Title: Environment Act Targets – Tree Canopy and Woodland cover target **IA No:** N/A **RPC Reference No:** RPC-DEFRA-5160(1). **Lead department or agency:** Defra **Other departments or agencies:** **N/A**	**Impact Assessment (IA)** **Date:** 19/12/2022 **Stage: Final** **Source of intervention:** Domestic **Type of measure:** Primary Legislation **Contact for enquiries:** ncf.treeprogramme@defra.gov.uk

Summary: Intervention and Options

RPC Opinion: N/A

Cost of Preferred (or more likely) Option (in 2019 prices)			
Total Net Present Social Value	**Business Net Present Value**	**Net cost to business per year**	**Business Impact Target Status**
£13,371m	N/A	N/A	

What is the problem under consideration? Why is government action or intervention necessary?

Woodland in England provides a range of environmental, social and economic benefits including carbon sequestration, water quality regulation and biodiversity gain. The Climate Change Act[1] (2019 amendment) commits the UK to reach net zero greenhouse gas emissions by 2050 and the Climate Change Committee has recommended that afforestation should increase to achieve this[2]. A statutory tree canopy and woodland cover target for England will support the delivery of net zero, and contribute to other outcomes, such as habitat restoration, flood regulation and improved water and air quality. Although net zero is a statutory target, there are different pathways for achieving it; setting a statutory tree and woodland cover target will help to ensure the woodland contribution to net zero and other outcomes is achieved by giving greater certainty to farm and forestry businesses, as well as and supply chain actors such as nurseries. Government intervention is also necessary to achieve the scale of planting required and to stimulate private investment and behavioural changes. The intervention will address two key market failures: carbon emissions (a negative externality) are causing climate change, and trees, which deliver public goods, are being underprovided by the market.

What are the policy objectives of the action or intervention and the intended effects?

The key objective of introducing a tree canopy and woodland cover target is to encourage carbon sequestration through the creation and protection of woodlands. Tree planting will support the delivery of the government's goals on climate change, biodiversity (depending on woodland design, including the species and location of planting), and other environmental outcomes. It can also generate substantial social benefits, including bringing woodlands and trees closer to communities to secure health and wellbeing benefits. Activity will be targeted to support levelling up; for example, large areas of new woodland are expected to be planted in the North East. Woodland creation will support thousands of jobs across the forestry, timber and wood processing industries. It will also help to support indirect job creation in areas such as tourism, horticulture and seed supply.

1 Climate Change Act 2008 (legislation.gov.uk)

2 https://www.theccc.org.uk/wp-content/uploads/2021/06/Progress-in-reducing-emissions-2021-Report-to-Parliament.pdf

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

In the 25 Year Environment Plan[3], the government announced an aspiration to increase the woodland coverage of England to 12% by 2060. In May 2021 the England Tree Action Plan 2021-24[4] was introduced as part of the pathway to meeting and exceeding this ambition, supported by the Nature for Climate Fund[5]**.** The Environment Act provides an opportunity to build upon these commitments by setting a long-term statutory target for tree and woodland creation. There are two options modelled alongside the baseline – but it should be noted they are hypothetical scenarios and should not be considered an expectation of how government will deliver the target.

Option 0 *Business as Usual (Baseline):* Existing government interventions are aiming to push tree planting rates to c.7,500 hectares (ha) per year by 2024/25. In the absence of any additional policy intervention, planting rates will likely fall back to current levels of approximately 2,100 ha per year in the long run after 2025[6], as there would be fewer incentives for tree planting. Low afforestation rates will mean that the government will rely on other options to meet net zero, which may be more costly or offer fewer additional benefits than trees.

Option 1: *16.5% tree canopy and woodland cover target by 2050, with more productive forestry:* This option models 7,500ha per year by 2025 and 10,300ha per year of woodland creation and agroforestry combined from 2035 to 2050. This option balances deliverability and carbon sequestration, with a higher level of conifer providing higher carbon savings and investment from private finance. ***This is the preferred option.***

Option 2: *17.5% tree canopy and woodland cover target by 2050:* this option models planting levels of 7,500 per year by 2025 rising to 16,700 ha per year of woodland creation and agroforestry combined by 2035 and maintained to 2050**.** This option is considered unfeasible owing to the very high level of planting required in contrast to the levels achieved over the last 20 years.

Will the policy be reviewed? It will be reviewed. **If applicable, set review date:** 2028

Is this measure likely to impact on international trade and investment?		Yes		
Are any of these organisations in scope?	**Micro** No	**Small** No	**Medium** No	**Large** No
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent) MT CO_2		**Traded:**	**Non-traded:** reduction of **110.53 MT CO_2**	

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible:Minister Trudy Harrison Date: 15/12/2022

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf

[4] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/987432/england-trees-action-plan.pdf

[5] https://www.gov.uk/government/news/budget-2020-what-you-need-to-know

[6] Government intervention or carbon markets are assumed to maintain baseline planting at the current rate in the long run. An alternative view is that planting would fall to the historic figure for planting without grant-aid, as set out in Baseline 2 and central scenarios of the GHG inventory projections (page 42 of https://uk-air.defra.gov.uk/assets/documents/reports/cat09/2010301108_LULUCF_Projections_to_2050-2100_2017i_.pdf) . This would give a baseline planting figure of 244 ha/yr.

Summary: Analysis & Evidence

Policy Option 1

Description:

FULL ECONOMIC ASSESSMENT

Price Base Year: 2019	**PV Base Year** 2020	**Time Period Years:** 2022-2100	**Net Benefit (Present Value (PV)) (£m)**		
			Low: £10,143	**High:** £14,663	**Best Estimate:** £13,371

COSTS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	£1,619	2025-2035	£313	£5,707
High	£1,841		£338	£ 6,596
Best Estimate	£1,761		£318	£5,974

Description and scale of key monetised costs by 'main affected groups'

The cost of reaching the targets will depend on what action is taken to meet them. It should be noted that what has been modelled here is a hypothetical scenario and should not be considered an expectation of how government will deliver the target.

Total social costs (discounted) of hypothetical preferred option: **£5,974m**

- **Rural woodland creation – £2,388m –** costs of planting 7,500 ha per annum from 2025 ramping up to 9,000 by 2035, continued to 2050.
- **Agroforestry – £192m –** costs of planting from 2025 ramping up to 1,300 ha of silvo-pasture per annum from 2035 to 2050.
- **Trees outside woodland - £3,488m–** costs of planting to achieve a net gain in canopy cover from 2025.

Other key non-monetised costs by 'main affected groups'

The target places a duty on government and does not itself lead to any direct costs to business. However, it is likely that some of the costs of meeting the target will be borne by the private sector, through trees funded through private finance. This could be in the form of co-financing or green finance markets. It has not been possible to split total social costs between government and business, as these costs will be dependent on how the target is implemented in the future. Additional policy levers, which may include regulatory measures, may be required to reach the target. Some of these changes may impose costs to business, but others could streamline the regulatory environment and reduce costs. Impact Assessments would be produced for any future regulatory changes.

BENEFITS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	£207	2025-2035	£1,058	£16,116
High	£217		£1,729	£20,903
Best Estimate	£207		£1,627	£19,345

Description and scale of key monetised benefits by 'main affected groups'

As above, the benefits will depend on what action is taken to meet them. Discounted benefits of the hypothetical preferred option are split between carbon **(£12,499m)** and other non-market benefits **(£6,846m),** including recreation, flood regulation, landscape, air quality and biodiversity, amongst others. Discounted benefits are:

- **Rural woodland creation – £12,491m**
- **Agroforestry - £375m**
- **Trees outside woodland - £6,478m**

Other key non-monetised benefits by 'main affected groups'	
• **Health Benefits -** improved societal wellbeing through improving both physical and mental health • **Environmnetal Benefits** - water quality improvements, noise, and heat reductions. • **Economic Productivity Benefits** – jobs supported through tree planting and knock-on supply chain benefits.	
Key assumptions/sensitivities/risks **Discount rate (%)**	First 30 years – 3.5%. After 30 years – 3%.
• The planting ratio for rural woodland is 70% broadleaf, 30% conifer • 0% cost and optimism bias, although the analysis includes assumptions on tree mortality (ranging from 15% to 70% depending on the type of planting) which acts as an indirect way of correcting potential optimism bias. • Rural afforestation costs based on the Nature for Climate Fund, with an average lifetime capital cost of £15,882 per hectare in 2020[7]. Agroforestry has an average lifetime capital cost of £5,447 per hectare[8] (silvo-pasture) in 2020. • The real per hectare costs for agroforestry and rural woodland are assumed to increase by 2.85% per year from 2020 to 2030, before being held constant from 2030 to 2050. This is in line with the historical trend of real woodland creation grant rates over the period 1988 to 2018, once adjusted for inflation[9]. • Trees outside woodland assumed average lifetime costs of £1,250 per tree[10]. Trees outside woodland costs are constant over the assessment period. • The assessment uses August 2021 BEIS central carbon prices[11].	

