantly been broadleaves (90% in the last five years)	New woodland planting data does not include a mixed woodland category
Woodland age	30% up to 20 years 46% 21-50 years 25% 50+ years	2014 (Forestry Commission, 2018)	n/a	No data on change in tree age distributions over time and no updates to the dataset since the 2010-15 cycle
Woodland condition	2% unfavourable 92% intermediate 6% favourable	2010-2015 (Forest Research, 2020)	n/a	No updates to the dataset since the 2010-15 cycle
Woodland management	44% unmanaged 56% managed	2024 (Forestry Commission, 2025b)	Slight decline in amount of woodland under management (2% decline over last five years)	Data is yes/no, and does not provide information on how woodland is managed

The available data on an individual aspect across these different sources generally provides a reasonable view of the type, age, condition, and management of woodland in England. Further, a lot of the data is specific to at least the regional level, and much of it can be cross-tabulated across aspects. Based on this data, woodland in England is mostly broadleaf dominant (73%), in intermediate ecological condition, and is generally quite young (under 50 years). These mixes do vary regionally (e.g., the North East is over 50% coniferous), but the overall trends persist. More details on the methods used and assumptions made to infer the starting state of woodlands and TOW are included in Appendix A3.3.

The makeup of TOW and their trends are less well known as methods to systematically map these trees are a more recent advancement.

Data on the management regimes on managed woodlands, on the other hand, is not as readily available at a national scale. However, it is estimated that slightly under half of woodlands (44%) in England are either unmanaged or undermanaged (Forestry Commission, 2025b). For this, various data sources and assumptions were combined to estimate a reasonable distribution of management regimes across England broken down by broad species type for use in the modelling (see Appendix A3.3 for more details).

2.3 Risks and wider impacts to woodland and TOW

2.3.1 Current and future risks to woodlands

Several risks affect the growth rate and condition of woodlands and trees and could result in tree mortality and even loss of entire woodland areas. Understanding, and where possible quantifying, these risks was an essential part of modelling future states of woodland and TOW.

Atkinson (2022) lists six primary risks to woodland and TOW: flooding, pest and disease, drought, windthrow, wildlife, and frost. All of these risks are expected to change in terms of severity and frequency in the future. Additional to these are pressures from development and competing land uses. Crucially, the evidence shows that the impact of each risk varies spatially, temporally, and by woodland profile (species, management, age, and resilience), with implications for the long-term benefits of each woodland type. The extent of these risks, and how they vary across woodlands and time is discussed in Appendix 2 and summarised in Table 2.2.

An important source in the evidence base is the previous research carried out for woodland carbon code (WCC) being integrated into the UK ETS (UK ETS Authority, 2025).[2] As shown in that research, data on some of these woodland risks is limited for England,[3] and there is uncertainty about the physical impact of each risk on woodlands in terms of outcome and severity, which will increase into the future due to climate change and the correlated nature of woodland risks. However, there are methods to aid in the estimation of future risks to woodlands under a changing climate, such as climate projections[4] (e.g., Yu *et al.*, 2021).

The evidence review on risks has the following implications for the approach used in this research:

- The uncertainties in the likelihood and severity of many risks, both now and into the future, highlight the value of using probabilistic analysis, which is better suited to giving a full set of potential outcomes based on the inherent uncertainty (e.g., as suggested by Saraev (2019)).
- The variation in risks by location and forest profile indicates that spatial forest profile elements were necessary to appropriate modelling.

[2] This Great Britain-wide analysis assumes the same percentage rates of permanent loss for all woodland types (conifer, broadleaf, mixed) and all age classes, i.e. no type- or age-specific disturbance rates are yet quantified at national scale (UK ETS Authority, 2025). However, UK adaptation guidance explicitly promotes mixed-species stands and wider age structures as key measures to reduce risks from windthrow, wildfire, pests/diseases and drought, indicating that mixed woodlands are expected to be more resilient than single-species conifer or broadleaf stands (Atkinson, 2022). There are other misalignments in the UK ETS Authority study and the use in this research. For example, the UK ETS Authority study estimates annual permanent loss to woodland (i.e. accounting for restocking), whereas this research is interested in gross annual loss to woodlands, rather than net loss. This work cites 'Establishing Rates of GB Forest Lost to Natural Disturbance' (Forestry Commission, 2025a) as the source for their estimates of annual loss rates.

[3] There is more evidence for the impacts of risks at a tree or stand level of scale, however for this work a larger scale is needed to model changes at a national level.

[4] The current main climate model projections are the UK Climate Projections (UKCP18) (Met Office, 2026)

- The relationship of many of the risks to climate change suggests that parameters for risk should increase over time, which is reflected in the modelling, and further means that the risks need to be accounted for over the entire period that costs and benefits are estimated.
- The impacts of risk events are varied but can be generally summarised as either a loss in condition (e.g., if trees become diseased or only a small portion of trees in a woodland are lost) or loss (mortality) of the woodland.

Table 2.2: Summary of risks to woodland and trees outside of woodland

Risk	Relative impact	Predicted change	Risk correlations	Factors that influence risk	5 year averaged annual estimate of impact
Pest and disease	High (mortality); high (condition)	Increase in risk	Drought; waterlogging; wildfire	Age, species, management/ condition, region, surrounding environment	Average of 880 ha felled due to statutory plant health notices in 2020-2024 (Forest Research, 2025d)
Development	High (mortality); medium (condition)	Increase in risk	N/A	Region	Average of 370 ha of woodland lost, ground under development or newly restored priority habitats in 2020-2024 (Forest Research, 2025d)
Windthrow	Medium (mortality & condition)	Increase in risk	Wildfire; flooding; pests and disease	Age, species, management/ condition, region, surrounding environment	Average of 1,510 ha of windthrow woodland type in 2020-2024 (Forestry Commission, 2025d)
Wildfire	Medium (mortality)	Increase in risk	Drought; pests and disease; windthrow	Age, species, management/ condition, region, surrounding environment	Average of 390 ha of woodland affected by wildfire in 2017-2021 (Forestry Commission, 2023a)
Flooding	Medium (mortality)	Mixed (wetter winters, drier summers)	Windthrow; pests and disease	Age, species, management/ condition, region, surrounding environment	n/a, no national estimate
Drought	Low (mortality); high (condition and growth)	Increase in risk	Wildfire; pest & disease	Age, species, management/ condition, region, surrounding environment	n/a, no national estimate
Frost	Low (mortality and condition)	Increase in risk (uncertain)[1]	Pests and disease; warming climate[1]	Region, tree species, condition, tree age	n/a, no national estimate

Table notes: (1) Earlier budburst can increase frost exposure if sub-zero events occur after flushing (Broadmeadow and Ray, 2005; Atkinson, 2022).

2.3.2 Approaches to predict risk impacts to woodlands

Predicting the impacts of future risks to woodlands is a complex task, especially given the number of factors that influence how likely or severe a risk will be for any given woodland or area of woodlands (see Table 2.2). Regardless of the specific approach, modelling and prediction rely on assessing both vulnerability (how likely an impact is if an event occurs) and hazard (the likelihood of an event). Overall risk is then the interaction between vulnerability and hazard. Lecina-Diaz *et al.* (2021) propose a framework using similar measures of exposure to hazard, hazard magnitude, susceptibility, and adaptability. Examples of models used to assess vulnerability and hazard in England include the ForestGALES model (Forestry Commission, 2015), which uses information on tree species, height, stem diameter, age, as well as site characteristics to estimate windthrow risk (specifically for conifer species).

2.3.3 Climate change and risk

The Climate Risk Indicator Explorer tool (University of Reading, 2023) provides an assessment of climate change impacts across a range of indicators and spatial scales within the UK. In particular, the tool provides outputs on wildlife risk, drought, and overall temperatures across a range of models, scenarios, and other assumptions. These outputs have been used to adjust the future climate risks within the modelling approach.

2.4 Woodland and TOW creation, management, and condition

2.4.1 Woodland and TOW creation

In the last four years[5] (2021/22 to 2024/25), an average of 3,900 ha of new woodland was planted annually in England, approximately split between 90% broadleaf and 10% conifer (Forest Research, 2025f). In addition, there has been an average of 800 ha of TOW planted annually (Forestry Commission, 2025b). There is no regional breakdown of these values, however, the regional distribution of new planting can be approximated by comparing NFI spatial datasets over time to see new areas of woodland, and then breaking this down per region.

2.4.2 Species mixes and tree provenance of new woodlands

In newly planted sites, the selection of tree species and tree provenance (the geographical region of the tree seed or stock) are driven by a variety of factors, including the suitability of the site to certain species, the aims of the landowner in creating the woodland, and the relevant regulations (such as the UK Forestry Standard (UKFS)). The species and provenance mix selected for any given site will have a large influence on benefits, costs, growth rate, and relevant risks to that woodland over time (Forest Research, 2025).[6]

Haufe *et al.*, (2024) provide a set of forest profiles which are suited to different climate and soil characteristics. This research also includes a climate map of the UK, indicating how the various climatic

[5] This is the earliest year with national data for the extent of new TOW planting.

[6] Information of tree provenance here: https://www.forestresearch.gov.uk/climate-change/adaptation-measures/choosing-tree-provenance/. Tree provenance is a relatively new area of study, however, and there is no conclusive evidence on which provenances will be best suited to planting in England in the near and long-term future. This is in part due to a lack of evidence on the performance of different provenances, but also the uncertainty of climate futures in England.

zones are expected to shift between now and 2090 (Figure 2.1). Notably, this projection estimates that most of England is expected to increase in average temperature and become slightly drier. Many of the species mix proposed are suitable to a range of temperatures and average moisture levels, but in some cases regional or local shifts in climate may dictate that different species mixes be planted in future when compared with today.

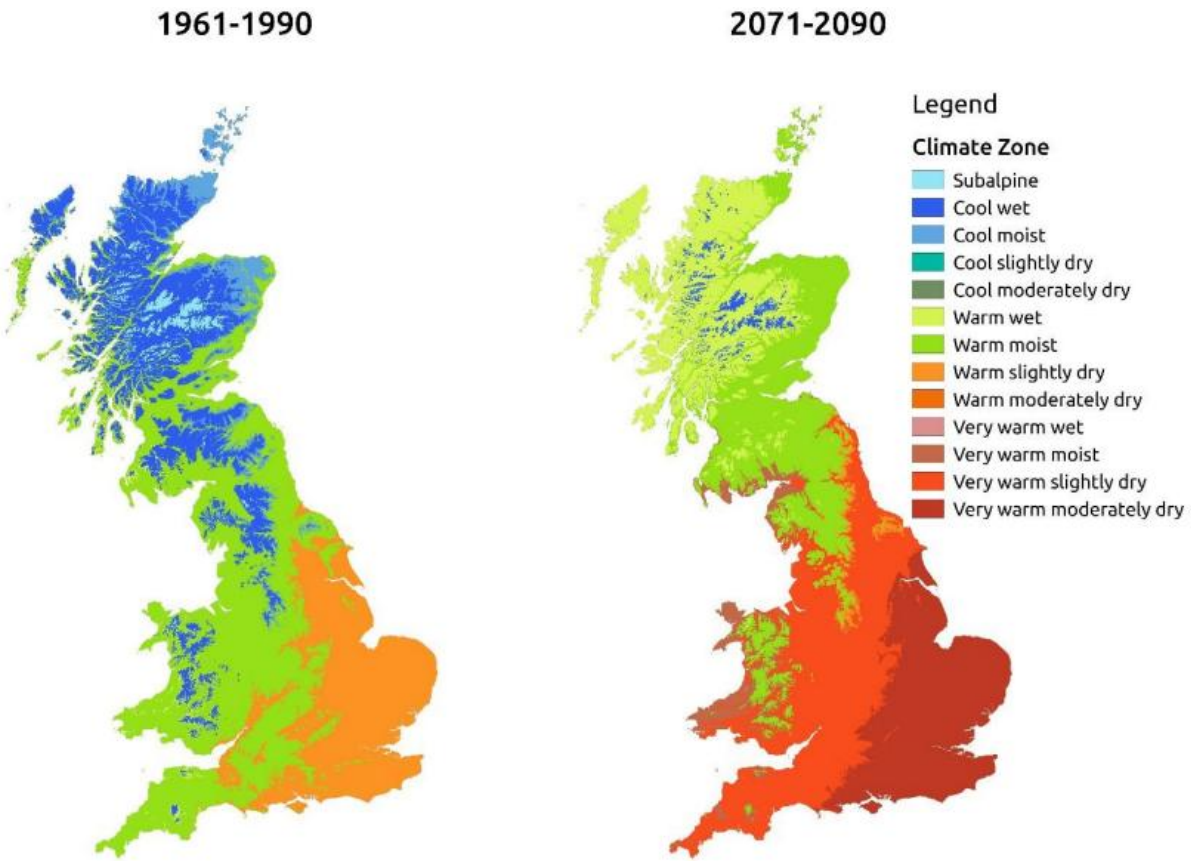


Figure 2.1: UK climate zones and predicted change over time
Source: (Haufe et al., 2024).

2.4.3 Woodland Management

Once planted, management of a woodland[7] is a critical factor in the benefits it provides over time, and its exposure to risks. Management can range from unmanaged woodland where no actions are taken after planting, to highly managed woodlands. Examples of individual management actions include (e.g., Forestry Commission, 2003):

- Planting (including timing, location, tree species and starting density) and/or natural regeneration management;
- Actions to reduce the density of trees (various kinds of respacing and thinning) as well as the density of vegetation (coppicing, pollarding, and pruning);
- Harvesting;

[7] There is less established literature on typical management actions or regimes for TOW, given the broadness of this category

- Pest management (general), protection against animals (e.g., deer fencing, tree guards), and culling or other herbivore control;
- Invasive species removal;
- Species introductions and habitat provision (e.g., bat boxes, deadwood retention);
- Monitoring;
- Fire and fuel management; and
- Grazing.

Objectives for a woodland area are achieved through a bundle of actions under a management regime. If one of the main goals of the woodland is timber production, then these regimes are called silvicultural systems. However, significant areas of woodland in England are managed for other purposes, such as for amenity, historic value, or biodiversity (Forestry Commission, 2025c). There are also those that integrate woodland and TOW into agricultural systems (silvo-agricultural systems or agroforestry). There is then significant variation across these broad classes of management regime, depending on the mix of objectives, location, and existing woodland.

In England, typical management regimes are:

- Silvicultural systems,[8] such as:
  - Even-aged silvicultural management of various rotation lengths, in which trees are planted and harvested in a single age class across the parcel (often referred to as clear-felling).
  - Shelterwood systems, in which trees are harvested in lots, such that patches of standing woodland are maintained across the patch.
  - Selection systems, in which trees are harvested in small groups such that most of the woodland structure is maintained year on year.
  - Continuous cover forestry (an extension of selection systems) in which trees are harvested individually such that the overall woodland structure is generally maintained.
- Silvo-agricultural systems, such as:
  - Silvopasture, in which trees are mixed with livestock and pasture.
  - Silvoarable, in which trees are mixed in with crop fields.
- Non-timber systems, such as:
  - Lightly managed woodland or managed semi-ancient woodland.
  - Plantation on ancient woodland site (PAWS) restoration.

2.4.4 Woodland age

Woodland age is often used as a proxy for tree height and woodland maturity stage. Further, woodland age under the different management regimes are often good indicators of woodland structure and

[8] More detail on silvicultural systems and classifications can be found on the Forest Research website: https://www.forestresearch.gov.uk/tools-and-resources/fthr/biomass-energy-resources/fuel/woodfuel-production-and-supply/woodfuel-production/forestry-for-woodfuel-and-timber/silviculture/

therefore management thresholds. There are three management thresholds which are important to this project, as they correspond to points at which the benefits provided by woodlands and their vulnerabilities to risk change. The first is the stage at which trees are no longer at acute risk from drought, browsing, or competition from shrubs or other trees. This is the threshold between young stand and thicket in Table 2.3. The second is the stage at which timber "matures" into economically viable timber which may be harvested, which occurs at some point in the timber stage. The third threshold, which only applies to woodlands which are not primarily managed for economic objectives, is the point at which woodlands become fully mature and begin to change character. One example of this is ancient woodlands (those woodlands that have continuously existed since 1600). However, it may not be strictly necessary for a woodland to be 425 years old to exhibit the characteristics of a fully mature forest, and this is an area which requires more research from a benefits point of view.

For woodlands with timber objectives, the management stages as woodland grows are presented in Table 2.3. Woodlands with other objectives are likely to have different management stages, and the tree age when each stage is reached will vary significantly between species.

Table 2.3: Woodland stages

Woodland stage	Physical characteristics	Management notes
Establishment	Trees newly in the ground	Planted or natural propagation in rare cases
Young stand	<3m height	Protection against animals / plants as necessary
Thicket	>3m height, <10cm DBH	Thinning if necessary for the species mix
Pole stage	10 to 20cm DBH	Continued thinning, including crown thinning
Timber stage	>20cm DBH to harvest size	Management highly tree and site specific

Table 2.4 provides some summary information about the expected tree ages at these important thresholds for conifers and broadleaves. Notably, there is a lot of variation in age at harvesting depending on the aim of the landowner and the species. For example, older stands can create logs that are suitable for specialty wood products such as particularly large beams and other structural members.

Table 2.4: Ages at important woodland thresholds

Species type	Age at "thicket" stage (canopy closure)	Age at harvesting	Age at maturity
Conifers	Sitka Spruce: 15-20 years Norway Spruce: 20 years+ Scots Pine: 15-20 years	Sitka Spruce: 30-50 years Norway Spruce: 50-120 years Scots Pine 60-140 years Douglas Fir: 50-140 years	Site and management dependent
Broadleaves	Birch: 15-20 years	Oak: 100-160 years Beech: 100-140 years Birch: 40-55 years Sycamore: 50-90 years Alder: 30-60 years	Site and management dependent

Source: Haufe et al. (2024)

2.4.5 Condition assessments

Woodland condition can be assessed against a variety of criteria, but the most common assessment framework in England is the Woodland Condition Assessment (WCA), which uses 15 woodland ecological condition indicators (Field Studies Council *et al.*, 2024). This is near identical to the approach used in the NFI Woodland Ecological Condition assessment (Forest Research, 2020). Each indicator is scored as unfavourable (1 point), intermediate (2 points), or favourable (3 points) (see A3.3.4 for more details on the WCA assessment indicators). The scores across all 15 indicators are then added, and woodlands with a total score of less than 26 are considered to be in unfavourable condition, while woodlands with a total score of more than 35 are considered favourable.

A national-level summary of the proportion of specific indicators in favourable or unfavourable condition can be seen in Table 2.5. Veteran trees, open space proportion, and deadwood volume are consistent issues in woodlands in England, and by default the nativeness of occupancy scores poorly for near- and non-native woods. Conversely, most woodlands score favourable on invasive species and tree pest and disease. Native woodlands score well for native trees, and non-native woodlands score well for parcel size (typically large) and the favourability of nearby land.

Table 2.5: NFI assessment of specific woodland condition indicators (2010 to 2015)

	Indicators typically assessed as unfavourable (60% or more)	Indicators typically assessed as favourable (60% or more)
Native woodland	Veteran trees Proportion of open space Deadwood volume	Invasive species Nativeness of occupancy Tree pests and diseases Number of native species
Near native woodland	Veteran trees Nativeness of occupancy Proportion of open space Deadwood volume	Invasive species Tree pests and diseases
Non-native woodland	Veteran trees Nativeness of occupancy Proportion of open space Deadwood volume	Invasive species Tree pests and diseases Size of woodland parcel Nearby land (woodland and favourable habitat)

Source: Forest Research (2020a)

Based on surveys from 2010 to 2015, the majority of woodlands in England are in intermediate condition (92%, or 1,235,000 hectares) (Forest Research, 2020). While this holds for all woodland types, near native and non-native woodlands were much more likely to be in unfavourable condition, while almost all woodland that achieved favourable condition overall was native woodland (Table 2.6). This reflects the scoring in Table 2.5, as several criteria are linked to the "nativeness" of a woodland.

Table 2.6: NFI assessment of woodland condition based (2010 to 2015)

	Unfavourable (ha, percent of type)	Intermediate (ha, percent of type)	Favourable (ha, percent of type)	Total (ha)
Native woodland	5,000 (0.5%)	815,000 (90.3%)	83,000 (9.2%)	900,000 (100%)
Near native woodland	1,000 (4.1%)	30,000 (95.3%)	200 (0.6%)	32,000 (100%)
Non-native woodland	18,000 (4.4%)	389,000 (95.4%)	1,000 (0.2%)	410,000 (100%)
Total woodland	24,000 (1.8%)	1,235,000 (92%)	84,000 (6.3%)	1,340,000 (100%)

Source: Forest Research (2020a)

2.4.6 Recent trends

Recent trends in English woodland creation and management represent a significant change from forestry practices of the previous decades. An overview of recent planting trends can be seen in Figure 2.2. There has been a significant shift away from conifer planting, particularly even-aged stands in large plantations, towards smaller scale broadleaf woodlands. The rate of new woodland creation has also increased significantly in the past 10 years, from around 1,000 ha planted in 2016, to over 5,000 ha in 2025. This follows observed cyclical trends in planting, which is a response to policy priorities and specific funding mechanisms that incentivises both the amount and broad type (conifer or broadleaf) of woodland planted (Forestry Commission, 2019).

The changes in trends around type also reflect shifts in management regimes favoured by the Forestry Commission and other stakeholders in England, with a greater emphasis on biodiversity, sustainable forestry practices, alternative timber management regimes (e.g., the development of continuous cover forestry), and resilience. This shift in approach can be seen in the development of the UK Forestry Standard (UKFS) (Forest Research, 2023), now in its fifth edition, with more emphasis on climate change mitigation and adaptation, impacts of grazers, pests and diseases, and a wider range of good practice requirements (e.g., around species diversity).

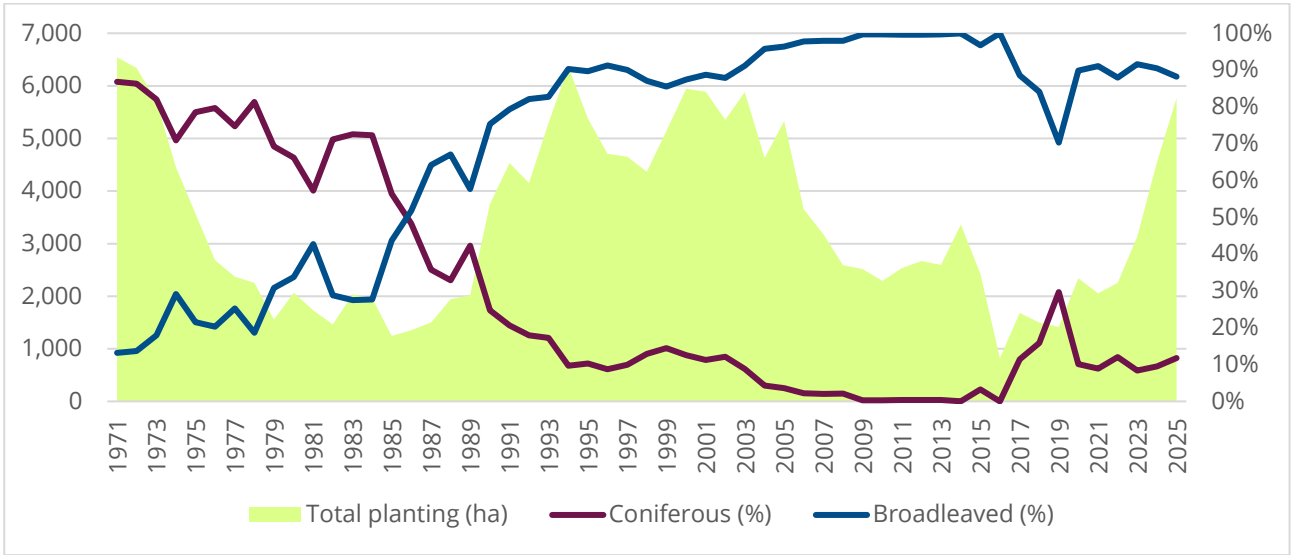


Figure 2.2: Total area of new woodland planted in England (1971-2025)
Source: Generated with data from Forest Research (2025d)

2.5 Benefits of woodlands

The benefits of woodland and TOW are well established and significant:

- The Office for National Statistics (2026) estimates the annual benefits of woodland (not including TOW) in England in 2023 were around £7.5 billion (2023 prices).[9] Of the benefits included, air pollutant regulation, greenhouse gas regulation, and recreation are the largest.
- The benefits of TOW across England are estimated to be between £1 billion and 2.7 billion annually (2020 prices) (Defra, 2022), of which air pollutant removal, carbon sequestration, and water retention are the largest benefits.

As the extent of woodland and the number of TOW increases, these benefits would also be expected to increase. At an average annual benefit of £5,000 to £11,000 per hectare, the potential benefits of achieving woodland targets are substantial (£1 to £2 billion per year).

These estimates do contain one particularly notable omission: biodiversity benefits. Recent research (eftec, 2025) estimated that household willingness to pay for increasing woodland biodiversity is in the range of £7,000 per hectare per year for woodlands with moderate levels of biodiversity.

These summary figures also don't provide insights into how the benefits of woodland and TOW vary with the composition, condition, and age of the woodland and TOW. As shown in several sources, the benefits vary substantially across individual woodlands parcels, and therefore benefits need to be estimated conditional on the outcomes of planting and management decisions in order to provide evidence on the trade-offs between different kinds of planting and management. Example sources on the variation of benefits across woodland type, age, and condition are eftec (2025) and (Matthews *et al.*, 2022). Table 2.7 provides a summary of the benefits of woodland, their determinants, and estimated annual value of these benefits where they exist, based on the latest woodland natural capital accounts, which are the official national source for UK woodlands.

Table 2.7: Benefits of woodlands

Benefit	Key determinant of benefit for a given woodland or TOW	National annual value estimates
Timber production	• Woodland type and management • Yield class (as measured in m^3 per hectare per year)	• £95 million in timber and fuelwood in 2024
Carbon Sequestration	• Woodland type and management • Age	• £2,392 million in greenhouse gas regulation in 2023
Water retention / regulation	• Woodland type and management • Age • Location	• £681 million in flood regulation in 2024
Water quality	• Woodland type and management • Woodland age	• No reliable national estimate

[9] This is a partial estimate and does not cover the value from all ecosystem services.

Benefit	Key determinant of benefit for a given woodland or TOW	National annual value estimates
Air pollutant removal	• Woodland type and management • Age • Location	• £1,742 million in air pollution regulation in 2024
Noise	• Woodland type and management • Age • Location	• £16 million in noise regulation in 2024
Local temperature mitigation	• Woodland type and management • Age • Location	• No reliable national estimate
Biodiversity	• Woodland type and management • Age • Condition	• No reliable national estimate
Recreation and physical health	• Woodland type and management • Access • Age • Location	• £928 million in health benefits in 2023 • £666 million in tourism and recreation expenditure in 2022

Sources: Main benefits from woodlands gathered from ENCA services databook (Defra, 2026b). National annual value estimates are from the 2026 release of the UK's woodland natural capital accounts, using data from England. Values are in 2024 prices (Office for National Statistics, 2026).
Table note: this is not an exhaustive list of the benefits of woodland and TOW.

2.6 Costs of increasing tree and woodland coverage

There are several sources of information on the planning, planting, restocking, maintenance, and opportunity costs of woodland creation and maintenance. Costs vary by woodland type, management regime, and age. Many costs will vary site by site, however, for this work, a range of estimated standardised costs were used (see Table 2.8).

The Nix Farm Management Pocketbook (2025 edition) (Redman, 2024) was used in the economic assessment for creation, restocking, and general maintenance costs. The Pocketbook is a widely recognised source for cost and revenue information for land managers in England; for example, it is used in the CCC's advice for the seventh carbon budget (CCC, 2025). Note that restocking costs are assumed to be £2,000 lower than establishment costs based on the detailed information about the necessary actions (Redman, 2024). Opportunity costs were estimated using an income-forgone approach, which represents the annualised net returns (inclusive of government grants) of the most likely alternative land use (Low *et al.*, 2024). The cost estimates vary according to the woodland and management type; a detailed breakdown can be found in Appendix 7.

Table 2.8: Costs included in the assessment

Cost and source used	Physical measure	Economic measure	Estimates used
Woodland establishment costs (Redman, 2024)	Area planted (ha)	£ / ha	£4,000-£10,500
Restocking costs based on (Redman, 2024)	Area restocked (ha)	£ / ha	£2,000-£8,500
Maintenance costs (Redman, 2024)	Area (ha) of woodland under each style of management	£ / ha	£110-£900
Opportunity cost of land (Low *et al.*, 2024)	Area (ha) of woodland under each style of management	£ / ha	Values for less favoured areas and lowland grazing are used (ranging from £123-£273).

3. Approach

This section describes the approach used in the analysis, which had two major components:

- **The woodland and TOW model,** which estimated the progression of woodland and TOW in England to predict the extent, type, age, and condition of woodland and TOW over the modelling period, based on the assumption that actions will be taken to meet the overall woodland and TOW target by 2050; and
- **The economic assessment**, which estimated the benefits and costs of the modelled woodland and TOW outcomes.

As noted in the evidence review, there is a large amount of uncertainty around future woodland and TOW outcomes. The approach therefore aims to understand both the benefits and costs of future woodlands and TOW as well as the uncertainties around those benefits and costs and achieves this by utilising both probabilistic methods (Monte Carlo simulations) and deterministic sensitivity testing (e.g., the use of confidence intervals in economic assessments).

3.1 Overview

The approach followed five steps (see Figure 3.1):

1. **Determine model specification and parameters** based on the evidence review (Section 2) (see discussion in Section 3.2).
2. **Specify scenarios** informed by both the evidence need and the evidence review. The scenarios consist of a set of inputs used in the modelling (Section 3.3 and Appendix 4).
3. **Use the woodland and TOW model to estimate progression to 2100** and conduct Monte Carlo simulation analysis to determine the stability of the modelled progressions subject to changes in the input parameters (Section 3.2 and Section 3.4).
4. **Estimate ecosystem service provision** based on the estimated woodland and TOW progressions and compare them to both current provision and other scenarios (Section 3.5).
5. **Estimate economic benefits and costs** based on the progressions and the associated ecosystem service flows for each scenario and compare across scenarios (Section 3.5).

The modelling estimated woodland and TOW progressions from 2025 until 2100 for each scenario. While the woodland target is for 2050 and is assumed to be met, a longer modelling period was required to capture the dynamics that occur as woodlands and trees mature. This was especially important given the uncertainty faced by woodlands due to climate change and the associated risks (Section 2.3). Many climate models project outcomes to 2100, and therefore this was the date selected for this research. Additionally, the benefits and costs arising from woodland and TOW change over time, and therefore an economic assessment across the entire period was more reflective of the outcomes. The modelling and the economic assessment were both conducted at the regional scale across England, with the potential to disaggregate outcomes to local authorities for estimating the value of specific benefits. Results were then scaled up to the national level for reporting. The spatial scale was determined by both data availability and the computational intensity of the modelling process. This aligns to the research aim of providing evidence at the strategic level for meeting the 2050 woodland target across England.

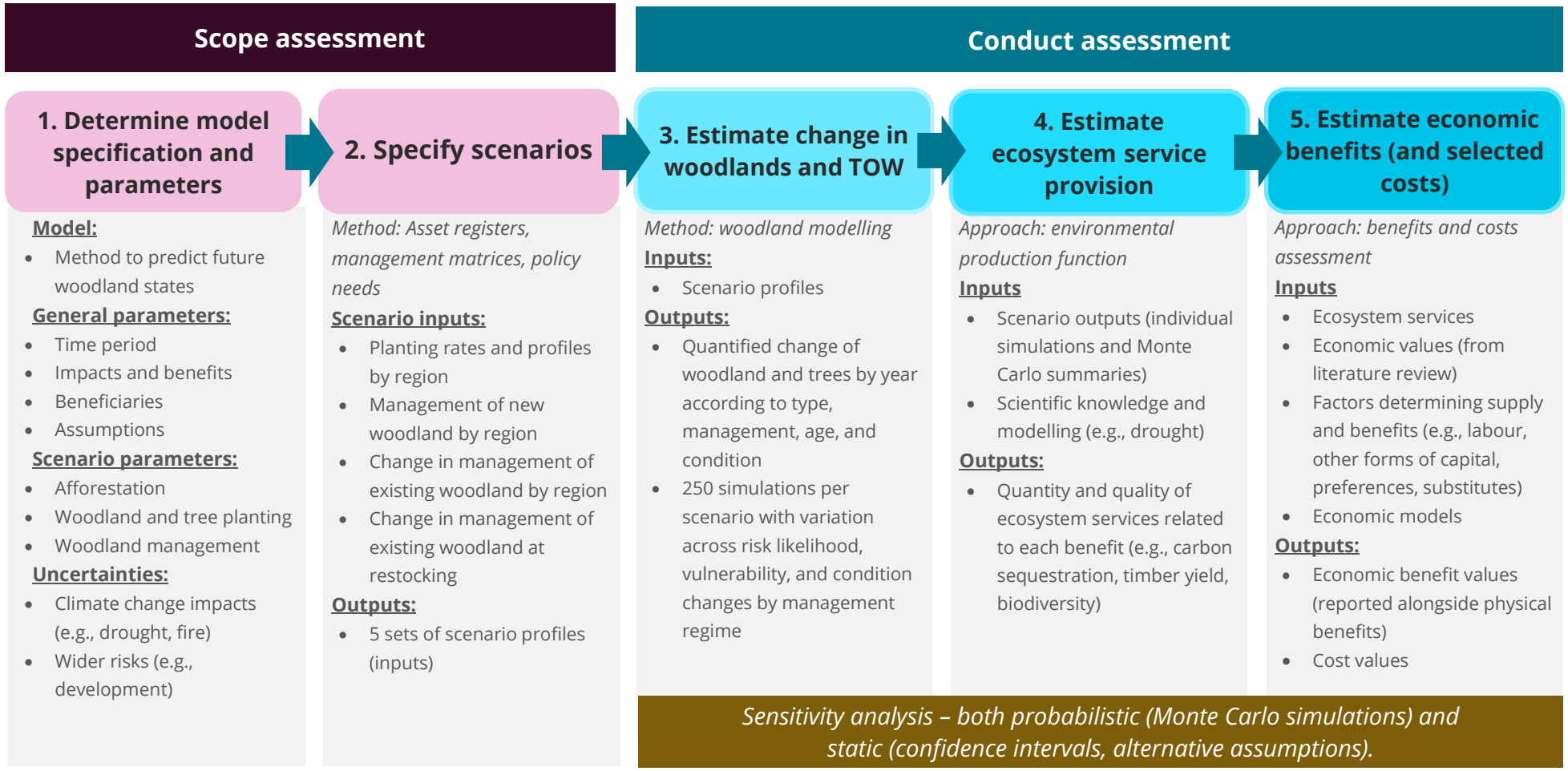


Figure 3.1: Overview of assessment framework for woodlands and TOW

3.2 Modelling approach and process

The woodland and TOW model estimated the change in woodland and TOW in England each year over the modelling period (2025 to 2100) to predict the state of woodland and TOW. The model can be described by the following key elements:

- The modelling units, which track the predicted progressions of woodland and TOW;
- The woodland profiles, which are how the state of each model unit is described;
- Scenarios, which describe how people influence the future of woodland and TOW through planting, restocking, and other management; and
- The model functions (modules), which predict how woodlands change year on year based on the current state, a set of assessment parameters informed by the woodland evidence, and the scenario inputs.

Included in the modelling are probabilistic and deterministic uncertainties, which vary the parameters in the model according to probability distributions, or randomly allocate outcomes based on a fixed parameter (Figure 3.1). An overview of the modelling approach can be seen in Figure 3.2. For more detail on the modelling process see Appendix 3.

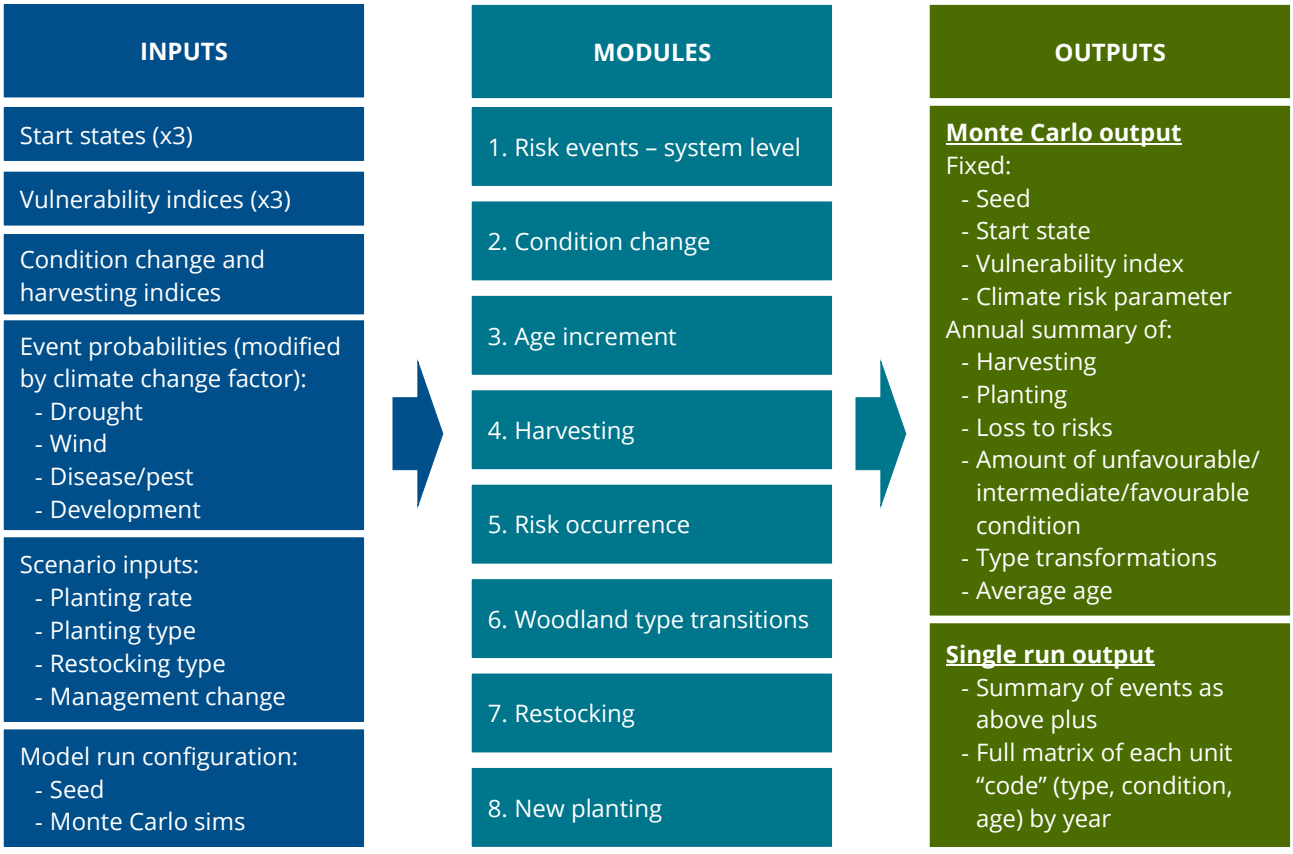


Figure 3.2: Flow diagram of the woodland and TOW model

3.2.1 Model units and cumulative structure

The model units are tracked using rows in a matrix that each represent a representative selection of 100 hectares in a specific region of England, which are tracked year on year through the columns to the matrix. The model units can either represent current woodland and TOW (as of 2024), or land that has the potential to become woodland in the future. Each unit does not represent a real land area, but rather is the minimum level of granularity within a specific region in the model. A unit, therefore, could represent several woodlands in aggregate, or a part of a larger woodland in the abstract. Overall, this structure leads to 24,000 rows in the model, totalling 2.4 million ha of land. This represents a substantial land area for modelling purposes: meeting the 16.5% woodland and TOW target equates to approximately 2.15 million ha, based on England's total land area of around 13 million ha. There are 76 columns for the years from 2025 to 2100, with each cell of the matrix therefore representing 100 ha of land in a specific year.

3.2.2 Woodland profiles and initial state

Each unit has a single "state" for a given year, which is specified by its woodland profile. Practically, the profile is a six-digit number that describes each unit across four key modelled dimensions: broad species type (digit 1), management regime (digit 2), condition (digit 3), and age (digits 4, 5, and 6) (see Figure 3.4). A location is also attached to each unit, but as a static, external variable that never changes and is not part of the profile code. In aggregate, the profiles summarise the state of woodland and TOW in England to a reasonable degree. In the starting state, this is based on the current NFI data, and then modelled into the future to capture the variation across the scenarios as well as the randomness embedded into the modelling process. The outcomes and economic assessment were then based on the information included in the aggregated profiles.

The aspects and levels included in the profiles were determined based on: (i) the necessary inputs to estimate costs and benefits; (ii) the necessary inputs to understand how woodlands evolve over time including how they are affected by various risks; and (iii) data availability (summarised in Table 3.1). TOW do not neatly fit into this framework, as they have uniquely high variability in terms of species mix, age, and condition. Further, their management regimes are not easily described in similar terms as woodlands. Additionally, there is far less data available at the regional or national scale for TOW, beyond total area. Therefore, TOW were considered as their own unique category in the modelling as well as the benefit and cost assessments.

Table 3.1: Profile aspects and which model outputs they affect

Profile aspect	Importance to progression	Importance to benefits	Importance to costs	Current data availability
Location	Variable	Variable	Variable	High
Woodland age	High	High	Moderate	Moderate
Species mix	High	High	High	High
Management regime	Moderate	High	High	Poor
Condition	Moderate	High	Low	Moderate

Location

Location is described in the modelling using the nine English regions.[10] The approach was selected based on the strategic nature of the assessment, as it allows for some spatial variation in inputs, risks, costs, and benefits, but is also compatible with the limits of current data sets. A more spatially precise model may have improved the accuracy of results at the parcel level but are unlikely to impact the results at the regional and national levels, as these outcomes are based on aggregate inputs and modelling probabilities.

Woodland age

The modelling uses a continuous age parameter, with age 0 being the year of first creation or the year of restocking after clear-felling or loss to risks. As such, the age parameter generally captures the ages of the woodland overall, and individual trees within the woodland may be younger than the age of the woodland itself, depending on how much individual tree restocking and natural regeneration occurs.

For estimating different exposures to risks and differences in benefits across tree ages, ages have been grouped into broad bands that correspond to the lifecycle of woodlands and management practices:

- Very young (0-10 years)
- Young (11-30 years)
- Intermediate (31-50 years)
- Maturing (51-80 years)
- Mature (81-140 years)
- Long-established[11] (141+ years)

These age bands can also be used to estimate the management type distribution. For example, medium rotation conifers should not be much older than 80 years, while continuous cover forestry (CCF), as a relatively new woodland management approach, is unlikely to be seen in mature or older stands.

Species mix and management

In England, management is closely linked to a dominant species, such as short rotation conifer forests often being stocked with Sitka spruce. This is due to both the appropriateness of certain management action to a species, and the appropriateness of tree species for certain management objectives.[12] Further, a woodland's dominant tree type and its management are crucial factors in predicting the progression of that woodland over time, as well as the benefits it provides and the costs of its creation and maintenance. The modelling therefore used broad categories of conifer, broadleaf, and mixed for the dominant species types[13] combined with common management regimes resulting in twelve woodland types plus TOW (Table 3.2Table 3.).

[10] These being: North East, North West, Yorkshire and The Humber, West Midlands, East Midlands, East of England, London, South West and South East

[11] Long-established woodland is defined by Natural England as woodland that is present since 1893 (at least 133 years old as of 2026). That definition is borrowed here to indicate woodlands that will have different biodiversity characteristics and high densities of veteran trees due to the overall age of the woodland.

[12] Some management objectives correspond primarily to a specific species (e.g., short rotation conifer and Sitka Spruce), while others are associated with a wide range of species and management actions taken (e.g., broadleaf with light management).

[13] While there may be some additional insight in moving beyond these categories to specific species (e.g., for risk exposure to specific pests and diseases), this would complicate the modelling beyond the scope of this work.

Table 3.2: Tree cover types (Description based on NFI classification methodology)

Tree cover type (code)	Description
Conifer unmanaged (10)	At least 80% coniferous species that are currently unmanaged
Conifer short rotation (12)	At least 80% coniferous species on rotation of around 30 to 50 years (typically Sitka Spruce in England)
Conifer medium rotation (13)	At least 80% coniferous species on a rotation of 50 to 80 years.
Conifer long rotation (14)	At least 80% coniferous species on 80+ year rotations.
Conifer CCF (15)	At least 80% coniferous species thinned and selectively harvested to maintain continuous tree cover
Broadleaf unmanaged (20)	At least 80% broadleaf species that are currently unmanaged
Broadleaf light management (21)	At least 80% broadleaf species under a management regime that does not involve the harvesting of timber. This category includes silvopastoral regimes.
Broadleaf rotational (24)	At least 80% broadleaf species managed for clear-felling on a 80+ year rotation.[14]
Broadleaf CCF (25)	At least 80% broadleaf species thinned and selectively harvested to maintain continuous tree cover
Mixed unmanaged (30)	A mix of broadleaf and coniferous species (minimum of 20% of each type) that are currently unmanaged
Mixed light management (31)	A mix of broadleaf and coniferous species (minimum of 20% of each type) under a management regime that does not involve the harvesting of timber
Mixed CCF (35)	A mix of broadleaf and coniferous species (minimum of 20% of each type) thinned and selectively harvested to maintain continuous tree cover
TOW[1] (40)	Small woodlands (<0.5 ha), lines of trees, and individual trees of any species mix, as well as silvoarable agroforestry. Assumed to have same benefits and costs as broadleaf light management

Table notes: (1) All TOW are captured in one profile due to lack of current disaggregated data.

Woodland condition

While species mix, management, and age are critical to understanding the benefits, costs, and change of woodland and TOW over time, a further aspect is necessary to capture overall health of woodland and TOW. Ecological condition (Forest Research, 2020), assessed on a three point scale (unfavourable, intermediate, favourable) measured by 15 indicators (see Section 2.4.4) is a good proxy for general woodland condition (eftec, 2025), and therefore is used in the modelling to link woodlands to the biodiversity and cultural benefits they provide and their vulnerability to risks. Appendix section A3.3.2 describes the assessment of ecological condition and how it is projected over time based on the other woodland aspects.

[14] Some broadleaves are also managed with short rotations for biomass and coppicing but are not included as they were excluded from the 2050 woodland target.

Initial state of woodlands and TOW

Three start states were developed in which an initial woodland profile was assigned to each model unit. 19,329 model units (corresponding to current woodland and tree cover, minus orchards) were assigned a profile for 2024. The profiles assigned were based on the available data[15] on existing woodlands by region, type, age, and condition, using a range of cross tabulations and data sources across the different parameters. Figure 3.3 provides an overview of the process used to generate the start states. While the data was not available for all aspects and combinations of aspects, likely distributions of the missing aspects and combinations could be inferred at the region level.

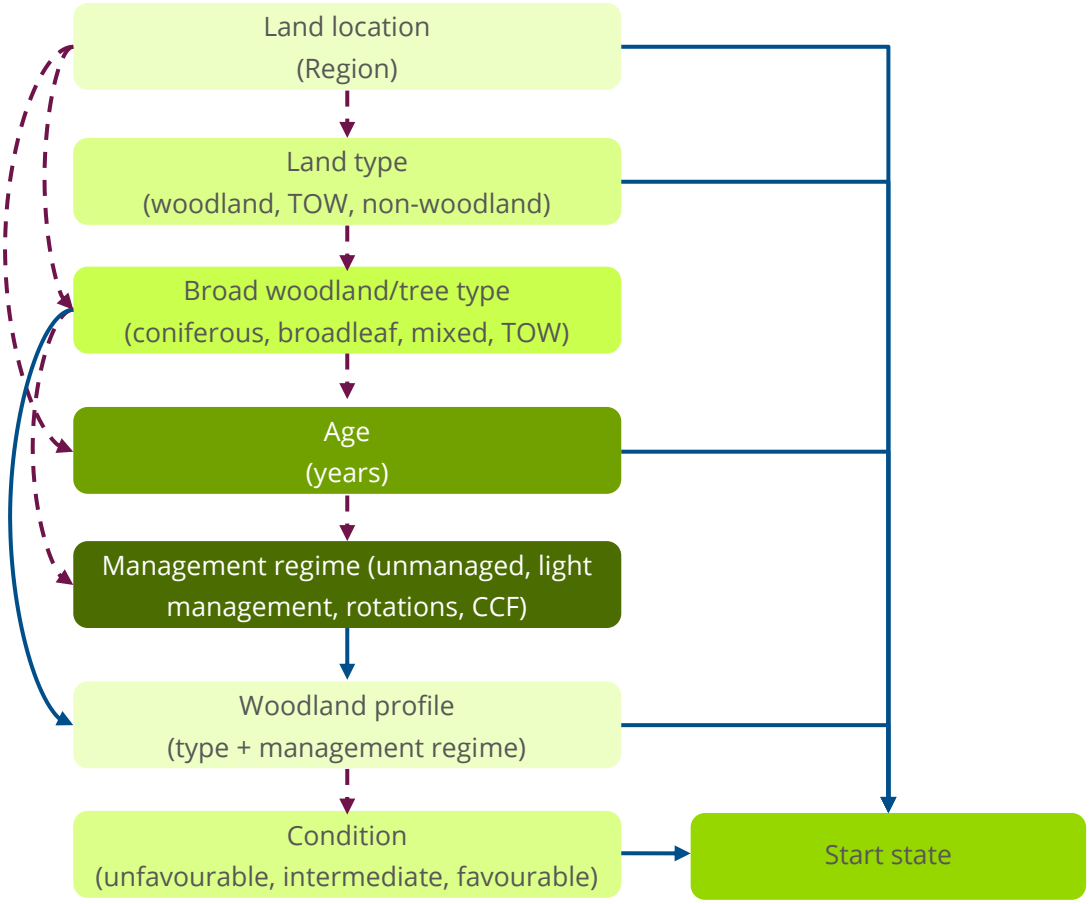


Figure 3.3: Overview of how the starting state data was estimated across key model parameters.
Figure note: blue arrows indicate direct input into that parameter, dashed purple arrows indicate that this parameter influenced the value of the parameter the arrow leads to, based on available data.

The final start states were generated using a random process based on the distributions of available and inferred data, with a process that ensured no unwanted correlation between model parameters for each unit. This was done three times with all three starting states used in the Monte Carlo simulations to ensure randomness in the inputs.[16] More detail on the data used, assignment process, and summary stats for the start states can be found in Appendix A3.3.

[15] Where recent data was not available it was extrapolated from the latest year available.
[16] The start state was not observed to have a systematic influence on the outcomes.

3.2.3 Change over time

From the start states, the progression of each model unit over time is based on a modelling process that determines for each year whether the model unit (i) is affected by risks; (ii) is harvested; (iii) changes management; or (iv) is planted with a new woodland (if non-woodland unit) and if so, what type is planted. An illustrative example of this process is shown in Figure 3.4 below.

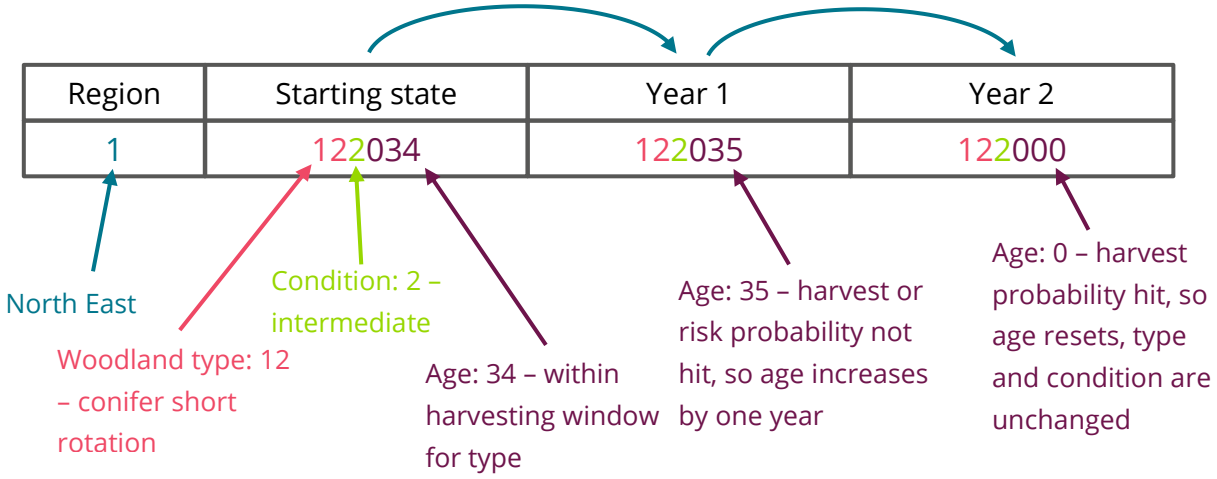


Figure 3.4 Example of unit evolution over time within the modelling structure.
Figure note: This example shows a unit aging, and what happens when a unit is harvested.

After this process has occurred, the profile of each unit and summary indicators for the year are recorded. These outputs can be aggregated by profile, region, and year to form the key outputs which become the inputs used in the economic appraisal. Each step in this process is described in more detail below.

Change due to risks

Risk was modelled as a function of both event probability and the relative vulnerability of woodlands to those risk events. The woodland units determined to be impacted by a risk then resulted in both woodland mortality and a decrease in woodland condition. It is assumed that in all cases the woodland is replanted the following year and then starts to regrow, starting from a lower condition level (this assumption is not dissimilar from historical data, which estimated that 10% of woodland affected by windthrow had not been replanted within 10 years (UK ETS Authority, 2025)). The interpretation of this is that even if the affected area is not replanted in the same spot, equivalent planting will take place within the same region.[17] In some cases woodland may be permanently lost (i.e. not replanted), but to help achieve the woodland target the unit would need to be replaced, and it is assumed this is done in the same region. Finally, while mortality is a relatively blunt way to assess risk, over the entire model process it results in good approximation of the impact across all woodland over time. A summary of the modelling approach for each risk is shown in Table 3.3.

Evidence of woodland area lost to risks each year is available at an annual level (see Section 2.3), and qualitative evidence is available about how different types of woodlands are affected by risks, both in terms of mortality and condition (see Appendix 2). This evidence was converted into the event probabilities at

[17] E.g., woodland lost to development is replaced elsewhere due to biodiversity net gain requirements. This assumption was deemed reasonable for the strategic scale modelling of this work.

national or regional levels and vulnerability indices for each woodland profile for each risk type (see Appendix A3.3.2). The former informed where risks impacted woodlands, and the latter distributed the risk impacts across woodland profiles according to informed relative probabilities (e.g., unmanaged forests more susceptible to fires, young trees more impacted by drought and fire than older trees, etc.). Both the event probabilities and vulnerability indices were weighted to ensure that the annual area affected by risks follows both the (limited) quantitative historical data and qualitative descriptions of risk exposure across the simulations. Given the uncertainty about the risk event probabilities, three different event probabilities matrices were estimated, with varying amounts of spread between risks. One of three was selected for each simulation run.

Table 3.3: Summary of risk modelling approach

Risk	Event probability notes	Woodland vulnerability index notes
Development	National probability, independent	Highest for TOW
Windthrow	Regional probabilities, independent	Highest for moderate age short rotation conifers in unfavourable condition
Drought	Regional probabilities, independent	Highest for young woodlands in unfavourable condition
Fire	Regional probability perfectly correlated to drought	Highest for young to moderate age conifer in unfavourable condition
Pest and disease	Woodland type probability, persistent over time	Highest for young woodlands in unfavourable condition

Table note: some risks can become correlated due to causality changes, such as woodland type correlating with region, and risks correlating with woodland type, leading risk to be correlated with specific regions.

The risk approach used did not account for extreme but rare events, such as very large-scale wildfires or severe, prolonged droughts. To date, these kinds of events have not occurred in England. However, recent events in the United States and Europe suggest that these events may become increasingly probable in England, and future research may consider applying a great range of high impact risk events to the analysis.

Change in age

Unless a unit is harvested or impacted by a risk, the age of a woodland or TOW unit is modelled to increase by one each year. This change in age represents an increase in biomass, changes in canopy closure, and potentially changes in risk vulnerability and likelihood of harvesting, depending on the current woodland profile.

Harvesting

Woodlands that are managed for rotational forestry (types 12, 13, 14, 24, and 34; see Table 3.2Table 3.) have a probability of being clear-felled (e.g., the unit is reset to an age of 0) based on a minimum age and a maximum age, after which the woodland has 100% probability of being harvested (unless the management regime changes first). See Appendix A3.3 for the harvesting rates, these are unchanged across each scenario.

Restocking

The units that are lost to risk or clear-felled are restocked in the modelling the next year, typically to the same type. However, the scenario inputs can include probabilities that the management and type of woodland change when land is restocked. To meet the 2050 woodland target, it is assumed that all clear-felled units are restocked. Note that as the units are abstractions, this restocking could happen elsewhere in the region.

Change in condition

A change in the condition of a woodland unit that is not due to a risk can result in either an increase or decrease in condition and is a function of the woodland profile, driven by the broad woodland type, management regime, and age of the woodland. Different profiles have different probabilities of changing condition, which were estimated using the Woodland Condition Assessment 4 (WCA4) indicators,[18] based on likely values for each woodland profile informed by the NFI data (see Appendix A3.3 for full description of this).

Most woodland in England is currently in an intermediate condition (approx. 90%). Therefore, the aggregate change in condition over the simulation should not significantly deviate from this in the no action scenario, taking into account the changing makeup of woodlands in England.[19] However, several indicators are linked to woodland age, and therefore as the overall stock of woodland in England ages, it is likely that condition (as scored by WCA4) would increase.

New planting

The annual planting rates for woodlands and trees were determined by the rates needed to achieve the 2030 interim target and the 2050 woodland target. Planting occurs from the first year of the modelling, 2025, up to 2050. This is modelled for each woodland profile in each region. The total amount of new planting per region is modelled deterministically in proportion to the increase in woodland cover in the last ten years, while the specific woodland profiles planted is probabilistic (but also informed by the recent planting in each region). Both the amount and type of woodland planted are determined through the scenario inputs, and the specific woodland profiles planted is a key difference between the scenarios.

See Appendix 3 for more details on the process to produce the new planting matrix and Appendix 4 for the specific parameters that dictate regional planting rates and the planting type distribution for each scenario.

Change in woodland management regime

The scenarios include annual probabilities for changes in woodland management regime while a woodland unit is still standing and are a key area of difference between them. The most likely changes are converting even-aged productive woodland into continuous cover forestry (CCF) or light management, or bringing unmanaged woodland into a management regime. These changes are meant to represent changes or continuations of (i) government policy (such as the UK Forestry Standard); and (ii) the economic incentives and current common practices for land managers. To remain consistent with new planting, change in woodland management profiles can also only occur up to 2050.

[18] These 15 indicators are near identical to those used to generate the NFI ecological condition

[19] For example, given the increase in planting of native broadleaves compared to non-native conifers in the last 25 years, we would expect the average condition to increase over the course of the century.

Uncertainties

There are several uncertainties that are considered in the modelling. This includes the impact of climate change on risk parameters and other woodland growth parameters. These uncertainties around risks to the growth of woodland and TOW are discussed in Section 2.2, and are mainly incorporated into the modelling using Monte Carlo simulation analysis, which provides a range of possible outcomes based on the range of input probabilities (see Section 3.2.4).

Beyond uncertainty relating to tree growth rates, there is policy uncertainty as it is unclear what type of woodland and tree planting and management will be incentivised and prioritised by the Government. This is a key motivating factor for this work and is reflected in the range of scenarios that are modelled, set out in Section 3.3.

Relationship to known policies, targets, and constraints

The modelling incorporates policies, targets, and constraints in different ways to ensure the modelling reflects likely future outcomes, and that the scenarios included are realistic and feasible to achieve (Table 3.4). The major constraints included are current good management practice (as defined by the UKFS), land availability, species suitability, nursery stock, and sector skills.

The modelling ensures that both the interim 2030 and 2050 woodland target are met, but other relevant targets may or may not be achieved (see Table 1.1 for main targets, and Appendix 1 for a more detailed assessment of relevant targets). The scenarios (see Section 3.3) are also constrained by the feasibility and existing trend for planting and managing specific types of woodland (e.g., the proportion of new planting that is coniferous), based on recent trends, current policy context, and expert stakeholder opinion.

Table 3.4: Constraints to woodland and TOW creation and management included in modelling

Constraint	Rationale	Inclusion in model	Evidence
Management practices	England has existing standards for woodland creation and management.	All newly created woodland at least "intermediate" condition and all new woodland is initially managed in some way	UK Forestry Standard (Forest Research, 2023)
Land availability	Land that is suitable to planting (in terms of condition, size, and opportunity cost) must be available for planting to occur.	The number of "empty" units in the model approximately reflects the availability of land for planting in each region, and no region's total planting exceeds this availability.	Woodland Opportunity Mapping work broken down at a region level by Friends of the Earth (2020) (1)
Species suitability	Species must be suitable to the site, otherwise the woodland either will not establish or will perform very poorly in terms of growth and condition.	It is assumed that each unit is planted with a species mix that is suited to the site and the management goals.	UK Forestry Standard (Forest Research, 2023); Forest Research ecological site classification decision support tool (Forest Research, 2026e)
Nursery stock	There must be enough available tree saplings from nursery stocks to achieve modelled planting rates (most planting comes from saplings rather than natural regeneration)	Planting rates do not significantly ramp up until 2030, and are assumed to be proportionate to existing regional trends. Planting rates are lower than those initially modelled as part of the impact assessment.	Planting rates follow the delivery plan (Defra, 2025d), and are lower than the preferred option in the impact assessment (Defra, 2023)
Skills	There must be enough skilled foresters to deliver new planting and maintenance, given there is currently a known skill shortage in the forestry sector (Royal Forestry Society, 2025)	Planting rates are lower and not much higher than current rates until 2030, and are assumed to be proportionate to existing regional trends. Planting rates are lower than those initially modelled as part of the impact assessment.	Planting rates follow the delivery plan (Defra, 2025d), and are lower than the preferred option in the impact assessment (Defra, 2023)

Table notes: (1) A similar dataset, the England Woodland Creation Low Sensitivity Map, is produced by the Forestry Commission (Forestry Commission, 2024). However, this has not been used due to the issues interpreting the spatial dataset at a regional level.

3.2.4 Monte Carlo simulations

There is inherent uncertainty in the model, coming from different sources, including:

- Starting data containing errors, that is out of date, or that is not broken down by all variables included in the model (e.g., management type)
- Poor data on the probabilities of risk events occurring, their overall impact, and their relative impact on different woodland profiles
- Uncertainty about how these risks will change over time due to climate change
- The model itself is inherently stochastic and dependent on random number draws (e.g., total amount of area affected by risk).

Put together, each simulation is one potential future pathway out of many, dictated by the model parameters, rather than a definitive outcome. Therefore, it is helpful to produce a range of outcomes to then analyse, rather than relying on a single simulation run. One way to deal with these uncertainties is to produce an envelope of model outcomes using Monte Carlo simulations (Table 3.5).

Table 3.5 Model parameters varied in the Monte Carlo simulation

Parameter	Description	How it was varied	Impact
Initialisation seed	The starting seed used in the modelling for probabilistic processes	Step change from initial seed, therefore each simulation run has a different starting seed	Changes: the random number draw for probabilistic parameters; what risks occur and where; harvesting; and types of planting
Climate scenario	A modifier to the probability of wind or drought events occurring regionally, or of pest and disease events, representing the future impact of climate change on these events	A uniform (0,1) parameter that determines the severity of increases to risk events due to climate change by the end of the model run	Shifts the average expected area affected by risk either up or down
Starting state	The starting state of trees and woodland in the modelling, specifically the distribution of age, condition, and management types per region	One of three starting states selected	Reflects the uncertainty in the starting state data; should not have massive impact on model outcomes
Vulnerability matrices	The relative probabilities of different woodland profiles (age + condition + management type) being impacted by risks	One of three event probability vectors selected (low, central, high)	Reflects the uncertainty in the risk data, will vary the spread of probabilities of different woodland profiles being impacted by risks.

The Monte Carlo simulation approach is preferred to static sensitivity analysis as it allows for a full distribution of outcomes to be seen, rather than a set number based on changing a few input parameters. Further, Monte Carlo simulation analysis is particularly suited to iterative modelling processes, in which random draws affect outcomes not only in one time period but across all periods in the future.

For the Monte Carlo simulations, each scenario (see Section 3.3) was run 250 times. The parameters that were varied are shown in Table 3.5. From this, key descriptive statistics were produced for each simulation[20], from which the range of outcomes could be seen. From this, individual simulations were replicated in full to give the full outputs needed for economic appraisal. The 5th, 50th (median), and 95th percentile runs, in terms of Age x Condition by 2100[21], were selected for this purpose.

3.3 Scenario definitions

This section sets out the scenarios and how they vary across the woodland modelling parameters described in Section 3.2. The scenarios are designed to explore policy-relevant hypotheses and build upon each other, such that each new scenario adds further policy targets to the overall scenario. The scenarios are:

- **Maintain existing woodland scenario –** no new planting or change in management practices, with the purpose of calibrating the model and providing a comparison point for the other scenarios.
- **Reach target with increase of current trends and practices scenario –** the 2050 woodland target is met by increasing the planting of woodland types in proportion to current trends. The proportion of woodland in management is assumed to continue near current estimates. This is the baseline scenario against which different policy focuses are modelled and assessed.
- **Reach target with increased management scenario –** the 2050 woodland target is met by increasing the planting of woodland types in proportion to current trends, and the proportion of woodland in management is increased (compared to the increase of current trends scenario) to meet government intentions (assumed at reaching approximately 70% of woodland by 2050). This explores the potential costs and benefits of higher levels of management.
- **Reach target with increased conifer proportion scenario –** the 2050 woodland target is met by planting a higher proportion of coniferous woodland than the increase of current trends scenario. Higher management rates (as per the increased management scenario) are also achieved. This explores the potential costs and benefits of conifer woodlands against other types and reflects the Government's intentions to increase the proportion of conifer woodlands being planted in EIP25.
- **Reach target with increased agroforestry proportion scenario –** the 2050 woodland target is met by using more land for agroforestry than the increase of current trends scenario. Higher management rates (as per the increased management scenario) are achieved. This explores the potential costs and benefits of agroforestry schemes against traditional woodlands and reflects the Government's intentions to increase the scale of agroforestry in EIP25.

[20] Producing the full output matrix for each run was too computationally intensive.

[21] Calculated as the average age by 2100 multiplied by the average condition (the weighted average of condition, where unfavourable = 1, intermediate = 2, and favourable = 3).

An overview of the scenario inputs can be seen in Table 3.6. All scenarios outside of the maintain existing woodland scenario meet the 2050 woodland target and the interim 2030 target, following the illustrative trajectory in the "Tree canopy and woodland cover Environment Act target delivery plan" (Defra, 2025d). That trajectory results in approximately 43,000 hectares of woodland planted between 2022 and 2030 (5,800 ha per year), and approximately 165,000 hectares between 2031 and 2050 (8,300 ha per year). Achieving the target overall will require an increase in woodland and TOW of approximately 208,500 hectares.[22]

The woodland profiles planted, the management practices of both newly established and existing trees and woodlands vary across the scenarios. Full scenario parameters for all scenarios can be seen in Appendix 4.

While each scenario was selected to help understand the potential outcomes of a pathway with specific focus for policies that impact woodland planting and management, they were constrained to ensure that each scenario could feasibly be achieved (see Section 3.2.3).

[22] Based on a 1.9% increase over a total estimated land area for England of 13,031,000 hectares.

Table 3.6: Overview of scenario inputs

Scenario input	Maintain existing woodland	Reach target with increase of current trends and practices	Reach target with increased management	Reach target with increased conifer proportion	Reach target with increased agroforestry proportion
Total new woodland and TOW planted each year by region	No new planting	Follows the trajectory to achieve the 2030 and 2050 woodland targets, with planting occurring in each region according to the relative proportion of recent planting.	Follows the trajectory to achieve the 2030 and 2050 woodland targets, with planting occurring in each region according to the relative proportion of recent planting.	Follows the trajectory to achieve the 2030 and 2050 woodland targets, with planting occurring in each region according to the relative proportion of recent planting.	Follows the trajectory to achieve the 2030 and 2050 woodland targets, with planting occurring in each region according to the relative proportion of recent planting.
Species and management of newly planted woodland and TOW by region	N/A – no new planting	Species and management in each region occur according to the relative proportions over the last ten years. All new woodland is assumed to be managed.	Species and management in each region occur according to the relative proportions over the last ten years. All new woodland is assumed to be managed.	More woodland is planted as coniferous species mixes and management regimes, to achieve a total proportion of 30%. All other types diminish in proportion to achieve the same overall planting target. All new woodland is assumed to be managed.	50% more woodland and TOW are planted in agroforestry schemes. All other types diminish in proportion to achieve the same overall planting target. All new woodland is assumed to be managed.
Species and management of restocked woodland and TOW by region	Species and management remain the same at restocking	Some woodland is brought into management at restocking, following the same distribution in management regime as newly planted woodland.	Some woodland is brought into management at restocking, following the same distribution in management regime as newly planted woodland.	Some woodland is brought into management at restocking, following the same distribution in management regime as newly planted ones.	Some woodland is brought into management at restocking, following the same distribution in management regime as newly planted ones.
Change in management of existing woodland and TOW over time	No change in management over time	Some existing woodland may also fall out of management. It is assumed that conifer woodland, which is largely owned by the Forestry Commission, is less likely to fall out of management.	All managed woodlands are assumed to continue to be managed, and woodlands are brought into management to achieve a management rate of 70%.	All managed woodlands are assumed to continue to be managed, and woodlands are brought into management to achieve a management rate of 70%.	All managed woodlands are assumed to continue to be managed, and woodlands are brought into management to achieve a management rate of 70%.

Table note: green shading indicates the same input as the reach target with increase of current trends scenario, orange represents a difference from this.

3.3.1 Maintain existing woodland scenario

This scenario was modelled to calibrate the model parameters to ensure realism and provide a counterfactual for the other scenarios for the economic assessment. In this scenario, woodlands and TOW in England do not change from their current state (i.e., no new planting), apart from losses to risk, harvesting, and restocking (which are then restocked). This scenario also includes the increase in risks over time due to climate change.

This scenario was modelled first to provide a starting point for the other scenarios. This enabled sensitivity testing of how various aspects of the modelling worked, calibration of parameters used in the subsequent analysis, and refinement of the approach used for the probabilistic sensitivity analysis. This scenario was also used to check and validate the parameters used in the modelling, for example by checking the outcomes of the modelling against other literature.

3.3.2 Increase of current trends scenario

This scenario reaches the 2030 interim and 2050 woodland target by increasing planting while following current trends and practices in terms of:

- Proportional distribution of woodland planting at a regional level and the types of land that are commonly planted on (e.g., low viability agricultural land);
- The types of woodland and TOW planted; and
- How new and existing woodland is managed, leading to changes in the distribution of woodland profiles.

Woodland planting will occur in a randomised nature on land with low sensitivity for woodland creation, in proportion with the net change of woodland over the last 10 years with data available (2014-2024) (Forestry Commission, 2024).

Woodland planting distribution across conifers and broadleaves follows existing trends in the past few years (assuming mixed woodlands are split 50/50) at a national level, with roughly 90% broadleaf and 10% conifer. From this, the regional distribution of each type is estimated by using weights based on the current proportion of that broad woodland category.

All newly planted woodland is under some kind of management regime. The management regimes of newly planted woodland are in proportion to the existing woodland management regimes (of woodlands that are managed). However, to maintain current rates of overall management (around 55-60%), it is assumed that some woodland falls out of management each year. A greater proportion of broadleaf woodland is managed privately (Forest Research, 2025c), and not managed for timber, therefore it is assumed that there is a higher chance that this kind of woodland falls out of management.

It is assumed that TOW planting continues as a proportion of total new planting. Data on new planting from the Forestry Commission shows that in the last four years, TOW has made up 17% of all newly planted woodlands and trees. Therefore, in this scenario TOW makes up 17% of new planting nationally. The region where TOW is planted is weighted according to how much TOW already exists in that region.

3.3.3 Policy pathway scenarios

Increased management

This scenario investigates the impact of higher management rates across woodland in England (the management of TOW is unknown based on current available data). This reflects the Government's intention to increase the proportion of woodlands in management as set out in EIP25.

This scenario follows the increase of current trends scenario across all parameters, apart from the management of woodland. It is assumed that no woodland falls out of management at any point in the modelling. Therefore, the proportion of woodland under some kind of management regime increases from 57% in 2025 to approximately 70% by 2050.

Increased conifer proportion

This scenario looks at outcomes when the proportion of conifer planting increases out of the total woodland planting (i.e. excluding TOW), while also increasing the management rates overall. This reflects the Government's intention to increase the proportion of newly planted woodlands being coniferous as set out in EIP25.

Conifer planting was assumed to increase to 30% of new woodland, up from the current rates of 11%. This figure was based on the proportion of conifer planting in the tree cover target Impact Assessment (Defra, 2023), other policy reports, and confirmed by conversations with the Forestry Commission, as a high but realistic level for conifer planting in England.

The regional distribution of conifer planting was weighted by the existing proportion of conifer woodland in each region, scaled to ensure that the 30% level was met nationally. This means that more conifer is planted in regions more suited for the species, in the north of England.

Increased agroforestry proportion

This scenario looks at the impact of increasing the uptake of agroforestry, relative to more traditional woodland creation methods. This reflects the Government's intention to increase the number of trees on farms via agroforestry systems as set out in EIP25.

In the modelling, agroforestry is split into two categories that fit within the classification system for woodland and TOW: silvopastoral (trees with pasture grazing) is modelled as lightly managed broadleaf woodland (albeit with a low stocking density), while silvoarable (trees alongside crops) is modelled as TOW, since it is unlikely to achieve the canopy cover needed to be classified as woodland. This classification follows the Impact Assessment (Defra, 2023), however, given the relative novelty of this approach as a widespread method of tree cover creation, there is more uncertainty in this accurately aligning with the types of woodland planted in this way.

The scenario is modelled by increasing the proportion of each of the relevant types (lightly managed broadleaf, TOW), by 50% in each region, while reducing planting of every other type proportionately. In the economic analysis, TOW is considered to be almost entirely broadleaf (same benefits as lightly managed broadleaf).

3.4 Woodland and TOW outputs

The output of the modelling is a breakdown of woodland and TOW in England for each year between 2025 and 2100, regionally and by woodland profile.

The output is presented annually, with values for age, condition and woodland type per unit that can be converted into area (ha) amounts and aggregated to the regional or national level. Outputs also include summaries at a national level of the total area subject to harvesting, planting, change in type, and exposed to different risks in the model.

These specific outputs can be combined across different variables or time periods[23] to provide further insight into the evolution of woodlands and trees over time, which form the basis for estimating the ecosystem services provided by woodland and TOW and how this varies across different woodland profiles.

3.5 Cost benefit assessment

The benefits covered in this analysis are drawn from the Enabling a Natural Capital Approach (ENCA) benefit categories (Defra, 2026b) and are considered material and practical to model within this analysis. Other benefits from woodland and TOW are not included because they are not practical to quantify and analyse for the assessment (e.g., visual amenity benefits) and/or are not material to the overall results (e.g., production of wild food).

Table 3.7 shows how ecosystem functions, services, and economic values are linked, and which model outputs are used to estimate physical flows of ecosystems. The different scenarios are also assessed against the other relevant physical targets (beyond the 2050 woodland target), to see if there are major differences and whether there is a scenario that aligns with meeting more targets.

These are compared to the costs of creating and maintaining the woodland and TOW (Table 3.8). The net present value and specific benefits or costs of each scenario can then be compared to see what the different magnitudes of benefits and any trade-offs may be.

[23] E.g., estimating tree growth by the area of tree that increases in age

Table 3.7: Benefits included in the assessment

Benefit	Linking ecological function to ecosystem services (biophysical indicators)	Ecosystem services to economic values (monetary indicators)	Input from woodland and TOW model
Timber production	• Tonnes of timber based on species growth rates, harvesting regime and area • Function well known.	• £ / m^3 overbark standing • Source: Forest Research (2026e)	• Species type • Management regime • Age
Carbon Sequestration	• Tonnes of carbon sequestered based on biomass production • Source: WCC calculator (2026)	• £ / tonne of carbon sequestered • Source: DESNZ (2023)	• Species type • Management regime • Age
Flood regulation	• Additional water storage capacity of woodland compared to grassland • Source: BMEA Broadmeadow *et al.* (2023)	• £ / m^3 flood water storage replacement cost • Source: Broadmeadow *et al.* (2023)	• Species type • Age
Water quality	• Kilograms of phosphorous, nitrogen, and fine particle load reduction • Sources: Tsai *et al* (2022); Environmental Protection Agency 2009).	• £ / kg of pollutant load reduction • Source: FARMSCOPER tool (Defra, 2013)[1]	• Age
Air pollutant removal	• Pollutants removed based on leaf area and respiration rates • Source: eftec and UKCEH (2025)	• £ / tonne of pollutant removed • Source: eftec and UKCEH (2025)	• Age • Region
Biodiversity	• Bundle of services provided based on biodiversity (cultural, non-use). Note – not easily quantified. Often the biodiversity level itself is valued directly. • Source: eftec (2025)	• £ / ha for changes in habitat condition levels • Source: eftec (2025)	• Condition
Recreation	• Bundle of services provided based on biodiversity (cultural, use). Note – not easily quantified. Often the biodiversity level itself is valued directly. • Source: eftec (2025)	• £ / ha for changes in habitat condition levels • Source: eftec (2025)	• Condition

Table note: Current work is ongoing to update the benefit values of improvements to water quality (eftec, forthcoming), and are likely to increase the benefit values of water quality ecosystem services

Table 3.8: Costs included in the assessment

Broad cost type	Individual actions included	Cost estimates	Input from woodland and TOW model
Woodland or TOW creation costs (new site)	Planning, site preparation, planting	• £ / ha • Source: (Redman, 2024)	• Species type • Management regime
Restocking of existing site costs	Planting	• £ / ha • Source: (Redman, 2024)	• Species type • Management regime
Maintenance costs	Pest control, monitoring	• £ / ha • Source: (Redman, 2024)	• Species type • Management regime
Opportunity costs	Forgone income	• £ / ha • Source: (Low *et al.*, 2024)	• Woodland type

4. Results

This section presents selected physical outcomes from the model runs (Section 4.1) and the full scope of economic assessment results (Section 4.2) across each scenario. Results were also explored at the regional level (see Appendix 9), which had similar findings in terms of differences and similarities across scenarios.

4.1 Woodland and tree model results

The woodland and TOW model produced two sets of outputs that are summarised in these results:

- The summary outputs by year from the Monte Carlo simulations; and
- The state of each model unit across all 75 years of the modelling from individual model runs.

Both sets of outputs are used in these results, and both serve different purposes. The summary outputs are most useful for understanding the range of potential outcomes based on the parameters varied in the Monte Carlo simulations. The results are presented as summary statistics of the values, typically either by 2050 or 2100. The individual model run outputs are most useful in understanding the more nuanced dynamics at play that end up resulting in those outcomes. These outputs are also used as inputs in the economic assessment, from which physical flows of ecosystem services are derived.

The maintain existing woodland scenario, in where current woodland and TOW are modelled without any woodland creation or changes in management, is included to:

1. Demonstrate how the modelling works and that estimated parameters are reasonable compared to historical data, such as the timber harvesting rates and annual losses to risks, without any other changes included; and
2. Create a comparison point in terms of how much of the economic costs and benefits are due to current woodland and TOW, and how much is due to the interventions included in the scenarios.

This scenario should not be confused with the increase of current trends scenario (see Section 3.3.2 and 4.2).

4.1.1 Summary of scenario outcomes

In aggregate, the predicted outcomes for woodland and TOW across the scenarios reflect a few notable shifts across the next 75 years, regardless of new planting and management (see Table 4.1).

- Woodland and TOW in England are likely to continue to mature. As woodland and tree cover was just over 5% in 1924 (Forest Research, 2025d), much of the woodland and TOW in England were planted or regenerated naturally relatively recently. This is reflected in several of the woodland condition statistics (Forest Research, 2020), in which veteran trees and complex vertical structure (both signs of older woodlands) are still relatively rare. This aging trend is very likely to continue unless there are major shifts in risk (such as very long-term drought or large-scale fires) or management (such as large-scale woodland harvesting), as is seen in the outcomes of the maintain existing woodland scenario.

- The amount of woodland achieving favourable ecological condition is likely to increase. This is primarily a function of woodland maturing, especially as a high percentage of current woodland is not likely to be harvested in the foreseeable future.
- The amount of woodland in unfavourable ecological condition does not systematically decrease, as many of the pressures and management practices that lead to unfavourable conditions (e.g., browsing damage, pest and disease, invasive species, non-native tree species, single stand height woodlands) are unlikely to decrease in the near term. Therefore the transition in condition is mostly from intermediate to favourable.
- Losses to risks (windthrow, fire, drought, flood, and development) over the time period is fairly consistent as a percentage of woodland. This is likely because several factors remain constant across scenarios, including the percentage of woodland that already exists (which is the same across scenarios), and because changes in planting and management are relatively small compared with the existing stock and therefore have limited influence on overall risk exposure.

These results were produced from the full Monte Carlo simulation runs for each scenario presented using box and whiskers plots of the outcome distributions across selected parameters.[24] Statistically significant differences between scenario outcomes were identified using a one-way ANOVA for differences between all groups, followed by the post-hoc Tukey's Honest Significant Test, which looks at whether each pair of scenario's outcomes are different from each other.[25]

[24] A box-and-whisker plot summarises a distribution using the minimum, first quartile (Q1), median, third quartile (Q3) and maximum; the box (Q1–Q3) shows the middle 50% of values, with the line showing the median. The whiskers extend to the minimum and maximum, excluding outliers which are represented as dots.

[25] ANOVA's for all variables were statistically significant at the 1% levels. Pairwise are reported if they were statistically significant at the 5% level. Details on Tukey's Honest Significant Test can be found in (Salkind, 2010).

Table 4.1: Physical outputs of the scenarios

Median run outcomes from Monte Carlo simulations)

Modelling outputs	Existing woodland (starting state)	Maintain existing woodland by 2100	Increase of current trends by 2100	Increased management by 2100	Increased conifer proportion by 2100	Increased agroforestry proportion by 2100
Woodland cover (ha)	1,339,100 ha	1,339,100 ha	1,509,000 ha	1,508,600 ha	1,510,700 ha	1,501,800 ha
TOW cover (ha)	593,900 ha	593,900 ha	626,700 ha	627,100 ha	625,000 ha	633,900 ha
Total woodland and TOW (ha)	1,932,800 ha	1,932,800 ha	2,135,700 ha	2,135,700 ha	2,135,700 ha	2,135,700 ha
Total canopy cover area (ha)	1,957,000 ha (15.02%)	1,957,000 ha (15.02%)	2,159,750 ha (16.6%)	2,159,750 ha (16.6%)	2,159,750 ha (16.6%)	2,159,750 ha (16.6%)
Woodland under management (%) (excludes TOW)	57%	57%	58%	71%	70%	70%
Woodland and TOW age (average, years)	46 years	91 years	88 years	87 years	86 years	87 years
Woodland[3] in unfavourable condition (ha)	43,700 ha (2%)	94,900 ha (7%)	94,500 ha (6%)	66,600 ha (4%)	84,600 ha (6%)	79,700 ha (5%)
Woodland[3] in intermediate condition (ha)	1,802,200 ha (92%)	1,046,800 ha (78%)	1,208,300 ha (80%)	1,176,400 ha (78%)	1,160,000 ha (77%)	1,146,100 ha (76%)
Woodland[3] in favourable condition (ha)	87,000 ha (6%)	197,400 ha (15%)	206,200 ha (14%)	265,600 ha (18%)	266,100 ha (18%)	276,000 ha (18%)
Total clear-fell harvested (ha) (note, all assumed restocked)	n/a	424,400 ha (5,584 ha / yr)	386,300 ha[(4)] (5,083 ha / yr)	434,300 ha (5,714 ha / yr)	458,800 ha (6,037 ha / yr)	422,400 ha (5,558 ha / yr)
Total woodland and TOW loss to risk (ha) (note, all assumed restocked)	n/a	470,600 ha (6,192 ha / yr)	493,400 ha (6,492 ha / yr)	506,400 ha (6,663 ha / yr)	517,600 ha (6,811 ha / yr)	499,300 ha (6,570 ha / yr)

Table notes: (1) This includes 24,000 of traditional orchards, which is included in the 2050 woodland target, but was not included in the modelling as they are managed very differently from woodland and TOW.

(2) Woodland and TOW age does not necessarily indicate tree age. This is simply the time over which the unit has continuously been a woodland or TOW without either clear-fell harvesting or loss to risk.

(3) Excludes TOW as condition metric was designed for woodland rather than TOW.

(4) This number is lower than all other harvest measures as some timber managed for woodland falls out of management over time, which does not happen (or happens at much lower rates) in the other scenarios.

4.1.2 Woodland ecological condition outcomes

The percentage of woodland and TOW in favourable condition by 2100 for each scenario is seen in Figure 4.1, and the proportion in unfavourable condition in Figure 4.2. The increase of current trends scenario results in a somewhat lower amount of favourable woodland and TOW, with a median of 19%, compared to the policy pathway scenarios which achieve 20-21% in favourable condition by 2100. This is expected, as lower management levels should result in relatively lower proportions of woodland in favourable condition as assessed by WCA4. There is also more woodland and TOW in unfavourable condition in the increase of current trends scenario (5%) compared to the policy pathway scenarios (4%), which reflects the same relationship between management and condition. In both cases, there is a statistically significant difference between the increase of current trends and every other scenario, but not between any of the other scenarios.