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m: 0			**Score for Business Impact Target (qualifying provisions only) £m: 0**
Costs: 0	**Benefits: 0**	**Net: 0**	N/A

[7] This is the average across all Nature for Climate Fund delivery mechanisms, which each have different associated per hectare costs. The cost of supporting activities including R&D and nursery capacity building is also included.
[8] Based on Defra analysis of standard costs for establishment, planting and maintenance.
[9] Based on payment data from the Woodland Grant Scheme (1988) and Countryside Stewardship Woodland Creation (2018) scheme.
[10] Based on Defra analysis for the Urban Tree Challenge Fund and Local Authorities Treescapes Fund.
[11] Valuation of greenhouse gas emissions: for policy assessment and evaluation - GOV.UK (www.gov.uk)

Contents

Executive Summary

Rationale for Intervention

Woodland in England provides a range of environmental, social and economic benefits. The Climate Change Act[12] (2019 amendment) commits the UK to reach net zero greenhouse gas emissions by 2050 and the Climate Change Committee (CCC) has recommended that afforestation should increase to achieve this[13]. There are several existing policy commitments and mechanisms in place to incentivise increased tree planting, including actions set out in the 25 Year Environment Plan[14], the England Trees Action Plan 2021-24[15], the Net Zero Strategy[16] and the Nature for Climate Fund (NCF)[17]. However, these actions alone are unlikely to lead to sufficient tree planting to meet the government's net zero ambitions. Low afforestation rates will mean that the government will rely on other options to meet net zero, which may be more costly or offer fewer additional benefits than trees. A statutory tree canopy and woodland cover target for England will support the delivery of net zero, and contribute to other outcomes, such as habitat restoration and improved water quality. Government intervention will address two market failures: carbon emissions (a negative externality) are causing climate change and trees, which deliver public goods (including carbon regulation, water quality regulation and flood regulation), are being underprovided by the market. Trees can also provide substantial biodiversity benefits, although these are dependent on woodland scheme design, which takes into account several variables including the species and location of planting. Mixed planting is most likely to benefit biodiversity through habitat creation and increased connectivity and resilience of woodlands, thus reducing the ecological stress caused by climate change[18,19].

Policy Options

This policy intends to create a long-term statutory target for trees and woodland which will focus on increasing tree canopy and woodland coverage in England. This Impact Assessment considers two policy options – but it should be noted they are hypothetical

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12 Climate Change Act 2008 (legislation.gov.uk)

13 https://www.theccc.org.uk/wp-content/uploads/2021/06/Progress-in-reducing-emissions-2021-Report-to-Parliament.pdf

14 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf

15 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/987432/england-trees-action-plan.pdf

16 UK's path to net zero set out in landmark strategy - GOV.UK (www.gov.uk)

17 https://www.gov.uk/government/news/budget-2020-what-you-need-to-know

18 https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/

19 https://www.gov.uk/government/publications/the-uk-forestry-standard

scenarios and should not be considered an expectation of how government will deliver the target.

- **Option 0: Business as Usual (Baseline):** with no legally binding target for tree planting levels, it is likely that planting rates would fall back to current levels of approximately 2,100 hectares[20] (ha) per year from 2025 once NCF funding is exhausted. Low afforestation rates will mean that the government will rely on other options to meet net zero, which may be more costly or offer fewer additional benefits than trees.
- **Option 1: *16.5% tree canopy and woodland cover target by 2050, with more productive forestry:*** This option will require 7,500ha per year by 2025 rising to 10,300ha per year of woodland creation and agroforestry combined from 2035 to 2050. The assumed split is 7,500ha of conventional woodland per year from 2025 rising to 9,000ha per year from 2035 to 2050. This option balances deliverability and carbon sequestration by taking less land than Option 2. It includes a net gain in canopy cover from trees outside of woodlands. ***This is the preferred option.***
- **Option 2: 17.5% tree canopy and woodland cover target by 2050:** This option will commit the government to increasing tree canopy and woodland cover in England by 3%. This equates to planting rates ramping up from 7,500 ha per year in 2025 to 16,700 ha per year by 2035, maintained to 2050, for woodland creation and agroforestry combined.

For options 0 and 2, it was assumed that conifers would constitute 20% of planting; for Option 1, 30% conifer planting was assumed.

These options were assessed in terms of achievability, strategic fit with meeting the government's net zero ambitions and the goals of the 25 Year Environment Plan and other wider risks. Option 0 was discounted for not delivering sufficient afforestation to fully support net zero ambitions. Option 2 was consulted upon. Careful consideration has been given to this option but it would not allow for a necessary period of sector transformation sufficient to support the sustained levels of planted required over time, given the rates of planting over the last 20 years.

These options all involve a canopy cover metric, however, other metrics such as number of trees planted were also considered. A canopy cover metric was preferred by stakeholders, as it is outcome based, and would provide an accurate picture of the progress being made towards government's existing planting targets. The inclusion of both woodlands and trees outside woodlands within the target recognises the wealth of diverse benefits both planting types generate.

[20] Government intervention or carbon markets are assumed to maintain baseline planting at the current rate in the long run. An alternative view is that planting would fall to the historic figure for planting without grant-aid, as set out in Baseline 2 and central scenarios of the GHG inventory projections (page 42 of https://uk-air.defra.gov.uk/assets/documents/reports/cat09/2010301108_LULUCF_Projections_to_2050-2100_2017i_.pdf) . This would give a baseline planting figure of 244 ha/yr.

Preferred option

Option 1, the 16.5% tree canopy and woodland cover target, represents a target which aims to increase woodland canopy cover by approximately two percentage points (from current tree canopy and woodland cover of 14.5%) and achieve a net gain in the canopy cover of trees outside woodland.

The target scope will include woodland cover, small woods, linear features and individual trees, orchards and agroforestry systems. Natural colonisation will be included, subject to certain reporting/remote sensing criteria. Purpose grown biomass plantations comprising short rotation forestry and coppice will not be included because of the lower biodiversity and carbon benefits of biomass forestry.

To achieve a 2 percentage point increase in tree canopy and woodland cover, there will need to be a net increase in woodland of 260,000 hectares by 2050. However, the baseline level of woodland cover is being updated in 2023 and will be revised to include traditional orchards, which have not been included to this point. This impact assessment assumes that this revision to the baseline will increase the level of woodland cover by approximately 20,000 hectares primarily as a result of the additional area of orchards that are excluded from the National Forest Inventory[21]. As such, the analysis assumes that only an additional 240,000 hectares will be required to achieve the 2 percentage point increase in tree canopy and woodland cover.

It is intended that the statutory target will partly be delivered through grant funding from environmental land management schemes. This will be supported by blended green finance, initially based on carbon markets, but potentially incorporating markets for other ecosystem services in the future. Additional policy levers, which may include regulatory or spending measures, will also be required to reach the target in the future. It is not currently possible to split out the relative proportions of the target that will be delivered through grant funding or other mechanisms such as private finance. It is possible that some landowners will need both grant funding and additional income streams such as timber revenues or private finance to incentivise them to plant trees. When designing tree planting grant schemes, the government is putting in place additionality rules to reduce the risk of spending public money on trees that would have been planted anyway without grant support.

Costs and benefits – preferred option

For the purposes of the assessment, the analysis has been split into three sections:

- **Rural Woodland Creation:** it is assumed that rural woodland creation will ramp up from 7,500 to 9,000ha per year between 2025 and 2035, maintained to 2050.

[21] The 20,000 hectare figure is based on internal Defra statistics. The extent of traditional orchards is reported as 23,000 hectares at UK level in 2021, Agriculture in the UK, 2022 - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1094493/Agriculture-in-the-UK-27jul22.pdf

- **Agroforestry:** it is assumed that silvo-pasture planting will ramp up from 0 to 1,300ha per year between 2025 and 2035, maintained to 2050. Agroforestry remains an important opportunity for land sharing and delivery of both this target and net zero. Government will keep this ambition level under review, including considering opportunities to go further. Silvo-arable systems are included as tree canopy cover outside woodland, due to the lower stocking densities and likelihood of not achieving the woodland definition of 20% canopy cover in these systems.
- **Trees outside woodland:** it is assumed that a total of 25.8 million trees will need to be planted outside of woodland to achieve a net gain in canopy cover, at an average rate of just over 1 million trees per year between 2025 and 2050. This is based on the estimated number of trees that might die due to ash dieback which is considered the largest threat to trees. More detail is included in the 'Cost assumptions' section of this Impact Assessment.

The monetised costs and benefits for the preferred option are outlined in Table 1.

Table 1: Summary of monetised costs and benefits for option 1 compared against the baseline, 2022 to 2100

Year	Total	Rural Woodland	Agroforestry	Trees Outside Woodland
Social benefit - Carbon (£m)	53,584	41,949	1,489	10,146
Social benefit – Non-Carbon (£m)	52,393	10,440	344	41,609
Optimism bias adjustment	-	-	-	-
Estimated risk costs	-	-	-	-
Social benefits (total) (£m)	105,977	52,389	1,833	51,756
Total Social benefits (discounted £m)	19,345	12,491	375	6,478
Social cost - All Capital (£m)	21,481	3,455	192	17,835
Social cost - Resource (£m)	962	778	-	184
Optimism bias adjustment	-	-	-	-
Estimated risk costs	-	-	-	-
Social costs - real (total £m)	22,444	4,233	192	18,019
Total social costs (discounted £m)	5,974	2,388	97	3,488
Net social benefits (discounted £m)	13,371	10,103	278	2,990

The analysis on the costs and benefits of the final options is built on high quality data and evidence. Cost data is largely based on well-established woodland creation and tree planting schemes, including previous Countryside Stewardship woodland creation schemes[22] and various delivery mechanisms under the NCF such as the England Woodland Creation Offer (EWCO)[23] grant scheme. Carbon benefits are estimated using outputs from an off-line version of Carbine[24], the greenhouse gas accounting model used to calculate the forestry contribution to the UK greenhouse gas inventory. Non-market environmental benefits are mainly modelled in line with Enabling a Natural Capital approach (ENCA) guidance[25], using published literature sources.

Cost assumptions

The assessment values the total social cost of delivering the target. These costs will fall on government and business (through private finance), although the relative split between these agents is uncertain and will depend on how the target is implemented. As such, the split of costs between business and government has not been estimated. Further analysis on this is provided in the 'Direct costs to business' section of this Impact Assessment.

The total social cost for woodland creation is based on the NCF average lifetime capital cost of £15,882 per hectare (/ha) and average lifetime resource cost of £3,578/ha. These are based on the existing NCF tree planting programme, which contains a range of planting mechanisms with different associated costs. Agroforestry costs are based on Forestry Commission standard costs for capital items and evidence from existing agroforestry schemes, which results in an average lifetime capital cost of £5,447/ha. A more detailed breakdown on these costs is set out in the 'Cost assumptions' section further in the document.