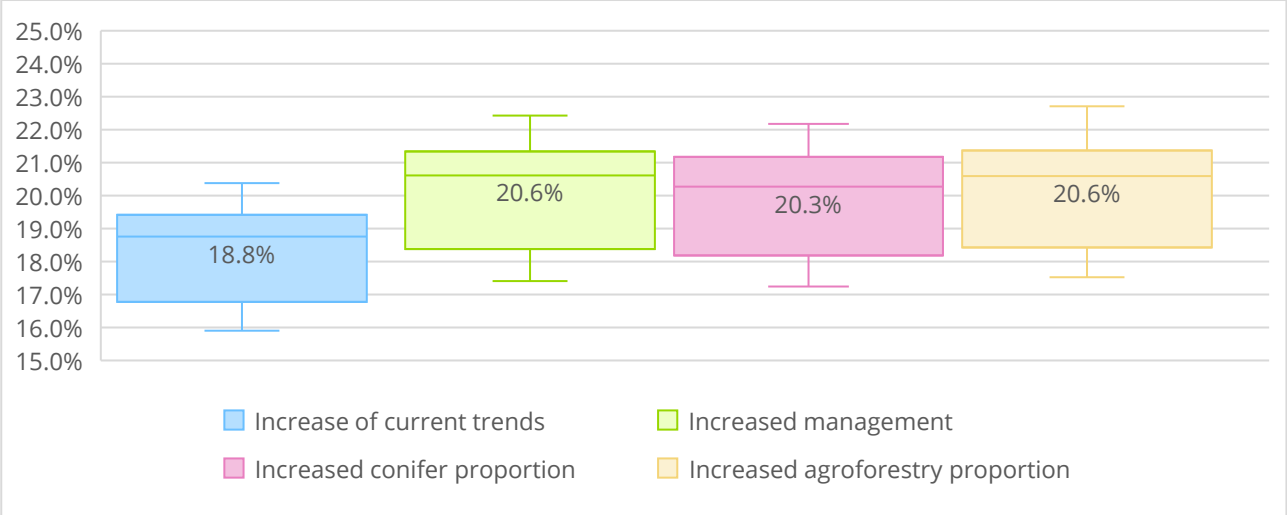


Figure 4.1: Percentage of total woodland and TOW in favourable ecological condition by 2100

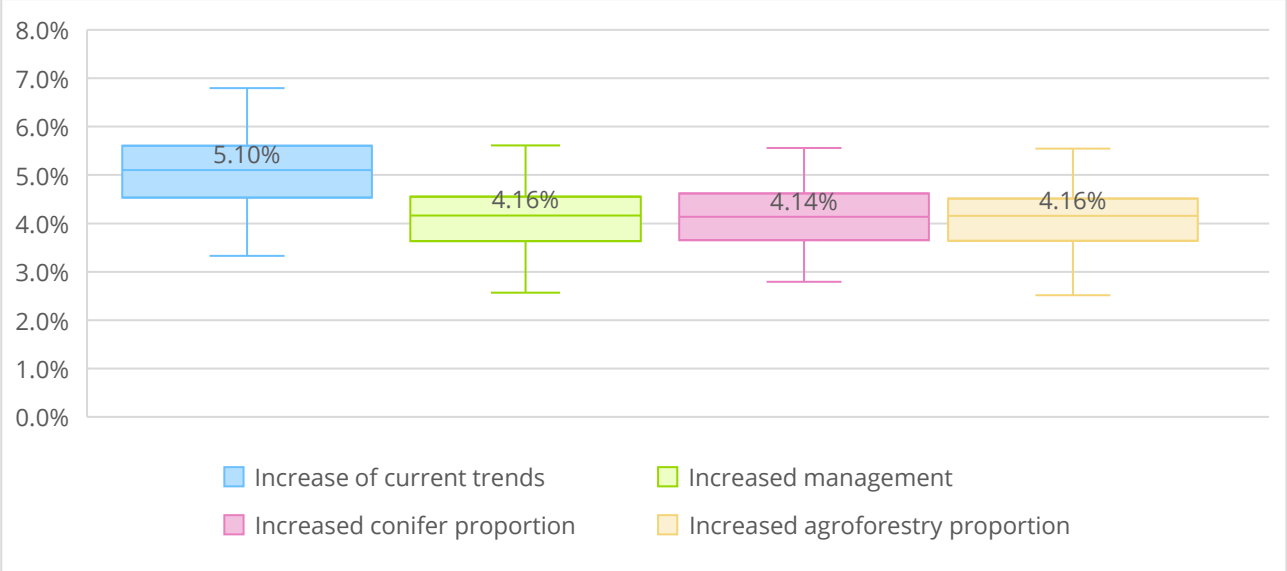


Figure 4.2: Percentage of total woodland and TOW in unfavourable ecological condition by 2100

4.1.3 Loss to risks

The modelled impact of risks (windthrow, drought, fire, pests/diseases, and development) to woodland and TOW across scenarios can be seen in Figure 4.3. The percentage is a rough approximation of the proportion of woodland that would be affected by some risk over a 75-year time period, and is within one percentage point across all scenarios. This figure is based on the aggregated amount of woodland affected by all risks across the full model period divided by the final total area of woodland and TOW. There is a statistically significant difference between the increase of current trends and every other scenario, but not between any of the other scenarios.

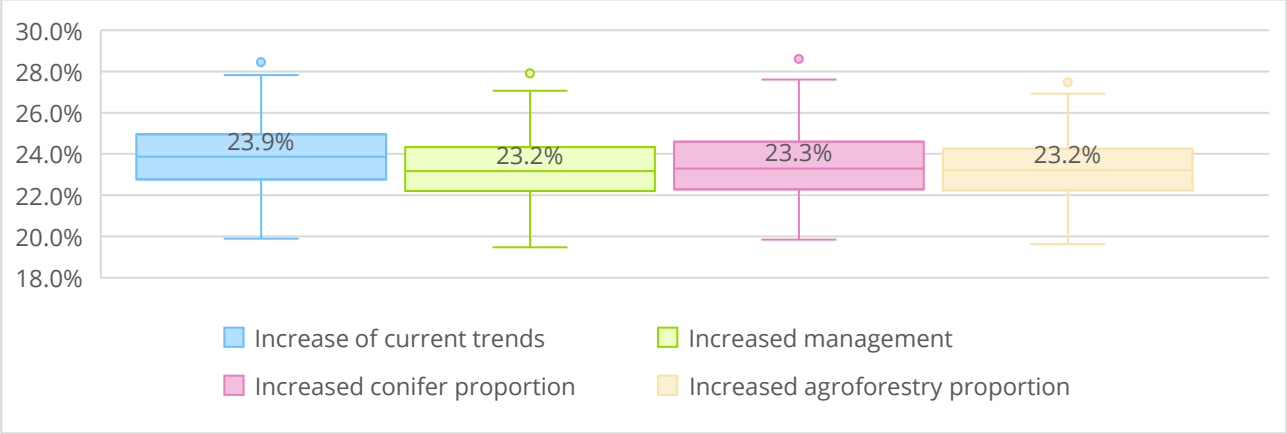


Figure 4.3: Percentage of total woodland and TOW affected by risk at some point by 2100

4.1.4 Clear-felled woodland

The total amount of woodland that is clear-felled[26] for timber in the model is shown in Figure 4.4. The lowest amount is seen in the increase of current trends scenario, reflecting the lower proportion of woodland in management regimes that involve clear-felling. Higher amount of clear-felling is seen in the increased conifer proportion scenario, driven by the fact that most conifers are in management regimes involving clear-felling, and that rotation lengths are shorter for the commonly planted conifer species in England. There is a statistically significant difference from every pairwise comparison between two scenarios.

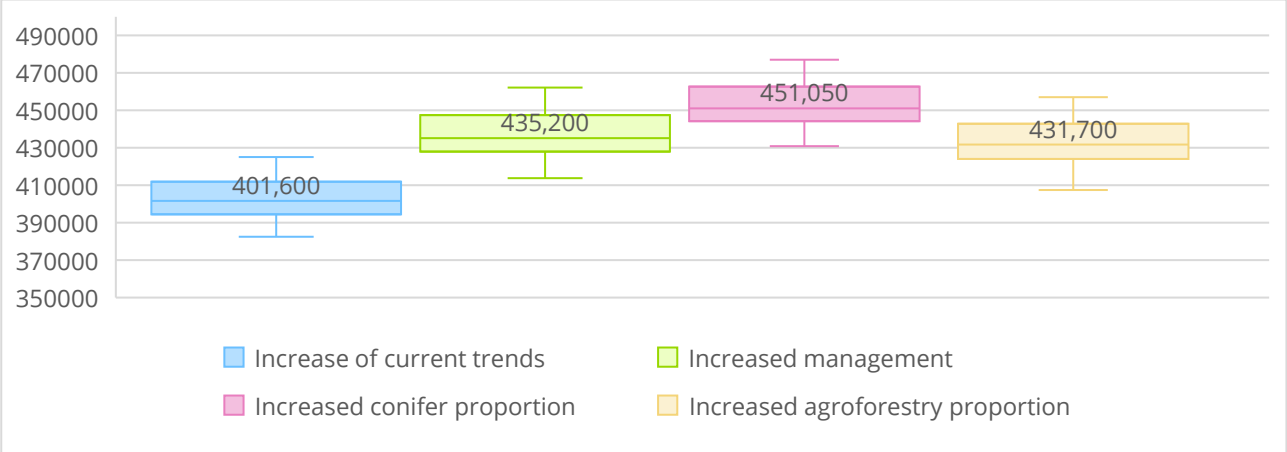


Figure 4.4: Total area of woodland (ha) clear-felled by 2100

[26] This does not include thinning, which is considered in the individual simulation runs as part of the economic assessment.

4.1.5 Woodland age

The average age of woodland and TOW is seen in Figure 4.5. As the risk impacts do not vary significantly across the scenarios (see Section 4.1.3), these findings are driven by the total amount of clear-felling. Therefore, the comparative positions of scenarios somewhat mirror Figure 4.4, with the highest average age in the increase of current trends scenario and the lowest in the increased conifer proportion scenario. There is a statistically significant difference from every pairwise comparison between two scenarios, apart from between the increased management and increased agroforestry proportion scenarios.

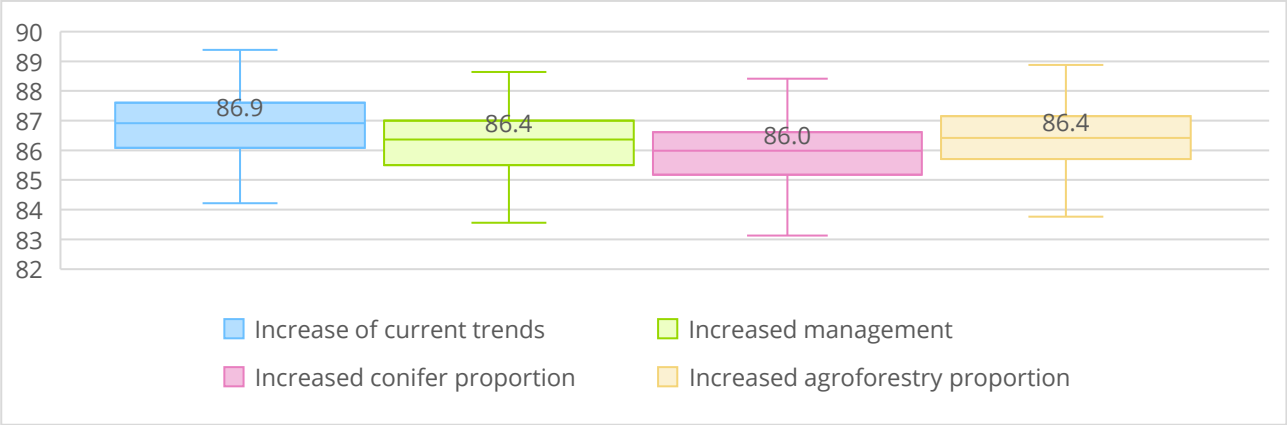


Figure 4.5: Average age of woodland and TOW at 2100

4.1.6 Woodland age x condition (single run selection parameter)

Finally, the parameter used to choose the individual runs to take forward for the economic assessment is seen in Figure 4.6. This is the average age by 2100, multiplied by the average condition in 2100,[27] which captures the overall outcome of the model run in a single comparable number. The differences across scenarios are small in terms of magnitude both in average and range. There is a statistically significant difference from every pairwise comparison between two scenarios, apart from between the increase of current trends and increased conifer proportion scenario, and between the increased management and increased agroforestry proportion scenarios.



Figure 4.6: Average age multiplied by average condition of woodland and TOW at 2100

[27] Calculated as the average age by 2100 multiplied by the average condition (the weighted average of condition, where unfavourable = 1, intermediate = 2, and favourable = 3, multiplied by the proportion at each condition).

4.2 Economic assessment results

The economic assessments were conducted on three model run outputs for each scenario, based on the 5th percentile, median (50th percentile), and 95th percentile outcome model runs as selected by the age x condition metric in 2100. These model runs were combined with low, medium, and high values for each benefit and cost. The lowest, median, and highest net benefit values for each scenario are used in reporting. Results are presented here at the national level. Regional level results did not vary greatly across pathways, as the total amount of planting did not vary per region (see Appendix 9 for more details).

4.2.1 Summary of benefits and costs

Regardless of the pathway, the benefits of meeting the 2050 woodland target are estimated to be an order of magnitude larger than the total costs (Table 4.2). Compared with the maintain existing woodland scenario (an estimation of the benefits of the current woodland stock and management over the next 75 years), the scenarios that achieve the 2050 woodland target result in around £31 to £38 billion in additional net benefits, mainly driven by additional increases in biodiversity provision and carbon sequestration. This is approximately a 10:1 benefit to cost ratio.

Comparing the pathway compliant scenarios, those with increases in management rates are found to have around 1% higher total assessed benefits (assuming that management is compliant with the UKFS), but also lead to slightly higher costs. The total net benefits of each pathway compliant scenario is similar; therefore, there are not any pathway compliant scenarios that were found to be obviously preferred to any other. Potential explanations of these findings are discussed more in Section 5.

Table 4.2: Costs and benefits of each scenario

Ranges in terms of smallest, median, and largest net benefits (PV75 terms in line with the model period of 2025 to 2100, £'billions)

	Maintain existing woodland	Increase of current trends	Increased management	Increased conifer proportion	Increased agroforestry proportion
Benefits	**£192 (£87 to £404)**	**£225 (£110 to £457)**	**£228 (£112 to £458)**	**£229 (£111 to £459)**	**£230 (£113 to £459)**
Carbon sequestration	£115 (£58 to £174)	£128 (£64 to £190)	£128 (£64 to £191)	£129 (£64 to £192)	£129 (£64 to £193)
Timber provision	£3 (£3 to £4)	£3 (£3 to £3)	£4 (£4 to £4)	£4 (£3 to £4)	£3 (£3 to £4)
Air pollutant removal	£61 (£21 to £197)	£64 (£22 to £208)	£64 (£22 to £208)	£64 (£22 to £207)	£64 (£22 to £208)
Flood regulation	£10 (£2 to £27)	£10 (£2 to £28)	£10 (£2 to £28)	£10 (£2 to £28)	£10 (£2 to £28)
Cultural benefits of increased biodiversity provision[1]	£3 (£3 to £4)	£17 (£15 to £23)	£19 (£17 to £24)	£19 (£16 to £24)	£20 (£18 to £23)
Change in recreational opportunity[2]	£0 (£0 to £0)	£4 (£3 to £4)	£4 (£3 to £4)	£4 (£3 to £4)	£4 (£3 to £4)
Water quality	£0 (£0 to £0)	£0 (£0 to £0)	£0 (£0 to £0)	£0 (£0 to £0)	£0 (£0 to £0)
Costs	**£28 (£21 to £37)**	**£31 (£24 to £41)**	**£32 (£25 to £42)**	**£33 (£25 to £42)**	**£32 (£24 to £42)**
Establishment cost	£0 (£0 to £0)	£1 (£1 to £1)	£1 (£1 to £1)	£1 (£1 to £1)	£1 (£1 to £1)
Restocking cost	£2 (£1 to £2)	£2 (£1 to £2)	£2 (£1 to £2)	£2 (£1 to £2)	£2 (£1 to £2)
Maintenance cost	£16 (£11 to £20)	£17 (£12 to £22)	£18 (£13 to £23)	£18 (£13 to £24)	£18 (£12 to £23)
Opportunity cost	£11 (£9 to £15)	£11 (£10 to £16)	£11 (£10 to £16)	£11 (£10 to £16)	£11 (£10 to £16)
Net benefits	**£164 (£66 to £368)**	**£194 (£86 to £417)**	**£196 (£87 to £417)**	**£197 (£86 to £417)**	**£198 (£89 to £418)**

Table notes: (1) biodiversity provision is assessed as the *change in* benefit, not the total benefit

(2) recreational opportunity is assessed solely as a function of the *change* in woodland extent and condition.

Table 4.3: Costs and benefits for newly planted woodland only

Ranges in terms of smallest, median, and largest difference in net benefits (PV75 terms in line with the modelling period of 2025 to 2100, £ billions)

	Increase of current trends	Increased management	Increased conifer proportion	Increased agroforestry proportion
Benefits (PV75) (£ billions)	**£34.2 (£23.4 to £50.9)**	**£34.6 (£23.5 to £51.0)**	**£35.3 (£23.9 to £52.2)**	**£34.7 (£23.7 to £51.3)**
Carbon sequestration	£12.2 (£6.1 to £18.4)	£12.3 (£6.1 to £18.5)	£13.1 (£6.5 to £19.7)	£12.4 (£6.2 to £18.9)
Timber provision	£0.1 (£0.1 to £0.1)	£0.1 (£0.1 to £0.1)	£0.2 (£0.1 to £0.2)	£0.0 (£0.0 to £0.0)
Air pollutant removal	£3.1 (£1.1 to £10.2)	£3.1 (£1.1 to £10.1)	£3.1 (£1.1 to £10.0)	£3.1 (£1.1 to £10.2)
Flood regulation	£0.4 (£0.1 to £1.1)	£0.4 (£0.1 to £1.1)	£0.4 (£0.1 to £1.1)	£0.4 (£0.1 to £1.1)
Cultural benefits of biodiversity provision[1]	£15.0 (£13.0 to £17.2)	£15.2 (£13.0 to £17.3)	£15.0 (£13.0 to £17.1)	£15.2 (£13.1 to £17.2)
Recreational opportunity[2]	£3.6 (£3.1 to £4.0)	£3.6 (£3.1 to £4.0)	£3.6 (£3.1 to £4.0)	£3.6 (£3.1 to £4.0)
Water quality	£0.0 (£0.0 to £0.0)	£0.0 (£0.0 to £0.0)	£0.0 (£0.0 to £0.0)	£0.0 (£0.0 to £0.0)
Costs (PV75) (£ billions)	**£3.3 (£2.7 to £4.1)**	**£3.4 (£2.8 to £4.2)**	**£3.5 (£2.8 to £4.3)**	**£3.2 (£2.5 to £3.9)**
Establishment cost	£1.1 (£1.0 to £1.2)	£1.1 (£1.0 to £1.2)	£1.0 (£0.9 to £1.2)	£1.1 (£1.0 to £1.2)
Restocking cost	£0.1 (£0.0 to £0.0)	£0.0 (£0.0 to £0.1)	£0.1 (£0.0 to £0.1)	£0.1 (£0.0 to £0.1)
Maintenance cost	£1.4 (£1.1 to £1.8)	£1.5 (£1.2 to £1.9)	£1.7 (£1.3 to £2.1)	£1.2 (£0.9 to £1.6)
Opportunity cost	£0.8 (£0.6 to £1.0)	£0.8 (£0.6 to £1.0)	£0.8 (£0.6 to £1.0)	£0.8 (£0.6 to £1.0)
Net benefit (PV75) (£ billions)	**£30.9 (£20.7 to £46.8)**	**£31.2 (£20.7 to £46.9)**	**£31.8 (£21.2 to £47.8)**	**£31.6 (£21.2 to £47.4)**

Table notes: (1) biodiversity provision is assessed as the *change in* benefit, not the total benefit

(2) recreational opportunity is assessed solely as a function of the *change* in woodland extent.

4.2.2 Benefits

The benefits included in the economic assessment were:

- Carbon sequestration;
- Timber provision;
- Air pollutant removal;
- Flood regulation;
- Cultural benefits of biodiversity provision;
- Recreational opportunity; and
- Water quality

For each scenario model run, outputs were converted from the form given by the model (i.e., area of different woodland profiles for each year), into an annual flow of physical ecosystem services, from which monetised benefits were estimated (see Table 3.7 for detail about what parameters each benefit depended on). More detail on the metrics used for the physical ecosystem services and the source of the monetary valuation evidence can be found in Appendix 6, while additional results from specific model runs can be found in Appendix 8.

Carbon sequestration

Carbon sequestration benefits increase substantially under all scenarios that increase woodland and tree cover (Figure 4.7). The range of estimates is wide in all scenarios, which is driven by the large differences in the low, central, and high carbon values used in government appraisal (DESNZ, 2023). However, over the entire appraisal period, there is not a large difference in the value of total annual carbon sequestration between scenarios that achieve the woodland target. Potential explanations for this finding, and whether it lines up with progress towards the 2050 Net Zero target, is discussed in Section 5. Looking at just newly planted woodland (see Table 4.3), the median carbon benefits are £1 billion higher for the increased conifer proportion scenario than the increase of current trends scenario (£13 billion versus £12 billion).



Figure 4.7 Carbon sequestration benefits (£ billions, PV75)

Timber production

The benefits from timber production can be seen in Figure 4.8. While it is an important source of revenue to private landowners, timber production is a relatively minor benefit of woodland and TOW when compared with some of the regulating services (such as carbon sequestration and air pollutant removal).

While there is very little difference between the scenarios in terms of timber benefits, the increased conifer proportion shows the highest benefit, as expected.[28] The similarity across scenarios can partly be explained by the timing of the clear-fell, which happens after the appraisal period due to the length of the rotation cycles for newly planted trees. Greater variation in timber benefit across the scenarios would be seen into the 2100s.

The value of timber benefit is based on the last three years' prices (Forest Research, 2026f), and the range of values is quite narrow, as prices have been quite stable over this period. Therefore, the differences in ranges across the scenarios is driven by the modelling process itself. This suggests that the increased management scenario, with current planting trends maintained, results in the smallest variance in timber benefit.

This benefit will be particularly sensitive to future supply and demand for timber products. If England moves towards construction methods that emphasise lower levels of embodied carbon or global timber supply weakens, the demand for wood products in the future could increase substantially and therefore raise prices and related benefits from woodlands managed primarily for timber.

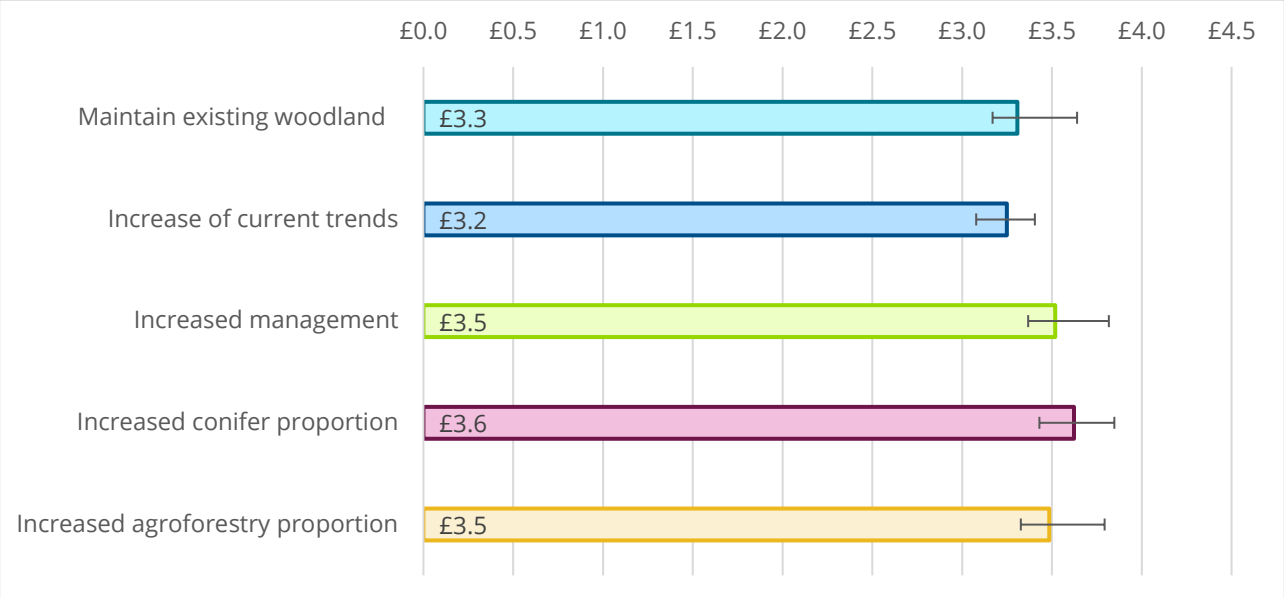


Figure 4.8: Timber benefits (£ billions, PV75)

[28] The decrease seen in the increase of current trends scenario compared to current woodland can be explained by productive woodland falling out of management, which does not happen in the current woodland scenario.

Air pollutant removal

The benefits from air pollutant removal by vegetation cover can be seen in Figure 4.9. It is one of the largest benefits of woodlands in England. Similar benefits are delivered across the scenarios since benefit assessment is not differentiated by broad woodland type. The range of estimates is large because the underlying air pollutant removal model uses the damage costs estimates (Defra, 2026a), which have a large range between low, central and high estimates.



Figure 4.9: Air quality benefits (£ billions, PV75)

Flood regulation

Figure 4.10 shows the benefits from flood regulation. They do not vary significantly across scenarios, as the variance in woodland type distributions between scenarios is low and flood retention rates do not differ substantially between woodland types. The large range of estimates across all scenarios is driven by the large differences in low and high estimates, based on values derived by Broadmeadow *et al.* (2023).



Figure 4.10: Flood regulation benefits (£ billions, PV75)

Water quality

Water quality benefits from woodland and TOW are the smallest estimated benefit (see Figure 4.11), at approximately £0.2bn in all scenarios. There is very little evidence on the link between woodland and TOW area and physical outcomes for water quality at this strategic scale of analysis. Therefore, the estimates here are based on conservative assumptions linking area of woodland and TOW to water pollutant load reductions, which are monetised using Farmscoper (Defra, 2013) values.

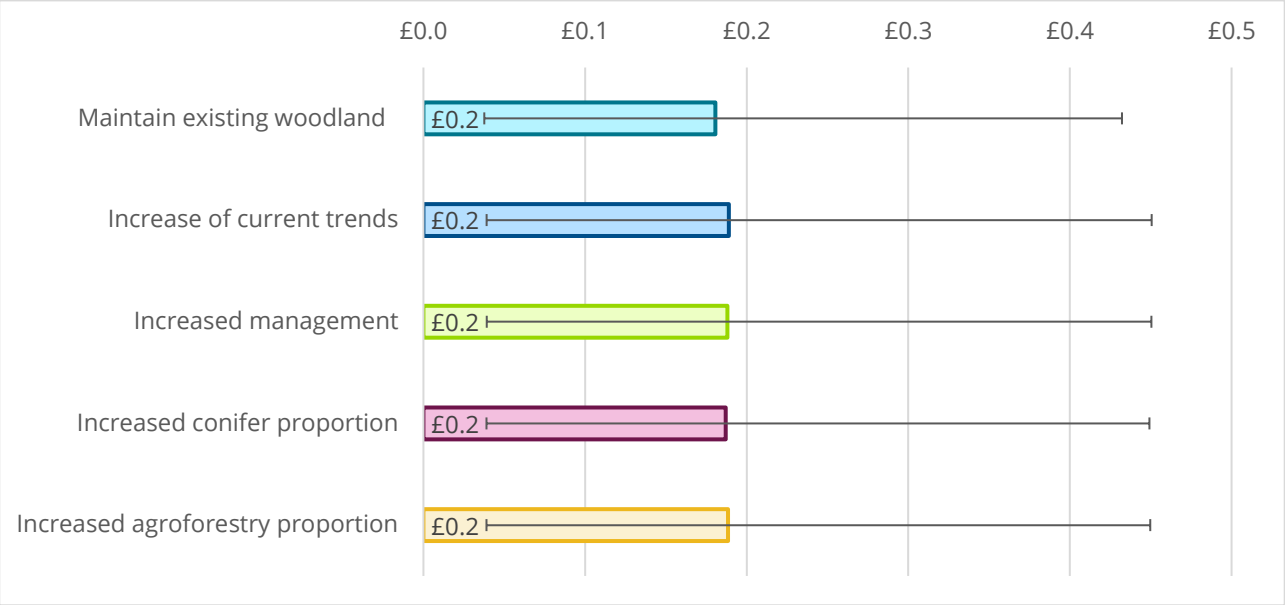


Figure 4.11: Water quality benefits (£ billions, PV75)

Cultural benefits of biodiversity provision

The cultural benefits of biodiversity provision can be seen in Figure 4.12. The economic evidence available on the cultural benefits of biodiversity provision from woodlands (eftec, 2025) values the relative increase in biodiversity compared with today's stock.[29] In this application, biodiversity is proxied by woodland condition, based on the WCA4 criteria. Regardless, increasing woodland biodiversity through increases in condition and extent, in line with achieving the overall targets, would result in benefits of around £18 billion to £21 billion (PV75). This is the biggest area of differentiation between the current woodland scenario and the scenarios where the 2050 woodland target is met. Slightly lower biodiversity benefits are seen in the increase of current trends and the increase conifer proportion scenarios, with greater amounts under the increased management and increased agroforestry scenarios. This corresponds with higher variance in outcome under the former two scenarios, compared to the other two scenarios. This difference is driven by the underlying impact of risks across each scenario, as the economic evidence does not vary across woodland types but woodland condition.

[29] This is because the economic evidence comes from a stated preference study which captures non-use values. The framing of the choice task explicitly asked respondents about changes to the level of biodiversity; therefore the values are applicable for estimating changes that come from the modelled outcomes, not the total existing stock of biodiversity in woodlands and TOW in England. This is in contrast to other economic evidence, e.g., carbon sequestration, for which the economic evidence can be applied to any flow of benefits, coming from both existing and newly planted woodland and TOW.

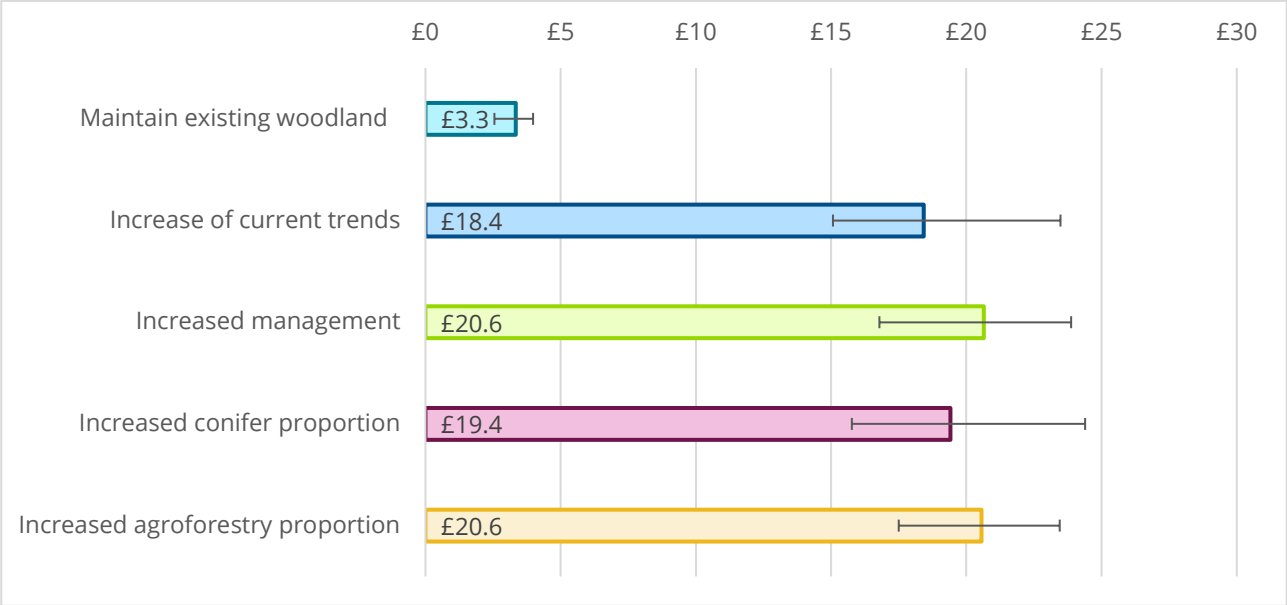


Figure 4.12: Change in biodiversity benefits (£ billions, PV75)

Recreational opportunities and amenity

Increased recreational amenity from woodlands can be seen in Figure 4.13. As each of the scenarios assumes that woodland is planted in the same proportions across locations, there are no differences in recreation and amenity benefits. However, this is partially the result of the available evidence that has been used, eftec, (2025) (see discussion of evidence used above), as recreation benefits are defined based on increased extent of woodland, not on change in condition, management or type. This application of evidence is also why maintaining existing woodland results in no additional benefits.

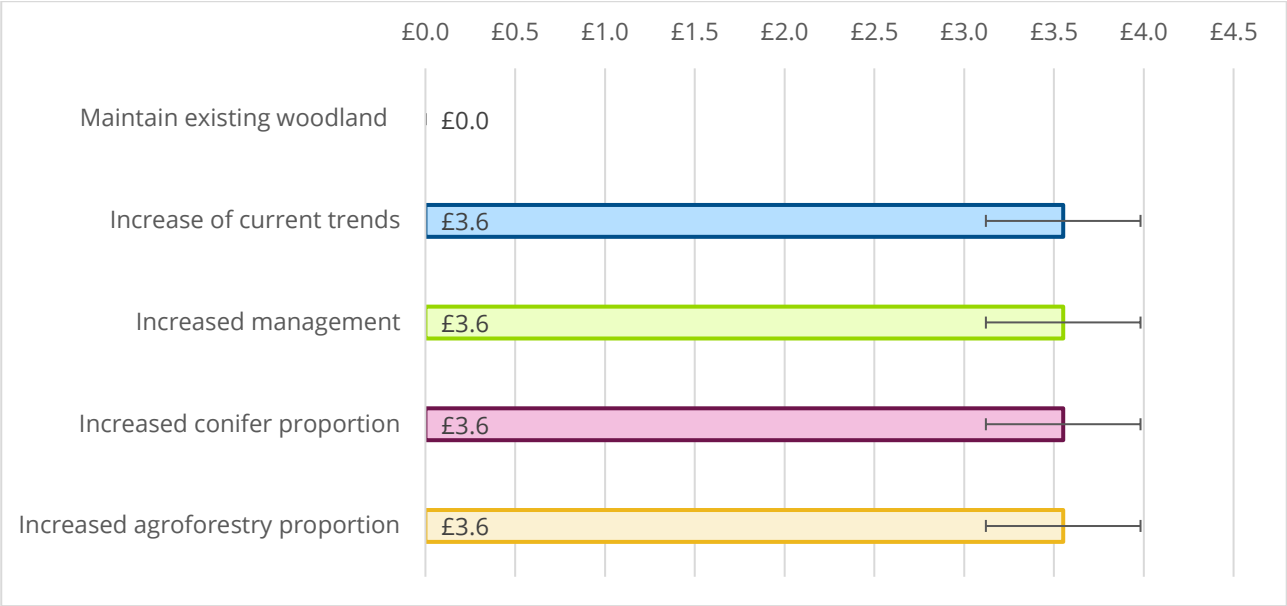


Figure 4.13: Change in recreational access and amenity benefit (£ billions, PV75)

4.2.3 Costs

The costs included in the economic assessment were:

- Capital costs (consisting of establishment costs and restocking costs);
- Operating costs (Maintenance costs); and
- Opportunity costs of land use change

Costs were estimated for each scenario run, which depended on the amount of new planting, restocking due to harvest and risk, and the extent of each type of woodland and TOW. Appendix 7 gives more detail on the sources used to estimate costs.

Capital costs

Capital costs are made up of establishment costs for new woodland, and restocking costs after clear-felling harvesting and replacing losses to risks. Estimates for establishment costs come from the John Nix pocketbook (Redman, 2024), while restocking costs reduce this value as there are no planning or site preparation costs. These costs can be seen in Figure 4.14. This cost is around £1.6 billion without any additional planting, and just over £2.5 billion in each scenario that achieves the 2050 woodland target.

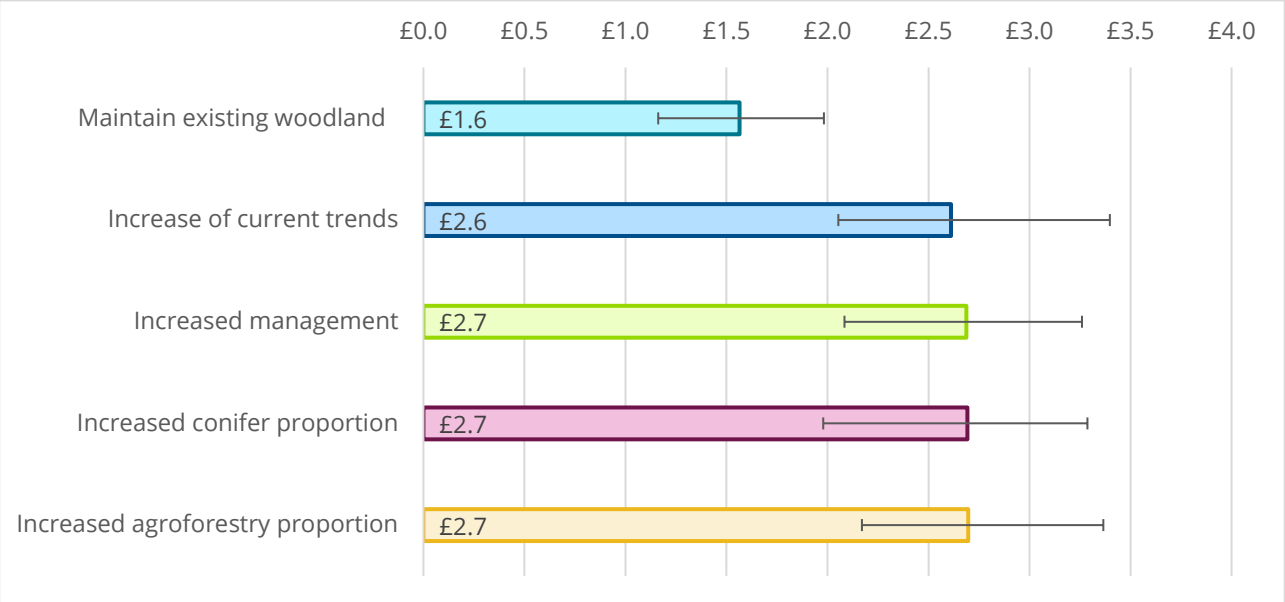


Figure 4.14 Capital costs (£ billions, PV75)

Operating costs

Operating costs consist of ongoing management costs for woodland and TOW, based on cost data from Nix (Redman, 2024), can be seen in Figure 4.15. Operating costs are higher for scenarios with additional planting (an additional £1-2 billion). Scenarios with increased woodland under management have greater operating costs than the increase of current trends scenario, reflecting the additional ongoing costs from active management.

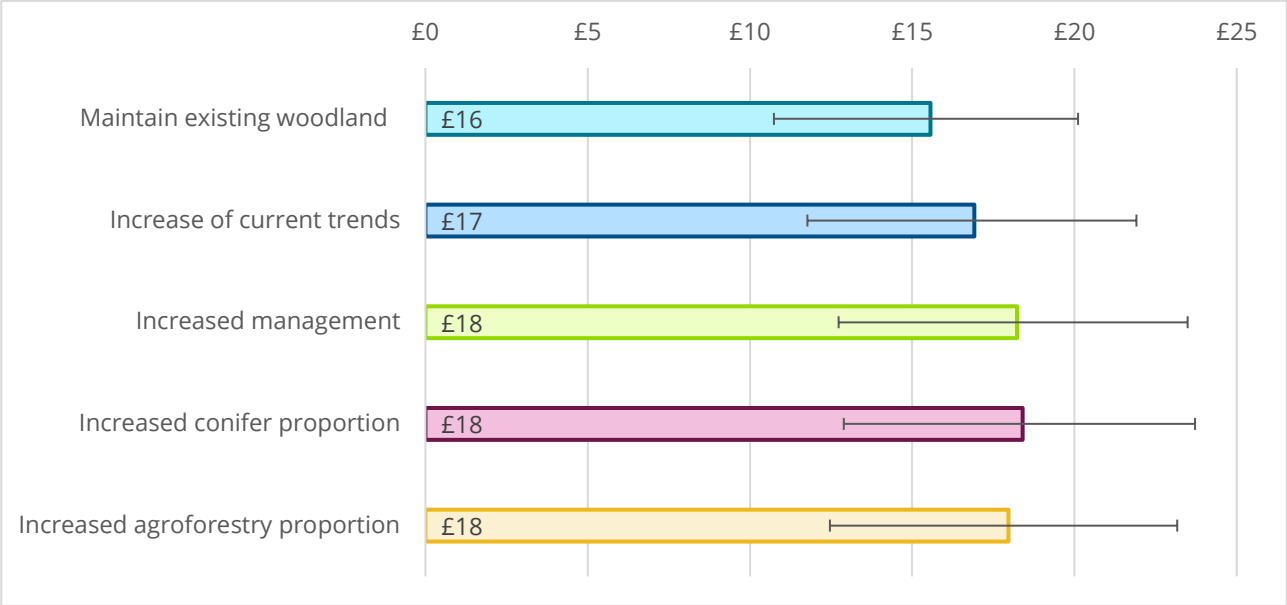


Figure 4.15: Maintenance costs (£ billions, PV75)

Opportunity costs

Opportunity costs are estimated using annualised net returns to alternative land uses, based on the recommendation of Low *et al.* (2024b). Values are used for Less Favoured Areas Grazing for conifer woodland, and lowland grazing for all other woodland and TOW.[30] Opportunity costs are higher in scenarios with planting but similar across those scenarios (see Figure 4.16). This is because the comparative returns are quite similar between modelled alternative land uses.

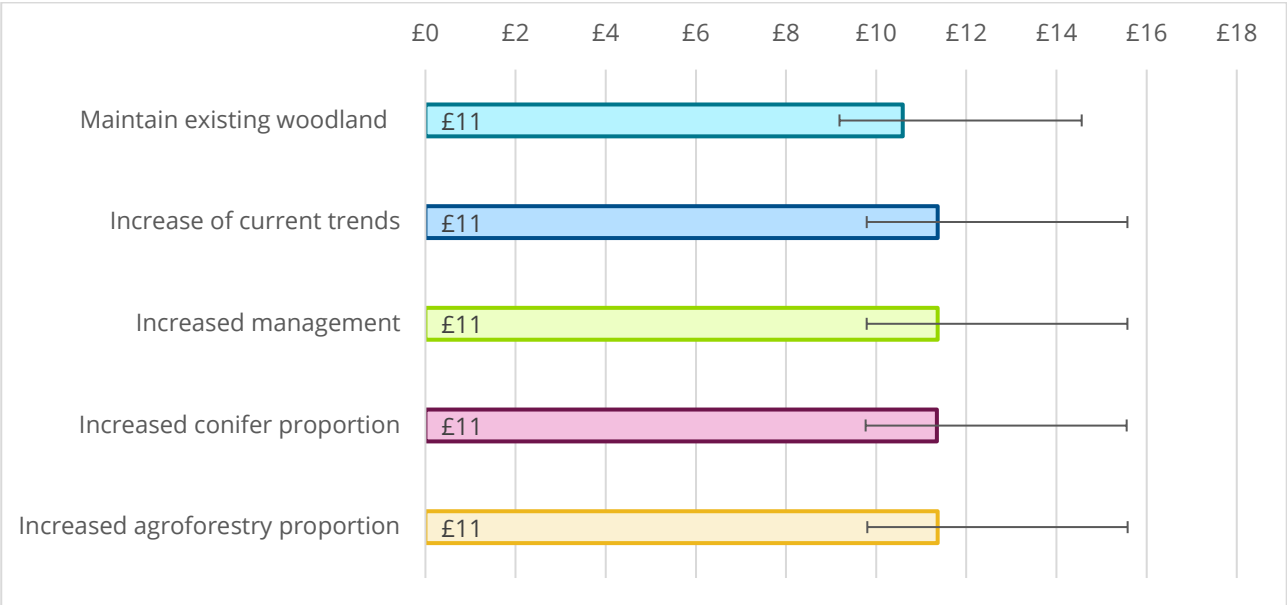


Figure 4.16: Opportunity Costs (£ billions, PV75)

[30] This represents the most common alternative land use, assuming woodland is not planted on high quality agricultural land classifications.

5. Discussion

This project produced evidence to help understand the potential long-term impacts of meeting the 2050 woodland target through different pathways (e.g., different national profiles of woodland creation and management). Across the modelled scenarios (the annual inputs in terms of planting and management) the differences were relatively modest at a national and regional scale, with the largest differences being between the net benefits of the current woodland and TOW stock (approximately 15% land cover in England) and the target (16.5% land cover).

Section 5.1 discusses the pathways and their policy implications of those differences in terms of:

- The contribution of the pathway to various government targets (e.g., 30by30, Net Zero 2050);
- The outcomes in terms of specific biophysical metrics (e.g., age, condition);
- The magnitude of select benefits and costs; and
- The total net benefits.

Section 5.2 presents the research recommendations and limitations, especially those that are related to questions this research was not able to address, or new questions that arose from this research.

5.1 Pathway outcomes and policy implications

The performance of each pathway against key targets and benefits is summarised in Table 5.1 (the overview of costs and benefits are in Table 4.2 and Table 4.3). This assessment shows that:

- Some government objectives are much more sensitive to whether and how the 2050 woodland target is achieved than others, and some depend on wider inputs and enabling factors (see Table 5.1 and further discussion in Section 5.1.1).
- Biophysical outcomes (e.g., average woodland age, condition, risk loss) vary somewhat by scenario, such as the woodland achieving favourable condition (best = 18% by 2100, worst = 15%) (see Table 4.1 and further discussion in Section 5.1.2).
- All of the 2050 woodland target pathways increase the provision of ecosystem services and benefits, and the differences across pathways are minimal. The uncertainty within pathways (such as the impact of future climate change, or the confidence intervals around economic values) are much more significant than the effect of how scenario inputs are defined. Consistent with the current national natural capital accounts (Office for National Statistics, 2026), the analysis shows carbon sequestration and air pollutant removal as the largest benefits. Cultural benefits of improved biodiversity provision are also observed to be a major benefit.
- All 2050 woodland target pathways have similar costs.

Table 5.1: Comparative results by scenario for key targets and associated benefits

Result	**Maintain existing woodland** *The benefits of today's woodland, modelled over time. Assumed management achieved: ~55%*	**Reach target with increase of current trends and practices** *Achieve the target in proportion to today's planting and management. Assumed management achieved: ~55%*	**Reach target with increased management** *Achieve the target while also increasing management. Assumed management achieved: ~70%*	**Reach target with increased conifer proportion** *Achieve target by planting a higher proportion of coniferous woodland. Assumed management achieved: ~70%*	**Reach target with increased agroforestry proportion** *Achieve target through a higher proportion of agroforestry. Assumed management achieved: ~70%*
Achieves 2050 woodland target*	✗✗	✓	✓	✓	✓
Aligned with CCC's CB7 advice for a Net Zero 2050 balanced pathway	✗✗	✗	✗	✗	✗
Achievement of contribution to 2042 Wildlife Rich Habitat Target	✗	✓	✓	✗	✓
Timber in Construction Roadmap 2025, Priority theme 4	✗	◇	◇	◇	◇
Average final woodland condition	▲	▲	▲▲	▲▲	▲▲
Woodland resilience	◇	◇	◇	◇	◇
Carbon sequestration	▲	▲▲	▲▲	▲▲	▲▲
Biodiversity provision (as proxied by woodland condition)	▲	▲▲	▲▲▲	▲▲▲**	▲▲▲
Timber provision	◇	◇	▲	▲▲	▲
Total increase in net benefit	▲	▲▲▲	▲▲▲	▲▲▲	▲▲▲

Table notes: Legend: ✗✗ = certainly off-track for target; ✗ = largely off track for target, ◇ = no change, no difference, or uncertain result, ✓ = largely on track for target, ▲ to ▲▲▲ = small, moderate, and large relative increase in provisions. * = All scenarios outside of "maintain existing woodland" were assumed in modelling to meet the target. This does not reflect the likelihood of meeting the target with current policies and practices. ** = The result that biodiversity increases under the increased conifer proportion scenarios is due, at least in part, to the use of woodland condition as a proxy. See Section 2.5 and 4.2.

5.1.1 Comparison to government objectives

The contribution of the scenarios to a selection of government targets relating to woodland and TOW are summarised in Table 5.2. The main findings are:

1. The 2050 woodland target pathways fall well short of achieving the Net Zero 2050 balanced pathway.
2. The Wildlife Rich Habitat Targets are highly sensitive to the types of woodland created (or managed) and therefore is likely to require specific management and planting.
3. Under the modelling assumptions, timber production varies little between pathways.

The 2050 woodland target pathways fall well short of achieving the contribution of afforestation to the CCC's latest Net Zero 2050 balanced pathway (advice for CB7), suggesting that the 2050 woodland target and this pathway are not in line with each other. The contribution of woodland and nature as a source of sequestration to achieve Net Zero 2050 is also small in comparison to other contributions (decarbonising electricity supply, reducing energy demand, switching to electric vehicles), and is even smaller in the Government's latest carbon budget delivery plan (CB6) (UK Government, 2025). This does not mean that the potential contribution of woodland is unimportant. The CCC's advice and analysis supports woodland playing a more prominent role in achieving Net Zero 2050 than the current government targets. This assessment does not directly investigate these higher levels of woodland creation (see Thomson, Young and Nickerson, 2025). However, given the wide range of co-benefits from woodland and TOW, the findings suggest that increasing the woodland target in line with the CCC's advice could lead to net benefits well in excess of costs. This is a strong argument for increasing the woodland target and rates of planting to meet the Net Zero 2050 balanced pathway.[31]

The Wildlife Rich Habitat Target is highly sensitive to the types of woodland created (or managed) and therefore is likely to require specific management and planting. The 2042 habitat target is based around specific habitat definitions and goals, and as such fulfilling them requires aligning some portion of woodland management and planting to those habitats. In aggregate, the contribution of woodland towards the 2042 habitat target is a large portion of the overall woodland creation (100,000 ha out of the 200,000 ha of woodland needed for the 2050 woodland target, or 50%), and therefore the actions to achieve the habitat target are an important subset of overall woodland and TOW management. Pathways with lower proportions of woodland habitats that contribute towards the habitats included in the target, such as the increased conifer proportion scenario, risk missing this target.

Timber production and other economic outputs from woodlands (such as tourism) are highly dependent on skills, infrastructure, and demand. The only economic target that is explicitly assessed is the general aims outlined in the "Timber in construction roadmap 2025" (Defra, 2025c). However, there are other major ways in which woodlands can contribute to economic activity at local, regional, and national levels, such as through tourism and recreation (spending for tourism in woodlands was approximately £666 million in 2023 within England (Office for National Statistics, 2026)). While all of the 2050 woodland target pathways increase timber stocks, the harvesting of those stocks depends on other factors. Therefore, while policies to increase woodland supply may be important (especially given the time necessary for trees to grow), policies are also necessary around the use of timber in construction and ensuring local processing capacity exists to create timber from trees. There is currently a skills gap in the forestry sector, which is

[31] This criticism was raised by Wildlife and Countryside Link & Greener UK, (2023) when the target was revised to 16.5% from 17.5%

expected to get worse over time (Royal Forestry Society, 2025). This is explicitly recognised in the Timber in Construction Roadmap (Defra, 2025c), which includes priorities around skills and capacity throughout the supply chain. However, as the UK is a major importer of timber (Barnes and Leitch, 2023), there is an opportunity towards higher levels of domestic timber production.

Table 5.2: Assessment of each 2050 woodland target compliant scenario's contribution towards key environmental targets

Long term target	Detail	Increase of current trends	Increased management	Increased conifer proportion	Increased agroforestry proportion	Description	Comment
2050 Woodland Target	16.5% of all land in England is covered by woodland and TOW by 2050	✓	✓	✓	✓	Assumed to be achieved under all scenarios, as specified in the model parameters.	This project did not assess the likelihood of the target being met.
Aligned with CCC's CB7 advice for a Net Zero 2050 balanced pathway	Contribution required from afforestation in England from the CCC's advice for the 7th carbon budget balanced pathway to achieve Net Zero by 2050 (Thomson et al., 2025)	✗	✗	✗	✗	Will not be met under any scenarios – rate of planting in all scenarios between 2025-2050 is roughly 40% of what is set out in CB7 balanced pathway afforestation requirements for England.[1]	Based on this, not even the increased conifer proportion scenario will reach the required sequestration rate by 2050 (30% new planting conifer, compared to 20% in balanced pathway).
2042 Species Abundance Target	Increase species abundance so that by 2042 it is greater than in 2022, and ≥10% greater than 2030	◇	◇	◇	◇	Unclear as link between extent and condition of woodland/TOW and species abundance is complicated.	A proxy assessment of this is the target for wildlife rich habitats what are assumed to contribute towards this target.
2042 Wildlife Rich Habitat Targets	Restore or create 500,000 ha of wildlife rich habitat outside protected areas by 2042 (100,000 ha of planting for the 2050 woodland target is expected to contribute to (Defra, 2025b))	✓	✓	✗	✓	~100,000 ha of new woodland could contribute under current trends,[2] management, and agroforestry scenarios. Only ~75,000 ha could contribute in the conifer scenario, as no conifer habitats are considered wildlife-rich in England.	Doesn't include the potential contribution of TOW. Assumes no new woodland is planted in protected areas.
Timber in construction roadmap 2025, EIP targets	Increasing the supply, harvesting and use of sustainable domestic timber (can only assess the potential supply in this analysis)	◇	◇	◇	◇	Timber production does not increase significantly in any scenario, even the increased conifer proportion one.	Rotations for new woodland are long enough that most harvesting is after the appraisal period. Increased timber in certain scenarios could be seen after 2100.

Table notes: Legend: ✗ = largely off track for target, ◇ = uncertain result, ✓ = largely on track for target. (1) The afforestation models used are different, and the scaling up of planting is different between this work and the CCC's work. (2) It was assumed that all broadleaved and mixed woodland at least at intermediate condition would contribute to the target. While the definition in the Environment Act Habitat Target for woodland is habitat aiming to achieve "Good" based on BNG metric, which is comparable to favourable condition as defined here (Natural England, 2026), much of the planting between now and 2042 is unlikely to be able to achieve favourable condition by then, as many of the indicators link to the age of a woodland, therefore intermediate was included as woodland that has the potential to reach this status in the future.

5.1.2 Comparison of woodland biophysical outcomes

Looking at the bio-physical outcomes across scenarios and across the Monte Carlo simulation, the main findings point to relatively small differences in outcomes:

- The differences in biophysical outcomes such as loss to risk, age, condition, etc., were similar across pathways.
- Losses differed significantly based on factors such as the climate outcomes with a specific model run, or the number of instances of pest and disease.

Aside from those differences in woodland and TOW that were a result of the scenario definitions (e.g., the woodland cover achieved, the rate of planting), the differences in biophysical outcomes such as loss to risk, age, condition, etc., were similar across pathways. This can be seen in Figure 5.1 and Figure 5.2, which show the differences in outcomes over time between the increase of current trends and increased management scenario.[32] There is not a huge amount of divergence in terms of proportion of woodland and TOW at favourable condition, or annual rate lost to risk. While these differences increase over time, they do not translate into large differences in final net benefits over the appraisal period.

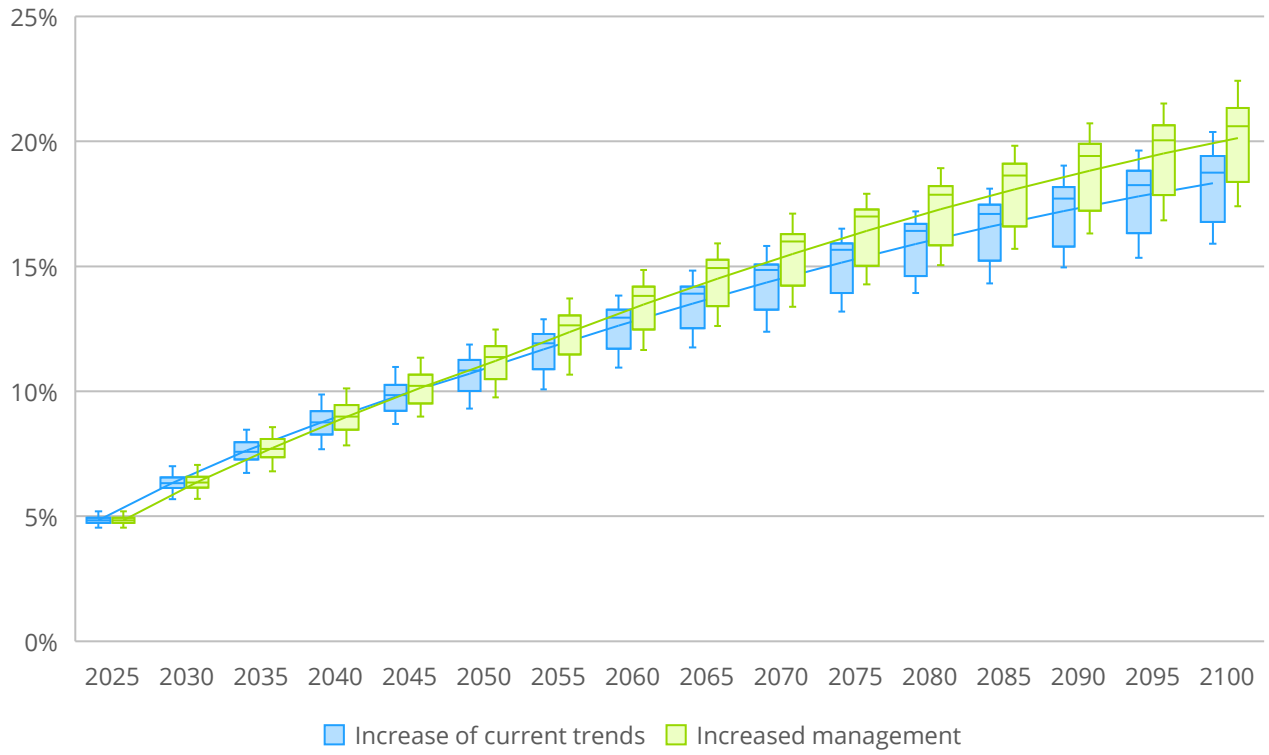


Figure 5.1: Proportion of woodland and TOW in favourable condition over model run period

[32] Only two pathways are shown for figure readability, however, a similar pattern is seen across all scenarios that increase proportion in management (increased management, increased conifer proportion, increased agroforestry proportion)

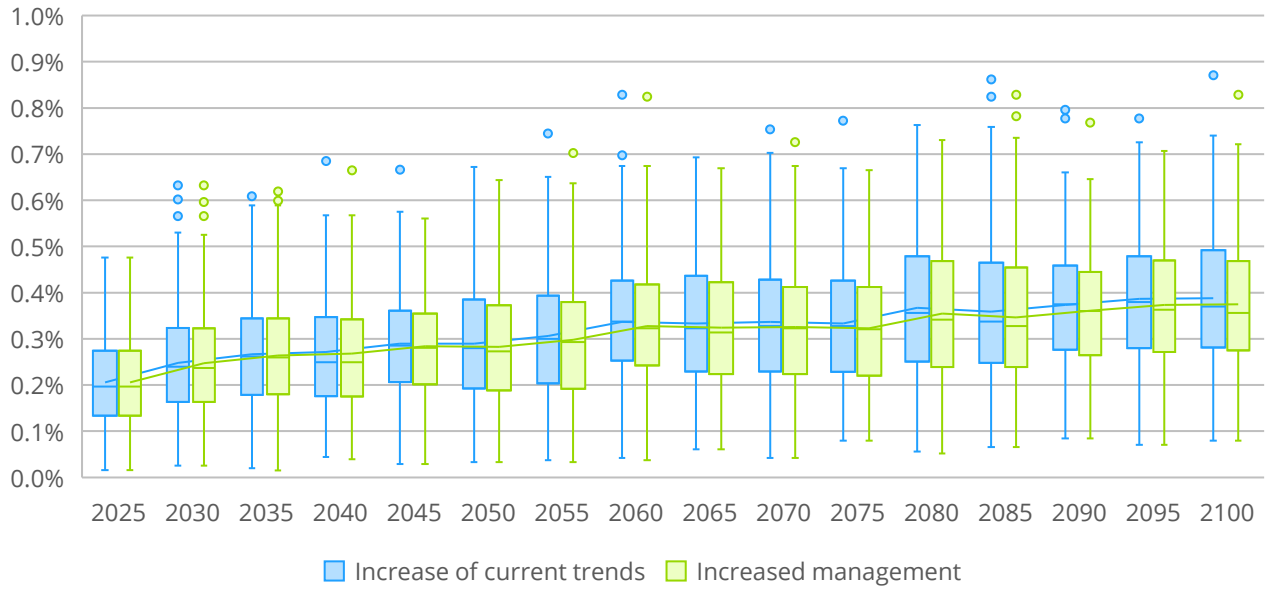


Figure 5.2: Annual proportion of woodland and TOW impacted by risks over model run period.
Figure note: the circles above each box and whisker are outliers (beyond the 95th percentile)

No scenario fared significantly better than the others in terms of loss to risk, as loss was driven mostly by the variation in future climate outcomes and the frequency of specific events. Over the 75 years modelled, using a range of climate scenarios informed by the CCC climate risks (CCC, 2025), an average of 25% of woodlands are impacted by risks, or an average of 0.33% per year (with the trend increasing from around 0.2% per year to closer to 0.4% per year). While the difference in total loss varied by up to 8 percentage points between now and 2100, this did not translate into equivalent economic losses, as woodland and TOW that was lost was assumed to be replaced (the differences between the best and worst outcomes are small by this metric and correspond to a difference in benefits of 2-3%).

This is reflected in recent observed data. Major pest and disease events, such as Ash dieback, have had a major impact on woodlands within England (Forest Research, 2026b), and drought has been shown to reduce establishment of young woodlands, reduce growth rates, and put pressure on nursery stocks (Environment Agency, 2025).

5.1.3 Comparison of benefits and costs

Three primary findings summarise the differences and similarities between the scenarios:

- The difference in benefits due to the increase in woodland and TOW to meet the 2050 woodland target is much larger than the differences between types and management of woodland and TOW across the pathways that meet the target.
- The amount of woodland under active management within the constraints of this research do not have a large impact on the benefits of woodland.
- Pathways with different proportions of woodland profile planting rates (e.g., plant more short and medium rotation coniferous woodlands) have very small differences in benefits.

The difference in benefits due to the increase in woodland and TOW to meet the 2050 woodland target is much larger than the differences between types and management of woodland and TOW across the pathways that meet the target. Within the boundaries explored in this research, achieving the 2050 woodland target will result in more biodiversity, greater levels of carbon sequestration and carbon storage, improved flood mitigation, better health outcomes, and increased recreational opportunities, regardless of the pathway. These benefits outweigh the increase in planting, maintenance, and opportunity costs by nearly 10:1 (Table 5.3), a finding in line with the previous impact assessment (Defra, 2023). This finding reinforces our understanding of the broad and significant benefits of woodlands to society. That said, some differences in benefit provision between scenarios may not be fully captured in the economic assessment, especially in localised outcomes.

Table 5.3: Net benefits comparison of increased woodland and TOW area

Economic costs and benefits of reaching target with current trends and practices versus maintaining existing woodland only (£ billions, PV75)

	Maintain existing woodland only	Increase of current trends and practices	Difference
Benefits (PV75) (£ billions)	**£192 (£87 to £404)**	**£225 (£110 to £457)**	**£34 (£22 to £53)**
Carbon sequestration	£115 (£58 to £174)	£128 (£64 to £190)	£13 (£6 to £18)
Timber provision	£3 (£3 to £4)	£3 (£3 to £3)	£0 (£0 to £0)
Air pollutant removal	£61 (£21 to £197)	£64 (£22 to £208)	£3 (£1 to £10)
Flood regulation	£10 (£2 to £27)	£10 (£2 to £28)	£0 (£0 to £1)
Cultural benefits of biodiversity provision	£3 (£3 to £4)	£17 (£15 to £23)	£14 (£12 to £20)
Recreational opportunity	£0 (£0 to £0)	£4 (£3 to £4)	£4 (£3 to £4)
Water quality	£0 (£0 to £0)	£0 (£0 to £0)	£0 (£0 to £0)
Costs (PV75) (£ billions)	**£28 (£21 to £37)**	**£31 (£24 to £41)**	**£3 (£3 to £4)**
Establishment cost	£0 (£0 to £0)	£1 (£1 to £1)	£1 (£1 to £1)
Restocking cost	£2 (£1 to £2)	£2 (£1 to £2)	£0 (£0 to £0)
Maintenance cost	£16 (£11 to £20)	£17 (£12 to £22)	£1 (£1 to £2)
Opportunity cost	£11 (£9 to £15)	£11 (£10 to £16)	£1 (£1 to £1)
Net benefit (£ billions, PV75)	***£164 (£66 to £368)***	***£194 (£86 to £417)***	***£30 (£19 to £49)***

Table notes: (1) biodiversity provision is assessed as the *change in* benefit, not the total benefit; (2) recreational opportunity is assessed solely as a function of the *change* in woodland extent and condition; (3) appraisal period: 2026 to 2100 (assuming no new actions between 2051 and 2100)

The amount of woodland under active management (as defined within the constraints of this research) does not have a significant impact on the benefits of woodland. The increased management scenario does lead to a positive net benefit over the increase of current trends scenario, despite higher costs, but the increase in the net benefits is very small (Table 5.4). The increase in the net benefit is likely due to the expected improvement in overall condition, as pest, disease, invasive species, and browsing damage are all minimised if managed in line with the UKFS. Part of this result is the trade-offs between managed and un-managed woodland, and the specifics of the management schemes. For example, while timber is an important source of income from some woodlands, the timber benefit is very small (£3 billion) compared to carbon sequestration (£128 billion), air pollution removal (£64 billion), and flood mitigation (£10 billion) (the latter two of which provide more benefits in relatively older woodlands). In particular, schemes like short rotation conifer forestry of less than 50-year cycles result in significant portions of the woodland lifecycle to be spent as seedlings and small trees that provide minimal amounts of ecosystem services compared to more mature woodlands. Finally, in some cases, less intensively managed woodland may provide more non-market benefits than actively managed woodland, for example where harvesting does not occur and ecosystem services such as carbon storage, biodiversity, flood regulation, and air pollutant removal are maintained (e.g., Paillet *et al.*, 2010 on biodiversity). However, ecosystem services provided depend on woodland type, condition and management, and unmanaged woodland is not inherently in better ecological condition.

Pathways with different proportions of woodland profile planting rates (e.g., plant more short and medium rotation coniferous woodlands) have very small differences in benefits. This can be seen in Table 5.5. This finding is, however, based on a conservative range of future climate and pest scenarios and a general assumption that management and species selection at the time of planting can resolve future challenges. If, for example, management is unable to address the eight-toothed spruce bark beetle or a similar species-specific pest, or if climate change leads to severe future drought cycles that are not well-managed, then the pathways could look significantly different compared to this research, especially if those risks occur to woodland types that are uniform in species and structure. However, as seen with Ash dieback, woodlands in England typically have enough genetic and species diversity to continue as woodland (without transitioning to a new land type) despite the presence of severe pests, especially if management actions can be taken to remove and replace diseased trees with alternative appropriate species.

Table 5.4: Net benefits comparison of increased woodland management

Economic costs and benefits of reaching target with current trends and practices versus with increasing proportion of woodlands that are managed (£ billions, PV75)

	Current trends and practices	Increased management	Difference
Benefits (PV75) (£ billions)	**£225 (£110 to £457)**	**£228 (£112 to £458)**	**£2 (£-1 to £5)**
Carbon sequestration	£128 (£64 to £190)	£128 (£64 to £191)	£0 (£0 to £-1)
Timber provision	£3 (£3 to £3)	£4 (£4 to £4)	£0 (£0 to £0)
Air pollutant removal	£64 (£22 to £208)	£64 (£22 to £208)	£0 (£0 to £2)
Flood regulation	£10 (£2 to £28)	£10 (£2 to £28)	£0 (£0 to £0)
Cultural benefits of biodiversity provision	£17 (£15 to £23)	£19 (£17 to £24)	£2 (£-1 to £4)
Recreational opportunity	£4 (£3 to £4)	£4 (£3 to £4)	£0 (£0 to £0)
Water quality	£0 (£0 to £0)	£0 (£0 to £0)	£0 (£0 to £0)
Costs (PV75) (£ billions)	**£31 (£24 to £41)**	**£32 (£25 to £42)**	**£1 (£1 to £1)**
Establishment cost	£1 (£1 to £1)	£1 (£1 to £1)	£0 (£0 to £0)
Restocking cost	£2 (£1 to £2)	£2 (£1 to £2)	£0 (£0 to £0)
Maintenance cost	£17 (£12 to £22)	£18 (£13 to £23)	£1 (£1 to £2)
Opportunity cost	£11 (£10 to £16)	£11 (£10 to £16)	£0 (£0 to £0)
Net benefit (£ billions)	**£194 (£86 to £417)**	**£196 (£87 to £417)**	**£1 (£-2 to £4)**

Table notes: (1) biodiversity provision is assessed as the *change in* benefit, not the total benefit
(2) recreational opportunity is assessed solely as a function of the *change* in woodland extent and condition.
(3) appraisal period: 2026 to 2100 (assuming no new actions between 2051 and 2100)

Table 5.5: Net benefits comparison of planting different proportions of woodland types

Economic costs and benefits of reaching target with increasing management and current planting proportions versus with increasing planting proportion of coniferous woodlands (£ billions, PV75)

	Increased management	Increased conifer proportion	Difference
Benefits (PV75) (£ billions)	**£228 (£112 to £458)**	**£229 (£111 to £459)**	**£2 (£-2 to £3)**
Carbon sequestration	£128 (£64 to £191)	£129 (£64 to £192)	£1 (£1 to £0)
Timber provision	£4 (£4 to £4)	£4 (£3 to £4)	£0 (£0 to £0)
Air pollutant removal	£64 (£22 to £208)	£64 (£22 to £207)	£0 (£0 to £1)
Flood regulation	£10 (£2 to £28)	£10 (£2 to £28)	£0 (£0 to £0)
Cultural benefits of biodiversity provision	£19 (£17 to £24)	£19 (£16 to £24)	£0 (£-3 to £2)
Recreational opportunity	£4 (£3 to £4)	£4 (£3 to £4)	£0 (£0 to £0)
Water quality	£0 (£0 to £0)	£0 (£0 to £0)	£0 (£0 to £0)
Costs (PV75) (£ billions)	**£32 (£25 to £42)**	**£33 (£25 to £42)**	**£0 (£0 to £0)**
Establishment cost	£1 (£1 to £1)	£1 (£1 to £1)	£0 (£0 to £0)
Restocking cost	£2 (£1 to £2)	£2 (£1 to £2)	£0 (£0 to £0)
Maintenance cost	£18 (£13 to £23)	£18 (£13 to £24)	£0 (£0 to £0)
Opportunity cost	£11 (£10 to £16)	£11 (£10 to £16)	£0 (£0 to £0)
Net benefit (£ billions, PV75)	**£196 (£87 to £417)**	**£197 (£86 to £417)**	**£1 (£-2 to £4)**

Table notes: (1) biodiversity provision is assessed as the *change in* benefit, not the total benefit
(2) recreational opportunity is assessed solely as a function of the *change* in woodland extent and condition.
(3) appraisal period: 2026 to 2100 (assuming no new actions between 2051 and 2100)

5.1.4 Policy implications

The comparative assessment is further summarised into five policy implications:

1. Increasing woodland and TOW cover is an appropriate and proportionate goal, as it yields net benefits and high cost-benefit ratios, and supports many government targets.
2. Achieving the woodland target yields net benefits, and greater delivery is needed to ensure the target is achieved.
3. Specific targets for woodland type (e.g., species mixes) and management might be more appropriate at regional or local levels or be determined by the most suitable practices for any given parcel of land.
4. Steps should continue to be taken to minimise risks to woodlands, both through research and guidance to woodland and tree owners and managers.
5. Woodlands contribute to several government targets, and increasing woodland cover, especially those types that provide high levels of biodiversity, will contribute to progress towards those targets.

Implication 1: Increasing woodland and TOW cover is an appropriate and proportionate goal. Under the assumption that new woodlands will adhere to the guidelines laid out in the UK Forestry Standard, the extent of Woodland and TOW is the biggest single determinant of the annual and total future benefits of woodlands in England. While management, species mix, and achieved condition all matter, their relative effect on the benefits is much smaller than the extent, based on the scenarios explored in this analysis. This suggests that a future canopy cover target, like the 2050 woodland target, is an appropriate way to define the policy aim to increase a range of benefits.

The modelling and economic assessments also suggest that there would be substantial benefits in increasing the target canopy cover. This is supported by the CCC's advice on the balanced pathway (Climate Change Committee, 2025), which proposes far higher rates of woodland and TOW creation than the current woodland target. While scenarios that were more ambitious than the 16.5% target were not modelled, the creation, maintenance, and opportunity costs in the scenarios were much less than the estimated benefits. This point should be explored further, potentially through refining this model and adding further scenarios to better understand if more ambitious outcomes by 2050 would result in similar benefits on a per additional hectare basis.

Implication 2: Achieving the woodland target yields net benefits, and focus on delivery is needed to ensure the target is achieved. This work has assumed that the planting target will be met. However, the current rate of planting will need to increase by 2030 to reach the woodland target, and how planting and land use change rates will be increased is not clear. Furthermore, uncertainties on future planting are compounded if the preferred pathway involves a change in planting trends (e.g., increase in conifer, change in management).

Implication 3: Targets around woodland type and management might be more appropriate at the regional or local level or be determined by the suitability of land. As achieving the 2050 woodland target should be the first priority, and variation in the costs and benefits of different regional and national pathways is minor, any targets on what is planted and how it is managed should be secondary (within

certain constraints, such as the UKFS). However, there may still be justifications for targets and guidance at more local levels to achieve higher levels of local benefits (see Section 5.2).

Implication 4: Steps should continue to be taken to minimise risks to woodlands, both through research and guidance to woodland and tree owners and managers. Future risk should not restrict government targets for pursuing larger extents of woodland cover, but the overall percentage of woodland that may be affected in the future, highlighted in Finding 4, demonstrates the need for planting species and using management regimes that are suited to the future risks of any given site. The Forestry Commission currently has several tools in place to aid with this kind of forward-looking woodland management (Forest Research, 2026e), and research is ongoing about tree provenance and particularly resilient species to inform future stocking and management decisions.

Implication 5: Woodlands contribute to several government targets, and increasing woodland cover, especially those types that provide high levels of biodiversity, will contribute to progress towards those targets. As discussed in Section 5.1.1, many targets depend on achieving higher levels of woodland cover, either at levels that meet the 2050 woodland target or at levels that exceed it (see discussion of the Net Zero 2050 pathways). The reliance of these targets on woodland and TOW planting and management reinforces all of the above policy implications.

5.2 Research recommendations and limitations

While this research represents a significant step forward in understanding the costs and benefits of pathways that might be taken to achieve the 2050 woodland target, the analysis and results have some limitations, from which recommendations for future research have been developed.

The limitations of the research can be summarised by:

- **Data availability:** through this report, several areas in which additional data (such as on the management of existing woodland) have been noted.
- **Applicability of ecological and economic evidence:** while there is a large body of literature on understanding how woodland and TOW produce services and the value of those services, this evidence can be difficult to practically apply in models. The approach has noted where these constraints exist.
- **Modelling constraints:** woodland and TOW are complex to model, and there is a trade-off between scale and precision. The approach has noted where decisions around this trade-off were made.

The research recommendations follow from some of the limitations as well as the project scope, and are summarised in Table 5.6. These recommendations mainly relate to assessing a wider range of scenarios and pathways for the future of woodland and TOW in England; developing evidence on the marginal trade-offs associated with individual woodland creation and management; and better understanding the services, benefits, and costs associated with specific kinds of woodlands and woodland management (such as agroforestry).

Table 5.6: Recommendation for future research

Recommendation	Rationale	Responsibility and importance	Detail
Assess a wider range of planting rates and total planting, especially planting beyond the 2050 woodland target	The evidence developed in this project, as well as other literature, suggest that planting more, faster may provide significant additional benefits.	OEP or Forest Research Very important – the evidence would be very useful to future policy decisions	Additional scenarios could be relatively easily done using the existing model structure. However, the inputs and constraints of the model could also be improved to better understand the opportunity costs of converting additional land (beyond the target) to woodland.
Assess a wider range of management and planting outcomes by species type	This project implemented relatively narrow constraints on the management and types of woodland that were created.	OEP or Forest Research Somewhat important – while the evidence would be useful, other methods may be more appropriate	Historic planting could be revisited to look at the outcomes of planting conifers or other woodlands that are currently uncommon in much higher proportions. This could be easily done in the model.
Use case studies and small-scale analysis to assess the costs and benefits of different kinds of woodland in different locations	This project has not been able to provide evidence on the marginal benefits or costs associated with individual woodlands and sites.	OEP or Forest Research Very important – this would provide a complementary perspective to this project	Case studies or forward-looking assessments of costs and benefits of a selection of woodlands could be used to assess specific costs and benefits of woodlands which fully account for the local context. This could be paired with other existing tools to look at risks to those woodlands based on the species that are proposed for planting or that currently exist on the site.
Better define trees outside of woodland, and develop evidence on how different kinds of TOW differ	TOW come in a variety of structures and management regimes, and more evidence is needed on the costs and benefits associated with the variety of TOW that exists at a strategic scale, especially for targets relating to agroforestry.	Forest Research or Defra Very important – if TOW and agroforestry are viewed as key to meeting the target, they need to be better defined and understood	The various agroforestry and other TOW profiles could be better defined, using something like the Forest Development Types: Flashcards (Haufe *et al.*, 2024). These profiles or types could then be more closely linked to their costs and benefits (such as by using existing research to assign them more accurate rates of air-pollutant removal or carbon sequestration).
Improve the primary evidence available on ecosystem service provision, economic benefits and costs as woodlands change in age, structure, and management	More evidence is needed to assess the nuance of the costs and benefits of woodlands with specific management, structures, ages, and context.	Forest Research Very important – this evidence would link (and assess) management practices to their benefits	This research would likely require new primary research across a range of disciplines, including ecology, forestry, and economics. However, understanding how woodland management affects the benefits provided is essential to developing better guidance and good practice, especially with climate change.

6. Conclusion

The woodland and TOW modelling and economic assessment show that the benefits of achieving the woodland target overall are significantly greater than the costs (in the range of £30 billion over 75 years). When combined with the continued benefits of existing woodland, the total future net benefits of woodland under the target are around £200 billion over the same period. These findings support previous evidence that achieving the 2050 woodland target of 16.5% woodland and canopy cover in England will result in significant benefits to society. In addition, the modelled scenario outcomes suggest that the different pathways to achieving the target result in minimal differences in the benefits of the new woodland and TOW delivered, at least at a national level.

At the site level, the existing literature demonstrates that woodlands with different species mixes and management strategies can have benefits and costs that differ significantly in magnitude, timings, and beneficiaries. However, at the strategic national level that this research covered, the key factor is the extent of woodland and TOW. There are two likely reasons behind this result:

- Future planting and management rates and regimes are likely to be similar to what is currently occurring based on existing practices, skills, policies (e.g., the UK Forestry Standard (Forest Research, 2023)) and resources (such as nursery stocks). These factors were embedded into the scenarios through the rates of planting, management, and woodland types, and therefore the difference between the scenarios was relatively small as those inputs did not vary widely.
- The evidence available for use in economic assessment is not yet adequately sensitive to certain characteristics of the type and condition of woodland. While this project endeavoured to improve on the existing methods and utilise all available evidence, constraints around woodland condition data and evidence on the differences in ecosystem service provision as woodlands age, diversify in structure, or increase in biodiversity limited the types of analysis that were possible.
- Using air-pollutant removal services as an example, the evidence is sensitive to some aspects of woodlands (age up to maturity, location), but not others (type, species mix, management, condition). This means that improvements in biodiversity, structure, management, or increases in age beyond 40 years do not provide additional benefits in the way scenarios have been possible to define.

Further analysis could usefully expand on these points for the purposes of informing OEP and policy level discussions. First, the same modelling process could be used to explore scenarios that have higher levels of differentiation between them, to see if policies to overcome current constraints might be worthwhile. Second, these scenarios could include outcomes in which the woodland target is significantly exceeded. The equivalent annual net benefit from the scenarios average £5,500 per hectare of new woodland which suggests that additional woodland could continue to generate positive net benefits despite diminishing marginal benefits or increasing marginal costs. Third, the regional and national model outputs and economic assessments could be paired with site level marginal analysis, to understand how the trade-offs present for any given parcel of land feed into the aggregate result and vice versa. Finally, the model could be refined to have a higher level of spatial precision to investigate the differences in location specific actions and outcomes.

Finally, it is clear from this project (as well as previous evidence) that achieving or exceeding the 2050 woodland target will have benefits greatly in excess of the costs. There is, therefore, the potential to

increase the target. However, given that the current rate of planting (6,387 ha was planted in England in 2025/26) will need to increase to over 8,000 ha per year after 2030, policy development should focus first on increasing this rate by putting appropriate policies and measures in place.

References

Atkinson, G. (2022) *Adapting forest and woodland management to the changing climate: UK forestry standard practice guide*. Edited by J. Morison and B. Nicoll. Edinburgh: Forest Research.

Barnes, T. and Leitch, A. (2023) *The National Wood Strategy*. Industry Leadership Group. Available at: https://static1.squarespace.com/static/656f6fa50d7b1d529ee964a9/t/65705b2c5d2ca6395e2835b1/1701862197787/The+National+Wood+Strategy+2023.pdf (Accessed: 10 December 2025).

Bateman, I.J., Anderson, K., Argles, A., Belcher, C., Betts, R.A., Binner, A., Brazier, R.E., Cho, F.H.T., Collins, R.M., Day, B.H., Duran-Rojas, C., Eisenbarth, S., Gannon, K., Gatis, N., Groom, B., Hails, R., Harper, A.B., Harwood, A., Hastings, A., Heard, M.S., Hill, T.C., Inman, A., Lee, C.F., Luscombe, D.J., MacKenzie, A.R., Mancini, M.C., Morison, J.I.L., Morris, A., Quine, C.P., Snowdon, P., Tyler, C.R., Vanguelova, E.I., Wilkinson, M., Williamson, D. and Xenakis, G. (2023) 'A review of planting principles to identify the right place for the right tree for "net zero plus" woodlands: Applying a place-based natural capital framework for sustainable, efficient and equitable (SEE) decisions', *People and Nature*, 5(2), pp. 271–301. Available at: https://doi.org/10.1002/pan3.10331.

Broadmeadow, M. and Ray, D. (2005) *Climate Change and British Woodland*. Available at: https://cdn.forestresearch.gov.uk/2005/05/fcin069.pdf.

Broadmeadow, S., Nisbet, T., Valatin, G., Blyth, E., Robinson, E., Fitch, A. and Laurence, J. (2023) *Revised valuation of flood regulation services of existing forest cover to inform natural capital accounts.* Forest Research. Available at: https://www.forestresearch.gov.uk/publications/revised-valuation-of-flood-regulation-services-of-existing-forest-cover/.

CCC (2025) *Methodology behind the CCC's carbon budget advice for the UK, Northern Ireland, Wales, and Scotland, published in 2025*. Available at: https://www.theccc.org.uk/wp-content/uploads/2025/05/Methodology-report-CCC-carbon-budgets-advice-2025.pdf.

Climate Change Committee (2025) *The Seventh Carbon Budget: Advice for the UK Government*. Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget/ (Accessed: 18 December 2025).

Crawford, A.J., Belcher, C.M., Morison, J.I.L., Doerr, S.H., Kettridge, N. and Clay, G.D. (2025) 'Fuel moisture and flammability of leaf litter in British forest plantations and their implications for wildfire risk', *Forestry: An International Journal of Forest Research*, p. cpaf029. Available at: https://doi.org/10.1093/forestry/cpaf029.

Defra (2013) *FARMSCOPER decision support tool*. Available at: https://adas.co.uk/services/farmscoper/ (Accessed: 2 August 2026).

Defra (2022) *Valuing Non-Woodland Trees*. Available at: https://cdn.forestresearch.gov.uk/2022/09/Valuing-our-Non-Woodland-Trees_Final-Report_2022-09-07.pdf (Accessed: 11 December 2025).

Defra (2023) *Environment Act Targets – Tree Canopy and Woodland cover target 2023 - Impact Assessment*. Available at: https://www.legislation.gov.uk/ukia/2023/18/pdfs/ukia_20230018_en.pdf.

Defra (2025a) *Environmental Improvement Plan 2025*. Available at:

https://assets.publishing.service.gov.uk/media/692d8d9cce50d215cae962a5/Environmental_Improvement_Plan__EIP__2025.pdf (Accessed: 2 April 2026).

Defra (2025b) *Habitat creation and restoration Environment Act target delivery plan*. Available at: https://www.gov.uk/government/publications/habitat-creation-and-restoration-environment-act-target-delivery-plan/habitat-creation-and-restoration-environment-act-target-delivery-plan (Accessed: 13 July 2026).