Since the consultation version of this impact assessment the per hectare capital costs for woodland creation have been revised down slightly (from £16,402/ha to £15,882/ha), but per hectare resource costs have increased (from £2,071/ha to £3,578/ha) to account for actual cost data from the NCF being slightly lower than originally estimated. However, the consultation impact assessment also assumed that 10% of woodland creation was through natural colonisation, at a lower cost rate of £12,000/ha. After reviewing the latest evidence on woodland creation, this assumption has been removed, so that all woodland creation is costed at £15,882/ha for capital costs. Whilst overall /ha costs have increased since consultation, the total costs for delivering the target have reduced because we are now proposing to deliver fewer hectares than the higher 17.5% tree canopy and woodland cover target that was originally consulted on. The Impact Assessment assumes that the real per hectare social costs for woodland creation and agroforestry will increase at 2.85% per year between 2020 and 2030, once inflation has been adjusted for. This is calculated using the historical average growth rate of tree planting payment rates from the Woodland Grant Scheme (1988)[26] and the Countryside Stewardship Woodland Creation (2018)[27] scheme. The assumption of increasing marginal costs to 2030 is because landowners may

[22] https://www.gov.uk/guidance/woodland-creation-grant-countryside-stewardship
[23] https://www.gov.uk/guidance/england-woodland-creation-offer
[24] https://www.forestresearch.gov.uk/research/forestry-and-climate-change-mitigation/carbon-accounting/forest-carbon-dynamics-the-carbine-carbon-accounting-model/
[25] Enabling a Natural Capital Approach (ENCA): Guidance - GOV.UK (www.gov.uk)
[26] Woodland creation grant rates listed on page 3, Farm Woodland Scheme (publishing.service.gov.uk)
[27] cs-woodland-creation-manual-2018.pdf (publishing.service.gov.uk)

require higher incentives to plant trees in the short term, to overcome barriers such as cultural attitudes to tree planting and increased competition for land. Post 2030, per hectare costs are held constant, as it is assumed that these barriers are only present in the short term. Furthermore, by 2030 there will be increased certainty that tree planting is a financially viable long-term option, meaning that landowners will not require higher payment rates to plant trees. Future costs are a key uncertainty which is examined in the 'Sensitivity analysis' section of this Impact Assessment.

The costs for trees outside woodland are based on an existing delivery mechanism, the Local Authorities Treescapes Fund (LATF), which results in an average lifetime capital cost of £690 per tree and an average lifetime resource cost of £7 per tree. Trees outside woodland marginal costs are held constant over the period as the planting rate is only sufficient to cover any trees lost to diseases or felling, so there are no land use pressures which could drive up future costs.

Benefits

The breakdown of *undiscounted* benefits between the different benefit types for each area of the assessment is shown in Table 2.

Table 2: Summary of monetised benefits for option 1 compared against the baseline, 2022 to 2100

	Carbon		Total
	Stored ($MT\ CO_2$)	Value (£m)	Non-Carbon[28] (£m)
Rural Trees	87.46	£41,949	£10,440
Trees outside woodland	20.19	£10,146	£41,609
Agroforestry	2.88	£1,489	£344

Overall, a 16.5% tree canopy and woodland cover target (option 1) generates substantial net benefits over the assessment period. The net social present value (NSPV) shows the current value of the project (i.e., discounted benefits minus discounted costs). Option 1 has a large positive NSPV of £13,371m, suggesting that the lifetime carbon and environmental benefits outweigh the costs.

It is also useful to analyse the cost effectiveness of carbon sequestration for the target. Overall, the target will lead to the sequestration of 110.53 MT CO_2 at a cost of £54.04 per tonne of CO_2. Costs per tonne of CO_2 sequestered for each area of the assessment are:

[28] Including air quality, recreation, biodiversity, landscape, flood management, rainfall interception and amenity

- Rural woodland = £27.31
- Agroforestry = £33.67
- Trees outside woodland = £172.74

Trees outside woodland are poorer value for money in terms of carbon sequestration compared to rural woodland and agroforestry. However, they provide large non-carbon benefits in terms of rainfall interception, air quality and overall amenity value.

The appraisal period is to 2100 to reflect that up-front costs are high, but that the benefits, particularly carbon sequestration, accrue in the longer term. It is considered highly unlikely that the negative emissions provided by woodland planted up to 2050 will not be a policy objective after 2100. The appraisal period broadly covers the life (harvest) cycle of a productive woodland providing an holistic assessment of the costs and benefits of woodland creation.

Although the area of tree canopy and woodland in option 1 is lower than in option 2, there is limited impact on carbon savings to 2050 (14.0 MtCO2 vs 15.9 MtCO2) as a result of more conifer being planted and a reduced contribution from silvo-pasture agroforestry. However, by 2100 the difference is larger (111 vs 148 MtCO2) due to the larger amount of overall planting in option 2 and the higher proportion of broadleaf, which by 2100 has begun to sequester a larger amount of carbon overall than the planting in option 1.

For productive woodland, it is also important to consider the role of harvested wood products in carbon savings. Although the carbon stored in harvested wood products is included in the appraisal, emissions reductions in other sectors through wood substituting for other materials such as concrete and steel is not considered. The emissions savings in 2100 are therefore likely to be an underestimate.

Costs and benefits – other options and sensitivities

For transparency, option 2 (17.5% target) was also analysed in this Impact Assessment, even though it was discounted on achievability considerations.

There are also several key uncertainties in the analysis which have been assessed through sensitivity testing around the core scenario of option 1 (16.5% tree canopy and woodland cover target):

- Sensitivity 1 examines uncertainty in the non-market benefit assumptions, by entirely removing the non-carbon benefits for agroforestry and removing the amenity benefits of trees outside woodland.
- Two sensitivities examine uncertainty in the uptake of agroforestry. Sensitivity 2 assumes that there is no agroforestry and the entire 16.5% tree canopy and woodland cover target is met through rural woodland creation alone. Sensitivity 3 assumes high agroforestry uptake. It assumes that twice as much silvo-pasture planting occurs compared to the core scenario, with up to 2,600 ha planted from

2035 to 2050. As a result, a lower proportion of rural woodland is required to meet the target (up to 7,700 ha per year from 2035 to 2050).

- Sensitivity 4 examines uncertainty around how costs might change in the future, by assuming that the per hectare costs of woodland creation and agroforestry continue to rise by an annual rate of 2.85% until 2050, rather than 2030 as is assumed in the core scenario.

Table 3 shows the total costs, benefits and NSPV for options 1 and 2 and all the sensitivity tests. All sensitivities have large positives NSPVs, demonstrating that the tree canopy and woodland cover target is likely to represent good value for money.

Table 3: Summary of monetised costs and benefits for all options and sensitivities compared to the baseline, 2022 to 2100

	Option 1: 16.5% tree canopy and woodland cover *Preferred*	Option 2: 17.5% tree canopy and woodland cover	Sensitivity 1: Reduced non-market benefits	Sensitivity 2: Zero agroforestry	Sensitivity 3: Low rural woodland	Sensitivity 4: Increasing marginal costs
Social benefits (total) (£m)	**105,977**	125,052	69,003	112,620	99,334	105,977
Total Social benefits (discounted £m)	**19,345**	23,049	16,116	20,903	17,787	19,345
Social costs - real (total £m)	**22,444**	23,626	22,444	22,937	21,951	23,803
Total social costs (discounted £m)	**5,974**	6,629	5,974	6,240	5,707	6,596
Net Present Social Value (discounted £m)	**13,371**	16,420	10,103	14,663	12,080	12,749

Direct costs to business and income forgone

The target places a duty on government and does not itself lead to any direct costs to business. However, it is likely that some of the costs of meeting the target will be borne by the private sector, through trees funded through private finance. This could be in the form of co-financing planting or green finance markets. It has not been possible to split total social costs between government and business, as these costs will be dependent on how the target is implemented in the future and how private finance markets develop.

Other key assumptions

Aside from the cost and benefit assumptions set out above, the following assessment assumptions (which are consistent across all scenarios) have been used:

- The assessment takes place over the period 2022 to 2100 due to the time and nature of the costs and benefits to accrue in tree planting.
- Where applicable, values have been deflated in line with Her Majesty's Treasury (HMT) Gross Domestic Product (GDP) deflator guidance. All values are in 2019 prices.
- The following stocking densities have been assumed:
  - Rural Woodland (assumes 70% broadleaf, 30% conifer split):
    - Conifer – 2500 stems /ha
    - Broadleaf – 1600 stems /ha
  - Agroforestry:
    - Silvo-pasture– 400 stems /ha
    - Silvo-arable – less than 100 stems/ha

Gaps and uncertainty in the evidence

There is inherent uncertainty in modelling land use change so far into the future. It should be noted that what has been modelled here is a hypothetical scenario and should not be considered an expectation of how government will deliver the target.

There are also key evidence gaps in our analysis, particularly on the level of deforestation, the level of tree canopy loss outside woodland associated with pest and diseases and urban tree management, the nature of future agroforestry schemes, uptake of agroforestry and future changes in the extent of orchards. There is also uncertainty in some of the non-market environmental benefits used in the analysis, particularly for agroforestry schemes, as well as the costs of achieving woodland creation at such scale. The sensitivity tests outlined in this Impact Assessment help to test some of this uncertainty.

Wider impacts

Non-monetised benefits

There are a several benefits from a 16.5% tree canopy and woodland cover target that it has not been possible to monetise. There may be some overlap between these benefits and those that have been monetised, so these benefits should not be viewed as entirely additional to those set out in the monetised section of this Impact Assessment.