Defra (2025c) *Timber in construction roadmap 2025*. Available at: https://www.gov.uk/government/publications/timber-in-construction-roadmap-2025/timber-in-construction-roadmap-2025 (Accessed: 16 July 2026).

Defra (2025d) *Tree canopy and woodland cover Environment Act target delivery plan*. Available at: https://www.gov.uk/government/publications/tree-canopy-and-woodland-cover-environment-act-target-delivery-plan/tree-canopy-and-woodland-cover-environment-act-target-delivery-plan (Accessed: 19 December 2025).

Defra (2026a) *Air quality appraisal: damage cost guidance*. Available at: https://www.gov.uk/government/publications/assess-air-quality-impacts/air-quality-appraisal-damage-cost-guidance (Accessed: 9 July 2026).

Defra (2026b) *Enabling a Natural Capital Approach (ENCA)*. Available at: https://www.gov.uk/guidance/enabling-a-natural-capital-approach-enca#enca-featured-tools.

DESNZ (2023) *Carbon valuation: updates to traded carbon values*, *GOV.UK*. Available at: https://www.gov.uk/government/collections/carbon-valuation--2 (Accessed: 27 March 2024).

eftec (2025) *Value of Forest Biodiversity*. Available at: https://sciencesearch.defra.gov.uk/ProjectDetails?ProjectId=21903 (Accessed: 27 May 2026).

eftec and UKCEH (2025) *Air Pollution Removal by Vegetation Calculator - version 2*. Available at: https://connect-apps.ceh.ac.uk/pollutionremoval/.

Environment Agency (2025) *Forestry - drought risks, impacts and actions: Drought prospects for spring 2026*, *GOV.UK*. Available at: https://www.gov.uk/government/publications/drought-prospects-for-spring-2026/8-forestry-drought-risks-impacts-and-actions-drought-prospects-for-spring-2026 (Accessed: 16 July 2026).

Environmental Information Data Centre (2026) 'Source apportionment of annual nutrient and sediment loads to rivers in England and Wales, from the SEPARATE framework'. Available at: https://www.data.gov.uk/dataset/3e698568-8492-4dfd-aa11-3439d77cd71a/source-apportionment-of-annual-nutrient-and-sediment-loads-to-rivers-in-england-and-wales-from-.

Environmental Protection Agency (2009) *Effectiveness of Riparian Buffers for Managing Nitrogen*. Available at: https://archive.epa.gov/ada/web/pdf/riparian_buffer.pdf.

Field Studies Council, Forestry Commission, Sylva Foundation, and Natural England (2024) *Woodland Condition Assessment - Woodland indicators guide (WCA4)*. Available at: https://www.field-studies-

council.org/shop/publications/wca-survey-pack/ (Accessed: 24 March 2024).

Fisichelli, N., Vor, T. and Ammer, C. (2014) 'Broadleaf seedling responses to warmer temperatures "chilled" by late frost that favors conifers', *European Journal of Forest Research*, 133(4), pp. 587–596. Available at: https://doi.org/10.1007/s10342-014-0786-6.

Forest Research (2014a) '50-year_forecast_of_hardwood_availability_spreadsheet.xls'. Available at: https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fcdn.forestresearch.gov.uk%2F2022%2F02%2F50-year_forecast_of_hardwood_availability_spreadsheet.xls&wdOrigin=BROWSELINK (Accessed: 31 March 2026).

Forest Research (2014b) '50-year_forecast_of_softwood_availability_spreadsheet.xls'. Available at: https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fcdn.forestresearch.gov.uk%2F2022%2F02%2F50-year_forecast_of_softwood_availability_spreadsheet.xls&wdOrigin=BROWSELINK (Accessed: 31 March 2026).

Forest Research (2020) *NFI Woodland Ecological Condition*, *Forest Research*. Available at: https://www.forestresearch.gov.uk/tools-and-resources/national-forest-inventory/what-our-woodlands-and-tree-cover-outside-woodlands-are-like-today-nfi-inventory-reports-and-woodland-map-reports/nfi-woodland-ecological-condition/ (Accessed: 19 December 2025).

Forest Research (2022) *Designing and managing forests and woodlands to reduce flood risk: UK forestry standard practice guide*. Roslin: Forestry Publishing Group. Available at: https://cdn.forestresearch.gov.uk/2022/10/UKFSPG027.pdf.

Forest Research (2023) *The UK Forestry Standard*. Available at: https://cdn.forestresearch.gov.uk/2023/10/The-UK-Forestry-Standard.pdf.

Forest Research (2025a) *Carrying out thinning operations*. Available at: https://www.forestresearch.gov.uk/climate-change/carrying-out-thinning-operations/ (Accessed: 18 December 2025).

Forest Research (2025b) 'Diversifying structure', *Forest Research*. Available at: https://www.forestresearch.gov.uk/climate-change/adaptation-measures/diversifying-structure/ (Accessed: 18 December 2025).

Forest Research (2025c) *Estimates of the ownership type and property type of woodlands in Britain: 2025 edition*. Available at: https://www.forestresearch.gov.uk/tools-and-resources/national-forest-inventory/what-our-woodlands-and-tree-cover-outside-woodlands-are-like-today-nfi-inventory-reports-and-woodland-map-reports/.

Forest Research (2025d) *Forestry Statistics 2025: Chapter 1 Woodland Area & Planning*. Available at: https://cdn.forestresearch.gov.uk/2025/09/FS2025_Ch1-68d4f71b97f6f.pdf.

Forest Research (2025e) 'Frost', *Forest Research*. Available at: https://www.forestresearch.gov.uk/climate-change/risks/frost/ (Accessed: 19 December 2025).

Forest Research (2025f) 'New planting and restocking'. Available at: https://www.forestresearch.gov.uk/tools-and-resources/statistics/publications/forestry-statistics/forestry-statistics-2025/.

Forest Research (2025g) *Pests & Diseases*. Available at: https://www.forestresearch.gov.uk/climate-change/risks/pests-and-diseases/ (Accessed: 18 December 2025).

Forest Research (2025h) 'The increasing risk from strong winds and storms', *Forest Research*. Available at: https://www.forestresearch.gov.uk/news/144060-new-video-highlights-increasing-risks-of-wind-and-storms-and-ways-to-mitigate-their-damage/ (Accessed: 18 December 2025).

Forest Research (2025i) *Using natural regeneration*. Available at: https://www.forestresearch.gov.uk/climate-change/adaptation-measures/using-natural-regeneration/ (Accessed: 18 December 2025).

Forest Research (2025j) *Wildfire*. Available at: https://www.forestresearch.gov.uk/climate-change/risks/wildfire/ (Accessed: 18 December 2025).

Forest Research (2026a) *50-year forecast of softwood timber availability (2026)*. Available at: https://www.forestresearch.gov.uk/tools-and-resources/national-forest-inventory/how-our-woodlands-might-change-over-time-nfi-forecast-reports/.

Forest Research (2026b) *Ash dieback (Hymenoscyphus fraxineus)*, *Forest Research*. Available at: https://www.forestresearch.gov.uk/tools-and-resources/fthr/pest-and-disease-resources/ash-dieback-hymenoscyphus-fraxineus/ (Accessed: 10 June 2026).

Forest Research (2026c) 'Continuous cover silviculture'. Available at: https://www.forestresearch.gov.uk/research/continuous-cover-silviculture/ (Accessed: 28 May 2026).

Forest Research (2026d) *Drought*. Available at: https://www.forestresearch.gov.uk/climate-change/risks/drought/ (Accessed: 10 June 2026).

Forest Research (2026e) *Forest Research Decision Support Tools Portal v2.0*. Available at: http://www.forestdss.org.uk/geoforestdss/ (Accessed: 16 July 2026).

Forest Research (2026f) 'Timber Price Indices'. Available at: https://www.forestresearch.gov.uk/tools-and-resources/statistics/publications/timber-price-indices/ (Accessed: 22 June 2026).

Forest Research (2026g) 'Timber Price Indices: Data to March 2026'. Available at: https://www.forestresearch.gov.uk/publications/timber-price-indices-data-to-march-2026/ (Accessed: 8 July 2026).

Forest Research (2026h) *Tree Species Database*, *Forest Research*. Available at: https://www.forestresearch.gov.uk/tools-and-resources/tree-species-database/ (Accessed: 31 March 2026).

Forestry Commission (2003) *The management of semi-natural woodlands: 1, Lowland acid beech and oak woods*. Edinburgh: Forestry Commission. Available at: https://www.forestresearch.gov.uk/publications/the-

management-of-semi-natural-woodlands-1-lowland-acid-beech-and-oak-woods/.

Forestry Commission (2014) *Building wildfire resilience into forest management planning - practice guide*. Edinburgh: Forestry Commission. Available at: https://www.forestresearch.gov.uk/publications/building-wildfire-resilience-into-forest-management-planning/.

Forestry Commission (2015) *Forest GALES A wind risk decision support tool for forest management in Britain*. Edinburgh. Available at: https://cdn.forestresearch.gov.uk/2022/02/forestgales_2.5_user_manual.pdf.

Forestry Commission (2018) 'NFI Stocked Area by Age Class'. Available at: https://cdn.forestresearch.gov.uk/2022/02/fr_nfi_stocked_area_by_age_class.xlsx.

Forestry Commission (2019) *Forest Services Board: FS's strategy for accelerating woodland creation*. Available at: https://assets.publishing.service.gov.uk/media/5d1dd44ce5274a08d29ecbf8/190424-FS_Board_1_-_5-1_WoodlandCreation.pdf (Accessed: 15 July 2026).

Forestry Commission (2023a) *Forestry Commission Wildfire statistics for England: Report to 2020-21 - Summary*. Available at: https://www.gov.uk/government/publications/forestry-commission-wildfire-statistics-for-england-report-to-2020-21/forestry-commission-wildfire-statistics-for-england-report-to-2020-21-summary (Accessed: 18 December 2025).

Forestry Commission (2023b) *Thriving for the Future: Forestry Commission Strategy 2023-28*. Available at: https://www.gov.uk/government/publications/forestry-commission-strategy-2023-2028/thriving-for-the-future-forestry-commission-strategy-2023-28 (Accessed: 21 November 2025).

Forestry Commission (2023c) *Wildfire statistics for England: Report to 2020-21*. Forestry Commission, p. 95. Available at: https://assets.publishing.service.gov.uk/media/63ecff77d3bf7f62edc835a1/FC-Wildfire-statistics-for-England-Report-to-2020-21-.pdf (Accessed: 10 June 2026).

Forestry Commission (2024) 'England Woodland Creation Low Sensitivity Map v4.0'. Available at: https://data-forestry.opendata.arcgis.com/datasets/fda2456794054ee9aa73935ee35b1044_0/about (Accessed: 9 February 2026).

Forestry Commission (2025a) *Establishing Rates of GB Forest Lost to Natural Disturbance*.

Forestry Commission (2025b) *Forestry Commission Key Performance Indicators: Headline Performance Update at 30 September 2025*. Available at: https://assets.publishing.service.gov.uk/media/691496c49d50fc2fe81616ab/FC-Headline-Key-Performance-Indicators-30-Sep-25.pdf (Accessed: 21 November 2025).

Forestry Commission (2025c) *Managing and maintaining woodlands: overview*, *GOV.UK*. Available at: https://www.gov.uk/guidance/managing-and-maintaining-woodlands-overview (Accessed: 16 June 2026).

Forestry Commission (2025d) 'National Forest Inventory England 2024'. Available at: https://data-forestry.opendata.arcgis.com/datasets/0682c7cb180e4abe9dee7e4d5cc35784_0/explore (Accessed: 10 February 2026).

Forestry Commission (2025e) 'Sustainably Managed Woodland England - Headline Key Performance Indicator 31 March 2025'. Available at: https://data-forestry.opendata.arcgis.com/datasets/05c700fff3144bdd98e192d61f594373_0/about (Accessed: 31 March 2026).

Forestry Commission (2026) 'Tree Species Map England'. Available at: https://www.data.gov.uk/dataset/05350a8c-3f9a-4d78-a671-908e83f24237/tree-species-map-england (Accessed: 31 March 2026).

Forestry Commission and Animal and Plant Health Agency (2026) *How biosecurity can prevent the introduction and spread of tree pests and diseases*, *GOV.UK*. Available at: https://www.gov.uk/guidance/prevent-the-introduction-and-spread-of-tree-pests-and-diseases (Accessed: 18 December 2025).

Forestry Commission and Animal Plant Health Agency (2025) *Tree pests and diseases*. Available at: https://www.gov.uk/government/collections/tree-pests-and-diseases.

Friends of the Earth (2020) 'Woodland opportunity mapping Where could we create woodland in England? | Local action'. Available at: https://groups.friendsoftheearth.uk/woodland-opportunity-mapping-england (Accessed: 31 March 2026).

Green, S. and Ray, D. (2009) *Potential impacts of drought and disease on forestry in Scotland*. Available at: https://cdn.forestresearch.gov.uk/2009/08/fcrn004.pdf.

Hale, S.E., Gardiner, B., Peace, A., Nicoll, B., Taylor, P. and Pizzirani, S. (2015) 'Comparison and validation of three versions of a forest wind risk model', *Environmental Modelling & Software*, 68, pp. 27–41. Available at: https://doi.org/10.1016/j.envsoft.2015.01.016.

Haufe, J., Kerr, G., Stokes, V. and Bathgate, S. (2024) *Forest Development Types: A guide to the design and management of diverse forests in Britain. V1.1*. Forest Research. Available at: https://cdn.forestresearch.gov.uk/2024/05/Forest-Development-Types-Guide-v1.1.pdf.

HM Treasury (2026) *The Green Book: UK Government Guidance on Appraisal*. Available at: https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent.

Hunter, F., Ditchburn, B., Burns, N. and Strong, C. (2025) *NCEA: National Trees Outside Woodland Map Method and User Guide Report*. Forest Research. Available at: https://www.forestresearch.gov.uk/tools-and-resources/fthr/trees-outside-woodland-tow-projects/trees-outside-woodland-map/.

Jones, L., Vieno, M., Morton, D., Cryle, P., Holland, M., Carnell, E., Nemitz, E., Hall, J., Beck, R., Reis, S., Pritchard, N., Hayes, F., Mills, G., Koshy, A. and Dickie, I. (2017) *Developing Estimates for the Valuation of Air Pollution Removal in Ecosystem Accounts. Final report for Office of National Statistics, July*. Available at: https://nora.nerc.ac.uk/id/eprint/524081/7/N524081RE.pdf.

Kennett, S., Rintoul-Hynes, N.L.J. and Sanders, C.H. (2024) 'The effects of recreational footpaths on terrestrial invertebrate communities in a UK ancient woodland: a case study from Blean Woods, Kent, UK', *Biodiversity*,

25(2), pp. 107–119. Available at: https://doi.org/10.1080/14888386.2024.2333305.

Knutzen, F., Averbeck, P., Barrasso, C., Bouwer, L.M., Gardiner, B., Grünzweig, J.M., Hänel, S., Haustein, K., Johannessen, M.R., Kollet, S., Müller, M.M., Pietikäinen, J.-P., Pietras-Couffignal, K., Pinto, J.G., Rechid, D., Rousi, E., Russo, A., Suarez-Gutierrez, L., Veit, S., Wendler, J., Xoplaki, E. and Gliksman, D. (2025) 'Impacts on and damage to European forests from the 2018–2022 heat and drought events', *Natural Hazards and Earth System Sciences*, 25(1), pp. 77–117. Available at: https://doi.org/10.5194/nhess-25-77-2025.

Lecina-Diaz, J., Martínez-Vilalta, J., Alvarez, A., Banqué, M., Birkmann, J., Feldmeyer, D., Vayreda, J. and Retana, J. (2021) 'Characterizing forest vulnerability and risk to climate-change hazards', *Frontiers in Ecology and the Environment*, 19(2), pp. 126–133.

Low, W.H., Gardner, E., Kadam, N., Saraev, V. and Valatin, G. (2024) *Opportunity Costs of Woodland Creation in England: A review of data sources and evidence*. Available at: https://cdn.forestresearch.gov.uk/2024/05/Opportunity_Costs_of_Woodland_Creation_Report.pdf.

Matthews, R., Henshall, P., Beauchamp, K., Gruffudd, H., Hogan, G., Mackie, E., Sayce, M. and Morison, J. (2022) 'Quantifying the sustainable forestry carbon cycle Summary Report'. Available at: https://www.forestresearch.gov.uk/publications/quantifying-the-sustainable-forestry-carbon-cycle-report-download-page/.

Met Office (2026) *UK Climate Projections (UKCP18)*, *Met Office*. Available at: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp (Accessed: 22 June 2026).

Morison, J. (2026) *Wildfires, woodlands and the changing climate*, *Forest Research*. Available at: https://www.forestresearch.gov.uk/research/climate-change-impacts/forest-fires-and-climate-change/ (Accessed: 10 June 2026).

Natural England (2026) *Environment Act Habitat Target – Definitions and Descriptions Version 2 - TIN219*, *Natural England - Access to Evidence*. Available at: https://publications.naturalengland.org.uk/publication/6427187599900672 (Accessed: 9 June 2026).

Natural Resources Wales (2017) *Forest Resilience Guide 1 Improving the structural diversity of Welsh woodlands*. Available at: https://naturalresourceswales.gov.uk/media/681945/gpg6_forest-resilience-1_structural-diversity.pdf.

Nicoll, B., Hale, S. and Locatelli, T. (2026) *Tree stability and wind risk to forests*, *Forest Research*. Available at: https://www.forestresearch.gov.uk/research/tree-stability-and-wind-risk-to-forests/ (Accessed: 10 June 2026).

Office for National Statistics (2026) 'Woodland natural capital accounts, UK: summary tables'. Available at: https://www.ons.gov.uk/economy/environmentalaccounts/datasets/woodlandnaturalcapitalaccountsuksummarytables (Accessed: 16 June 2026).

Paillet, Y., Bergès, L., Hjältén, J., Ódor, P., Avon, C., Bernhardt-Römermann, M., Bijlsma, R., De Bruyn, L., Fuhr, M., Grandin, U., Kanka, R., Lundin, L., Luque, S., Magura, T., Matesanz, S., Mészáros, I., Sebastià, M. -Teresa, Schmidt, W., Standovár, T., Tóthmérész, B., Uotila, A., Valladares, F., Vellak, K. and Virtanen, R. (2010)

'Biodiversity Differences between Managed and Unmanaged Forests: Meta-Analysis of Species Richness in Europe', *Conservation Biology*, 24(1), pp. 101–112. Available at: https://doi.org/10.1111/j.1523-1739.2009.01399.x.

Perry, M.C., Vanvyve, E., Betts, R.A. and Palin, E.J. (2022) 'Past and future trends in fire weather for the UK', *Natural Hazards and Earth System Sciences*, 22(2), pp. 559–575. Available at: https://doi.org/10.5194/nhess-22-559-2022.

Pukkala, T., Laiho, O. and Lähde, E. (2016) 'Continuous cover management reduces wind damage', *Forest Ecology and Management*, 372, pp. 120–127. Available at: https://doi.org/10.1016/j.foreco.2016.04.014.

Redman, G. (2024) *John Nix Farm Management Pocketbook for 2025.* 55th edn. Melton Mowbray: Agro Business Consultants.

Ritchie, P.D.L., Harper, A.B., Smith, G.S., Kahana, R., Kendon, E.J., Lewis, H., Fezzi, C., Halleck-Vega, S., Boulton, C.A., Bateman, I.J. and Lenton, T.M. (2019) 'Large changes in Great Britain's vegetation and agricultural land-use predicted under unmitigated climate change', *Environmental Research Letters*, 14(11), p. 114012. Available at: https://doi.org/10.1088/1748-9326/ab492b.

Royal Forestry Society (2025) *Forestry Sector Skills Plan 2025 - 2035*. Available at: https://rfs.org.uk/wp-content/uploads/2025/05/Forestry-Sector-Skills-Plan-2025.pdf (Accessed: 19 December 2025).

Ryan, L. (2012) *Impacts of nearby development on ancient woodland – addendum*. Available at: https://www.woodlandtrust.org.uk/media/43619/impacts-of-nearby-development-on-the-ecology-of-ancient-woodland-addendum.pdf.

Salkind, N. (ed.) (2010) *Encyclopedia of Research Design*. SAGE Publications, Inc. Available at: https://sk.sagepub.com/ency/edvol/researchdesign/toc#_ (Accessed: 17 July 2026).

Saraev, V. (2019) *Review of economic models for quantifying risk and uncertainty in forestry*. Forest Research. Available at: https://cdn.forestresearch.gov.uk/2017/12/review_of_economic_models_for_quantifying_risk_and_uncertainty_in_forestry.pdf.

Sellier, D. and Suzuki, S. (2020) 'Age Dynamics of Wind Risk and Tree Sway Characteristics in a Softwood Plantation', *Frontiers in Forests and Global Change*, 3. Available at: https://doi.org/10.3389/ffgc.2020.00089.

The Rivers Trust (2025) *Woodlands for Water*, *The Rivers Trust*. Available at: https://theriverstrust.org/our-work/our-projects/woodlands-for-water (Accessed: 2 September 2026).

Thomson, A., Young, H. and Nickerson, R. (2025) *The Seventh Carbon Budget Land Use Emission Pathways*. UK CEH. Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget-land-use-emission-pathways-ukceh/.

Tsai, Y., Zabronsky, H.M., Zia, A. and Beckage, B. (2022) 'Efficacy of Riparian Buffers in Phosphorus Removal: A Meta-Analysis', *Frontiers in Water*, 4. Available at: https://doi.org/10.3389/frwa.2022.882560.

UK ETS Authority (2025) *Integrating Greenhouse Gas Removals in the UK ETS: Main Response - Woodland evidence annex*. Available at: https://assets.publishing.service.gov.uk/media/687e75a78adf4250705c96ed/uk-ets-ggrs-main-response-woodland-annex.pdf.

UK Government (2025) *Carbon Budget and Growth Delivery Plan*. Available at: https://assets.publishing.service.gov.uk/media/6901d0c2a6048928d3fc2b55/carbon-budget-and-growth-delivery-plan-report.pdf (Accessed: 13 August 2026).

University of Reading (2023) *Climate Risk Indicators*. Available at: https://uk-cri.org/ (Accessed: 9 June 2026).

Wildlife and Countryside Link & Greener UK (2023) *The Environmental Targets (Woodland Trees) (England) Regulations - Link and Greener UK briefing*. Available at: https://www.wcl.org.uk/docs/The%20Environmental%20Targets%20(Woodland%20%20Trees)%20(England)%20Regulations%20-%20Link%20and%20Greener%20UK%20briefing%2020.01.23.pdf (Accessed: 16 July 2026).

Woodland Carbon Code (2025) 'Carbon Calculator V3.0'. Available at: https://www.woodlandcarboncode.org.uk/sites/default/files/2025-09/CarbonCalculator_V3.0_August2025.xlsx (Accessed: 1 April 2026).

Yu, J., Berry, P., Guillod, B.P. and Hickler, T. (2021) 'Climate Change Impacts on the Future of Forests in Great Britain', *Frontiers in Environmental Science*, 9. Available at: https://doi.org/10.3389/fenvs.2021.640530.

Appendix 1 Relevant targets assessment

This appendix sets out the targets from the Environment Improvement Plan 2023 (EIP23) (Appendix Table 1) and the Environment Improvement Plan 2025 (EIP25) (Appendix Table 2) for which the creation and/or improvement of woodland and TOW may contribute.

Appendix Table 1 Relevant targets set out in EIP23

EIP23 area	EIP 23 goal no.	EIP23 goal	Target type (and relevant Act)	Legally binding?	Target description	Short-form Target (Achieve by year + High-level Outcome)	Achieved by	Level of relevance (1-4)
The apex goal	Goal 1	Thriving plants and wildlife	EA21	Y	By the end of 2050 at least 16.5% of all land in England is covered by woodland and trees outside woodland (2050 target for woodland and trees outside woodland).	2050 Woodland cover	2050	4
The apex goal	Goal 1	Thriving plants and wildlife	EA21	Y	By 31 January 2028 increase tree canopy and woodland cover by 0.26% (34,000 ha) (2028 target for woodland and trees outside woodland).	Interim Woodland cover	2050	4
The apex goal	Goal 1	Thriving plants and wildlife	EA21	Y	By the end of 2030, we will halt the decline in species abundance (2030 species abundance target).	2030 Species abundance	2030	3
The apex goal	Goal 1	Thriving plants and wildlife	EA21	Y	By the end of 2042, we will increase species abundance so that it is greater than in 2022 and at least 10% greater than in 2030 (long-term target to reverse the decline of species abundance).	2042 Species abundance	2042	3
Improving our mitigation of climate change	Goal 7	Mitigating and adapting to climate change	Climate Change Act 2008	Y	A UK-wide legally binding target of net zero emissions by 2050, including carbon budgets 4, 5, and 6 from 2023 to 2037; and our 2030 Nationally Determined Contribution.	2050 Net Zero	2050	3
Improving our use of resources	Goal 6	Using resources from nature sustainably	Other targets or commitments	N	Halt and reverse forest loss and land degradation globally by 2030.	2030 Global forest loss	2030	3
The apex goal	Goal 1	Thriving plants and wildlife	Other targets or commitments	N	Ensure that by 2030 at least 30 per cent of areas of degraded terrestrial, inland water, and marine and coastal ecosystems are under effective restoration	2030 CBD Target 2	2030	3

EIP23 area	EIP 23 goal no.	EIP23 goal	Target type (and relevant Act)	Legally binding?	Target description	Short-form Target (Achieve by year + High-level Outcome)	Achieved by	Level of relevance (1-4)
The apex goal	Goal 1	Thriving plants and wildlife	Other targets or commitments	N	Ensure and enable that by 2030 at least 30 per cent of terrestrial and inland water areas, and of marine and coastal areas, are effectively conserved and managed through ecologically representative, well-connected, and equitably governed systems of protected areas and other effective area-based conservation measures.	2030 CBD Target 3	2030	3
The apex goal	Goal 1	Thriving plants and wildlife	EA21	Y	By the end of 2042, we will improve the Red List Index for species extinction compared to 2022 levels (long-term species extinction risk target).	2042 Species extinction	2042	2
The apex goal	Goal 1	Thriving plants and wildlife	EA21	Y	By the end of 2042, we will restore or create in excess of 500,000 hectares of a range of wildlife-rich habitats outside protected sites, compared to 2022 levels (long-term wildlife-rich habitat restoration or creation target).	2042 Wildlife-rich habitats	2042	2
Improving environmental quality	Goal 2	Clean air	The National Emission Ceilings Regulations 2018	?	Legal emission reduction targets for five damaging pollutants by 2030 relative to 2005 levels: Reduce emissions of nitrogen oxides by 73%; Reduce emissions of sulphur dioxide by 88%; Reduce emission of PM2.5 by 46%; Reduce emissions of ammonia by 16%; Reduce emissions of non-methane volatile organic compounds by 39%.	2030 NECR	2030	2
Improving our mitigation of climate change	Goal 7	Mitigating and adapting to climate change	Other targets or commitments	N	Under the Paris Agreement, we are committed to limiting global warming to well below 2 degrees Celsius compared to pre-industrial levels, and aiming for 1.5 degrees under our presidency of the UN Climate Summit COP26.	2100 Paris Agreement	2100	2
Improving our mitigation of climate change	Goal 8	Reduced risk of harm from environmental hazards	Other targets or commitments	N	Better protect 100,000 properties from flooding and coastal erosion by 2024, and 336,000 by 2027.	2027 FCERM properties	2024, 2027	2

EIP23 area	EIP 23 goal no.	EIP23 goal	Target type (and relevant Act)	Legally binding?	Target description	Short-form Target (Achieve by year + High-level Outcome)	Achieved by	Level of relevance (1-4)
Improving our mitigation of climate change	Goal 8	Reduced risk of harm from environmental hazards	Other targets or commitments	N	Double the number of government-funded projects to reduce flooding and coastal erosion through nature-based solutions to 260 projects by 2027.	2027 FCERM NbS	2027	2
Improving the beauty of nature	Goal 10	Enhancing beauty, heritage, and engagement with the natural environment	Other targets or commitments	N	Everyone should live within 15 minutes' walk of a green or blue space.	Walkable G&B space	Not stated	2
Improving the beauty of nature	Goal 10	Enhancing beauty, heritage, and engagement with the natural environment	Other targets or commitments	N	Conserve and enhance the natural, geological, and cultural diversity of landscapes, and protect the historic and natural environment for the benefit and enjoyment of future generations.	Enhance landscape	Not stated	2
The apex goal	Goal 1	Thriving plants and wildlife	Other targets or commitments	N	Restore 75% of protected sites to favourable condition by 2042.	2042 Protected sites condition	2042	2
The apex goal	Goal 1	Thriving plants and wildlife	Other targets or commitments	N	65–80% of landowners and farmers adopting nature-friendly farming on at least 10–15% of their land by 2030.	2030 Nature-friendly farming	2030	2
Improving environmental quality	Goal 2	Clean air	The Air Quality Standards Regulations 2010	Y	Legal concentration limits for a number of other key pollutants. (Air Quality Standards Regulations limits, targets, and long-term objectives - 12 pollutants to protect human health and vegetation).	AQSR	Not stated	2

Table note: Ranking of relevance: 4 – main target for woodland creation; 3 – directly relevant to woodland planting or mentioned in spec; 2 – indirectly/maybe relevant to woodland planting; 1 – unsure whether relevant or not.

Appendix Table 2 Relevant targets set out in EIP25

EIP25 goal	EIP 25 commitment	Responsible	Legally binding?	Target description	Short-form Target (Achieve by + High-level Outcome)	Achieved by	Level of relevance (1-4)
1: Restored nature	11	Defra, FC, NE, EA	Y	Increase England's tree canopy and woodland cover by 0.33% of land area by December 2030 from the 2022 baseline of 14.9%. (Equivalent to a net increase of 43,000 hectares).	2030 Interim target	2030	4
1: Restored nature	7-9	Defra, FC, NE	N	Set a target to increase woodland management in 2026 to improve woodland condition, resilience, and biodiversity.	2026 Woodland management target	2026	3
1: Restored nature	7-9	Defra, FC, APHA, NE	N	Manage the impact of mammals on woodlands better so that woodlands are more biodiverse, resilient, and commercially viable.	Mammal impact management	N/A	3
1: Restored nature	7-9	MHCLG, Defra	N	Maintain current protections in the National Planning Policy Framework for ancient woodland and ancient and veteran trees and improve the implementation of the policy.	2027 Protections policy	2027	3
1: Restored nature	7-9	Defra, NE	N	Build upon and review the evidence base for the value of long-established woodlands and consider their biodiversity status. Publish the Long-Established Woodland Inventory.	2026 LEW Inventory	2026	3
1: Restored nature	10-13	Defra	N	Deliver up to 300,000 hectares of wildlife rich habitat creation and restoration by 2042 through Agri-environment scheme (AES) agreements running since 2023. Deliver up to 200,000 hectares of peatland restoration and woodland creation.	2042 woodland creation	2042	3
1: Restored nature	10-13	Defra, FC, NE, EA	N	Incentivise the planting of high-quality woodlands and TOW with a further £816 million of funding between 2026 to 2027 and 2029 to 2030 financial years, including by continuing the England Woodland Creation Offer (EWCO).	2030 High quality planting funding	2030	3
6: Resources	52	Defra, local authorities	N	Increase the proportion of conifer species contributing to national tree planting.		?	3
7: Climate change	64	Defra	N	Increase the number of trees on farms, with a focus on silvoarable (trees with crops) and silvopastoral (trees with livestock) agroforestry systems.		?	3

Table note: Ranking of relevance: 4 – main target for woodland creation; 3 – directly relevant to woodland planting or mentioned in spec; 2 – indirectly/maybe relevant to woodland planting; 1 – unsure whether relevant or not.

Appendix 2 Risks to woodlands and TOW

This appendix provides more detailed information on the assessment of different risks to woodlands and trees outside of woodland (TOW). The risks to trees and woodland that were considered for inclusion in the model, based on the evidence review (see Appendix 2), are shown in Appendix Table 3 .

Appendix Table 3 Risk parameters

Risk	Spatial variation in application	Change over time	Dependence on other risks	Characteristics that vary impact of risk	Parameter type
Pest and disease	Regional variation – if a disease occurs that affects a specific species or mix, then this is likely to spread regionally or nationally (e.g., ash blight, etc)	Increase in occurrence Increase in extent Increase in severity	Drought, flood	Age, species, management/condition, surrounding environment	National probabilistic vector by type
Development	Variation based on suburban / urban tag – this is an independent risk to all units	Decrease in occurrence No change in extent No change in severity	None	n/a	National probabilistic vector
Windthrow	Variation based on Regional and land type – wind events are likely to impact lots of units within the same spatial boundary	Increase in occurrence Increase in extent Increase in severity	Drought, flood, frost	Age, species, management/condition, surrounding environment	Regional probabilistic vector
Wildfire	Variation based on regional and land type – wildfire is likely to affect units in different geographical boundaries more than others.	Increase in occurrence Increase in extent No change in severity	Drought	Age, species, management/condition, surrounding environment	Regional probabilistic vector based on drought events
Flooding	Regional variation– rainfall events leading to flooding are likely to be regional	Increase in occurrence Increase in extent No change in severity	None	Age, species, management/condition, surrounding environment	Captured by windthrow events (flooding increases impact of windthrow events)
Drought	Regional / national variation – as with rainfall, low rainfall is likely to be regional	Increase in occurrence Increase in extent Increase in severity	Wildfire, windthrow, pests & disease	Age, species, management/condition, surrounding environment	Regional probabilistic vector
Frost	Regional variation	Regionally dependent (based on climate modelling)	None	Age, species, management/condition	Not included in model

A2.1 Pests and disease

Average permanent loss from pests and diseases across all GB woodland is estimated at 0.003% of woodland area per year between 2010 and 2014, with a maximum of 0.01% loss annually, of which only 4.2% of affected woodland was not restocked (UK ETS Authority, 2025)

For conifer woodland, climate-driven shifts, including milder winters, warmer temperatures, and phenology changes combined with storm damage and drought stress, are expected to increase trees' susceptibility to damage and mortality from pests and diseases (Forest Research, 2025g). Stresses from drought or waterlogging are also predisposing trees to pest and pathogen attack, and large-scale windthrow or drought stress can lead to bark beetle outbreaks (Forest Research, 2025g). Pine weevils can damage or kill young conifers planted on clear-cut sites, with a significant number of unprotected trees being killed when populations are high and heavy, early thinning can be used to reduce the impacts of needle blight, with subsequent enrichment to shift composition. Climate change is expected to increase pest and disease risk, with warmer, wetter springs favouring foliar and aerial pathogens such as Phytophthora ramorum and drought stress predisposing trees to root pathogens that are common on conifer sites (Atkinson, 2022). Large, uniform stands and low species diversity increase vulnerability to pest and disease outbreaks, with even-aged plantation conifers comprised of mature, closed canopy stands being more susceptible than structurally diverse or mixed stands (Atkinson, 2022).

For broadleaf woodland, large-scale damaging outbreaks, including ash dieback and acute oak decline, suggest that climate-driven pest and disease risks are increasing for broadleaf as well as conifer stands (Atkinson, 2022). Mixed species and structurally diverse broadleaf stands are more resilient to pests and diseases than single species, even-aged stands, favouring vertical and compositional diversity over young uniform plantations or coppice (Atkinson, 2022). Indeed, because many pathogens and insect pests are host specific, mixed broadleaf/conifer stands should have lower expected stand-level loss from a given pest outbreak than equivalent even-aged conifer or broadleaf monocultures.

In management terms, intensive systems are generally expected to be more susceptible to widespread stand-level impacts because these low-diversity, even-aged systems concentrate exposure in the same susceptible species and stage. Thus, management practices that increase structural variation (multiple species and age cohorts) can reduce the risk of severe damage from agents that affect particular species and/or growth stages (Natural Resources Wales, 2017). Woodlands under multi-use or moderate management should be less susceptible, due to higher levels of structural diversity. Yet susceptibility to introduction or spread of pests, pathogens, and non-native species is higher where there is frequent movement of people between sites, such that multi-use forests may have particularly elevated risk (Forest Research, 2023; Forestry Commission & Animal and Plant Health Agency, 2025). Minimally-managed forests should be less susceptible, as close-to-nature approaches increase structural and species diversity and promote natural regeneration, with the UKFS explicitly linking close-to-nature, continuous cover with increased diversity and resilience under climate change (Forest Research, 2023b).

Appendix Table 4 Summary of pest and disease risk and relationship to other parameters

Parameter relationship	Description of Variation	Source
Age	• Dependent on pest species; young often more susceptible	• (Natural Resources Wales, 2017)
Woodland type / species mix	• Broadleaf and conifer	• (Atkinson, 2022)
Management/existing condition	• Intensive systems more susceptible	• (Natural Resources Wales, 2017)
Spatial and temporal	• Location-specific variation; increase in risk over time	• (Forest Research, 2025g; Knutzen *et al.*, 2025)
Mortality	• Does cause permanent loss	• (UK ETS Authority, 2025)
Condition	• Condition and growth affected; limited evidence	• Forestry Commission and Animal and Plant Health Agency, 2018

Correlated risks

Pests and diseases correlate with drought and waterlogging because both stresses predispose trees to attack and infection, and disturbance events can create conditions that favour outbreaks (Atkinson, 2022; Forest Research, 2025g). Pest and disease impacts can also elevate wildfire risk by adding deadwood and opening stands, which can increase surface fuels and drying (Forest Research, 2023; Forest Research, 2025f).

Future risk

The expectation is increased pest and pathogen pressures as the climate warms, since milder winters and longer growing seasons can favour survival, spread, and impacts of pests, especially when combined with more frequent drought and storm stress (Forest Research, 2025g; Knutzen *et al.*, 2025). Guidance therefore places increasing emphasis on species and structural diversity to reduce stand-level vulnerability by minimising exposure in a single susceptible species or age class (Atkinson, 2022; Forest Research, 2023).

A2.2 Development

Between 2006 and 2024, for Great Britain, there was a recorded annual average of 480 hectares of woodland loss, 129 hectares of ground under development and 86 hectares of newly restored priority habitats (Forest Research, 2025d). Average permanent loss from development across all GB woodland is 0.023% of woodland area per year (2006/07-2022/23) (UK ETS Authority, 2025). Development has complex interactions with woodland and tree cover: whilst it is a significant cause of woodland and tree loss, and a cause of damage to adjacent woodland, the current policy landscape also strives to mitigate loss of habitat to development, such as through the Biodiversity Net Gain (BNG) policy. Regardless of existing policies, the loss figures illustrate that, while total UK woodland area has been broadly stable or slightly increasing due to planting and restocking, development continues to directly remove woodland each year. Development poses a particular risk to ancient woodland: they contain complex soils, long-established ecological networks, and specialist species that cannot be quickly re-established once disturbed, making both direct loss and nearby development disproportionately harmful compared to newer, more easily replaceable woodland. This is further complicated as developments near trees and woodland facilitate increased benefit provision due to subsequent air quality, recreation, and physical health benefits. Therefore, from a

cost-benefit perspective development, encroaching on existing woodlands may have significant benefits to those new residents and communities.

Appendix Table 5 Summary of development risk and relationship to other parameters

Parameter	Description of Variation	Source
Age	• All; ancient woodland of particular concern	• Forest Research, 2023b
Spatial and temporal	• Dependent on development rates	• N/A
Mortality	• High impact on mortality	• (UK ETS Authority, 2025)
Condition	• Can impact condition	• Ryan 2012
Others	• Not relevant	• NA

Correlated risks

Development can contribute to flooding risk to trees: site infrastructure, including culverts, drains, and bridges are risk factors to trees from flooding (Forest Research, 2025b). Further, development can lead to local abstraction from existing water resources, and change protection for stands leading to windthrow.

Future risk

Continued demand for housing and infrastructure will likely maintain the pressure for land conversion unless stronger habitat protection and net gain safeguards are enforced.

A2.3 Windthrow

Average permanent loss from windstorm, including windthrow and wind snap, across all GB woodlands is 0.007% of woodland area per year, of which 10.2% was not restocked. The maximum observed permanent loss from windstorm in GB over the last several decades was 0.047% of woodland area in 2021, when 12,741 ha were affected by Storm Arwen and subsequent storms (UK ETS Authority, 2025).

Windthrow loss rates should be increased relative to the GB average for tall, even-aged conifer stands on exposed or waterlogged sites, and decreased for mature irregular broadleaf or mixed stands with continuous cover (Hale *et al.*, 2015). For conifer woodland, increasing tree height and local wind speed are the main factors associated with increased wind damage probability, with models showing higher damage probabilities in taller stands at a given wind speed intensity level (Hale *et al.*, 2015). Continuous cover systems with structural diversity and careful thinning and felling reduce wind risk compared with large, even-aged clear-fell conifer stands, implying that mature, closed canopy conifer stands under clear-fell regimes are most wind-sensitive (Atkinson, 2022).

Many broadleaf species have higher critical wind speeds than shallow-rooted conifers, indicating inherently greater wind resistance of mature broadleaf stands under similar exposure. Conversion to continuous cover systems and structurally diverse stands can reduce wind risk due to lower windthrow risk for mature, irregular broadleaf stands than for comparable mature conifer clear-fell stands (Atkinson, 2022).

For mixed woodland, conversion of even-aged plantations to continuous cover mixed woodland is cited as a strategy to reduce wind risk by developing varied age structures and avoiding large clear-cut sections that

expose stand edges (Atkinson, 2022). Mature mixed stands with closed canopy and structural diversity should generally have lower windthrow loss probabilities than basal-area-equivalent pure conifer stands when parameterising simulations.

In management terms, intensive approaches are more susceptible because even-aged woodlands are more susceptible to catastrophic storm and wind damage, as windblow can spread quickly through even-aged stands until it reaches a windfirm boundary (Natural Resources Wales, 2017). Under moderate management, susceptibility can be reduced by well-timed thinning regimes, but susceptibility is explicitly higher immediately after thinning because more wind enters the stand (Forest Research, 2025h). Minimally managed stands are less susceptible, provided there is sufficient structural diversity and continuous cover, as established young trees beneath are linked to reduced windthrow severity (Forest Research, 2023).

Appendix Table 6 Summary of windthrow risk and relationship to other parameters

Parameter	Description of Variation	Source
Age	• Worse for taller older trees; even-aged woods more susceptible	• Sellier and Suzuki, 2020
Woodland type / species mix	• Worse for conifers (shallow roots)	• (Atkinson, 2022)
Management/existing condition	• Intensive systems worse e.g., even-aged woods are more susceptible	• (Natural Resources Wales, 2017)
Spatial and temporal	• Varies with climate and local conditions (e.g., soil, aspect) • Increasing due to climate change	• (Forest Research, 2022) • (Yu *et al.*, 2021)
Mortality	• Evidenced impact on mortality	• (UK ETS Authority, 2025)
Condition	• Limited evidence	

Correlated risks

Windthrow risk is often higher on waterlogged sites because saturated soils reduce root anchorage and increase the likelihood of overturning during storms (Atkinson, 2022; Forest Research, 2022). Wind damage can also increase downstream risks by creating stressed trees and leaving broken or downed timber that can raise fuel loads and provide material that supports pest and pathogen dynamics (Atkinson, 2022; Forest Research, 2023).

Future risk

Over the next several decades, windthrow vulnerability is expected to increase in many places due to wetter winters increasing the frequency of saturated soils and poor anchorage (Forest Research, 2022); (Yu *et al.*, 2021). Where growth rates increase, stands may also reach more wind-sensitive heights sooner, which can increase exposure even without large changes in average wind speeds or climate (Atkinson, 2022).

A2.4 Fire

Permanent loss from wildfire across GB woodlands averages 0.006% of woodland area per year, with permanent loss around 8.4% of area burned (UK ETS Authority, 2025), and the rest restocked or replanted. Maximum observed permanent loss from wildfire is 0.028% of woodland area in the worst year of 2009-

2015 (UK ETS Authority, 2025). There were approximately 360,000 wildfires in England between 2009 and 2021, of which only 14.2% of incidents occurred in woodland, with 10.4% in broadleaf woodlands and 1.8% in conifer woodlands (Forestry Commission, 2023a).

For conifer woodland, young stands of pine, spruce, or fir are categorised as high-risk wildfire habitats, with risk highest where ground vegetation and residues provide abundant surface fuels and low canopy height serves as ladder fuel (Atkinson, 2022). There is likewise a greater risk of fire spread and crown fire in large, uniform stands with no breaks in tree cover, which aligns with the structure of many mid-rotation conifer plantations. Compounded with lower moisture content in ground litter within conifer stands, this increases the spread and severity of forest fires (Crawford *et al.*, 2025), and raises the risk of wildfire loss for young or dense conifer plantations compared with the average across all other woodlands (Atkinson, 2022).

Broadleaved, mixed, and yew woodlands are classified as low-risk wildfire habitats (Atkinson, 2022). Crown fire risk is greater in large, uniform stands and where continuous canopy cover and heavy surface fuels coincide, conditions that are less typical of many semi-natural broadleaf woods than of conifer plantations. For mixed woodland, fire-resistant broadleaf species and varied age classes are suggested to improve woodland structure and resilience, and annual permanent wildfire loss for mixed stands is likely at or below the GB average, with extreme year losses bounded by 0.028% per year from the national dataset (UK ETS Authority, 2025).

Intensive management approaches are more susceptible to fire risks when forestry operations leave high volumes of harvesting residues and slash on the forest floor. Minimally-managed forests can likewise have high susceptibility if coarse woody debris, foliage or needles, or standing dead wood is allowed to accumulate (Forest Research, 2023). Because fire risk is highest with high recreational pressure, multi-use forests are likely to have the highest rates of wildfire occurrence, although with lower severity due to understory dead wood or debris (Forestry Commission, 2014; Forest Research, 2025j).

Appendix Table 7 : Summary of fire risk and relationship to other parameters

Parameter	Description of Variation	Source
Age	• Young trees are particularly vulnerable	• (Atkinson, 2022)
Woodland type / species mix	• Coniferous more susceptible, broadleaf low risk	• (Atkinson, 2022)
Management/existing condition	• Recreational multi-use sites most at risk, dense sites more at risk	• (Forest Research, 2023)
Spatial and temporal	• Increasing due to climate change • Higher risk in the southeast of England	• (Yu *et al.*, 2021)
Mortality	• Documented mortality and permanent loss	• (UK ETS Authority, 2025)
Condition	• Limited evidence on condition	

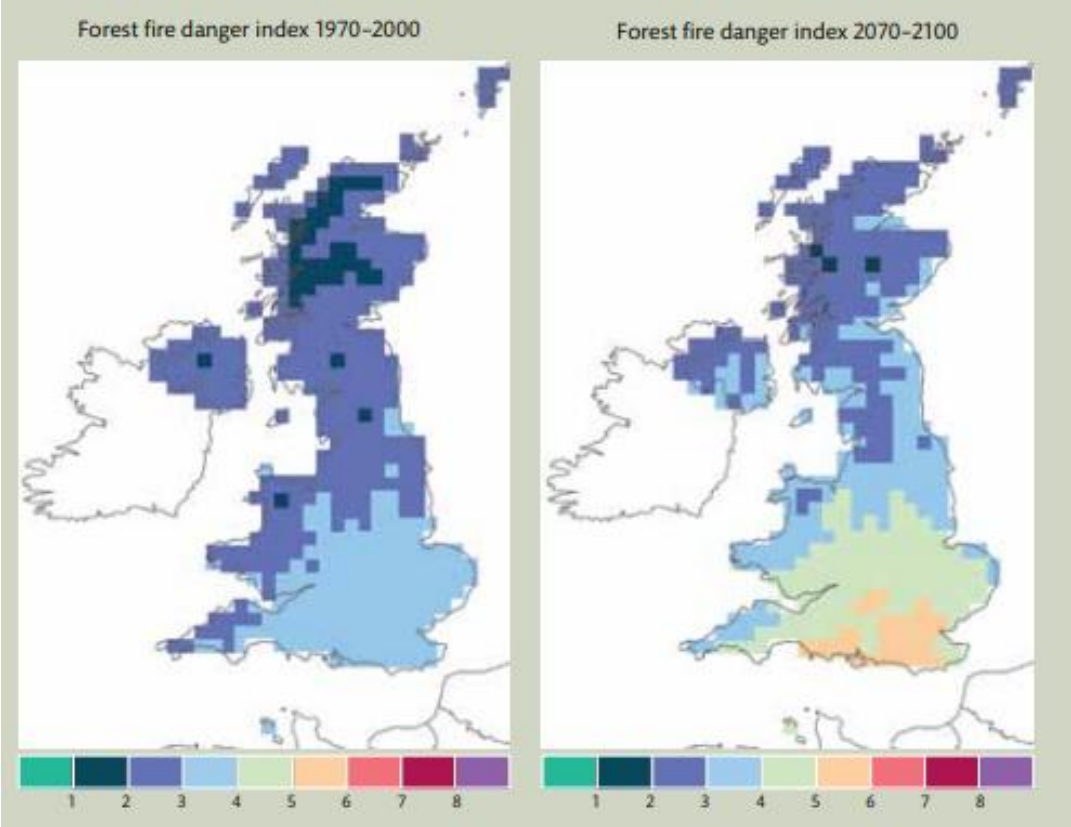
Correlated risks

Wildfire correlates most strongly with drought and heat because fuel drying and heatwaves increase the likelihood of severe fire weather and larger fires. (Perry *et al.*, 2022; Knutzen *et al.*, 2025). Wildfire risk is also linked with windthrow and disease because storm damage and widespread mortality can increase

deadwood and surface fuels, while fuel ladders can enable surface fires to transition toward the canopy (Forestry Commission, 2014; Forest Research, 2023).

Future risk

The outlook is for increased wildfire risk due to altered precipitation regions (Perry *et al.*, 2022; Forest Research, 2025j); see Appendix Figure 1 . In England, woodland wildfires remain rare and account for a minority of total burned area compared with open habitats, but damaging woodland fires are a growing concern under hotter and drier conditions (Forestry Commission, 2023a).



Appendix Figure 1 Woodland fire risk index
Source: Forestry Commission (2014)
Figure note: forest fire danger index, 1 is minimal and 8 is high

A2.5 Flooding

There is minimal data on woodland loss due to flooding in the UK, in part because it is difficult to disentangle flooding from windthrow damage. Increased winter rainfall and waterlogging can reduce root anchorage, especially on poorly drained soils with shallow rooting (i.e., in conifers vs. broadleaf stands), thereby increasing windthrow risk rather than mortality by inundation per se (Atkinson, 2022). Indeed, in previous models, loss due to flooding have been generally captured within the 0.007% per year permanent loss attributed to windstorms above (Forestry Commission, 2025a). Nevertheless, fostering mixed-species stands on flood-prone sites can combine flood-tolerant and less-tolerant species, reducing stand-level mortality in flood events. Climate change impact assessments for UK forests highlight increased frequency of winter storms and the potential for reduced root anchorage due to increased waterlogging.

In management terms, intensive clear-fell or single-cohort rotation systems can be more susceptible to increased peak water flow, as forestry operations and harvesting can create bare ground that increases run-off. Similarly, large-scale felling can increase local peak flows via the temporary loss of woodland benefit, with added exposure from bare clear-cut ground, drains, and roads and tracks. Multi-use woodlands can likewise have increased susceptibility if visitors or animal trampling compacts soils and contributes to overland groundwater flow, in tandem with road access and paths (Kennett, Rintoul-Hynes and Sanders, 2024). Minimal close-to-nature and continuous cover approaches are generally less susceptible due to reduced water flow (Forest Research, 2022).

Appendix Table 8 Summary of flooding risk and relationship to other parameters

Parameter	Description of Variation	Source
Woodland type / species mix	• Species sensitive to root damage during flooding	• (Forest Research, 2022)
Management/existing condition	• Intensive clear-fell or single-cohort rotation systems more at risk • Multi-use woods	• (Kennett, Rintoul-Hynes and Sanders, 2024)
Spatial and temporal	• Soil type and local hydrology • Increasing due to climate change	• (Yu *et al.*, 2021) • (Forest Research, 2022)
Mortality	• Minimal data isolating flood risk	• (Atkinson, 2022)
Condition	• Limited evidence	

Correlated risks

Flooding and waterlogging correlate strongly with windthrow because saturated soils and restricted rooting reduce anchorage and increase the likelihood of storm damage (Atkinson, 2022; Forest Research, 2022). They also correlate with pests and disease, as physiological stress and root damage can increase susceptibility to infection (Atkinson, 2022; Forest Research, 2025g).

Future risk

The outlook for the UK is toward wetter winters alongside hotter and drier summers, which increases the importance of soil protection and species selection on wetter ground (Yu *et al.*, 2021); (Forest Research, 2022). While flooding is primarily treated as a driver of woodland area loss, the expectation is that waterlogging will likely increase vulnerability to other hazards, especially windthrow (Atkinson, 2022; UK ETS Authority, 2025).

A2.6 Drought

UK-wide woodland losses to drought are not adequately quantified, in part because it is assumed that over the long term these hazards affect condition and growth but do not cause net permanent woodland area loss after regrowth or replanting (UK ETS Authority, 2025).

Nevertheless, there is some evidence of stand-specific effects. Young stands on exposed sites and drought-prone soils should generally have higher mortality, as should veteran/ancient trees (Atkinson, 2022), though there is no clear evidence for >0% loss across GB. For conifers, mapping of drought-risk forest sites in

eastern Scotland identifies 288 medium/high drought-risk forests, 125 containing major Sitka spruce components, indicating elevated drought susceptibility for conifer plantations on free-draining soils (Green and Ray, 2009). Indeed, shallow, light-textured and freely draining soils are key site factors increasing drought risk, particularly relevant for large areas of upland conifer plantations (Atkinson, 2022). Young conifer trees are most at risk from drought, along with higher drought mortality for newly-planted/open-canopy conifer stands than for established closed-canopy stands on the same site (Atkinson, 2022). In the GB disturbance analysis, no permanent woodland loss fraction is assigned to drought, so conifer drought damage is implicitly assumed to be followed by regeneration/replanting, contributing 0% to national permanent area loss under current conditions (UK ETS Authority, 2025).

For broadleaves, some species are expected to experience increased drought stress over the coming century, in particular drought-sensitive broadleaves such as beech in southern and eastern England, likewise on free-draining soils (Broadmeadow and Ray, 2005). As with conifers, site soil characteristics (shallow, freely draining soils) dominate drought risk, with young broadleaf trees most at risk. This mirrors conifer behaviour, but broadleaf trees often exhibit deeper rooting in mature stands, offering some resilience on suitable soils (Atkinson, 2022, p. 202). Drought effects on broadleaves are treated, as for conifers, as reducing growth and condition rather than causing net permanent woodland area loss in the GB disturbance model (0% explicit permanent loss from drought) (UK ETS Authority, 2025).

For mixed woodlands, combining different species with contrasting rooting depths and drought tolerances is recommended to spread drought risk within stands, reducing the chance that any single drought event causes large-scale mortality, particularly once stands reach closed-canopy conditions (Atkinson, 2022). In management terms, intensive systems are more susceptible to drought, as dense, single-cohort stands exhibit higher competition for water (Forest Research, 2025a). Under moderate management, drought susceptibility is reduced when canopy cover is retained and recruitment/restocking is done under some shelter (Forest Research, 2025b). However, moderate management or multi-use woodlands can exhibit higher drought stress and increase mortality among young/shallow-rooted trees if management removes protective shade (Forest Research, 2025a). Minimal management (close to nature) is generally least susceptible to drought, as natural regeneration is expected to reduce drought risk via shade and shelter effects (Forest Research, 2025i).

Appendix Table 9 Summary of drought risk and relationship to other parameters

Parameter	Description of Variation	Source
Age	• Mortality: primarily young stands and ancient/veteran trees • Condition: all ages	• (Atkinson, 2022)
Woodland type / species mix	• Conifer & broadleaf; particularly Sitka spruce and drought-sensitive broadleaves such as beech	• (Atkinson, 2022); • (Broadmeadow and Ray, 2005)
Management/existing condition	• Intensive systems are more susceptible to drought; and young open canopy stands	• (Forest Research, 2025a); • (Atkinson, 2022)
Spatial and temporal	• Higher risk in the southeast of England; higher risk on free-draining soils and fragmented woods; increasing with climate change	• (Atkinson, 2022) • (Yu *et al.*, 2021)
Mortality	• Not sufficient data, as often assumed to be replanted in summary statistics	• (UK ETS Authority, 2025)
Condition	• Drought reduces condition and growth	• (UK ETS Authority, 2025)

Correlated risks

Drought is closely linked with wildfire because fuel moisture declines during dry, hot periods, which increases ignition and spread potential (Perry *et al.*, 2022; Forest Research, 2025j). Drought also correlates with pests and disease because water stress can weaken tree defences and enable secondary agents to establish (Atkinson, 2022; Forest Research, 2025g).

Future risk

The outlook is for increasing drought and heat stress risk, especially in warmer and drier parts of Great Britain and on free draining or shallow soils (Yu *et al.*, 2021, Atkinson, 2022). Policy syntheses also treat drought mainly as a driver of condition and growth impacts and as a contributor to interacting hazards, rather than as a dominant driver of permanent woodland area loss at national scale (UK ETS Authority, 2025).

A2.7 Frost

Permanent woodland loss due to frost damage is likely to be near 0%, especially using a 20% canopy cover threshold. Frost is not quantified as a separate cause of permanent woodland loss in previous GB disturbance analyses, and no GB-scale permanent area loss rate is assigned to frost, implying its contribution is negligible compared with wind, pests and diseases, and wildfire at the national scale (UK ETS Authority, 2025).

Although warmer winters are expected to reduce frost damage, there remains a continuing risk from late spring frosts for early flushing species (e.g., beech and sycamore), albeit with impacts generally limited to shoot damage and growth rates rather than large-scale stand mortality (Broadmeadow and Ray, 2005; UK ETS Authority, 2025). Mixed woodlands with a combination of frost-tolerant and frost-sensitive species are expected to suffer lower stand-level damage in frost events than pure stands of sensitive species.

Young trees and regenerating stands are likely to experience the highest rates of frost damage, such that clear-cut forestry plantations may be more susceptible overall. In contrast, closed-canopy, minimally managed stands are generally less susceptible to frost damage due to increased shade and shelter that protects young seedlings/saplings from frost risk (Forest Research, 2025i).

Appendix Table 10 Summary of frost risk and relationship to other parameters

Parameter	Description of Variation	Source
Age	• Young trees and regenerating stands at highest risk	• (Forest Research, 2025i)
Woodland type / species mix	• Broadleaf impact more so than conifer	• Fisichelli, Vor and Ammer 2014
Management/existing condition	• Clear-cut plantations most susceptible, closed canopy minimal	• (Forest Research, 2025i)
Spatial and temporal	• Higher risk inland, and relating to aspect • Increase in risk	• (Broadmeadow and Ray, 2005); • (Atkinson, 2022); • Forest Research, 2025a
Mortality	• Negligible impact	• (UK ETS Authority, 2025)
Condition	• Potential growth implication e.g., reduction in stem length	• Fisichelli, Vor and Ammer 2014

Correlated risks

Frost risk interacts with warming primarily through phenology, as earlier budburst can increase exposure if sub-zero events occur after flushing, which can lead to canopy damage and growth reduction (Broadmeadow and Ray, 2005; Atkinson, 2022). Frost damage can also increase susceptibility to pests and disease by stressing tissues and creating entry points for infection, even when mature stand mortality remains limited (Atkinson, 2022).

Future risk

The outlook is mixed because overall frost frequency is expected to decline as winters warm (Broadmeadow and Ray, 2005). However, late spring frost damage risk may not decline proportionally if budburst advances while variability in spring cold events persists (Broadmeadow and Ray, 2005; Atkinson, 2022).

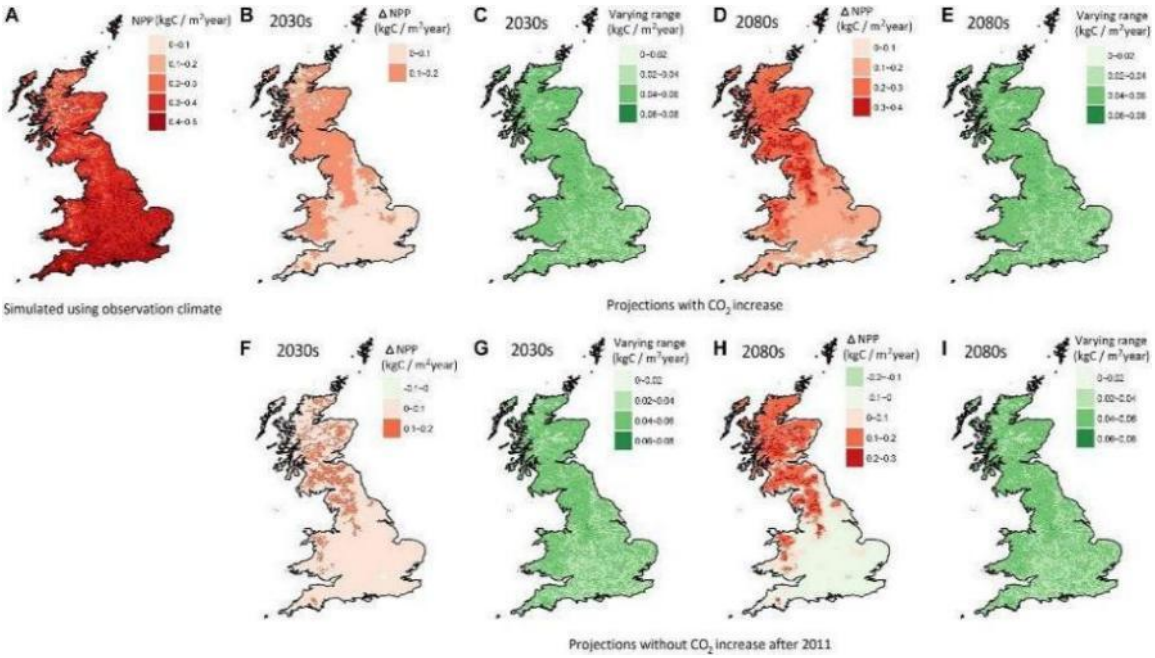
A2.8 Wider impacts to woodland and trees: changes in mean climate conditions and atmospheric CO_2

This section builds on the review of risks from extreme events by considering the effects of long-term changes in mean climate conditions associated with climate change. Under climate change, there is expected to be an increase in average temperatures, alongside changes in average rainfall patterns, including drier summers and wetter winters, and rising atmospheric CO_2 levels. These wider climatic shifts are covered in the preceding sections in relation to the risks from extreme events. In addition, they bring trends from changes to mean conditions and other variables such as CO_2 levels, and will impact growth rates.

The impact of these climatic changes on overall trends in woodland and tree cover is likely to vary spatially and by woodland profile, particularly between tree species and woodland management. In particular, climate change is likely to favour growth rates on native broadleaved trees compared to non-native coniferous trees, such as Sitka spruce (Bateman *et al.*, 2023). Rising atmospheric CO_2 levels are expected to increase plant net primary productivity (NPP), though the extent to which this is realised is dependent on nutrient availability, water stress and other limiting factors. Ritchie *et al* (2019) and Yu *et al.*, (2021) explore the effect of temperature, precipitation and atmospheric CO_2 on trees in Great Britain. Yu *et al.*, (2021) included climatic inputs from a novel large climate scenario ensemble derived from a regional climate model (RCM) under an RCP 8.5 emission scenario. They were assessed using leaf area index (LAI) and net primary productivity (NPP) for the 2030s and the 2080s compared to baseline (1975–2004).

The potential CO_2 effects, which are highly uncertain, were estimated using a constant CO_2 level scenario for comparison. Despite future reductions in precipitation and increasing temperatures, mean projected LAI and NPP generally showed an increase over Britain, with a larger increment in Scotland, northwest England, and west Wales. The CO_2 increase (B and D, Appendix Figure 2 shows higher projected NPP compared to baseline levels, especially in the north (A). However, without accounting for plant-physiological effects of elevated CO_2, NPP in Southern and Central Britain and easternmost parts of Wales showed a decrease relative to 2011, implying less ecosystem service provisioning, e.g., in terms of timber yields and carbon storage (F and H, Appendix Figure 2 .

Yu *et al.*, (2021) also show South East England is the most susceptible to climate change and drought by tree species, with reduced suitability for broad-leaved trees such as beech, small-leaved lime, and hornbeam (climate vulnerability by tree species is mapped by region), which could lead to important changes in woodland composition across England.



Appendix Figure 2 NPP under climate change with and without projected increases in CO_2
Source: Yu et al. (2021).
Figure Note: The modelled present-day NPP (A) averaged over the period from 1975 to 2004 driven by observation climate dataset; the mean (B,D,F,H) and range (C,E,G,I) of the NPP change in the 2030s and the 2080s with and without a CO2 increase, respectively.

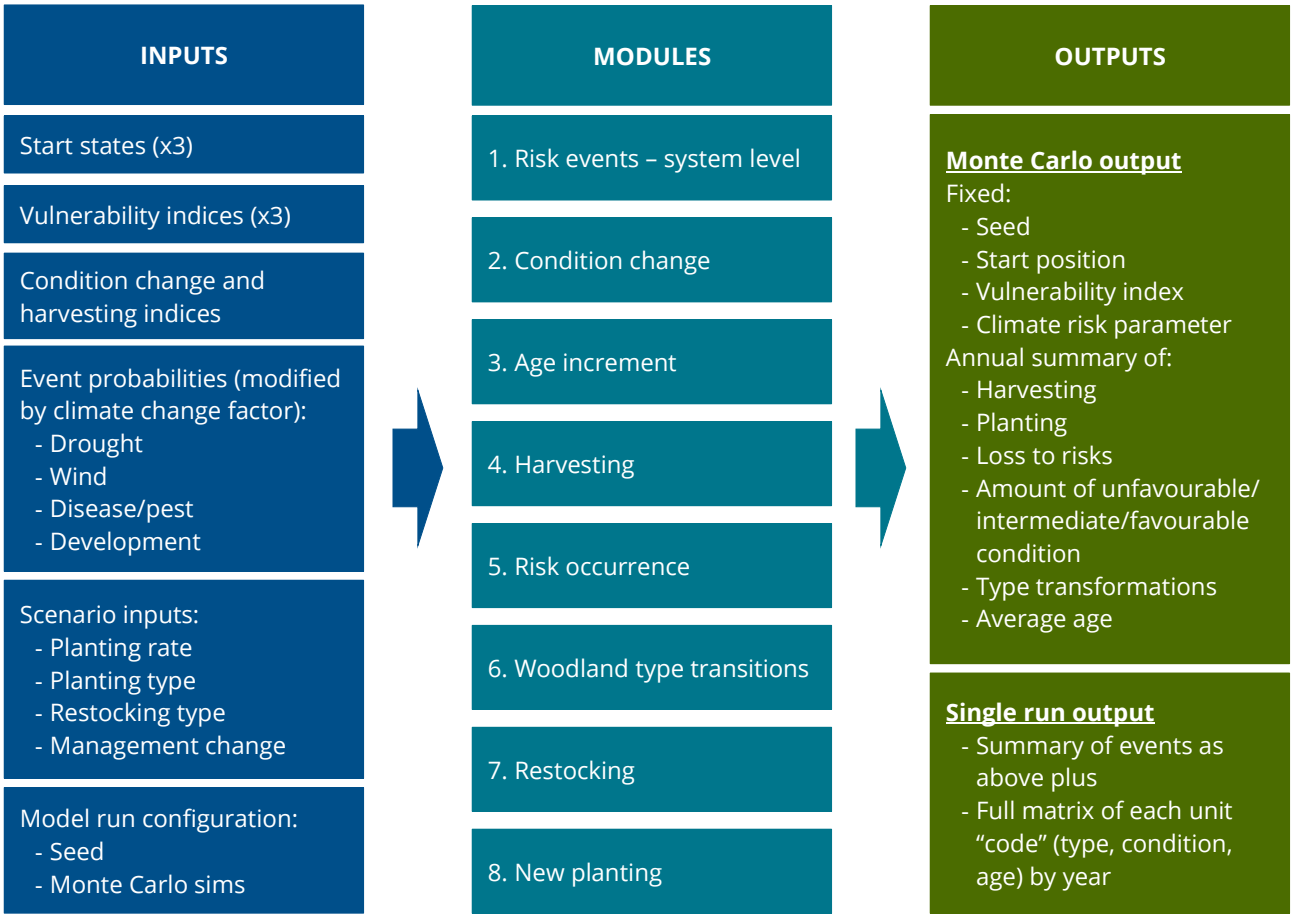
This is corroborated by (Ritchie *et al.*, 2019): with no changes in CO_2, the impact of climate change on broadleaves is a decline in NPP, largely in central and southern England. In contrast, broadleaf trees in the north benefit from the warmer conditions, creating a heterogeneous response. Combined with the physiological effect of increased CO_2, broadleaf tree productivity increases in almost all of England, even in the water-limited region of southeast.

Appendix 3 Woodland and TOW progression model

The woodland and TOW progress model was developed to create probabilistic predictions of the progression of woodland and TOW in England over time based on the current state of woodland and TOW as well as several sets of assumptions and inputs. To do this, the model represents abstracted units of land (100 ha each) as rows in a matrix, which change year on year according to a mix of deterministic and probabilistic processes to predict the progression in woodlands and TOW over time. The model is flexible, in that the processes each unit undergoes from year to year can be adapted by changing a set of input parameters, both to reflect external pressures (e.g., risks) to woodlands, as well as interventions to units (e.g., planting, management, harvesting).

A3.1 Model structure

The model was coded in Visual Basic for Applications (VBA) in Excel, and the inputs and outputs of the model are contained in an Excel spreadsheet. Appendix Figure 3 provides a high-level flow diagram for how the model works.



Appendix Figure 3 Flow diagram of the woodland and TOW model

The model consists of four key elements:

- The woodland and TOW progression matrix, which consists of 24,000 rows which represent 100 ha units of land, and 76 columns, which are the years starting from 2024 until 2100, inclusive. Each unit (row) in the model has:
  - **Static characteristics** which are inputs into the change processes (an ID code and a region code); and
  - **Temporal characteristics** which will both feed into the change process but also capture the outcomes (woodland profile, condition, and age)
- There are also model input vectors and matrices:
  - **Starting state matrix** which defines the extent, profile, condition, and age of woodland in the first year of the model.
  - **Event probability matrix** which defines the likelihood of any given change occurring to woodland or TOW of a specific type, age, and condition.
  - **Risk matrices and vectors** which define the risk of an event occurring either nationally or regionally year on year.
  - **Scenario matrices** which define the planting rates, planting types, restocking types, and management over time.
- Processing modules, coded in VBA:
  - **Pseudo-random number generator** which takes a seed and generates a repeatable string of random numbers between 0 and 1 along a uniform distribution. By changing seed, the outcome of any given simulation is random, but by recording the seed and inputs, the results are repeatable (assuming no interim changes are made to the modules);
  - **Main simulation module** which contains several sub-modules that determine the progression based on occurrences of planting, harvesting, management, and occurrences of risks. This is done using a Markov chain, where the state of a row in the next year is a function of the state in the current year. This also contains trackers of certain events that last multiple years (e.g., pest and disease events).
  - **Monte Carlo module** which re-runs the main simulation module many times based on user specified inputs to create a distribution of progressions and outcomes.
  - **Supporting modules** such as optimisers, output modules, and lookups.

A3.2 The progression matrix

Each row in the progression matrix is a model unit, which is an abstraction of real land somewhere within England. Each model unit is assigned characteristics (such as a region, land type, current state, and management scheme) on a representative basis, such that the sum of all units in the model broadly represent the available data and understanding of the woodlands and TOW in England, as well as land that is able to be converted into woodland.

A3.2.1 Unit size

As the units in the model are an abstraction, they take a uniform size to enable easier calculations and interpretation. The unit size is set to 100 ha for this research. At this size, each unit can take a single state (combination of woodland type, condition, age, etc.), risks can occur to entire units, and the sum of all units and their progression are still a good estimate of the progression of woodlands at a regional level and in England as a whole, as the level of precision is adequate to approximate real changes.

The number of units is determined by the amount of land that is currently woodland, contains TOW, or could become woodland in the future. The current target is approximately 2,200,000 hectares, which divided by 100 ha would be 22,000 units. However, as the modelling also needs to contain land that could become woodland, and this will be different across model runs, the model size is 24,000 units to account for this variation in land use.

As the model is a probabilistic process, it is important that each unit is small enough to not overly influence the outcome of that process. For example, if the unit size is too large, the loss of a woodland to windthrow or the harvesting of a unit could over- or under-represent expected outcomes. However, at 24,000 total units, there would be an average of 2,667 units per region of England, and an average of around 80 units per local authority. This means that any individual unit would represent 0.004% of the national (England) total, 0.035% of the regional total, and 1.25% of the average local authority total. None of these percentages are large enough to produce an outsize influence on the model outputs.

A3.2.2 Woodland and land profiles

Each unit is defined according to a set of static and temporal characteristics.

Only one static characteristic is included in the modelling, region, which serves two purposes: (i) as an input into the modelling process (such as the determination of certain risks); and (ii) to better calculate costs and benefits in the economic modelling.

The temporal characteristics track the progression of the land through the modelling process, and include enough information to understand: (i) the contribution of the land to the woodland targets; (ii) the benefits of that woodland to people; and (iii) how the woodland is likely to change in the next period of the model. Four characteristics have been identified for that purpose:

- **Woodland type (species mix) or not woodland (e.g., agriculture) –** the broad species type of the woodland or the other current land use was captured as one characteristic, as all outcomes of this kind are mutually exclusive. For example, a woodland may move from agricultural production into planting and become a mixed species woodland. This is an outcome variable in itself, but also an input into the management scheme, risks, and the costs and benefits of the woodland in the economic model.
- **Woodland age –** the age of the woodland progressed linearly until such a time that woodland is entirely harvested or lost to a risk (if at all). This is an outcome variable in itself, but also an input into the risks, condition of woodland, and the costs and benefits of the woodland in the economic model.

- **Management scheme of the unit –** this determines if and when woodland is harvested, how the condition of the woodland will change over time, the susceptibility of the woodland to certain risks, and the costs and benefits of the woodland in the economic model.
- **Woodland condition –** this is an outcome variable in itself, but also an input into the risks and the costs and benefits of the woodland in the economic model.

Starting point for each unit

The starting point for each unit is produced by assigning an initial state of the characteristics above, such that it approximates available national data as best as possible. This captures the existing extent and condition of woodland and TOW at the end of 2024 based on best available data. This includes extent data from the national forest inventory (NFI) and TOW map (Forestry Commission, 2025d), condition data based on the NFI woodland ecological indicator (Forest Research, 2020), other national datasets, and best estimates of current rate of woodland felled and lost to different risks each year (e.g., from Forestry Statistics datasets (Forest Research, 2025d)).

This approach provides an initial value across all static and temporal characteristics for each model unit. This means that the temporal data points of the year 2024 will be fixed, such that each unit is defined by the input characteristics above to have the sum of all units represent the current extent and condition of woodland and TOW in the UK as closely as possible. See Appendix A3.3 for more details.

Summary

In summary, each unit is assigned one static characteristic and four temporal characteristics (see Appendix Table 11). This provides the necessary information about that unit and how it progressed over time both to model that process itself but also to understand the outcome by 2100 to estimate the costs and benefits of the aggregate change to woodlands across England.

Appendix Table 11 Unit characteristics

Characteristics of each unit that are static over time	Characteristics of each unit that vary over time
• Region	• Woodland type (species mix) or if not woodland • Woodland age • Management regime • Woodland condition

A3.3 Model inputs and parameters

The model inputs and parameters that govern the model's transition processes can be categorised according to how they vary through time and across scenarios. They can be grouped by whether they are fixed or variable, and if they change over time or between scenarios (see Appendix Table 12). They define planting, management, harvesting, and risk events, and therefore determine how woodland and TOW progress through the model over time. This section describes how each model input and parameter was derived that does not vary between scenarios (i.e., that make up the underlying model), while Appendix 4 sets out the parameter values for each scenario.

Appendix Table 12 Categorisation of model parameters

Parameter category	Description	Examples in the model
Fixed point values	Values that do not vary over time or between scenarios	Unit size; unit region; model start and end years;
Fixed vectors or matrices	Values that vary over time, region, type, or age, but are fixed across scenarios	Event probability matrices; type transition matrices
Scenario inputs	Values that vary between scenarios	Planting type; management change
Probabilistic parameters	Values that vary between model runs or determine probabilistic events	Risk events; climate modifier; vulnerability index selection; starting state matrix

A3.3.1 Dynamic scenario inputs

Other inputs were varied across scenarios, these were:

- **Species mix for new and replacement planting:** which defined the relative proportion of new woodland and replacement woodland that is conifer, broadleaf, or mixed woodland, or TOW
- **Woodland management changes:** how woodlands are to be managed (in aggregate) in the future, based on transitions between management regimes.

A3.3.2 Risk parameters

In the modelling, risks to woodland and TOW vary probabilistically, depending on the static and dynamic characteristics of each unit. Additionally, risks vary over time, increasing due to climate change. Risks are modelled as impacting tree mortality and condition. Risks are modelled in two stages: risk events, followed by risk impacts on units. Some risk events vary regionally, others by type, while the impact of a risk is dependent on the characteristics of a woodland unit, including its type, management regime, and condition.

The literature on impact of risks to woodland based on different variables featured in the modelling (broad species, management regime, condition, age) is predominantly qualitative. A summary of the relative expected impact of different risks across states for woodland variables are shown in Appendix Table 13 – Appendix Table 16 .

Appendix Table 13 Relative risks by broad woodland type

Risk / Broad type	Conifer	Broadleaf	Mixed
Windthrow	**Higher** – shallow-rooted species (esp. Sitka on wet soils) more vulnerable, ForestGALES treats rooting depth and species as key inputs (Forestry Commission, 2015)	**Lower** – deeper rooting, deciduous habit reduces winter wind loading (same source)	**Intermediate** – no UK quantitative comparison found
Drought	**Lower for most conifers** (except Sitka spruce, which is more sensitive than Douglas fir). Douglas fir and western hemlock are more tolerant of drought (Forest Research, 2026d)	**Higher** – beech, birch and sycamore are more sensitive than hornbeam or native oak species (same source)	**Intermediate** – no UK quantitative comparison found
Fire	**Substantially higher per hectare** - Conifer woodland accounted for 2,361 ha burned vs 884 ha in broadleaf, despite conifers being ~25% of England woodland area (Forestry Commission, 2023c) (Forest Research, 2025d). Upwards of 3-5x higher	**Lower per hectare** – same data, broadleaf is ~75% of England woodland but ~25% of area burned	**Intermediate** – no UK quantitative comparison found
Pests & Diseases	Species-dependent	Species-dependent	**Intermediate** – no UK quantitative comparison found

Appendix Table 14 Relative risks by woodland age

Risk / Age	Young	Intermediate	Mature
Windthrow	**Much lower** – below critical windthrow height, (Forestry Commission, 2015)	**Baseline**	**Higher** - windthrow is a major determinant of rotation length in upland areas (Nicoll, Hale and Locatelli, 2026)
Drought	**Much higher** for establishment – >60% loss on worst sites	**Lower** – established root systems	**Somewhat higher** – higher water demand, e.g., beech, but no overall rate
Fire	**Higher** – poor canopy closure allows ground fuel drying (Morison, 2026)	**Lower** – closed canopy suppresses ground fuel	**Baseline**
Pests & Diseases	**Higher for some** – young ash dies faster from dieback, young conifers vulnerable to Hylobius weevil (Forest Research, 2026b)	**Baseline**	**Somewhat higher** – weakened mature trees susceptible to secondary Armillaria attack

Appendix Table 15 Relative risks by woodland management type

Risk / Management type	Unmanaged	Short Rotation	Long Rotation	Continuous Cover Forestry (CCF)
Windthrow	**Somewhat higher** – no thinning reduces individual tree stability, but also no new edges	**Lower** – harvested before reaching critical height	**Higher** – taller trees at greater risk	**Lower** – (Pukkala, Laiho and Lähde, 2016)
Drought				**Possibly lower** – structurally complex stands showed lower drought mortality
Fire	**Higher** – fuel accumulation, no management (Morison, 2026)	**Lower** – regular harvesting reduces fuel load	**Baseline**	
Pests & Diseases	**Somewhat higher** – no sanitation felling	**Baseline**	**Baseline**	**Possibly lower** – species diversity reduces pest pressure in European meta-analyses. Not quantified for UK.

Appendix Table 16 Relative risks by woodland condition

Risk / condition	Unfavourable	Intermediate	Favourable
Windthrow	**Higher –** increased risk where exposure is high and soils are shallow, waterlogged, or poorly drained	**Baseline**	**Lower –** reduced by design and management that avoid high exposure and improve rooting and edge stability
Drought	**Higher –** risk increased by shallow soils, poor drought tolerance species, and strong ground vegetation competition	**Baseline**	**Lower –** reduced where soils hold more water and species and establishment practices fit site moisture constraints
Fire	**Higher –** hazard increased by dead or dying trees, brash, windthrow damage, and constrained access for response	**Baseline**	**Lower –** reduced through good practice in design, planning, operations, and access that limits fuel and spread
Pests and diseases	**Higher –** stress increases susceptibility and large scale windthrow or drought stress can trigger outbreaks	**Baseline**	**Lower –** reduced where stress is minimised and resilience and biosecurity measures are applied

Each of these qualitative descriptions was translated into vulnerability factors which gave the relative probability of each parameter value being affected by risk (if a risk event occurs which it qualifies for). These are shown in Appendix Table 17 . These were based on the descriptions above and adjusted to ensure the total expected risk impact area lined up with historical data.

Appendix Table 17 Relative vulnerability factors

Parameter/ Risk	Windthrow	Drought	Fire	Pests and diseases	Development
Type					
Coniferous unmanaged	1.5	0.5	3	1	1
Coniferous short rotation	2	1	2	0.75	0.25
Coniferous medium rotation	1.5	0.5	2	0.75	0.25
Coniferous long rotation	2	0.5	2	0.75	0.25
Coniferous CCF	1.5	0.5	1.5	0.625	0.25
Broadleaved unmanaged	0.5	1.25	0.75	1	1
Broadleaved light management	0.25	1	0.5	0.75	0.25
Broadleaved rotation	0.33	1	0.33	0.75	0.25
Broadleaved CCF	0.25	1	0.33	0.625	0.25
Mixed unmanaged	1.25	0.5	1	0.75	1
Mixed light management	1	0.5	0.5	0.5	0.25
Mixed CCF	0.5	0.5	0.33	0.33	0.25
Trees outside woodland unmanaged	2	1.25	0.25	1	3
Condition					
Unfavourable	2	2	2	2	2
Intermediate	1	1	1	1	1
Favourable	0.5	0.5	0.5	0.5	0.5
Age					
Very young (0-10)	0.1	5	10	2	0.25
Young (11-30)	0.25	1.25	2	1	1
Intermediate (31-50)	1	0.5	1	1	1
Maturing (51-80)	2	0.75	0.75	1.25	1.25
Mature (81-140)	2.5	1	0.625	1.25	1
Long-established (141+)	0.25	1	0.5	1	0.25

From these vulnerability factors, each woodland combination (across type, condition, and age) was given a vulnerability value to create a vulnerability index, created from the following formula:

$$vulnerability\ value = \exp\left(spread\ factor * \left(ln(factor_{type}) + ln(factor_{age}) + ln(factor_{condition})\right)\right)$$

The spread factor was varied to allow for differing correlation between values and hence the clustering of different woodland combinations. In the model, three values were used: 0.33, 0.67, and 1. The range of outcomes from this can be seen in Appendix Table 18 . The range of vulnerability values is far lower when the spread factor is 0.33 compared to 1. This is included in the modelling to reflect the uncertainty about the impact of different woodlands to risks and the correlation between risks and woodland factors.

Appendix Table 18 Range of vulnerability values from vulnerability index

	Windthrow	Drought	Fire	Pests and diseases	Development
Low spread (0.33)					
Min	0.23	0.50	0.40	0.55	0.31
Median	0.79	0.91	1.00	0.93	0.63
Max	2.15	2.32	3.91	1.59	1.96
Medium spread (0.67)					
Min	0.05	0.25	0.16	0.30	0.10
Median	0.63	0.83	1.00	0.86	0.40
Max	4.64	5.39	15.33	2.52	3.83
High spread (1)					
Min	0.01	0.13	0.06	0.17	0.03
Median	0.50	0.75	1.00	0.80	0.25
Max	10.00	12.50	60.00	4.00	7.50

From this vulnerability index, the probability of each woodland combination being impacted when a risk event is present in a year was derived based on limited quantitative data on average annual area of woodland affected by risks in England in recent years. A summary of this data is presented in Appendix Table 19 . Each vulnerability value was multiplied by the estimated area scalar[33] and, if relevant, the expected risk event probability, providing a starting point for average area affected by risks absent of climate change impacts.

[33] Each scalar is based on quantitative statistics for woodland area, transformed into a % woodland affected for the year which the data is available for. As there is no national level data on risks impact on TOW, it is assumed that TOW were affected at the same rate as woodland for each risk, meaning the % of woodland and tree area affected remains the same.

Appendix Table 19 Estimated area of woodland and TOW affected by risks in 2024

Risk	Estimated area affected in 2024 (%)	Estimated area affected in 2024 (ha)	Source/Notes
Windthrow	0.13%	2,513	NFI woodland data from 2024 (Forestry Commission, 2025d)
Drought	0.01%	193	Judgment, based on Knutzen *et al.*, (2025) who says drought impacts to woodland are lower but same order of magnitude as other risks in Europe
Fire	0.03%	483	Forest research wildfire statistics (Forestry Commission, 2023c)
Pest and disease	0.05%	877	Forestry statistics data on area with statutory health plant notice (Forest Research, 2025d)
Development	0.04%	696	Forestry statistics data on area under development (Forest Research, 2025d)

A3.3.3 Risk events and climate modifiers

Annual risk events were determined separately for each risk where the impact was likely to vary across units (either spatially, or by broad type). Drought and windthrow are modelled as regional annual events, while disease/pests is modelled as events that impact specific broad types of woodland (e.g., conifer). Disease/pest events are persistent and assumed to last for 10 years. Wildfire events correlate with drought, and only occur if there is drought in that region.The probability of an event occurring is an annual roll based on probability per region/type. If these events occur, then for units matching these characteristics, there is a probability that a unit is affected based on its vulnerability index.