- **Water quality improvements, noise, and heat reductions** – these are all positive externalities associated with tree planting but have not been monetised due to a lack of robust data. These benefits will be location dependent and are therefore harder to quantify at this stage.
- **Health benefits:** Planting trees contributes to societal wellbeing through improving both physical and mental health. Providing increased public access to woodland has shown to improve individuals' mental health.
- **Jobs:** An increase in afforestation is likely to lead to an estimated 1,400 additional jobs being required in the nursery and forestry sectors by 2035 and indirect job creation such as in tourism or local farming. However, it is currently uncertain whether these will be 'new' jobs created or a structural shift from other sectors as land use changes. As such, these benefits have not been monetised.
- **Economic productivity:** Timber and biomass sales are private benefits to the seller of the tree and feed into the economy through multipliers associated with the processing and logging supply chain.
- **Educational benefits:** Educational benefits are derived from engaging people in the planting and maintenance of trees, particularly young people. These benefits are maximised when planting trees in or near educational institutions (e.g. schools).

Skills and workforce

UK nursery production would need to increase substantially to deliver a woodland cover target and to increase domestic timber supply for increased use in construction.

Private Finance markets

Private finance models are expected to be developed to support future planting. The forestry sector is well-placed to develop private/green finance models, through the Woodland Carbon Code and Woodland Carbon Guarantee. Biodiversity Net Gain (BNG) is also expected to support development-funded woodland creation. These models could generate substantial revenue streams for landowners in the future. However, such markets are still relatively novel, and as such the overall potential of private investment is uncertain. It is worth noting that trees planted through BNG funding may not have full benefit values for biodiversity and carbon depending on habitat loss to development elsewhere. The net impact of planting must therefore be considered where BNG is applied.

Crossover with other Environment Act targets

Due to the nature of the Environment Act Targets setting process there is inevitable overlap between some of the statutory target impacts:

- **Air Quality:** the tree canopy and woodland cover target values the air quality benefits provided by tree planting. Within the context of the air quality targets, tree planting only has a marginal impact on overall pollutant removal. The air quality benefits provided by trees are quantified within this Impact Assessment and not accounted for in the air quality targets Impact Assessment.
- **Water:** Incentivising targeted woodland expansion could lead to a reduction in agricultural diffuse water pollution by reducing the quantity of sediment and associated nitrate/phosphate from entering water courses[29]. The benefits of this are counted under the water target rather than the tree canopy and woodland cover target. The tree canopy and woodland cover target contains a quantified value for the benefit of flood regulation, but these benefits are not accounted for in the water target. There might be some double counting of non-water benefits from trees. It is not possible to quantify the level of double counting between the two Impact Assessments, as they use different methodologies.
- **Biodiversity:** The tree canopy and woodland cover target Impact Assessment values biodiversity benefits of woodland creation. Woodland creation also contributes to the biodiversity habitats target, as deciduous woodland is a priority habitat. Only deciduous woodland created outside of Sites of Special Scientific Interest (SSSI) areas counts towards the wider habitats target. The tree canopy and woodland cover target assumes that 70% of woodland creation will be broadleaf and of this 88% of this would be outside SSSIs (based on current proportions). This means that approximately 100,000 hectares of priority woodland habitat is expected to be created outside protected sites by 2042, which would contribute to the biodiversity habitats target. To avoid double counting, the monetised costs and benefits of this woodland creation are only included in this Impact Assessment.

The *Overarching Impact Assessment for proposed Environment Act (2021) targets* provides a high-level, descriptive, and largely qualitative analysis of all the targets under the Environment Act.

Monitoring and Evaluation

The Environment Act creates a new statutory cycle of monitoring, planning and reporting. Long-term targets will be supported by interim targets, which will set a five-year trajectory towards meeting the long-term targets. The Act requires Government to set interim targets in the Environmental Improvement Plan. This will ensure that there is always a shorter-term goal Government is working towards, as well as the long-term target and will allow for an ongoing assessment of whether the government is on track to meet its long-term target ambitions.

[29] ibid

The tree canopy and woodland cover metric will measure woodland, small woods, groups of trees and individual trees (including urban). Woodland cover is currently measured by National Forestry Inventory and administrative records are used to monitor and report net increase in woodland cover with a robust dataset stretching back to 1971. Small woods, groups of trees and individual trees (including urban) will be measured by remote sensing published by National Forestry Inventory Assessment of Tree Cover Outside Woodland.

1. Problem under consideration

The economic rationale for a statutory target on tree planting is the presence of market failures, both in the provision of public goods and problems with climate change. Public goods provide positive externalities beyond individual benefit and arise due to their characteristics of being both non-excludable (it is not feasible to selectively allow consumption) and non-rivalrous (one person's consumption of a unit of a good does not diminish the amount for others to consume). Therefore, a profit maximising firm cannot profit from the production of a public good. As a result, public goods are under provided when left to the markets. Many of the benefits provided by trees (including carbon regulation, biodiversity, water quality regulation and flood regulation) provide positive externalities which benefit wider society, beyond those individuals involved directly in tree planting. This leads to an under production of tree planting compared to a socially optimum outcome and thus government can intervene to increase demand levels.

Climate change can be viewed as a collection of market failures, and government intervention is justified to manage the risk of global warming. A statutory tree canopy and woodland cover target will directly contribute to reducing these risks.

Human-made emissions are warming the planet to dangerous levels through the greenhouse gas effect. The Climate Change Committee (CCC) (2021) has recommended[30] that woodland cover will need to increase across the UK to realise the government's commitments to limit global heating to less than 2°C above pre-industrial levels and achieve net zero carbon emissions by 2050. Current planting rates are approximately 2,100 hectares (ha) per year in England[31]. Without intervention, planting rates are highly unlikely to increase and low afforestation rates will mean that the government will rely on other options to meet net zero, which may be more costly or offer fewer additional benefits than trees.

[30] https://www.theccc.org.uk/wp-content/uploads/2021/06/Progress-in-reducing-emissions-2021-Report-to-Parliament.pdf
[31] https://www.forestresearch.gov.uk/documents/8143/Ch1_Woodland_FS2021_eiwRX2H.pdf

2. Rationale for intervention

Creating and managing woodlands has been identified as one of the most effective ways of removing atmospheric carbon and otherwise mitigating the effects of climate change. Setting a legally binding statutory target for tree planting under the Environment Act will ensure that woodland creation plays a central role in meeting these ambitions. Whilst there are other pathways to net zero that could involve lower levels of tree planting, this would increase the burden on other areas of the economy to reduce carbon emissions. This may not be as cost effective or deliver the scale of benefits as delivering the same emissions savings through tree planting.

Afforestation will address the future harms of climate change and biodiversity loss. Tree planting will also create habitats, improve water runways, improve air quality in urban areas, improve water quality, reduce flood risks and prevent soil erosion.

Tree planting can also generate wider benefits, including bringing woodlands and wider treescapes closer to communities to secure health and wellbeing benefits and targeting activity across England to support levelling up. This generates recreation and landscape benefits. Woodland creation will directly support thousands of jobs across the forestry, timber and wood processing industries, as well as indirectly supporting jobs in areas such as tourism, horticulture and seed supply.

Current business models in the forestry sectors are not sufficiently developed to deliver the levels of planting required to support net zero, with the wide range of benefits currently difficult to monetise and often undervalued. Despite the potential for carbon sequestration and other natural capital benefits from trees, they are not currently delivered by the market. Many of the markets for the services trees provide – such as biodiversity – are in their nascent stages, with limited demand, and some ecosystem services (such as flood risk mitigation) are very place-specific and can be difficult to monetise more broadly.

The relevant sectors lack the capacity, capability and skills to achieve and sustain the rates of planting, management and restoration required to support net zero. A statutory target is needed to ensure that landowners commit to plant trees and manage woodland at the scale needed.

3. Rationale and evidence to justify the level of analysis used in the Impact Assessment

A thorough approach has been taken to the options assessment, considering multiple factors, including the scale of ambition, the scope of the target, likely stakeholder reaction, risks and overall achievability. Further detail on this is provided in the Evidence report and summarised in the 'Description of options considered' section of this Impact Assessment.

An appropriate and proportionate approach for determining the baseline level of woodland cover has been taken. Evidence for current and future canopy cover in England will be provided through two methods:

- Administrative records will be used to monitor and report net increase in woodland cover and there is a robust dataset[32] stretching back to 1971. This previous use of woodland rather than tree cover for measuring woodland creation, has led to its continuation in this Impact Assessment, for consistency.
- Tree cover outside of woodland is detected through remote sensing by the National Forestry Inventory Assessment and will be updated every five years. The last update for current modelling was in 2017[33].

The analysis of the costs and benefits of the final options is built on high quality data and evidence. Cost data is largely based on well-established woodland creation and tree planting schemes, including previous Countryside Stewardship woodland creation schemes[34] and various delivery mechanisms under the Nature for Climate Fund (NCF)[35] such as the England Woodland Creation Offer (EWCO)[36] grant scheme. Carbon benefits are estimated using outputs from an off-line version of Carbine[37], the greenhouse gas accounting model used to calculate the forestry contribution to the UK greenhouse gas inventory. Non-market environmental benefits are mainly modelled in line with Enabling a Natural Capital approach (ENCA) guidance[38], using published literature sources. Further detail on the assumptions is set out in the 'Risks and assumptions' section of this Impact Assessment.

There is inherent uncertainty in modelling land use change so far into the future. In addition, there are some key evidence gaps in our analysis, particularly on the level of deforestation, the level of tree canopy loss outside woodland associated with pest and diseases and urban tree management, the nature of future agroforestry schemes, uptake of agroforestry and future changes in the extent of orchards. There is limited data available on early growth of woodland, biomass expansion factors, agroforestry models and

32 https://www.forestresearch.gov.uk/tools-and-resources/statistics/statistics-by-topic/woodland-statistics/
33 https://www.forestresearch.gov.uk/documents/2699/FR_Tree_cover_outside_woodland_in_GB_statistical_report_2017.pdf
34 https://www.gov.uk/guidance/woodland-creation-grant-countryside-stewardship
35 https://www.gov.uk/government/news/budget-2020-what-you-need-to-know
36 https://www.gov.uk/guidance/england-woodland-creation-offer
37 https://www.forestresearch.gov.uk/research/forestry-and-climate-change-mitigation/carbon-accounting/forest-carbon-dynamics-the-carbine-carbon-accounting-model/
38 Enabling a Natural Capital Approach (ENCA): Guidance - GOV.UK (www.gov.uk)

management regimes for agroforestry systems. There is also uncertainty in some of the non-market environmental benefits used in the analysis, particularly for agroforestry schemes. Future per hectare costs for woodland creation and agroforestry are also uncertain.