The frequency of events is expected to increase over time due to climate change, although there is a lack of quantitative evidence about: i) how much increase there will be, and ii) how this will translate into impacts for trees and woodland. This uncertainty is included in the model with a climate modifier. Some qualitative evidence has been used to inform the expected increase in risk events by 2100 (e.g., 50% increase, double chance etc.). In addition, a random climate event modifier is selected at the start of each run. This is a parameter between (0,1) that modifies how much the increase in risks will be by 2100 and the slope of the change (in a high-risk scenario it assumes the risk is exponential, as the impact from climate change becomes increasingly severe over time). The same climate modifier is applied to the risk event matrices for windthrow, drought and disease/pests for each run.

A3.3.4 Management, condition, and growth parameters

Growth in tree biomass is kept track of via the age of the woodland from the year of planting. However, several parameters also use age to determine when and if certain other events occur. This includes harvesting and the determination of certain ecosystem services, such as carbon sequestration and biodiversity provision. Furthermore, management regimes determine when events like harvesting occur, as well as the progression of condition over time, and therefore each management regime has a probabilistic impact on how the woodland progresses over time.

Management regimes represent a collection of actions taken by the land manager over time (see Section 2.4.2). The modelling does not look at individual actions occurring to each unit but rather uses probabilistic changes to the woodland characteristics such as tree species mix (or land use, if not currently woodland or TOW), condition, and age. Appendix Table 20 presents an indicative set of management regimes, specific example actions that would be expected, and probabilistic outcomes for each set of management actions. Each scenario is made up of different probabilities for what happens to different woodland profiles, reflecting their broad type and management regime.

Appendix Table 20 Management regimes and their probabilistic outcomes

Category	Management regime	Objective	Indicative actions	Probabilistic outcomes
Silvicultural schemes (production focused)	Short-rotation forestry (even aged)	Timber or other wood products production (e.g., pulp)	Relatively uniform planting (within regulatory constraints) Thinning Harvesting at short cycles	Lower relative woodland ages at time of harvest (30-50 years) Specific woodland species mixes Lower relative woodland condition
	Medium-rotation forestry (even aged)	Timber, carbon sequestration	Relatively uniform planting (within regulatory constraints) Thinning Harvesting at moderate cycles	Moderate relative woodland ages at time of harvest (50-80 years) Specific woodland species mixes Lower relative woodland condition
	Long-rotation forestry (even aged)	Specific timber species or products, other objectives	Relatively uniform planting (within regulatory constraints)	Moderate relative woodland ages at time of harvest (80+ years) Specific woodland species mixes Intermediate woodland condition
	Continuous cover forestry or mixed rotation forestry	Timber, carbon sequestration, biodiversity	Higher variety in planting Thinning Harvesting at moderate cycles	No discrete harvest, rather continuous lower levels of timber production Specific woodland species mixes Higher relative woodland condition
Other schemes (other benefit focuses)	Lower intensity management approaches (LIMA)	Carbon sequestration and storage, biodiversity	Natural regeneration Thinning Invasive species removal	No discrete harvest Some small amounts of timber may be harvested as a result of management actions Various species mixes Higher relative woodland condition
	Multifunctional forest management	Recreation, carbon sequestration, biodiversity	Selective replanting Thinning Invasive species removal Habitat provision	Higher relative woodland ages (70+ years) Various species mixes Higher relative woodland condition

Change in condition for each woodland profile is estimated using an annual probability index, based on likely woodland condition for the specific characteristics of a unit (species, management regime, and age). These were derived from the woodland condition assessment (WCA) indicators (Field Studies Council *et al.*, 2024),[34] which are near identical to those used in the NFI Ecological Condition classifications. Based on the qualitative description of each indicator, a likely value for the typical specific woodland type was estimated, and then aggregated together to produce an overall expected condition value.

[34] These indicators are: age distribution of trees; wild, domestic and feral herbivore damage; invasive or non-native plant species; number of native tree species; cover of native tree and shrub species; open space within woodland; proportion of favourable land cover; woodland regeneration; tree health; vegetation and ground flora; woodland vertical structure; veteran trees; amount of deadwood; size of woodlands; and woodland disturbance.

This produced an array of expected conditions for each combination of woodland profile The lowest expected condition was 1.69 for unmanaged coniferous woodland in the youngest age category (0-10 years), and the highest was 2.48 for CCF broadleaved or mixed woodland in the oldest age category (141+ years). From these, the probability of a woodland profile changing type at each condition was produced,[35] such that these expected values would be met by woodland profiles of that type overall.

A3.3.5 Harvest parameters

Clear-fell harvesting was dictated by a combination of woodland profile and age. The summary of harvesting regimes by woodland profile type can be seen in Appendix Table 21 If a unit is a type that can be clear-felled, and its age is within the age band, then there is a probability each year that the unit gets harvested, resetting its age. If it reaches the upper age for harvesting, it is automatically harvested. Note that thinning takes place in many of these regimes, however, it does not lead to a reset in age, and is considered an output that is estimated based on woodland age after the modelling has taken place.

Appendix Table 21 Woodland profile harvesting parameters

No.	Type	Clear-fell harvesting
0	Non-woodland	N/A
10	Coniferous unmanaged	No
12	Coniferous short rotation	30-50 years
13	Coniferous medium rotation	50-80 years
14	Coniferous long rotation	80-140 years
15	Coniferous CCF	Not in model
20	Broadleaved unmanaged	No
21	B. light management and silvo-pastural	No
24	Broadleaved rotation	80-140 years
25	Broadleaved CCF	Not in model
30	Mixed unmanaged	No
31	Mixed light management	No
35	Mixed CCF	Not in model
40	TOW and silvo-arable	Not in model

A3.3.6 New planting parameters

New planting was included deterministically in the modelling, based on the annual national rate of planting needed to achieve the interim target by 2030 (5,800 ha per year between 2025-2029), and the 2050 woodland target (8,300 ha per year between 2030-2050). Planting rates are constant within these two phases. The distribution of planting per region was also deterministic, based on the increase in total

[35] i.e., for woodland at unfavourable condition, the probability of increasing condition to intermediate; for woodland at intermediate condition, the probability of increasing condition to favourable and the probability of decreasing condition to unfavourable; and for woodland at favourable condition, the probability of decreasing condition to intermediate.

woodland area per region. This was estimated from the difference in woodland area between NFI spatial data from 2014 and 2024 (Forestry Commission, 2025d). The increase was converted into a relative proportion of new planting for each region, which was used in the modelling for future planting. This was used to convert hectares into model units (100 ha), averaged across the planting period to ensure the average annual planting rate was reached.[36] To ensure alignment with the constraints included in the modelling, the total amount of planting in each region in the model was compared to the total woodland opportunity area in a region (Friends of the Earth, 2020), to ensure the total woodland planting was feasible. The values can be seen in Appendix Table 22 . Within the modelling, each year, non-woodland units are converted into woodland to reach the total required new planting per region.

Appendix Table 22 New planting rates per region

Region	Annual planting rate (2025-2029) (ha)	Annual planting rate (2030-2050) (ha)	Total planting (2025-2050) (ha)	Total woodland opportunity area (ha)
North East	960	1,380	33,800	40,200
North West	1,546	2,221	54,300	70,700
Yorkshire and The Humber	703	1,010	24,700	60,100
East Midlands	384	552	13,500	34,000
West Midlands	580	833	20,400	49,100
East of England	450	646	15,800	31,100
South West	652	937	23,000	131,600
London	31	45	1,100	2,200
South East	460	660	16,200	48,200

The specific woodland profiles (broad species + management regime) are determined probabilistically from a planting type matrix for each region. These were varied across scenarios. The process for the increase of current trends scenario is set out below. The subsequent scenarios were adjusted from this scenario, to ensure that the scenarios were feasible to achieve.

For the increase of current trends scenario, the broad species categories were determined based on recent new planting proportions at a national level. For woodland, 11% is conifer with an assumption that the rest is split based on existing woodland between broadleaf and mixed. TOW were assumed to make up 17% of all new planting at a national level. The proportion of each type across regions was distributed based on relative proportions of existing woodlands, weighted by planting rates to ensure the national percentages were met. For the management profiles, it was assumed that all newly planted woodland would be managed (at least initially). The split of management profiles within each broad species mix was based on the relative proportions of each (managed) management category.

[36] For example, London should have an average planting rate of 0.45 model units per year between 2030-2050. This was done by having some years where one unit was planted, and others with zero units planted, such that the average totalled 0.45 across the period.

A3.4 Starting point definition (year 0)

The starting state in the model is based on available datasets relating to woodland and TOW extent and type, land available for woodland creation, woodland age, woodland management, and ecological condition (Appendix Table 23

Appendix Table 23 Starting state description and data sources

Parameter	Description	Source	Year of data	Spatial scale	Notes
Woodland extent and type	Extent of existing woodland (by broadleaved, coniferous, and mixed) and TOW	National Forest Inventory (NFI) 2024 (Forestry Commission, 2025d), TOW map report (Hunter *et al.*, 2025)	2024	Region	No dependencies
Land type: land available for woodland creation	Land available for creation of woodland (opportunity mapping)	Friends of the Earth (2020)	2020	Region	No dependencies
Woodland age	NFI softwood and hardwood stocked area by age class	Forest Research (2014); Forest Research (2014a)	2014	Region	Dependent on type
Woodland management	Type of management regime: unmanaged, light management, short rotation (30-50), medium rotation (50-80), long rotation 80+, continuous cover forestry (CCF)	Various quantitative and qualitative sources & expert judgement; see description below	Multiple	England	Dependent on age and type
Condition	NFI overall ecological condition score (favourable, intermediate, and unfavourable); based on 15 individual condition indicators[37]	(Forest Research, 2020)	2014	Region (note national level data was used)	Dependent on management regime and type

[37] Age distribution of trees; herbivore damage; invasive plant species; number of native trees; occupancy of native trees; open space; proportion of favourable land cover; woodland regeneration (stand-level); woodland regeneration (square-level); tree health; vegetation and ground flora; woodland vertical structure; veteran trees; volume of deadwood; total area of woodland (Forest Research, 2020)

A3.4.1 Derivation of management regimes distribution

Management regimes are broken down by unmanaged, light management, short-rotation (30-50) years, medium rotation (50-80 years), long rotation (80+ years), and CCF. The total area of unmanaged woodland is assumed to be 44%, in line with Forestry Commission (2025b); although this reflects woodland that is not recorded as being managed, it is often cited in relation to the proportion of unmanaged or under-managed woodland in England. There is no definitive data source on the breakdown of the 56% managed woodlands, either between broad species type (conifer, broadleaf, mixed) or management regime (e.g., rotation length), therefore assumptions were made based on various quantitative and qualitative sources to produce the distribution of management regimes seen in Appendix Table 24 .

Appendix Table 24 Management regime distribution of current woodland in England

Management number and description	All species (weighted average)	Coniferous	Broadleaved	Mixed
0. Unmanaged	44%	5%	57%	40%
1. Light management	17%	0%	23%	20%
2. Short rotation 30-50	3%	13%	0%	0%
3. Medium rotation 50-80	17%	72%	0%	0%
4. Long rotation 80+	9%	0%	12%	0%
5. CCF	10%	10%	8%	40%
Total	100%	100%	100%	100%

To reach the 44% unmanaged area across woodland species types, it was assumed that 5% of conifers, 57% of broadleaves, and 40% of mixed trees are unmanaged. This is based on the understanding that almost all conifer woodland are managed for timber, meaning the majority of unmanaged woodland will come from other species types.

The remainder of coniferous trees is split between short and medium rotation, and CCF, with the proportions determined by species type (Forestry Commission, 2026) and typical rotation length for a given species, as reported by Forest Research (2026). It was assumed that Sitka spruce is managed for short-rotation, with other conifer species managed as medium rotation. No coniferous species fall into the long-rotation category in the starting state, based on typical rotation lengths of common conifers currently found in England. Managed broadleaved woodlands are assumed to be split between light management, long rotation, or CCF, with the majority falling into light management. Managed mixed woodlands are assumed to be split between light management and CCF, with twice the amount assigned to CCF.

Based on Forestry Commission research (Forest Research, 2026c), 10% of Forestry Commission woodlands are managed using CCF. Assuming this is the same across all woodlands, this was used to derive CCF proportions across each woodland type.

Once these overall management distributions were derived, specific distributions were estimated for three different age classes: 0-50, 50-80, and 80+. This was done to reflect the age classes of different management profiles (e.g., ensure that no woodland older than 50 years is assigned to short rotation coniferous, given

that the maximum harvesting age is 50 year). It also assumes that generally a higher proportion of unmanaged woodland is older, and that CCF is younger, given that newly planted woodland is more likely to be under active management (e.g., as a requirement for grant funding), and CCF is a relatively new management regime.

A3.4.2 Starting state summary stats

Starting state summary stats, averaged across the three potential starting states, in terms of area of woodland are shown in Appendix Table 25 , Appendix Table 26 , and Appendix Table 27 . This gives the amount of each type of broad woodland type by region, and the age distribution and condition per specific woodland profile.

Appendix Table 25 Starting state (averaged) area of each woodland broad type by region

	Coniferous	Broadleaved	Mixed	TOW	Total
North East	68,500 ha	46,800 ha	7,400 ha	18,900 ha	**141,600 ha**
North West	31,400 ha	88,500 ha	8,000 ha	54,000 ha	**181,900 ha**
Yorkshire and The Humber	33,600 ha	79,600 ha	7,200 ha	46,800 ha	**167,200 ha**
West Midlands	24,100 ha	87,900 ha	8,900 ha	73,500 ha	**194,400 ha**
East Midlands	20,200 ha	79,600 ha	4,400 ha	58,800 ha	**163,000 ha**
East of England	36,900 ha	116,500 ha	4,100 ha	84,900 ha	**242,400 ha**
London	200 ha	12,900 ha	100 ha	15,500 ha	**28,700 ha**
South West	52,600 ha	189,700 ha	15,100 ha	126,400 ha	**383,800 ha**
South East	49,500 ha	253,800 ha	11,600 ha	115,000 ha	**429,900 ha**
Total	**317,000 ha**	**955,300 ha**	**66,800 ha**	**593,800 ha**	**1,932,900 ha**

Appendix Table 26 Starting state (averaged) area of each woodland profile by age category

	Very young (0-10 years)	Young (11-30 years)	Intermediate (31-50 years)	Maturing (51-80 years)	Mature (81-140 years)	Long-established (141+ years)	Total
Conifer unmanaged	367 ha	1,367 ha	1,500 ha	1,667 ha	9,733 ha	900 ha	**15,533 ha**
Conifer short rotation	4,500 ha	15,000 ha	21,300 ha	0 ha	0 ha	0 ha	**40,800 ha**
Conifer medium rotation	16,100 ha	51,267 ha	79,400 ha	80,767 ha	0 ha	0 ha	**227,533 ha**
Conifer CCF	2,567 ha	10,333 ha	16,167 ha	4,067 ha	0 ha	0 ha	**33,133 ha**
Broadleaf unmanaged	63,567 ha	139,133 ha	131,533 ha	120,000 ha	77,633 ha	14,167 ha	**546,033 ha**

Broadleaf light management	25,467 ha	56,167 ha	50,733 ha	48,967 ha	31,267 ha	5,933 ha	**218,533 ha**
Broadleaf rotational	7,733 ha	18,333 ha	15,233 ha	41,100 ha	27,600 ha	4,467 ha	**114,467 ha**
Broadleaf CCF	15,867 ha	30,633 ha	29,767 ha	0 ha	0 ha	0 ha	**76,267 ha**
Mixed unmanaged	1,000 ha	4,800 ha	4,333 ha	10,667 ha	4,833 ha	867 ha	**26,500 ha**
Mixed light management	767 ha	1,633 ha	2,233 ha	5,500 ha	2,800 ha	467 ha	**13,400 ha**
Mixed CCF	4,733 ha	11,100 ha	11,067 ha	0 ha	0 ha	0 ha	**26,900 ha**
TOW	61,967 ha	149,333 ha	164,133 ha	139,800 ha	67,633 ha	10,933 ha	**593,800 ha**
Total	**204,633 ha**	**489,100 ha**	**527,400 ha**	**452,533 ha**	**221,500 ha**	**37,733 ha**	**1,932,900 ha**

Appendix Table 27 Starting state (averaged) area of each woodland profile by condition

	Unfavourable	Intermediate	Favourable	Total
Conifer unmanaged	833 ha	14,700 ha	0 ha	**15,533 ha**
Conifer short rotation	1,700 ha	39,033 ha	67 ha	**40,800 ha**
Conifer medium rotation	7,700 ha	219,067 ha	767 ha	**227,533 ha**
Conifer CCF	0 ha	32,267 ha	867 ha	**33,133 ha**
Broadleaf unmanaged	4,933 ha	527,000 ha	14,100 ha	**546,033 ha**
Broadleaf light management	0 ha	173,233 ha	45,300 ha	**218,533 ha**
Broadleaf rotational	3,733 ha	109,567 ha	1,167 ha	**114,467 ha**
Broadleaf CCF	0 ha	59,767 ha	16,500 ha	**76,267 ha**
Mixed unmanaged	1,000 ha	25,433 ha	67 ha	**26,500 ha**
Mixed light management	0 ha	12,067 ha	1,333 ha	**13,400 ha**
Mixed CCF	0 ha	23,900 ha	3,000 ha	**26,900 ha**
TOW	21,467 ha	571,000 ha	1,333 ha	**593,800 ha**
Total	**41,367 ha**	**1,807,033 ha**	**84,500 ha**	**1,932,900 ha**

A3.5 Model outputs

The outputs of the model are the woodland extent and condition by year at the 100 ha unit level for an individual model run (where a model run is the combination of a scenario and a specific set of probabilities determined by a simulation seed). Each model run is only a single data point within a much larger Monte

Carlo simulation structure however, and therefore these outputs need to be summarised across all model runs for each scenario.

Some outcomes can be reported across all model runs, such as the total woodland area, average condition, and average woodland age. These can be reported in terms of the distribution of outcomes for a scenario. Computationally, however, it was not possible to produce outputs per unit per year for each run,[38] and therefore perform the economic analysis across all benefit categories for each model run within a scenario. The summary statistics across the modelling runs can be used to select individual instances in which the economic modelling is performed. For example, the "minimum" outcome of each scenario (lowest aggregate weight sum of woodland area, age, and condition), "maximum" outcome, and average outcome give a reasonable view of the envelope of potential outcomes as well as a likely outcome for a scenario.

As such, the scenario model outputs can be summed over total units or woodland area according to the following components:

- Location: region;
- Woodland attributes: sum by woodland type, age, and other characteristics; and
- Year.

The economic appraisal can be broken down by region (see Appendix 8); benefit (cost) type; and scenario. The appraisals produce outputs for each scenario, which can be viewed comparatively.

The appraisal reflects probabilistic outcomes in the scenario model outputs because ecosystem services provision by woodland is dependent on the characteristics of woodland, and the timing of changes to woodland e.g., loss due to risks. These factors directly affect the time profiling for ecosystem service provision and economic value.

[38] This would be 24,000 * 76 * 250 = 456,000,000 output cells overall

Appendix 4 Scenario parameters

This appendix provides the specific input parameters for each scenario, as well as an explanation of why those inputs are used.

A4.1 Maintain existing woodland scenario

The maintain existing woodland scenario is the pathway used to calibrate the model to verify that risks, harvest rates, natural changes in condition over time, and replanting of existing woodland are all behaving as expected. The outputs of this scenario also help to understand the expected benefits of the current woodland and TOW in England, once all natural changes, risks, and harvesting cycles are accounted for.

The scenario inputs are:

- No woodlands are assumed to be planted outside of restocking, so all new planting is set to 0 ha / region / year (Appendix Table 28);
- As no new woodland is planted, no probabilities are assigned to newly planted woodland by type (all values are assigned 0 or not applicable) (Appendix Table 29);
- Restocking is assumed to occur such that the existing woodland is replaced, so the probabilities are set to 1 from a type to the same type, and 0 everywhere else (Appendix Table 30);
- The management of all woodlands is assumed to remain as is, so the probabilities are set to 1 from a type to the same type, and 0 everywhere else (Appendix Table 31)

Appendix Table 28 Maintain existing woodland – new planting per region by year

Region / Year range	'26 to '30	'31 to '35	'36 to '40	'41 to '45	'46 to '50	After '50
North East	0	0	0	0	0	0
North West	0	0	0	0	0	0
Yorkshire and The Humber	0	0	0	0	0	0
East Midlands	0	0	0	0	0	0
West Midlands	0	0	0	0	0	0
East of England	0	0	0	0	0	0
South West	0	0	0	0	0	0
London	0	0	0	0	0	0
South East	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**

Table note: The number in each cell is the average total ha planted per year per region, using 5-year bands.

Appendix Table 29 Maintain existing woodlands – new woodland type probability matrix

Type planted / Region	North East	North West	Yorkshire and The Humber	East Midlands	West Midlands	East of England	South West	London	South East
00. Non-woodland	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. C. unmanaged	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12. C. short rotation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13. C. medium rotation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14. C. long rotation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15. C. CCF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20. B. unmanaged	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21. B. light management	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24. B. rotation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
25. B. CCF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30. M. unmanaged	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
31. M. light management	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
35. Mixed CCF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
40. TOW	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table note: The number in each cell is the probability for a newly created woodland unit to be a certain type depending on the region.

Appendix Table 30 Maintain existing woodlands – Annual change in woodland type probability matrix

Type in year t / type in year t + 1	00	10	11	12	13	15	20	21	24	25	30	31	35	40
00. Non-woodland	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. C. unmanaged		1												
12. C. short rotation			1											
13. C. medium rotation				1										
14. C. long rotation					1									
15. C. CCF						1								
20. B. unmanaged							1							
21. B. light management								1						
24. B. rotation									1					
25. B. CCF										1				
30. M. unmanaged											1			
31. M. light management												1		
35. Mixed CCF													1	
40. TOW														1

Table note: The number in each cell is the probability of a change from one woodland type to another in any given year that is not a restocking year.

Appendix Table 31 Maintain existing woodlands – Change in woodland type at restocking probability matrix

Type in year t / type in year t + 1	00	10	12	13	14	15	20	21	24	25	30	31	35	40
00. Non-woodland	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. C. unmanaged		1												
12. C. short rotation			1											
14. C. medium rotation				1										
15. C. long rotation					1									
15. C. CCF						1								
20. B. unmanaged							1							
21. B. light management								1						
24. B. rotation									1					
25. B. CCF										1				
30. M. unmanaged											1			
31. M. light management												1		
35. Mixed CCF													1	
40. TOW														1

Table note: The number in each cell is the probability of a change from one type to another in any given year that is not a restocking year.

A4.2 Increase of current trends scenario

The increase of current trends scenario assumes that the current trends in woodland management and planting continue in terms of type but increases the planting rates to achieve the woodland targets.

The scenario inputs are:

- Planting is assumed to occur in quantities to meet the woodland targets and in proportion to recent planting trends (see Section 3.2.2) (Appendix Table 32);
- Woodland is assumed to be planted in types following recent planting trends for each region, with no woodland being planted as unmanaged or long rotation conifer (Appendix Table 33);
- Replanting is assumed to occur such that the woodland has a positive probability of becoming a managed type if it is unmanaged, in proportion to the current planting trends (Appendix Table 34);
- The aggregate level of woodland management is maintained. Currently unmanaged woodland has a 1% annual probability of entering management (Appendix Table 35), while currently managed woodland has a low annual probability of falling out of management. The exact probabilities depend on woodland profile, with the assumption made that broadleaf woodland is more likely to fall out of management as it is largely managed privately. Further, it is assumed that management regimes involving clear-felling are less likely to fall out of management

Appendix Table 32 Increase of current trends – new planting per region by year

Region / Year range	'26 to '30	'31 to '35	'36 to '40	'41 to '45	'46 to '50	After '50
North East	960	1,380	1,380	1,380	1,380	0
North West	1,540	2,220	2,220	2,220	2,220	0
Yorkshire and The Humber	700	1,010	1,010	1,010	1,010	0
East Midlands	380	550	550	550	550	0
West Midlands	580	830	830	830	830	0
East of England	440	650	650	650	650	0
South West	660	940	940	940	940	0
London	40	40	40	40	40	0
South East	460	660	660	660	660	0
Total	**5,760**	**8,290**	**8,290**	**8,290**	**8,290**	**0**

Table note: The number in each cell is the average total ha planted per year per region, using 5-year bands.

Appendix Table 33 Increase of current trends – new woodland type probability matrix

Type planted / Region	North East	North West	Yorkshire and The Humber	East Midlands	West Midlands	East of England	South West	London	South East
00. Non-woodland	0%	0%	0%	0%	0%	0%	0%	0%	0%
10. C. unmanaged	0%	0%	0%	0%	0%	0%	0%	0%	0%
12. C. short rotation	3%	1%	2%	1%	1%	1%	1%	0%	1%
13. C. medium rotation	17%	7%	8%	6%	6%	7%	6%	0%	5%
14. C. long rotation	0%	0%	0%	0%	0%	0%	0%	0%	0%
15. C. CCF	2%	1%	1%	1%	1%	1%	1%	0%	1%
20. B. unmanaged	0%	0%	0%	0%	0%	0%	0%	0%	0%
21. B. light management	32%	36%	36%	36%	34%	36%	36%	37%	40%
24. B. rotation	17%	19%	19%	19%	18%	19%	19%	19%	21%
25. B. CCF	11%	12%	12%	13%	12%	13%	12%	13%	14%
30. M. unmanaged	0%	0%	0%	0%	0%	0%	0%	0%	0%
31. M. light management	3%	2%	2%	1%	2%	1%	2%	0%	1%
35. Mixed CCF	6%	4%	4%	3%	4%	2%	4%	0%	2%
40. TOW	8%	17%	17%	21%	22%	20%	20%	30%	16%

Table note: The number in each cell is the probability for a newly created woodland unit to be a certain type depending on the region.

Appendix Table 34 Increase of current trends – Change in woodland type at restocking probability matrix

Type in year t / type in year t + 1	00	10	12	13	14	15	20	21	24	25	30	31	35	40
00. Non-woodland	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. C. unmanaged		0.5	0.11	0.33		0.06								
12. C. short rotation			1											
13. C. medium rotation				1										
14. C. long rotation					1									
15. C. CCF						1								
20. B. unmanaged							0.5	0.28	0.10	0.12				
21. B. light management								1						
24. B. rotation									1					
25. B. CCF										1				
30. M. unmanaged											0.5	0.17	0.33	
31. M. light management												1		
35. Mixed CCF													1	
40. TOW														1

Table note: The number in each cell is the probability of a change from one woodland type to another, when a woodland unit is restocked.

Appendix Table 35 Increase of current trends – Annual change in woodland type probability matrix

Type in year t / type in year t + 1	00	10	12	13	14	15	20	21	24	25	30	31	35	40
00. Non-woodland	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
10. C. unmanaged		0.99	0.002	0.0065		0.0015								
12. C. short rotation		0.002	0.998											
13. C. medium rotation		0.0065		0.9935										
14. C. long rotation					1									
15. C. CCF		0.0015				0.9985								
20. B. unmanaged							0.99	0.0055	0.002	0.0025				
21. B. light management							0.022	0.978						
24. B. rotation							0.004		0.996					
25. B. CCF							0.005			0.995				
30. M. unmanaged											0.99	0.0035	0.0065	
31. M. light management											0.007	0.993		
35. Mixed CCF											0.0065		0.9935	
40. TOW														1

Table note: The number in each cell is the probability of a change from one type to another in any given year that is not a restocking year.

A4.3 Increased management scenario

The increased management scenario looks at the impact of increasing the overall proportion of woodland that is in management. This is done by bringing currently unmanaged woodland into management while ensuring that managed woodland does not fall out of management.

The scenario inputs are:

- Planting is assumed to occur in quantities to meet the woodland targets and in proportion to recent planting trends (see Section 3.2.2) (Appendix Table 36);
- Woodland is assumed to be planted in types following recent planting trends for each region, with no woodland being planted as unmanaged or long rotation conifer (Appendix Table 37);
- Replanting is assumed to occur such that the woodland has a positive probability of becoming a managed type if it is unmanaged, in proportion to the current planting trends (Appendix Table 38);
- The management of all woodlands is assumed to remain as is, unless it is currently unmanaged, in which case there is a 1% annual probability of entering management (Appendix Table 39) while no currently managed woodland falls out of management, such that approximately 70% of woodland will become managed by 2050 (from 57% in 2025).

Appendix Table 36 Increased management – new planting per region by year

Region / Year range	'26 to '30	'31 to '35	'36 to '40	'41 to '45	'46 to '50	After '50
North East	960	1,380	1,380	1,380	1,380	0
North West	1,540	2,220	2,220	2,220	2,220	0
Yorkshire and The Humber	700	1,010	1,010	1,010	1,010	0
East Midlands	380	550	550	550	550	0
West Midlands	580	830	830	830	830	0
East of England	440	650	650	650	650	0
South West	660	940	940	940	940	0
London	40	40	40	40	40	0
South East	460	660	660	660	660	0
Total	**5,760**	**8,290**	**8,290**	**8,290**	**8,290**	**0**

Table note: The number in each cell is the average total ha planted per year per region, using 5-year bands.

Appendix Table 37 Increased management – new woodland type probability matrix

Type planted / Region	North East	North West	Yorkshire and The Humber	East Midlands	West Midlands	East of England	South West	London	South East
00. Non-woodland	0%	0%	0%	0%	0%	0%	0%	0%	0%
10. C. unmanaged	0%	0%	0%	0%	0%	0%	0%	0%	0%
12. C. short rotation	3%	1%	2%	1%	1%	1%	1%	0%	1%
13. C. medium rotation	17%	7%	8%	6%	6%	7%	6%	0%	5%
14. C. long rotation	0%	0%	0%	0%	0%	0%	0%	0%	0%
15. C. CCF	2%	1%	1%	1%	1%	1%	1%	0%	1%
20. B. unmanaged	0%	0%	0%	0%	0%	0%	0%	0%	0%
21. B. light management	32%	36%	36%	36%	34%	36%	36%	37%	40%
24. B. rotation	17%	19%	19%	19%	18%	19%	19%	19%	21%
25. B. CCF	11%	12%	12%	13%	12%	13%	12%	13%	14%
30. M. unmanaged	0%	0%	0%	0%	0%	0%	0%	0%	0%
31. M. light management	3%	2%	2%	1%	2%	1%	2%	0%	1%
35. Mixed CCF	6%	4%	4%	3%	4%	2%	4%	0%	2%
40. TOW	8%	17%	17%	21%	22%	20%	20%	30%	16%

Table note: The number in each cell is the probability for a newly created woodland unit to be a certain type depending on the region.

Appendix Table 38 Increased management – Change in woodland type at restocking probability matrix

Type in year t / type in year t + 1	00	10	12	13	14	15	20	21	24	25	30	31	35	40
00. Non-woodland	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. C. unmanaged		0.5	0.11	0.33		0.06								
12. C. short rotation			1											
13. C. medium rotation				1										
14. C. long rotation					1									
15. C. CCF						1								
20. B. unmanaged							0.5	0.28	0.10	0.12				
21. B. light management								1						
24. B. rotation									1					
25. B. CCF										1				
30. M. unmanaged											0.5	0.17	0.33	
31. M. light management												1		
35. Mixed CCF													1	
40. TOW														1

Table note: The number in each cell is the probability of a change from one woodland type to another, when a woodland unit is restocked.

Appendix Table 39 Increased management – Annual change in woodland type probability matrix

Type in year t / type in year t + 1	00	10	12	13	14	15	20	21	24	25	30	31	35	40
00. Non-woodland	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. C. unmanaged		0.98	0.004	0.013		0.002								
12. C. short rotation			1											
13. C. medium rotation				1										
14. C. long rotation					1									
15. C. CCF						1								
20. B. unmanaged							0.98	0.011	0.004	0.005				
21. B. light management								1						
24. B. rotation									1					
25. B. CCF										1				
30. M. unmanaged											0.98	0.007	0.013	
31. M. light management												1		
35. Mixed CCF													1	
40. TOW														1

Table note: The number in each cell is the probability of a change from one woodland type to another in any given year that is not a restocking year.

A4.4 Increased conifer proportion scenario

The increased conifer proportion scenario looks at the impact of increasing the proportion of new woodland planting that is coniferous, while still meeting the canopy cover target and increasing the proportion of woodland that is managed.

The scenario inputs are:

- Planting is assumed to occur in quantities to meet the woodland targets and in proportion to recent planting trends (see Section 3.2.2) (Appendix Table 40);
- Woodland is assumed to be planted in types such that conifer planting totals 30% of new planting at a national scale, at the expense of other woodland planting (TOW planting remains unchanged). The distribution of conifer planting is weighted for each region by the amount of existing conifer woodland there, reflecting the regions more suited to conifer species. No woodland is planted as unmanaged or long rotation conifer (Appendix Table 41);
- Replanting is assumed to occur such that the woodland has a positive probability of becoming a managed type if it is unmanaged, in proportion to the current planting trends (Appendix Table 42);
- The management of all woodlands is assumed to remain as is, unless it is currently unmanaged, in which case there is a 1% annual probability of entering management (Appendix Table 43) while no currently managed woodlands fall out of management, such that approximately 70% of woodland will become managed by 2050 (from 57% in 2025).

Appendix Table 40 Increased conifer proportion – new planting per region by year

Region / Year range	'26 to '30	'31 to '35	'36 to '40	'41 to '45	'46 to '50	After '50
North East	960	1,380	1,380	1,380	1,380	0
North West	1,540	2,220	2,220	2,220	2,220	0
Yorkshire and The Humber	700	1,010	1,010	1,010	1,010	0
East Midlands	380	550	550	550	550	0
West Midlands	580	830	830	830	830	0
East of England	440	650	650	650	650	0
South West	660	940	940	940	940	0
London	40	40	40	40	40	0
South East	460	660	660	660	660	0
Total	**5,760**	**8,290**	**8,290**	**8,290**	**8,290**	**0**

Table note: *The number in each cell is the average total ha planted per year per region, using 5-year bands.*

Appendix Table 41 Increased conifer proportion – new woodland type probability matrix

Type planted / Region	North East	North West	Yorkshire and The Humber	East Midlands	West Midlands	East of England	South West	London	South East
00. Non-woodland									
10. C. unmanaged									
12. C. short rotation	8%	4%	4%	3%	3%	3%	3%	0%	2%
13. C. medium rotation	45%	20%	23%	16%	16%	19%	17%	1%	13%
14. C. long rotation									
15. C. CCF	6%	3%	3%	2%	2%	3%	2%	0%	2%
20. B. unmanaged									
21. B. light management	15%	28%	26%	30%	28%	28%	29%	36%	34%
24. B. rotation	8%	14%	14%	15%	14%	15%	15%	19%	18%
25. B. CCF	5%	10%	9%	10%	10%	10%	10%	13%	12%
30. M. unmanaged									
31. M. light management	1%	2%	1%	1%	2%	1%	1%	0%	1%
35. Mixed CCF	3%	3%	3%	2%	3%	1%	3%	0%	2%
40. TOW	8%	17%	17%	21%	22%	20%	20%	30%	16%

Table note: The number in each cell is the probability for a newly created woodland unit to be a certain type depending on the region.

Appendix Table 42 Increased conifer proportion – Change in woodland type at restocking probability matrix

Type in year t / type in year t + 1	00	10	12	13	14	15	20	21	24	25	30	31	35	40
00. Non-woodland	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. C. unmanaged		0.5	0.11	0.33		0.06								
12. C. short rotation			1											
13. C. medium rotation				1										
14. C. long rotation					1									
15. C. CCF						1								
20. B. unmanaged							0.5	0.28	0.10	0.12				
21. B. light management								1						
24. B. rotation									1					
25. B. CCF										1				
30. M. unmanaged											0.5	0.17	0.33	
31. M. light management												1		
35. Mixed CCF													1	
40. TOW														1

Table note: The number in each cell is the probability of a change from one woodland type to another, when a woodland unit is restocked.

Appendix Table 43 Increased conifer proportion – Annual change in woodland type probability matrix

Type in year t / type in year t + 1	00	10	12	13	14	15	20	21	24	25	30	31	35	40
00. Non-woodland	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. C. unmanaged		0.98	0.004	0.013		0.002								
12. C. short rotation			1											
13. C. medium rotation				1										
14. C. long rotation					1									
15. C. CCF						1								
20. B. unmanaged							0.98	0.011	0.004	0.005				
21. B. light management								1						
24. B. rotation									1					
25. B. CCF										1				
30. M. unmanaged											0.98	0.007	0.013	
31. M. light management												1		
35. Mixed CCF													1	
40. TOW														1

Table note: The number in each cell is the probability of a change from one woodland type to another in any given year that is not a restocking year.

A4.5 Increased agroforestry proportion scenario

The increased agroforestry proportion scenario looks at the impact of increasing the proportion of new planting that is a type of agroforestry, while still meeting the canopy cover target and increasing the proportion of woodland that is managed.

The corresponding model inputs are:

- Planting is assumed to occur in quantities to meet the woodland targets and in proportion to recent planting trends (see Section 3.2.2) (Appendix Table 44);
- Woodland is assumed to be planted in types such that agroforestry planting types (lightly managed broadleaf for silvopastoral, TOW for silvoarable) increase by 50% for each region. Remaining planting follows the same regional distribution as the increase of current trends scenario, adjusted down for the increase in agroforestry. No woodland is planted as unmanaged or long rotation conifer (Appendix Table 45);
- Replanting is assumed to occur such that the woodland has a positive probability of becoming a managed type if it is unmanaged, in proportion to the current planting trends (Appendix Table 46);
- The management of all woodlands is assumed to remain as is, unless it is currently unmanaged, in which case there is a 1% annual probability of entering management (Appendix Table 47), while no currently managed woodland falls out of management, such that approximately 70% of woodland will become managed by 2050 (from 57% in 2025).

Appendix Table 44 Increased agroforestry proportion – new planting per region by year

Region / Year range	'26 to '30	'31 to '35	'36 to '40	'41 to '45	'46 to '50	After '50
North East	960	1,380	1,380	1,380	1,380	0
North West	1,540	2,220	2,220	2,220	2,220	0
Yorkshire and The Humber	700	1,010	1,010	1,010	1,010	0
East Midlands	380	550	550	550	550	0
West Midlands	580	830	830	830	830	0
East of England	440	650	650	650	650	0
South West	660	940	940	940	940	0
London	40	40	40	40	40	0
South East	460	660	660	660	660	0
Total	**5,760**	**8,290**	**8,290**	**8,290**	**8,290**	**0**

Table note: The number in each cell is the average total ha planted per year per region, using 5-year bands.

Appendix Table 45 Increased agroforestry proportion – new woodland type probability matrix

Type planted / Region	North East	North West	Yorkshire and The Humber	East Midlands	West Midlands	East of England	South West	London	South East
00. Non-woodland	0%	0%	0%	0%	0%	0%	0%	0%	0%
10. C. unmanaged	0%	0%	0%	0%	0%	0%	0%	0%	0%
12. C. short rotation	2%	1%	1%	1%	1%	1%	1%	0%	1%
13. C. medium rotation	11%	4%	5%	3%	4%	4%	4%	0%	3%
14. C. long rotation	0%	0%	0%	0%	0%	0%	0%	0%	0%
15. C. CCF	2%	1%	1%	0%	0%	1%	1%	0%	0%
20. B. unmanaged	0%	0%	0%	0%	0%	0%	0%	0%	0%
21. B. light management	49%	50%	50%	50%	47%	50%	50%	48%	54%
24. B. rotation	11%	11%	11%	11%	11%	11%	11%	11%	12%
25. B. CCF	7%	8%	8%	8%	7%	8%	8%	7%	8%
30. M. unmanaged	0%	0%	0%	0%	0%	0%	0%	0%	0%
31. M. light management	2%	1%	1%	1%	1%	0%	1%	0%	1%
35. Mixed CCF	4%	2%	2%	1%	3%	1%	2%	0%	1%
40. TOW	11%	21%	20%	25%	26%	24%	24%	34%	19%

Table note: The number in each cell is the probability for a newly created woodland unit to be a certain type depending on the region.

Appendix Table 46 Increased agroforestry proportion – Change in woodland type at restocking probability matrix

Type in year t / type in year t + 1	00	10	12	13	14	15	20	21	24	25	30	31	35	40
00. Non-woodland	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. C. unmanaged		0.5	0.11	0.33		0.06								
12. C. short rotation			1											
13. C. medium rotation				1										
14. C. long rotation					1									
15. C. CCF						1								
20. B. unmanaged							0.5	0.28	0.10	0.12				
21. B. light management								1						
24. B. rotation									1					
25. B. CCF										1				
30. M. unmanaged											0.5	0.17	0.33	
31. M. light management												1		
35. Mixed CCF													1	
40. TOW														1

Table note: The number in each cell is the probability of a change from one woodland type to another, when a woodland unit is restocked.

Appendix Table 47 Increased agroforestry proportion – Annual change in woodland type probability matrix

Type in year t / type in year t + 1	00	10	12	13	14	15	20	21	24	25	30	31	35	40
00. Non-woodland	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. C. unmanaged		0.98	0.004	0.013		0.002								
12. C. short rotation			1											
13. C. medium rotation				1										
14. C. long rotation					1									
15. C. CCF						1								
20. B. unmanaged							0.98	0.011	0.004	0.005				
21. B. light management								1						
24. B. rotation									1					
25. B. CCF										1				
30. M. unmanaged											0.98	0.007	0.013	
31. M. light management												1		
35. Mixed CCF													1	
40. TOW														1

Table note: The number in each cell is the probability of a change from one woodland type to another in any given year that is not a restocking year.

Appendix 5 Model outputs

This appendix includes more detailed model outputs that support the main reporting. Results are presented for the median run from the Monte Carlo simulations of the increase of current trends scenario, to show how the model functions and typical results from a single model run. There are three main outcomes of the woodland and TOW modelling for which the detailed results help show its functioning: (i) the loss of woodland to risks; (ii) the rates of harvesting and replanting; and (iii) the change in woodland condition and average over time based on (i), (ii), and the influence of the currently assumed management regimes.