To address some of this uncertainty, the analysis includes sensitivity tests and an overall range for costs and benefits. One sensitivity test removes the less robust non-market benefits to see the impact this has on value for money. Two other tests assess uncertainty in agroforestry uptake by changing the relative delivery split between agroforestry and rural woodland creation. The final test assesses the possibility for increasing marginal costs across the whole assessment period. Further detail is provided in the 'Sensitivity analysis' section of this Impact Assessment.

4. Policy objective

Increasing woodland creation will deliver several policy objectives including climate mitigation and nature restoration. This policy intends to do that by creating a long-term statutory target which will focus on increasing woodland coverage in England and achieving a net gain in canopy cover of trees outside woodland. This intervention will increase carbon sequestration, helping to realise the government's net zero ambitions. There will be wider benefits for biodiversity, although these benefits are dependent on the species and location of planting. Mixed planting is most likely to benefit biodiversity through habitat creation and increased connectivity and resilience of woodlands, thus reducing the ecological stress caused by climate change[39,40]. Water quality can be improved as trees prevent nitrate and phosphorous run off from farms entering runways and polluting the water[41], provided they are planted in the right location. Air quality benefits can also be generated by tree planting in urban areas as recognised by the ONS[42]. The right tree in the right place can lead to highly localised improvements to urban air quality by removing particulate matter. Soil erosion will be slowed down through tree root binding and trees also provide flood regulation benefits.

The main policy objective to increase tree canopy and woodland cover is SMART (Specific, Measurable, Achievable, Relevant and Time-bound). It is *specific* in its nature as the required canopy cover increase is stated. Annual planting rates to meet this are also defined with key milestones such as 2025, 2035 and 2050. Canopy cover increase will be *measured* through the National Forestry Inventory and remote sensing which will be analysed to augment the administrative data. The target will be challenging but *achievable.* It is modelled on data from a range of published sources including the CCC's recommendations and all policy assumptions and risks have been thoroughly assessed. By modelling on published papers and recommendations from a range of bodies we've ensured the policy is also *relevant.* The target is *time-bound* to 2050.

Success of the policy will be indicated through the numerous positive outcomes, which will each have their own individual success metrics determined by individual policy teams. On carbon specifically, the canopy cover of England will be determined using administrative records and remote sensing. The carbon intake will be determined by an off-line version of Carbine, the greenhouse gas accounting model. Carbon intake can then be compared to the UK's carbon output to enable effective evaluation of the effectiveness of the statutory target.

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39 https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/
40 https://www.gov.uk/government/publications/the-uk-forestry-standard
41 https://www.ceh.ac.uk/news-and-media/news/trees-flood-alleviation-natural-flood-management-report
42 Woodland natural capital accounts, UK - Office for National Statistics (ons.gov.uk)

5. Description of options considered

There are several existing policy commitments and mechanisms in place to incentivise tree planting:

- In the 25 Year Environment Plan, the government has announced an aspiration to increase woodland cover to 12% by 2050[43].
- In May 2021, the government published the England Trees Action Plan 2021-24[44], setting out intentions to treble current planting rates this parliament.
- The NCF was announced through Budget 2020[45] which will provide £500m in capital funding to plant more than 40 million trees.
- An additional £124m of funding was announced for the NCF as part of the UK's Net Zero Strategy, which was launched in October 2021[46]. A high level of afforestation is given as part of the proposed pathway in the Net Zero Strategy. An illustrative scenario, not a target, is afforestation levels of 50,000 hectares (ha) for the UK by 2035 maintained to 2050.

However, these actions alone will not lead to the level of sustained tree planting required to support the government's net zero ambitions. The Environment Act provides an opportunity to build upon existing commitments by setting a long-term statutory target for tree and woodland creation.

Option 0: Business as Usual scenario (Baseline)

This is the current situation. The baseline includes the 25 Year Environment Plan, the England Trees Action Plan 2021-24 and the NCF. Through these mechanisms, tree planting rates will rise to around 7,500 ha per year by 2024/25.

However, with no legally binding target for tree planting levels, it is likely that planting rates would fall back to current levels from 2025 once NCF funding is exhausted. Planting rates from the last five years peak at 2,340 ha and the maximum planting rates on record for England are 6,540 ha recorded in 1971. This assumes some low levels of government intervention or private finance mechanisms will support planting in the future[47]. It is possible that tree planting rates may reach a long-term level slightly above current levels,

43 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf

44 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/987432/england-trees-action-plan.pdf

45 https://www.gov.uk/government/news/budget-2020-what-you-need-to-know

46 UK's path to net zero set out in landmark strategy - GOV.UK (www.gov.uk)

47 An alternative view is that planting would fall to the historic figure for planting without grant-aid, as set out in Baseline 2 and central scenarios of the GHG inventory projections (page 42 of https://uk-air.defra.gov.uk/assets/documents/reports/cat09/2010301108_LULUCF_Projections_to_2050-2100_2017i_.pdf) . This would give a baseline planting figure of 244 ha/yr.

for example due to growing private finance markets, but any increases are likely to be incremental.

In the baseline scenario, it is likely that afforestation rates remain low. This will mean that the government will rely on other options to meet net zero, which may be more costly or offer fewer additional benefits than trees. There will also be no noteworthy increase in biodiversity, air quality, water quality, flood risk management or an improvement in soil erosion rates.

Option 1: 16.5% tree canopy and woodland cover target by 2050

This option models 7,500ha per year by 2025 and 10,300ha per year of woodland creation and agroforestry combined from 2035 to 2050. This option balances deliverability and carbon sequestration, with a higher level of conifer providing higher carbon savings and investment from private finance.

With a 16.5% tree canopy and woodland cover target, planting rates will increase to more than the highest levels on record, and it is more likely than the baseline scenario that the government's commitment to net zero will be met. An increase in woodland creation will be met partly through environmental land management tree planting schemes supported by expanded green finance models, for the period following the NCF. Given the unprecedented scale of annual planting required, the government will need additional policy levers beyond these initiatives to encourage more landowners to change land use in favour of woodland. This could include regulatory and spending measures. However, these are relatively unexplored in this Impact Assessment analysis due to the lack of policy certainty. An expansion of agroforestry schemes will also contribute to the achievement of the statutory target, although uptake is uncertain.

The target places a duty on government and does not itself lead to any direct costs to business. However, it is likely that some of the costs of meeting the target will be borne by the private sector. It has not been possible to split total social costs between government and business, as these costs will be dependent on how the target is implemented in the future and how private finance markets develop.

It is possible that some landowners will need both grant funding and additional income streams such as timber revenues or private finance to incentivise them to plant trees. When designing tree planting grant schemes, the government is putting in place additionality rules, to reduce the risk of public money being used to plant trees that would have been planted anyway without grant support. For example, landowners that want to register with the Woodland Carbon Code (WCC) must first demonstrate that their woodland creation project requires carbon income to make it financially viable. This increases the likelihood that woodland registered with the WCC is truly additional and would not have occurred with grant funding alone. Furthermore, grant funding through EWCO includes supplementary payments for certain public goods that a woodland provides, including nature recovery, flood risk reduction, water quality improvements and public access. However, EWCO does not include an explicit payment for carbon benefits. This avoids double paying for the carbon which landowners are compensated for through the WCC.

The current regulatory regime does not require landowners to plant trees to meet the tree canopy and woodland cover target. However, in the future, regulatory changes may be required to meet tree planting targets, which could impose additional costs on businesses. Conversely the regulatory regime may also be streamlined which could reduce costs to business and make it easier to plant trees. Any future regulatory change will be subject to an Impact Assessment in which the costs to businesses will be explored. Further detail on costs to businesses is provided in the ‘Direct costs and benefits to business calculations’ section of this Impact Assessment.

The target would be fixed in terms of overall ambition and is achievable, but flexible with regards to delivery between agroforestry and rural woodland. This would enable a greater range of woodland creation options, lower pressure on land requirements through ‘land sharing’ and reduced dependency on the forestry supply chain. However, substantial landowner behavioural change is still required and there remains some uncertainty in how agroforestry will be delivered.

Other options considered and discounted

Potential options for the metric were discussed in an Applicants Focus Group (AFG) stakeholder meeting in November 2020. Options discussed were total area of woodland/tree cover in England (ha), area of woodland/number of trees planted (ha) and tree canopy cover including woodlands and trees outside woodlands. There was a clear preference at the workshop for a tree canopy and woodland cover metric, as it is outcome based, and would provide an accurate picture of the progress being made towards government's existing planting targets. The inclusion of both woodlands and trees outside woodlands within the target recognises the wealth of diverse benefits both planting types generate.

Several other options have been considered as part of the policy development process for both the scope and ambition level of the target.

The proposed target’s scope and ambition have been produced in line with the requirements of the Environment Act[48]. Literature, workshops and stakeholder meetings have been used to produce objectively measurable definitions, identify potential options and to gather data on the benefits, risks and uncertainties. As required by the Environment Act the scientific community has been consulted throughout the process through the Tree and Woodland Scientific Advisory Group (TAW-SAG)[49].

A Defra model was produced to assess the levels of ambition proposed within the literature. Modelling accounted for deforestation and woodland loss and the level of trees

[48] https://www.legislation.gov.uk/ukpga/2021/30/contents/enacted
[49] https://www.gov.uk/government/groups/trees-and-woodlands-scientific-advisory-group

outside woodland lost to poor plant health. For each planting scenario the resultant net change in woodland area was calculated by subtracting assumed woodland loss; the development-related loss was assumed to remain constant throughout the period of analysis.

On the scope, it was considered whether to have separate targets for different types of trees (conifers, broadleaves) or an undifferentiated target. Individual targets were also considered for woodlands and trees outside woodland. However, it was deemed that an undifferentiated aggregate of woodland cover and tree canopy cover outside of woodland would provide more flexibility. The flexible approach mitigates the risk of unintended consequences, such as adverse biodiversity outcomes, whilst still delivering carbon savings to support net zero ambitions. A differentiated target would be challenging to both monitor and implement in practice.

There was also consideration of whether to have a target focussed on a narrow definition of trees by only including woodlands and certain trees outside woodland, but excluding agroforestry, orchards, and all hedgerows. However, a wide scope for the metric was supported by TAW-SAG to recognise the ecosystem services that these other landforms provide.

On ambition level, several alternative options were considered. Of these, the **17.5% tree canopy and woodland cover by 2050** was seen as a plausible option. This is equivalent to planting 16,700 hectares by 2035, as well as a net increase in trees outside woodland.

Ambition levels were then assessed against the land use change required, the level of carbon each sequestered, the current capacity of the forestry sector, the behavioural change required and their affordability as to decide which was the most feasible, viable and desirable. For the 17.5% tree canopy and woodland cover target, planting levels in this scenario were seen as desirable, but challenging due to the very rapid ramping up of planting rates required. An option which sequestered a similar amount of carbon for net zero by 2050 but with lower land-use take was considered preferable.

6. Summary and preferred option with description of implementation plan

Option 1, the 16.5% tree canopy and woodland cover target, represents a target which aims to increase woodland canopy cover by approximately 2% (up from current tree and woodland cover of 14.5%). This will be met through total planting of rural woodland and silvo-pasture up to 10,300ha/year by 2035, maintained to 2050, with a net gain in the canopy cover of trees outside woodland.

Woodland is defined by the National Forest Inventory (NFI) as a group of trees of at least 0.5 hectares in area with a minimum of 20% canopy cover and 20 m width and that have the potential to reach a height of at least 5 m[50].

In the scope of the target will be:

- Woodland cover, small woods, linear features and individual trees; hedgerows will be excluded unless they meet the definition of 'tree linear features', although trees in hedgerows will be included,
- Orchards,
- Agroforestry systems, with silvo-pasture included as woodland, and silvo-arable as tree canopy cover outside woodland, due to the likelihood of not achieving the woodland definition of 20% canopy cover in silvo-arable systems.
- Natural colonisation will be included, subject to certain reporting/remote sensing criteria. Natural colonisation occurs in some instances where woodland will be allowed to establish from seeds dispersed naturally from local sources, rather than direct planting. Further detail on natural colonisation is set out in the 'Risks and assumptions' section of this Impact Assessment.

Purpose grown biomass plantations comprising short rotation forestry and coppice will not be included within the metric, because of the lower biodiversity and carbon benefits of biomass forestry.

Permanent woodland lost to development and open habitats that meets the National Forest Inventory definition of woodland is accounted for and published annually in the Forestry Commission Key Performance Indicator report[51]. The baseline (2022) level of woodland loss was assumed to an average of that reported for the five-year period, 2012/13 to 2016/17, the most recent data available at the time of analysis. Woodland loss is categorised as either for development (baseline of 368 ha assumed in 2022) or for open habitat restoration (baseline of 509 ha assumed in 2022).

[50] https://www.forestresearch.gov.uk/tools-and-resources/national-forest-inventory/about-the-nfi/

[51] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1002042/Forestry-Commission-Key-Performance-Indicators-Report-for-2020-21-.pdf

Orchards have been proposed as they provide several ecosystem services - fruit production, climate regulation, soil nitrogen availability, water regulation, pest and disease control, and pollination (Demestihas et al. 2017)[52]. Similarly, agroforestry systems provide many valuable ecosystem services - timber, climate regulation, flood regulation, soil improvement, landscape, and biodiversity benefits (Nworji et al. 2017)[53, 54]. Such benefits should be recognised by a statutory tree and woodland target.

To achieve a 2 percentage point increase in tree canopy and woodland cover, there will need to be a net increase in woodland of 260,000 hectares by 2050. However, the baseline level of woodland cover is being updated in 2023 and will be revised to include traditional orchards, which have not been included to this point. This impact assessment assumes that this revision to the baseline will increase the level of woodland cover by approximately 20,000 hectares primarily as a result of the additional area of orchards that are excluded from the National Forest Inventory[55]. As such, the analysis assumes that only an additional 240,000 hectares will be required to achieve the 2 percentage point increase in tree canopy and woodland cover.

This option will be introduced as secondary legislation and will act as a Statutory Instrument (SI) for tree and woodland coverage of 16.5% of England by 2050.

It is intended that the statutory target will partly be delivered through grant funding under environmental land management schemes. This will be supported by green finance, initially based on carbon markets, but potentially incorporating markets for other ecosystem services in the future. Defra and its arm's length bodies will be responsible for enforcement and implementation. In the future additional government levers may also be required to reach the statutory target including other spending or regulatory measures.

There is scope for experimentation with delivery schemes for the policy. EWCO has already been released and the number of applicants will give some indication of the potential uptake for woodland creation grant schemes. Improvements to the scheme will also be carried forward to any future policy to help increase uptake. Other novel approaches such as Woodland Creation Partnerships are being utilised with an aim to develop locally backed natural capital approaches to tree planting which leverage private finance. It is likely that a combination of different public and private sector delivery mechanisms will be needed to deliver tree planting ambitions in the future.

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[52] Demestihas.C. (2017). Ecosystem services in orchards. A review. In: INRA Science&Imapct

[53] Nworji.J. (2017). Physical and bioeconomic analysis of ecosystem services from a silvopasture system. In: Bangor University

[54] s://www.soilassociation.org/farmers-growers/technicalinformation/agroforestry-on-your-farm/download-the-agroforestry-handbook/

[55] The 20,000 hectare figure is based on internal Defra statistics. The extent of traditional orchards is reported as 23,000 hectares at UK level in 2021, Agriculture in the UK, 2022 - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1094493/Agriculture-in-the-UK-27jul22.pdf

7. Monetised costs and benefits of preferred option

This section presents the results of the cost benefit analysis for the preferred option. The modelling scenarios used contain theoretical policy choices that may be required to reach the targets. However, the measures included in these scenarios should not be considered an expectation on how government intends to take action to meet the target, which will be for future policy decisions, with public consultations and impact assessments conducted as and when required. Therefore, alternative pathways to reach the same targets could have different associated costs and benefits.

For the purposes of the assessment, the modelling has been split into three sections. Option 1 assumes:

- **Rural Woodland Creation:** it is assumed that planting rates will increase to 9,000ha per year between 2025 and 2035, this will then be maintained until 2050.
- **Agroforestry:** it is assumed that 1,300ha of silvo-pasture will be created annually from 2035 to 2050. Planting rates will linearly increase from 0 ha in 2025 to 1,300 ha in 2035. Agroforestry remains an important opportunity for land sharing and delivery of both this target and net zero. Government will keep this ambition level under review, including considering opportunities to go further. Silvo-arable systems are included as tree canopy cover outside woodland, due to the lower stocking densities and likelihood of not achieving the woodland definition of 20% canopy cover in these systems.
- **Trees outside woodland:** it is assumed that a total of 25.8 million trees will need to be planted outside of woodland to achieve a net gain in canopy cover, at an average rate of just over 1 million trees per year between 2025 and 2050. This has been adjusted for the estimated number of trees that might die due to ash dieback. The disease affects ash trees by blocking the water transport systems, leading to dieback of the crown of the tree. This makes it brittle and places it at risk of death. There are an estimated 27.2 million ash trees outside woodland[56] in small woods, hedgerows, urban areas and in the countryside. Ash dieback is likely to lead to substantial losses, with mortality rates estimated between 90% and 99% over the next 100 years[57]. The analysis assumes that all ash trees outside woodland (12% of small woods or 10% of individual trees in 1998) are likely to be subject to ash dieback and felled between now and 2050. This level of loss is unlikely to be realised but is included in the analysis to represent mortality/removal of all trees outside woodland from other threats including natural mortality, development or tree-health related issues.

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56 http://sciencesearch.defra.gov.uk/Document.aspx?Document=13337_ChalarainNonWoodlandSituationFinal.pdf

57 https://www.cell.com/cms/10.1016/j.cub.2019.03.033/attachment/7e150c1b-0bac-40fc-91a8-b71e1a0a3b82/mmc2.xlsx

The monetised costs and benefits for option 1 compared against the baseline (option 0) are outlined in Table 4. The impacts are measured over the period 2022 to 2100 and are split between each of the three sections of the assessment outlined above. The table only shows total costs and benefits within each category.

Further information and a full breakdown of costs and benefits can be found in the 'Risks and assumptions' section of this Impact Assessment. This includes full detail on cost and benefit values, evidence sources, methodologies, and assumptions.

Table 4: Summary of monetised costs and benefits for option 1 compared against the baseline, 2022 to 2100

Year	Total	Rural Woodland	Agroforestry	Trees Outside Woodland
Social benefit - Carbon (£m)	53,584	41,949	1,489	10,146
Social benefit – Non-Carbon (£m)	52,393	10,440	344	41,609
Optimism bias adjustment	-	-	-	-
Estimated risk costs	-	-	-	-
Social benefits (total) (£m)	105,977	52,389	1,833	51,756
Total Social benefits (discounted £m)	19,345	12,491	375	6,478
Social cost - Capital (£m)	21,481	3,455	192	17,835
Social cost - Resource (£m)	962	778	-	184
Optimism bias adjustment	-	-	-	-
Estimated risk costs	-	-	-	-
Social costs - real (total £m)	22,444	4,233	192	18,019
Total social costs (discounted £m)	5,974	2,388	97	3,488
Net social benefits (discounted £m)	**13,371**	**10,103**	**278**	**2,990**

8. Costs

The assessment values the total cost to society of delivering the target. These costs will fall on government and business (through private finance), although the relative split between these agents is uncertain and will depend on how the target is implemented. As such, the split of costs between business and government has not been estimated. Further analysis on the potential cost split between government and business is provided in the 'Direct costs to business' section of this Impact Assessment.