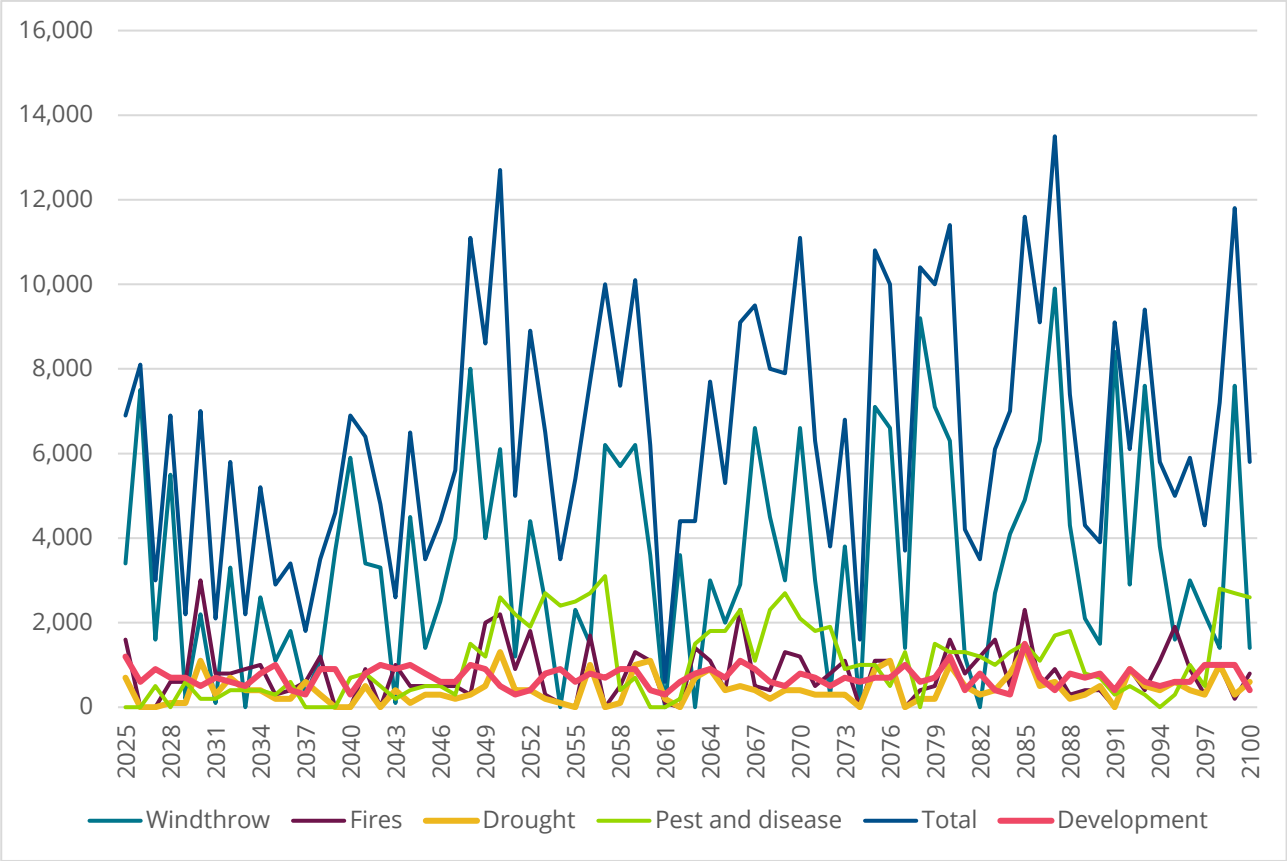
A5.1 Loss of woodland to risks

The average area affected by risks annually can be seen in Appendix Figure 4 .

This shows that the largest risk to woodland and TOW in the modelling is windthrow, which drives the overall area affected by risk. There is high variability in the total amount affected by windthrow, reflecting years in which there are more severe regional events that cause windthrow.

Looking at how other risks are realised in the modelling:

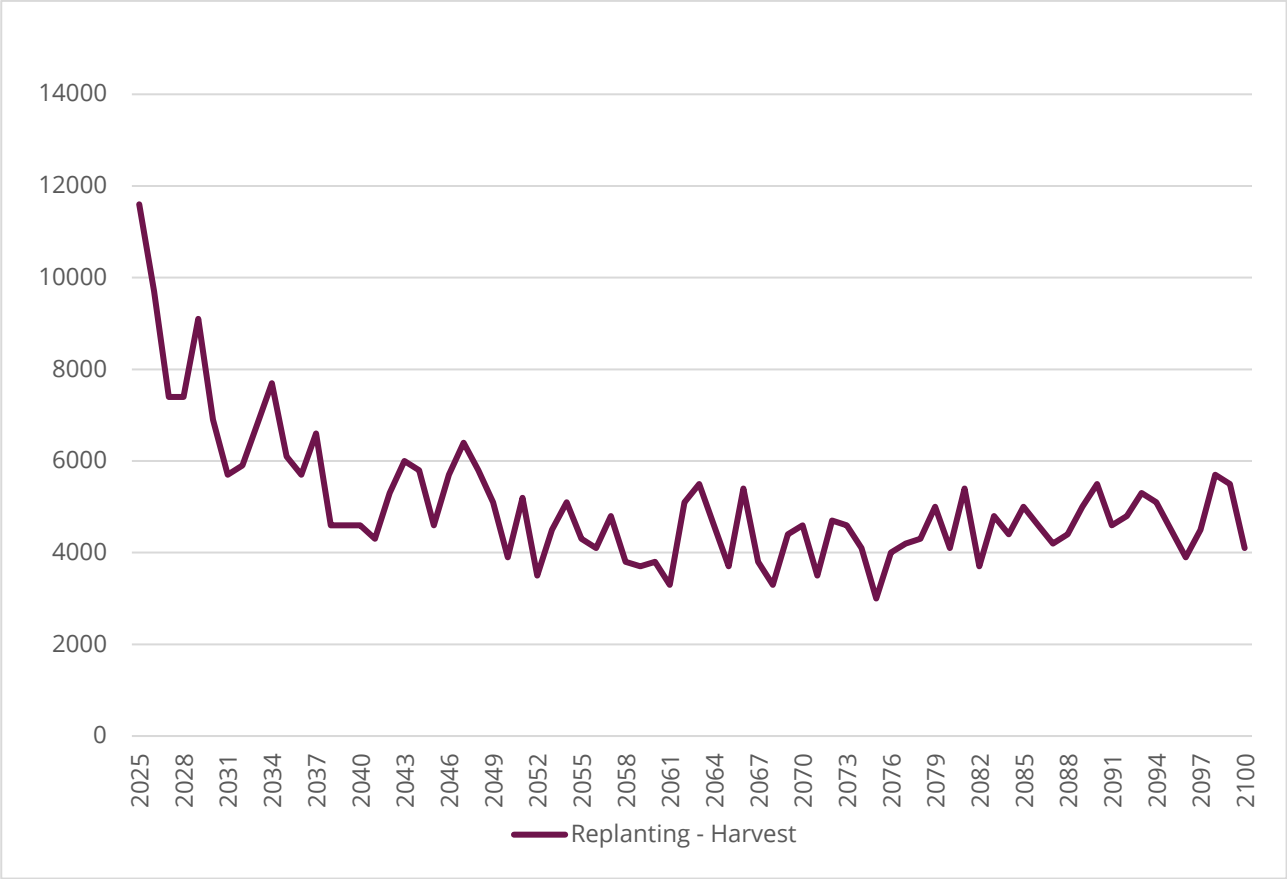
- Woodland lost to development is quite consistent over time with low variance, reflecting the steady stream of woodland and TOW lost to development (it is assumed that equivalent area is planted elsewhere within the same region)
- Pests and disease are quite low with higher spikes that last several years. This simulates how pests and disease spread in the real world and, once established, can impact for several years, especially regarding felling due to statutory health plant notices
- The impact of drought and wildfire is low in terms of mortality, however they show correlation with each other



Appendix Figure 4 **Gross annual area of woodland and TOW lost to risks**

A5.2 Harvesting rates

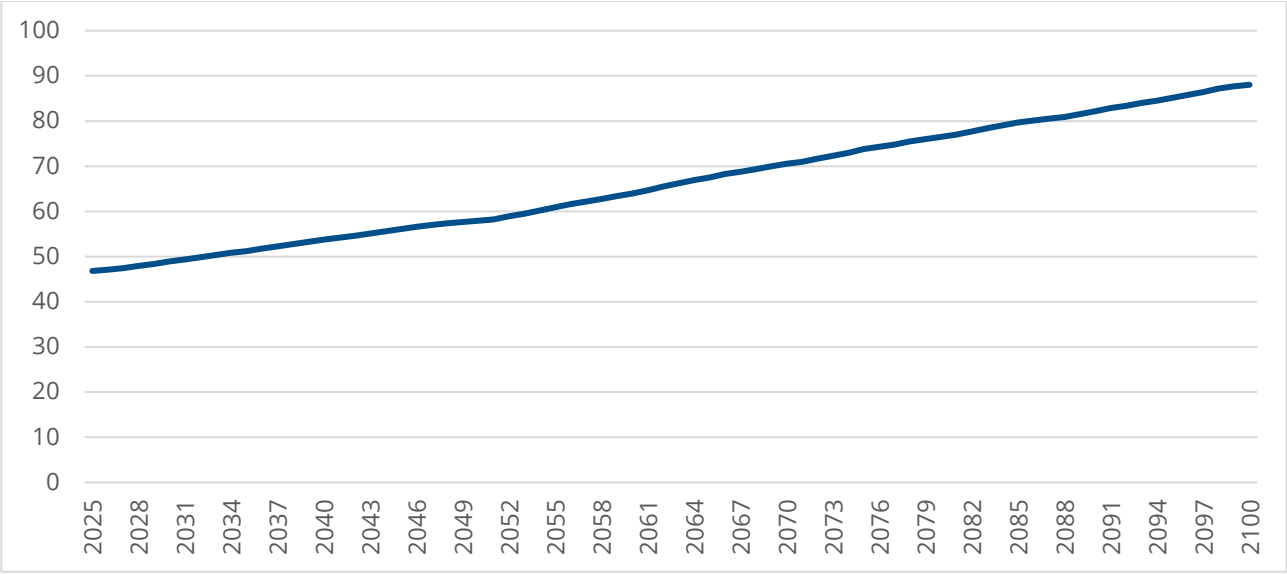
Clear-fell harvesting rates are dictated by the management regime and the age of the woodland. Annual harvesting rates are shown in Appendix Figure 5 . Clear-felling rates are initially high before declining, stabilising, and then increasing slightly towards the end of the modelled period. This aligns with forecasts on the future available stock of timber in the UK, which is expected to decline as large amounts of productive (coniferous) forest are close to reaching harvesting age (Forest Research, 2026a).



Appendix Figure 5 **Annual area (ha) of woodland harvested (clear-fell)**

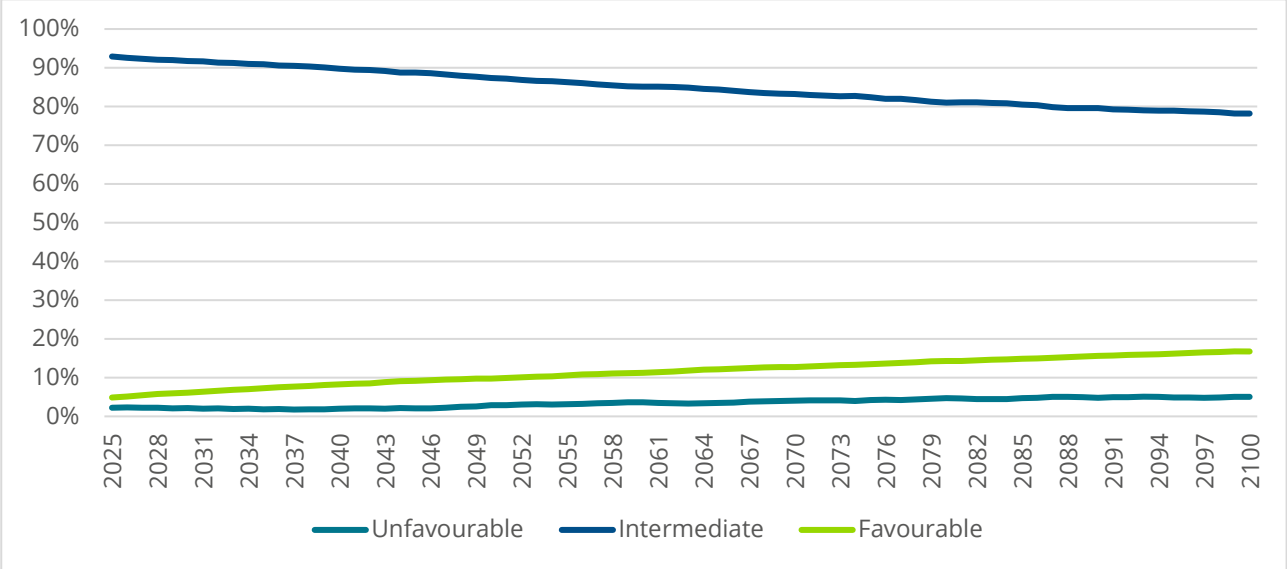
A5.3 Progression of woodland condition and average age

The average age of woodland is seen in Appendix Figure 6 . The average age increases over time, from roughly 45 years to just under 100 years.



Appendix Figure 6 **Average age of woodland (years)**

The proportion of woodland condition at each level over time is shown in Appendix Figure 7 . There is a steady decline in the proportion of woodland at intermediate condition, while both favourable and unfavourable increase. The increase in favourable can be explained by the increase in age of woodland over the model (age is a determinant of condition), and the fact that the UK FS means that all new woodland is modelled as starting at least at intermediate, and therefore has more likelihood of increasing condition to favourable. The increase in unfavourable can be explained by the increased prevalence of risks over time due to climate change.



Appendix Figure 7 Proportion of woodland at each condition level

Appendix 6 Benefit valuation

A6.1 Carbon sequestration

Carbon sequestration benefits were estimated for woodland and TOW. This benefit was estimated using the sequestration rates for each habitat (tonnes CO2 equivalent per hectare) and the non-traded price of carbon.

The Woodland Carbon Code (WCC) calculator (Woodland Carbon Code, 2025) was used to estimate the tCO2e sequestered by woodland and TOW. The 'small' project calculator, which has default assumptions and species-management combinations, was used to calculate carbon sequestration rates over time for nine of the 13 woodland profiles.[39] The remaining profiles, which relate to woodland in rotation, were calculated using the standard calculator. Coniferous short rotation was assumed to be Sitka spruce; coniferous medium rotation was calculated using a combination of Lodgepole pine, Norway spruce, European larch, Scots pine, Corsican pine, and Douglas fir as inputs; coniferous long rotation uses Scots pine; and broadleaf long rotation uses Pedunculate/common oak. Spacing and yield class assumptions entered were based on information on each species available on the Forest Research website (Forest Research, 2026h). The marginal net carbon sequestration each year from planting was multiplied by the area of woodland by age in each of the profiles in each year.

The amount of CO2e sequestered was then valued by multiplying the estimated tonnes of CO2e sequestered by the DESNZ (2023) non-traded central price timeseries per tonne of CO2e, inflated to 2026 prices. Future flows of carbon are valued using the carbon values series until 2050. Following DESNZ (2023) advice, a real annual growth rate was then applied starting at the most recently published value for 2050 and into the future. High, medium, and low values were applied for sensitivity.

A6.2 Timber production

The volume of removals from both thinning and clear-fell was estimated according to the modelled outputs. Appendix Table 21 provides the woodland profile clear-fell harvesting age parameters. The standing volume at clear-fell (m^3 overbark per hectare) is assumed to be 400 for coniferous short rotation (profile 12), 350 for coniferous medium rotation (profile 13), 400 for coniferous long rotation (profile 14) and 250 for broadleaved rotation (profile 24). Assumptions on thinning age, frequency, and percentage of woodland thinned are shown in Appendix Table 48 .

[39] Coniferous unmanaged (10): native Scots pine minimum intervention / no thinning; coniferous CCF (15): conifer area thinned; broadleaved unmanaged (20): broadleaf minimum intervention; broadleaf light management (21): broadleaf minimum intervention; broadleaf CCF (25): broadleaf thinned; mixed profiles are assigned to the same categories respectively; TOW (40): broadleaf minimum intervention.

Appendix Table 48 Thinning assumptions

No.	Type	Thinning age (subsequent thinning frequency), years	Standing volume at thinning age (assumed % thinned)
0	Non-woodland	NA	NA
10	Coniferous unmanaged	NA	NA
12	Coniferous short rotation	18 (5)	81 (0.5)
13	Coniferous medium rotation	25 (5)	56 (0.5)
14	Coniferous long rotation	30 (5)	56 (0.5)
15	Coniferous CCF	NA	NA
20	Broadleaved unmanaged	NA	NA
21	B. light management and silvo-pastural	NA	NA
24	Broadleaved rotation	30 (10)	10 (1)
25	Broadleaved CCF	30 (10)	10 (1)
30	Mixed unmanaged	NA	NA
31	Mixed light management	NA	NA
35	Mixed CCF	25 (7)	10 (1)
40	TOW and silvo-arable	NA	NA

The monetary value of timber products was estimated by applying unit values per cubic meter of overbark standing using the Timber Price Indices (Forest Research, 2026g). The average price over the period 2023–2026 (£34) is used as the central estimate. High and low estimates are defined as one standard deviation above and below the mean, respectively (£36 and £33).

A6.3 Air pollutant removal

Air quality benefits arise from the ability of different types of vegetation to remove pollutants from the air. This benefit was estimated for the amount of PM2.5 removed by woodland (which makes up more than 70% of this benefit in the UK (Jones *et al.*, 2017)) and the human health benefits of this removal.

Jones *et al.*, (2017) modelled this benefit for the UK national accounts using data on the variety of different levels of PM2.5 concentration, types and extent of vegetation and density of human population across the country. An update to this study has produced estimates of PM2.5 removal per hectare of woodland by local authority.

The economic value of this service is estimated through the resulting avoided healthcare cost at local authority level (eftec and UKCEH, 2025). The analysis shows the benefits as the result of avoided health care cost due to PM2.5 removed for a given local authority area (eftec and UKCEH, 2025), which was multiplied by the total area of woodland. For this analysis, the local authority-level PM2.5 removal values were weighted according to the amount of existing woodland in the local authority, thereby assuming that the

distribution of woodland new planting, which was modelled at the regional level, follows the same distribution. The weighted average PM2.5 removal per hectare by region was then multiplied by the £ per ha, and then by the woodland area each year in the model outputs.

It should be noted that as time goes on, PM2.5 removal is estimated to fall based on an assumption about emissions and concentrations falling over time (eftec and UKCEH, 2025). As such, future benefits decline in line with the lower emission / concentration assumption. Moreover, as woodland matures, its capacity to remove PM2.5 increases. Accordingly, in each time period, the area of woodland in each region, by year since planting, was adjusted using a 'time from planting' factor. Benefits were discounted at lower levels using the lower health discount rates (HM Treasury, 2026).

A6.4 Flood regulating

Flood regulating benefits were based on an estimate of the additional water storage capacity of woodland compared to grassland from Broadmeadow *et al.* (2023). They estimate the higher water use of trees compared to shorter vegetation by woodland type (conifer and broadleaves) and converted to cubic metre (m^3) equivalent flood water storage per hectare. This comprises two components: the direct evaporation of water due to wet canopy evaporation (commonly known as interception) during an actual flood event; and the additional potential available water storage within woodland soils created by the higher woodland water use over consecutive days leading up to a flood event. Moreover, estimates for the volume of flood water retained by hydraulic roughness are provided. The total water stored/used applied in the analysis is 332 m^3 per ha for conifer, 430m^3 per ha for broadleaves, 301m^3 for TOW and 362 m^3 for mixed woodland. The unit value for the annual average additional woodland soil water storage capacity was applied to the total area of woodland each year. Note that flood regulating benefits are not applied to woodland under 15 years of age.

As used in Broadmeadow *et al.* (2023), the annualised "replacement" cost of providing such flood water storage (based on seven reservoirs at an average of £0.47/m^3) was then used as an estimate of the flood alleviation value provided by woodland. The range reported in Broadmeadow *et al.* (2023) (£0.11/m^3 to £1.32/m^3) was applied in the sensitivity analysis.

A6.5 Water quality

Maintaining the quality of water in the environment could have financial benefits for businesses (e.g., avoided water treatment costs) and welfare benefits to the public as a proxy for many ecosystem services provided. The physical change was estimated by calculating the water quality impact area attributable to woodland areas. This was assumed to be 2% of woodland and TOW area, based on a conservative approximation of planting that contributes to water quality (e.g., woodlands for water projects) (The Rivers Trust, 2025). Water pollutant load reductions for phosphorous, nitrogen, and fine particles were then applied to the impact area (Appendix Table 49). Load reductions were calculated based on the tonnes and effectiveness of load reductions from the Separate source apportionment model (Environmental Information Data Centre, 2026) and evidence from the literature (Tsai *et al.*, 2022; Environmental Protection Agency., 2009).

Appendix Table 49 Pollutant load reduction

Pollutant	Pollutant load reduction – Low (kg/ha)	Pollutant load reduction – Medium (kg/ha)	Pollutant load reduction – High (kg/ha)
Phosphorous	0.33	0.52	0.73
Nitrogen	9.43	19.62	30
Fine particles	38.1	228.57	476.19

The annual value of reducing a kilogram of nitrate, phosphorus and fine particles in water from agricultural sources was obtained from the FARMSCOPER tool (Defra, 2013), as reported in ENCA (Defra, 2026b). Note that water quality benefits were not applied to woodland under 15 years of age. There is uncertainty around these values, and these simple costings per unit of pollution reduced assumes that all reductions are equally beneficial, whereas reductions in relatively pristine waters may not be as beneficial as the same reductions in more polluted waters (Defra, 2026b).

A6.6 Biodiversity and recreation

Research on the value of forest biodiversity (eftec, 2025) was used to estimate the changes in welfare value from improved forest biodiversity. The household values and corresponding aggregate benefit estimates provided by this study are interpreted as a direct contribution to household welfare from forest biodiversity. The estimates are split into use values (such as benefits from recreation and amenity) and non-use values (such as values held due to bequest and altruism motivations).

Forest biodiversity is represented by changes in species diversity within forests and woodlands due to management changes, as well as the creation of new forest and woodland habitats through land-use change. However, measuring the impact of woodland creation and management changes on forest biodiversity directly (and at the scale of this analysis) is challenging. In this application, biodiversity is proxied by woodland condition, based on the WCA4 criteria. Therefore, woodland at higher condition, regardless of specific woodland type or management practices, is assumed to have higher levels of biodiversity.

Within an ecosystem services framework, the values estimated by this project can be understood as the cultural ecosystem service benefits associated with forests and woodlands. Unit non-use and use values are used to estimate the cultural value of biodiversity and recreation due to modelled changes in woodland condition.

The estimated non-use values of changes in forest condition can be seen in Appendix Table 50 . These vary according to the extent of the change in condition. Appendix Table 51 shows the use value derived from changes in forest condition. There is no difference in estimated values across the extent of the change, and only an increase in extent of woodland increases the use value, rather than the condition of that woodland.

Appendix Table 50 Non-use value of changes in forest biodiversity (condition), 2026 prices

Change in condition	£/hectare – Low	£/hectare – Central	£/hectare – High
Minimum to unfavourable	£0	£0	£0
Minimum to intermediate	£3,200	£3,700	£4,200
Minimum to favourable	£4,600	£5,300	£6,000
Unfavourable to intermediate	£3,200	£3,700	£4,200
Unfavourable to favourable	£4,600	£5,300	£6,000
Intermediate to favourable	£1,400	£1,600	£1,800

Appendix Table 51 Use-value of changes in forest biodiversity, 2026 prices

Change in condition	£/hectare – Low	£/hectare – Central	£/hectare – High
Minimum to unfavourable	£2,900	£3,300	£3,700
Minimum to intermediate	£2,900	£3,300	£3,700
Minimum to favourable	£2,900	£3,300	£3,700
Unfavourable to intermediate	£0	£0	£0
Unfavourable to favourable	£0	£0	£0
Intermediate to favourable	£0	£0	£0

Appendix 7 Costs

The costs reported in Appendix Table 52 are the central estimates used in the analysis for each woodland profile. There are four cost categories. Establishment costs, which are applied in the year the woodland or TOW is first created. Restocking costs, which are applied whenever the woodland or TOW is replanted (either after clear-felling for timber or after being lost to a risk). Maintenance costs are applied every year, as are opportunity costs. Low and high values reported by (Redman, 2024) and Low *et al.* (2024) were also applied in sensitivity testing.

Appendix Table 52 Per hectare costs used in the modelling

Woodland type	Establishment (first planting)	Restocking (subsequent plantings)	Maintenance	Opportunity cost
Source	(Redman, 2024)	Establishment cost minus £2,000	(Redman, 2024)	Low *et al* (2024)
Conifer unmanaged (10)	£5,400	£3,400	£0	£189
Conifer short rotation (12)	£5,400	£3,400	£750	£189
Conifer medium rotation (13)	£5,400	£3,400	£750	£189
Conifer long rotation (14)	£5,400	£3,400	£750	£189
Conifer CCF (15)	£5,400	£3,400	£750	£189
Broadleaf unmanaged (20)	£9,500	£7,500	£0	£222
Broadleaf light management (21)	£9,500	£7,500	£193	£222
Broadleaf rotational (24)	£9,500	£7,500	£750	£222
Broadleaf CCF (25)	£9,500	£7,500	£750	£222
Mixed unmanaged (30)	£7,040	£5,040	£0	£206
Mixed light management (31)	£7,040	£5,040	£193	£206
Mixed CCF (35)	£7,040	£5,040	£750	£206
TOW (40)	£6,150	£4,150	£243	£154

Appendix Table 53 provides a detailed categorisation of the costs. This includes what specific items/activities each cost category includes, how each cost is included in the appraisal and the rationale for inclusion or exclusion.

Appendix Table 53 Costs included and excluded from the assessment

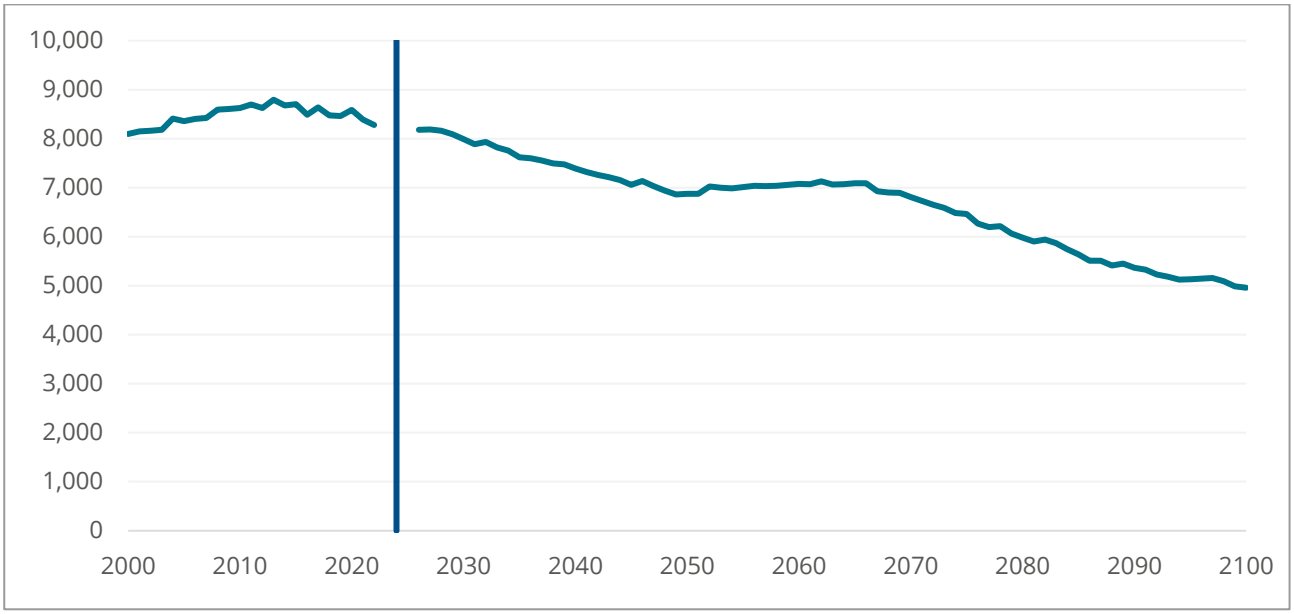
Category	Items/activities	Included in...	Rationale
Planning	• Surveys • Management plan development	• Establishment costs	• Important to realising benefits • Genuine opportunity cost
Site preparation	• Scrub removal	• Establishment costs	• Important to realising benefits • Genuine opportunity cost
Ground preparation	• Ploughing • Mounding	• Establishment costs	• Important to realising benefits • Genuine opportunity cost
Planting	• Sapling purchase • Labour	• Establishment costs • Restocking costs	• Important to realising benefits • Genuine opportunity cost
Tree protection and fencing	• Deer fencing • Tree guards and shelters • Destructive species control (deer)	• Establishment costs • Maintenance costs	• Important to realising benefits • Genuine opportunity cost
Roads and tracks	• Roads • Paths • Gates	• None	• No clear assumption about existing v. new infrastructure required, may not represent a genuine opportunity cost
Ongoing management	• Maintenance	• Maintenance costs	• Woodland management included, capital infrastructure maintenance not included
Insurance	• Premiums	• None	• Lost production from risk already implicit in model
Opportunity costs	• Forgone income from other sources	• Opportunity cost	• Genuine opportunity cost

Appendix 8 Economic appraisal results

This appendix presents further results from the economic assessment of the median Monte Carlo simulation for the increase of current trends scenario. Results are presented over time and in comparison to (available) historical data from England woodland natural capital accounts (Office for National Statistics, 2026), to show the credibility of the model and the appropriateness of the appraisal.

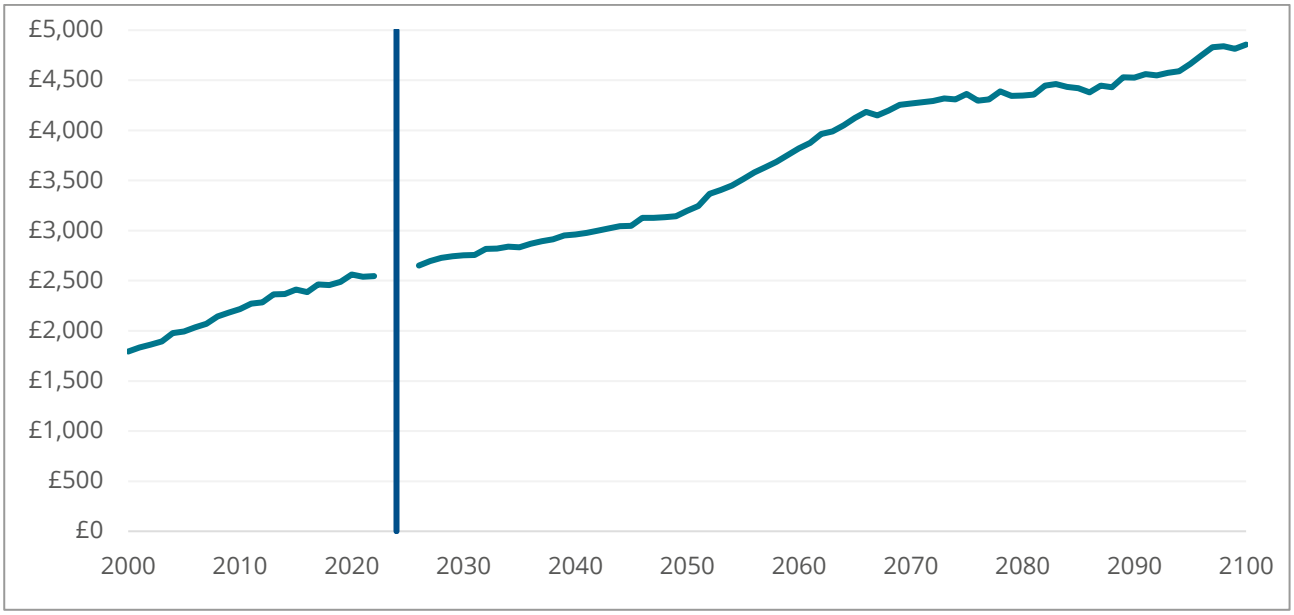
Carbon sequestration

The annual carbon sequestration rate of woodland (excluding TOW) can be seen in Appendix Figure 8 . Trends from historical data are matched well. This aligns with modelling done by the CCC for the UK's carbon budgets, and reflecting the maturing of England's woodland, at which carbon sequestration rate declines (the stock of carbon storage continues to increase) (Thomson, Young and Nickerson, 2025).



Appendix Figure 8 Carbon sequestration annual physical flow
Figure note: Units are million tCO2e per year. Vertical line is 2025, values before that line are historical data, values after that line are projections)

The undiscounted value from benefits of carbon sequestration from woodlands is expected to increase over time. This is shown in Appendix Figure 9 and is driven both by the increase in woodland area from planting and by the increase in the social value of carbon into the future.

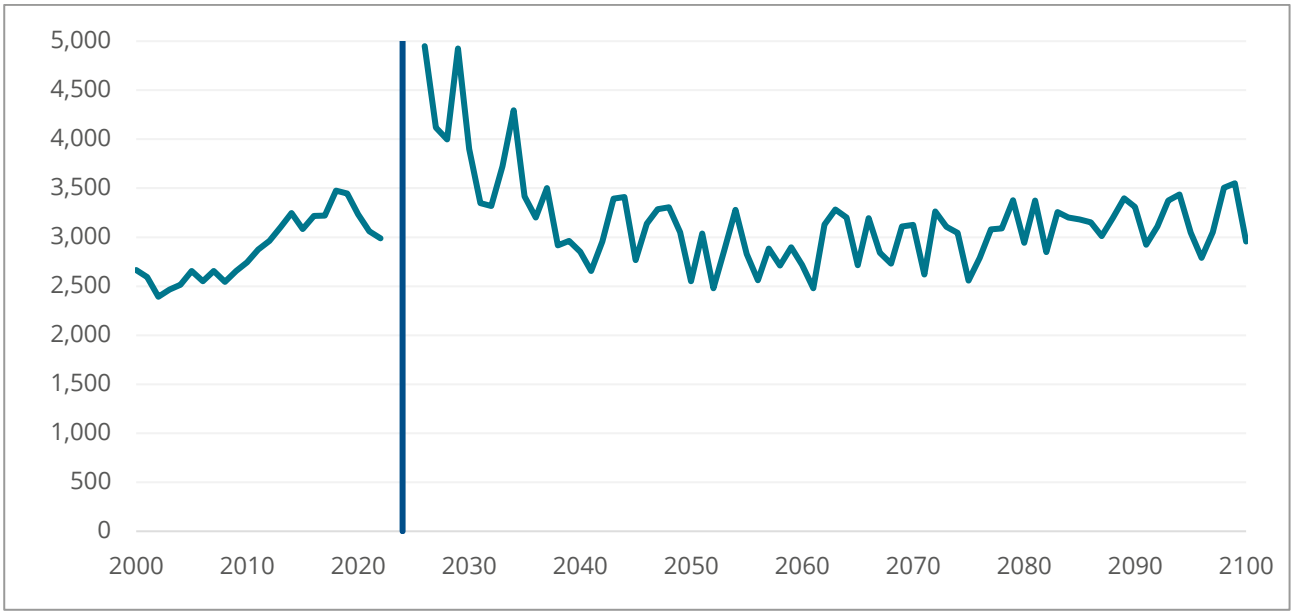


Appendix Figure 9 Carbon sequestration benefits over time

Figure note: Units are million £ per year. Vertical line is 2025, values before that line are historical data, values after that line are projections.

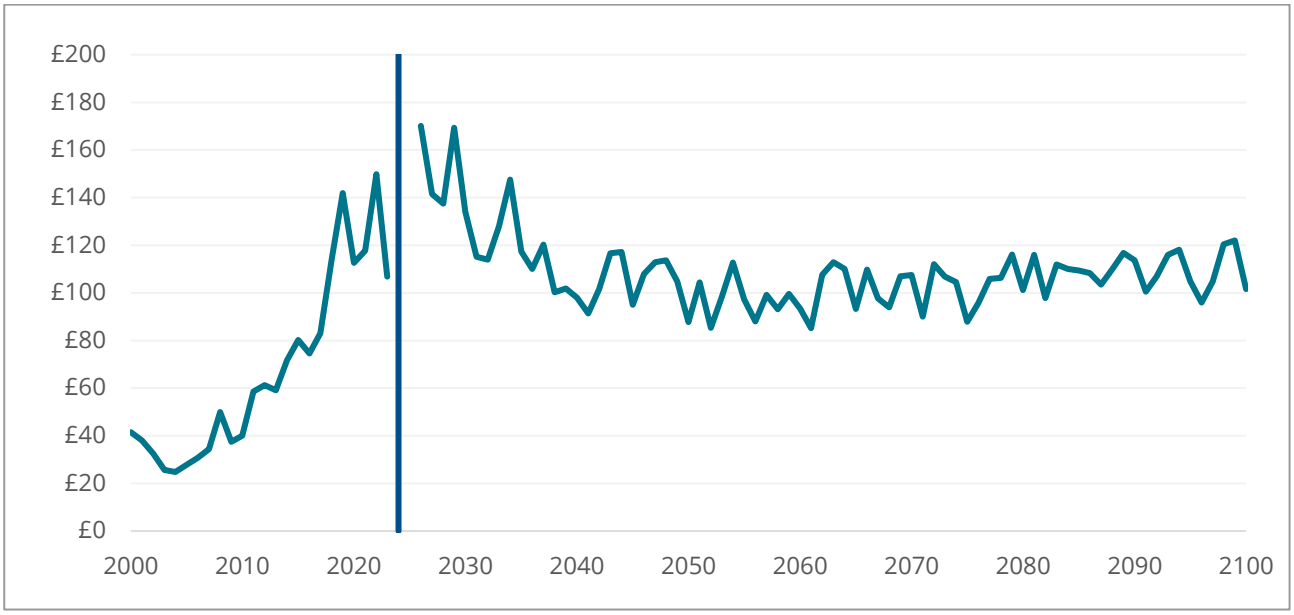
Timber provisioning

Timber provisioning, on the other hand is highly variable depending on the price of timber at any given time. Looking at the historic annual provision of timber in physical terms (Office for National Statistics, 2026), this has been between 2,000 and 3,500 thousand cubic metres overbark per year (standing), see Appendix Figure 10 . Modelled annual timber production is somewhat higher initially, before declining to roughly similar levels. This can be explained as the model harvests all overdue timber each year. Newly planted woodland does not make a big difference to overall harvesting rates, as most clear-felling of newly planted woodland happens beyond 2100. This model output also requires conversion from area (ha) to volume of timber (m^3 overbark), and therefore assumptions about this conversion rate have been made (see Appendix A6.2 for details), whereas historical data is based on timber volume data itself.



Appendix Figure 10 Timber production from clear-fell over time
Figure note: Units are thousand m^3 overbark standing. Vertical line is 2025, values before that line are historical data, values after that line are projections.

However, compared to the physical value, the benefits of timber production have risen by more over time. This is shown in the historical data in Appendix Figure 11 , where the annual value of timber provisioning service has increased from approx. £40 million to over £100 million, driven by increase in timber prices over the period. In the assessment, timber prices are modelled as having a range (with a central value of £35 / m^3), therefore the same trend is not seen in the modelled data.



Appendix Figure 11 Non-discounted timber benefits over time
Figure note: Units are million £ per year. Vertical line is 2025, values before that line are historical data, values after that line are projections

Appendix 9 Regional level results

An example of comparisons between regional level results, across different regions and different scenarios can be seen in Appendix Table 54 . While the costs and benefits of woodland and TOW planting and maintenance do vary by region, the modelled differences are mostly due to differences in woodland and TOW area. The differences between scenarios are minimal at the regional level as well as the national level, demonstrating that scenarios have minimal regional variation and impact on results within the modelling framework used.

Appendix Table 54 Example regional net benefits for increased management and increased conifer proportion scenarios

Ranges in terms of smallest, median, and largest net benefits (PV75 terms in line with the model period of 2025 to 2100, £'billions)

Region	North East	North East	South East	South East
Scenario	**Increase of current trends**	**Increase conifer proportion**	**Increase of current trends**	**Increase conifer proportion**
Benefits	**£20.1 (£11.0 to £33.1)**	**£20.7 (£11.3 to £33.7)**	**£38.3 (£17.9 to £77.1)**	**£39.2 (£18.6 to £77.8)**
Carbon sequestration	£13.7 (£6.7 to £20.4)	£14.3 (£7.0 to £21.2)	£23.7 (£12.2 to £35.6)	£24.7 (£12.2 to £36.5)
Timber provision	£0.6 (£0.6 to £0.7)	£0.7 (£0.7 to £0.7)	£0.6 (£0.5 to £0.6)	£0.6 (£0.6 to £0.6)
Air pollutant removal	£1.7 (£0.6 to £5.8)	£1.7 (£0.6 to £5.6)	£9.9 (£3.4 to £32.1)	£9.7 (£3.4 to £31.9)
Flood regulation	£0.8 (£0.2 to £2.2)	£0.8 (£0.2 to £2.2)	£2.2 (£0.5 to £6.1)	£2.1 (£0.5 to £6.0)
Cultural benefits of increased biodiversity provision[1]	£2.7 (£2.3 to £3.3)	£2.7 (£2.3 to £3.3)	£1.7 (£1.1 to £2.4)	£1.8 (£1.6 to £2.5)
Change in recreational opportunity[2]	£0.6 (£0.5 to £0.7)	£0.6 (£0.5 to £0.7)	£0.3 (£0.2 to £0.3)	£0.3 (£0.2 to £0.3)
Water quality	£0.0 (£0.0 to £0.0)	£0.0 (£0.0 to £0.0)	£0.0 (£0.0 to £0.1)	£0.0 (£0.0 to £0.1)
Costs	**£3.1 (£2.4 to £3.9)**	**£3.4 (£2.5 to £4.2)**	**£6.1 (£4.7 to £8.0)**	**£6.5 (£5.0 to £8.5)**
Establishment cost	£0.2 (£0.2 to £0.2)	£0.2 (£0.1 to £0.2)	£0.1 (£0.1 to £0.1)	£0.1 (£0.1 to £0.1)
Restocking cost	£0.2 (£0.1 to £0.2)	£0.2 (£0.1 to £0.2)	£0.3 (£0.3 to £0.4)	£0.4 (£0.3 to £0.4)
Maintenance cost	£1.9 (£1.4 to £2.4)	£2.2 (£1.6 to £2.6)	£3.2 (£2.2 to £4.2)	£3.5 (£2.6 to £4.7)
Opportunity cost	£0.9 (£0.7 to £1.2)	£0.9 (£0.7 to £1.2)	£2.5 (£2.1 to £3.3)	£2.5 (£2.1 to £3.3)
Net benefits	**£17.0 (£8.6 to £29.2)**	**£17.4 (£8.8 to £29.5)**	**£32.2 (£13.2 to £69.2)**	**£32.8 (£13.6 to £69.5)**

eftec
economics for
the environment



10F Printing House Yard, Hackney Road,
London, E2 7PR

+44 (0) 20 7580 5383

eftec@eftec.co.uk

eftec.co.uk

@eftec.bsky.social