The cost for woodland creation is based on the NCF average lifetime capital cost of £15,882 per hectare (/ha) and average lifetime resource cost of £3,578/ha. The costs are based on the existing NCF tree planting programme, which contains a range of planting mechanisms. For example, the Forestry England Woodland Partnership[58] is a leasehold scheme which includes both tree planting and land acquisition costs and so has a higher cost per hectare than grant schemes such as EWCO, which focus more on the capital costs of tree planting. Considering the scale of planting required under the tree canopy and woodland cover target, it is reasonable to assume that several delivery mechanisms will be required, including environmental land management grant schemes, but potentially other government funded schemes and private financed planting. As the costs of these delivery mechanisms are not yet known, the analysis uses the average per hectare cost across all existing NCF schemes as a proxy for the cost of rural woodland creation under the target.

The per hectare figures also include the costs of supporting activities such as R&D, monitoring and evaluation and investment in additional nursery capacity. It is not known what supporting activities may be required in the future to deliver woodland creation on such scale and it is possible that the market will deliver additional capacity without further government investment. Including the costs of NCF supporting activities implies that total spending on supporting activities will increase proportionately with hectares. This is a conservative assumption, as in reality it is expected that fewer supporting activities would be required on a per hectare basis as afforestation scales up, due to economies of scale.

Since the consultation version of this impact assessment the per hectare capital costs for woodland creation have been revised down slightly (from £16,402/ha to £15,882/ha), but per hectare resource costs have increased (from £2,071/ha to £3,578/ha) to account for actual cost data from the NCF being slightly lower than originally estimated. However, the consultation impact assessment also assumed that 10% of woodland creation was through natural colonisation, at a lower cost rate of £12,000/ha. After reviewing the latest evidence on woodland creation, this assumption has been removed, so that all woodland creation is costed at £15,882/ha for capital costs. Whilst overall /ha costs have increased since consultation, the total costs for delivering the target have reduced because we are now

58 https://www.forestryengland.uk/sites/default/files/documents/Forestry%20England%20Woodland%20Partnership.pdf

proposing to deliver fewer hectares than the higher 17.5% tree canopy and woodland cover target that was originally consulted on.

Cost assumptions for silvo-pasture agroforestry are based on Defra analysis on the standard costs for establishment, planting and maintenance of agroforestry schemes, as well as data from the Forestry Commission. The average lifetime capital cost for silvo-pasture is £5,447/ha.

The future costs of tree planting will be determined by:

- The variable costs of tree planting, including labour, capital equipment such as fencing and tree guards, and saplings.
- Landowners' attitudes to tree planting and the level of financial incentive required by landowners to change land use, including changes in revenue driven by future timber and carbon prices.

This analysis assumes that variable costs remain constant over time, as input costs have not been subject to noteworthy changes above inflation over the past decades. Furthermore, the standard costs of tree planting are well understood given the number of existing planting schemes being delivered by the Forestry Commission. As such, no optimism bias is applied in the analysis.

However, landowners' attitudes to tree planting and the financial incentives they require to change land use are more uncertain. It is possible that several factors could increase the incentives required by landowners to plant trees in the short run (2026 to 2030), leading to increasing per hectare costs:

- **Agricultural land may become more valuable due to increasing land pressures.** The development of agrotourism and other farm diversification options, as well as increasing housing development, will provide a broad range of options for farmers alongside tree planting. This will put more pressure on landowners to avoid the permanent land use change of woodland conversion. Therefore, in the short run, it is assumed that higher grant rates may be required to incentivise woodland creation rather than alternative land use choices.
- **Short term sapling supply constraints.** Bolstered nursery capacity is essential to ensuring a biosecure, healthy, and diverse pipeline of sapling supply. The sector has been led by market demand and so is not currently ready for the ramping up of demand that will be required to achieve the tree canopy and woodland cover target. Whilst the NCF is investing in nursery capacity to mitigate this, it is possible that supply may be temporarily constrained during some periods over the next 10 years. This could drive up woodland creation costs in the short term.

As a result, the Impact Assessment assumes that per hectare costs for woodland creation and agroforestry will need to increase in real terms in the short term to achieve the tree canopy and woodland cover target. There is uncertainty on the rate at which real costs should increase. The analysis uses historical data to investigate how grant payments have changed over time and inform the possible rate of change in the future. Specifically, the analysis uses data on the Woodland Grant Scheme (1988)[59] and Countryside Stewardship Woodland Creation (2018)[60]. EWCO was not used for the analysis because EWCO payments cover a higher proportion of costs than previous woodland creation grants. The analysis uses the upper range standard cost payment rate of £1,375/ha for the Woodland Grant Scheme and the standard costs cap of £6,800/ha for the Countryside Stewardship woodland creation scheme. Through converting both values to 2018 prices to remove the impact of inflation, the real values of £2,926 and £6,800/ha are calculated. The compounded annual growth rate is then calculated. This shows that payment rates have increased by an average annual growth rate of 2.85% above inflation since 1988. The analysis assumes that the real per hectare costs increase at this rate between 2020 and 2030, before being held constant after 2030.

Post 2030, there is greater uncertainty surrounding land use change, however, there is a justification for keeping real per hectare costs constant. A lot of work is being done through the agricultural transition to shift attitudes in the farming community towards tree planting. It is reasonable to assume that this may have had sufficient impact by 2030 to ensure a greater proportion of farmers are aware of the benefits of tree planting and are willing to invest without having to be incentivised through increasing payment rates. Moreover, in the medium and long term, it has been assumed that industry capacity will increase sapling supply to meet market demand.

It is also expected that by 2030 there will be greater certainty about how private finance models will support afforestation in the long term. The forestry sector is well-placed to develop private finance models, with the WCC[61] a relatively mature standard which enables forest owners to generate independently verified carbon units. The Woodland Carbon Guarantee[62] then enables these units to be sold to the government at a guaranteed price. The announcement of the Climate Emergency by businesses and government bodies has resulted in a recent upturn in new project registrations under the WCC. Biodiversity Net Gain (BNG)[63] is also expected to support development-funded woodland creation. These mechanisms are relatively novel, but by 2030 they are expected to play a greater role in incentivising landowners to plant trees. The increased future certainty of revenue will mean that more landowners are willing to invest in tree planting without the need for grant rates to increase further beyond 2030.

The assumption of constant real per hectare costs past 2030 is a key uncertainty in the analysis. A sensitivity which assumes increasing costs of planting across the whole assessment period has been produced to test this uncertainty. The results are set out in the 'Sensitivity analysis' section of this Impact Assessment.

The costs for trees outside woodland are based on an existing delivery mechanism, the Local Authorities Treescapes Fund (LATF), which results in an average lifetime capital

[59] Woodland creation grant rates listed on page 3, Farm Woodland Scheme (publishing.service.gov.uk)
[60] cs-woodland-creation-manual-2018.pdf (publishing.service.gov.uk)

[61] https://woodlandcarboncode.org.uk/
[62] https://www.gov.uk/guidance/woodland-carbon-guarantee
[63] https://www.gov.uk/government/consultations/biodiversity-net-gain-updating-planning-requirements

cost of £690 per tree and an average lifetime resource cost of £7 per tree. Trees outside woodland marginal costs are held constant over the period as the planting rate is only sufficient to cover any trees lost to diseases or felling. Given that there will be no additional land use change required for maintaining trees outside woodland, this supports an approach of constant real costs over the assessment period.

The real costs of each element are set out in Table 5 below. Further information and a full breakdown of cost assumptions can be found in the ‘Risks and assumptions’ section of this Impact Assessment.

Table 5: Tree planting lifetime cost assumptions for option 1[64]

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030 to 2050
Rural Woodland: lifetime capital /ha	£15,882	£16,335	£16,800	£17,279	£17,772	£18,279	£18,800	£19,336	£19,887	£20,454	£21,038
Agroforestry: lifetime capital /ha	£5,447	£5,602	£5,762	£5,926	£6,095	£6,269	£6,448	£6,632	£6,821	£7,015	£7,215
Trees Outside Woodland: lifetime capital per tree	£690	£690	£690	£690	£690	£690	£690	£690	£690	£690	£690

[64] There is no actual planting in years 2020 to 2025, but these costs have been shown to illustrate how tree planting costs are expected to change over time.

9. Benefits

Rural woodland creation generates the highest discounted social benefits of £12,491m. This is largely due to rural woodland sequestering a much larger amount of carbon per hectare than agroforestry. Rural woodland also has higher non-market benefit values than agroforestry, particularly for recreation and biodiversity. Agroforestry generates substantially lower total discounted benefits of £375m.

Trees outside woodland generate benefits of £6,478m. These benefits are particularly driven by the high lifetime amenity values of trees outside woodland (£15,278 per tree for large trees and £10,489 for whips and feathers). These values are derived from the Capital Asset Valuation of Amenity Trees tool (CAVAT)[65].

Discounted benefits are split between carbon (£12,499m) and other non-market benefits (£6,846m). Non-market benefits vary across the types of planting:

- **Rural woodland** includes recreation, flood management, landscape, air quality and biodiversity.
- **Agroforestry** includes flood management, landscape, air quality and biodiversity, but at different rates to rural woodland.
- **Trees outside woodland** includes air quality, amenity and rainfall interception.

Carbon sequestration is calculated differently for each area of the assessment. Rural woodland and agroforestry calculate carbon on a per hectare basis, but agroforestry uses a lower sequestration rate to reflect the lower stocking density. Carbon sequestration through agroforestry is a key uncertainty, as it will depend on the design of agroforestry systems, stocking densities and the species and location of trees. Carbon sequestration for trees outside woodland is based on Defra's Urban Trees Challenge Fund (UTCF) modelling, which uses individual tree growth models based on data from iTree eco surveys[66].

The breakdown of *undiscounted* benefits between the different benefit types for each area of the assessment is shown in Table 6. This shows that rural woodland sequesters the most carbon (87.46 MT CO_2 sequestered at a value of £41,949m). Trees outside woodland generate the largest non-carbon benefits at a value of £41,609m.

[65] https://www.forestresearch.gov.uk/research/street-tree-valuation-systems/
[66] An open access public version of the iTree eco tool can be found here: https://www.itreetools.org/tools/i-tree-eco

Table 6: Breakdown of undiscounted monetised benefits for option 1 compared against the baseline, 2022 to 2100. (Some totals may not match due to rounding)

	Carbon		Non-Carbon (£m)							Total
Target Area	Stored ($MT\ CO_2$)	Value (£m)	Air Quality	Recreational	Biodiversity	Landscape	Flood Management	Rainfall Interception	Amenity (CAVAT)	Non-Carbon (£m)
Rural Trees	87.46	£41,949	£991	£6,333	£1,904	£445	£767	N/A	N/A	£10,440
Trees outside woodland	20.19	£10,146	£4,627	N/A	N/A	N/A	N/A	£352	£36,629	£41,609
Agroforestry	2.88	£1,489	£117	N/A	£118	£20	£90	N/A	N/A	£344

10. Value for money and cost effectiveness of carbon sequestration

Overall, a 16.5% tree canopy and woodland cover target (option 1) generates substantial net benefits over the assessment period. The net social present value (NSPV) shows the current value of the project for each option (i.e., discounted benefits minus discounted costs). It provides a measure of the overall impact of an option. Option 4 has a large positive NSPV of £13,371m, suggesting that the lifetime carbon sequestration and non-market environmental benefits outweigh the overall costs. Of the three separate areas of the assessment, all types of planting generate positive NSPVs, although rural woodland generates the largest NSPV of £10,103m.

It is also useful to analyse the cost effectiveness of carbon sequestration for the target. Overall, the target will lead to the sequestration of 110.53 MT CO_2 at a cost of £54.04 per tonne of CO_2. Costs per tonne of CO_2 sequestered for each area of the assessment are:

- Rural woodland = £27.31
- Agroforestry = £33.67
- Trees outside woodland = £172.74

Trees outside woodland are poorer value for money in terms of carbon sequestration compared to rural woodland and agroforestry. However, they provide substantial non-carbon benefits in terms of rainfall interception, air quality and overall amenity value. When considering all these benefits alongside carbon sequestration, trees outside woodland represent good value for money. Further detail on the value for money analysis of trees outside woodland is provided in the 'Risks and assumptions' section of this Impact Assessment.

The appraisal period is to 2100 to reflect that up-front costs are high, but that the benefits, particularly carbon sequestration, accrue in the longer term. It is considered highly unlikely that the negative emissions provided by woodland planted up to 2050 will not be a policy objective after 2100. The appraisal period broadly covers the life (harvest) cycle of a productive woodland providing an holistic assessment of the costs and benefits of woodland creation.

Although the area of tree canopy and woodland in option 1 is significantly lower than in option 2, there is limited impact on carbon savings to 2050 (14.0 MtCO2 vs 15.9 MtCO2) as a result of more conifer being planted and a reduced contribution from silvo-pasture agroforestry. However, by 2100 the difference is much larger (111 vs 148 MtCO2) due to the larger amount of overall planting in option 2 and the higher proportion of broadleaf, which by 2100 has begun to sequester a larger amount of carbon overall than the planting in option 1..

For productive woodland, it is also important to consider the role of harvested wood products in carbon savings. Although the carbon stored in harvested wood products is included in the appraisal, emissions reductions in other sectors through wood substituting for other materials such as concrete and steel is not considered. The emissions savings in 2100 are therefore an underestimate.

11. Sensitivity analysis

There are several key uncertainties in the analysis which have been assessed through sensitivity testing.

Sensitivity 1: Non-market benefits

The first sensitivity tests uncertainty in the non-market benefit assumptions for both agroforestry and trees outside woodland:

- There are no established values in the literature for the non-market environmental benefits of an agroforestry scheme, so some assumptions have been made to model these benefits. Our approach has been to scale down the rural woodland non-market benefit per hectare values. This assumes no recreation benefits, as agroforestry schemes are unlikely to have any public access. Biodiversity and landscape benefits are scaled down by the ratio of the stocking density for an agroforestry system compared to the stocking density for rural woodland. Air quality and flood regulation benefits for agroforestry are assumed to be the same as for rural woodland. Air quality benefits are dependent on achieving canopy cover closure. As an agroforestry system would still achieve full canopy closure, it is assumed that benefits would be the same as for a rural woodland. Similarly, the stocking density of an agroforestry system is sufficiently high to provide the same level of flood regulation benefits as rural woodland. Overall, the approach to estimating non-market environmental benefits of agroforestry is highly uncertain.
- For trees outside woodland, the assessment estimates the amenity value of trees using CAVAT. CAVAT estimates the value of the asset (and the cost of replacing it) rather than the flow of ecosystem service benefits. The CAVAT tool values trees based on factors including tree trunk size, proximity to people, tree crown size and condition and finally life expectancy. The overall value is presented as a benefit in the final year of the assessment to reflect the ongoing amenity value of the tree for the years following the end of the assessment period. Whilst this is in line with Green Book best practice for recording assets, this methodology creates a much higher benefit value than other methodologies (such as that of typical rural woodland creation). As this analysis incorporates mortality rates, most trees outside woodland that are planted do not live until the end of the period. The costs of those surviving trees are also included in the maintenance costs of trees outside woodland up to 2100. Given that the analysis accounts for tree mortality, it is reasonable to include the amenity value for remaining trees at the end of the assessment period, as it is likely that these trees would remain as assets.

Further detail on these assumptions is set out in the ‘Risks and assumptions’ section of this Impact Assessment.

Given the uncertainty in these non-market benefits, it is useful to see the impact on the assessment if these benefits are entirely removed. Table 7 shows the impact of the sensitivity test on the total benefits and NSPV of option 1.

Table 7: Summary of monetised benefits for Sensitivity Test 1: option 1, with and without certain non-market benefits for agroforestry and Trees outside woodland, 2022 to 2100:

	All benefits included				Non-carbon agroforestry benefits and CAVAT values for trees outside woodland excluded			
	Total	**Rural Woodland**	**Agroforestry**	**Trees outside woodland**	**Total**	**Rural Woodland**	**Agroforestry**	**Trees outside woodland**
Social benefit – Non-Carbon (£m)	52,393	10,440	344	41,609	15,420	10,440		4,980
Social benefits (total) (£m)	105,977	52,389	1,833	51,756	69,003	52,389	1,489	15,126
Total Social benefits (discounted £m)	19,345	12,491	375	6,478	16,116	12,491	305	3,320
Net Present Social Value (discounted £m)	13,371	10,103	278	2,990	10,143	10,103	208	-168
% difference in Net Present Social Value – sensitivity test compared to core scenario					-24%	-	-25%	-106%

Table 7 shows that even with all non-market benefits from agroforestry and the amenity benefits of trees outside woodland removed, the overall NSPV of the 16.5% tree canopy and woodland cover target remains large and positive at £10,165m. This suggests that even if the core assessment has overestimated non-market benefits, the total benefits would still outweigh the costs. The effect of removing the amenity value of trees outside woodland causes that element of the assessment to have a small negative NSPV of -£168m, demonstrating that the amenity value makes up a large proportion of total benefits for trees outside woodland.

Sensitivity 2: Uptake of agroforestry – low uptake

The tree canopy and woodland cover target has been designed to be flexible, so that it can be delivered through different rates of rural woodland creation or agroforestry, rather than having fixed targets for each system. The assessment assumes a split of up to 9,000ha rural woodland creation and 1,300 ha of agroforestry. However, there is uncertainty on the actual uptake of agroforestry, which might be much lower or higher than expected. There is also uncertainty on the carbon sequestration rates of agroforestry systems, which will be dependent on the configuration of the system, stocking densities and the species planted.

To test these uncertainties, the second sensitivity test assumes:

- No hectares of agroforestry are created.
- up to 7,500 ha of rural woodland will be created in 2025, with annual planting rates increasing to 10,300 ha per year by 2035. This rate of planting is maintained until 2050. The average capital cost for this is in line with the core scenario.
- Assumptions for trees outside woodland are unchanged from the core scenario.

Table 8A: Summary of monetised costs and benefits for Sensitivity Test 2: option 1, with zero agroforestry and higher rural woodland planting, 2022 to 2100

	Total	% difference: sensitivity compared to core	Rural Woodland	Agroforestry	Trees outside woodland
Social benefit - Carbon (£m)	58,893	10%	48,746	-	10,146
Social benefit – non-Carbon (£m)	53,728	3%	12,118	-	41,609
Optimism bias adjustment	-	-	-	-	-
Estimated risk costs	-	-	-	-	-
Social benefits (total) (£m)	112,620	6%	60,865	-	51,756
Total Social benefits (discounted £m)	20,903	8%	14,424	-	6,478

Table 8B: Summary of monetised costs and benefits for Sensitivity Test 2: option 1, with zero agroforestry and higher rural woodland planting, 2022 to 2100

	Total	% difference: sensitivity compared to core	Rural Woodland	Agroforestry	Trees outside woodland
Social cost - All Capital (£m)	21,849	2%	4,014	-	17,835
Social cost - Resource (£m)	1,088	13%	904	-	184
Optimism bias adjustment	-	-	-	-	-
Estimated risk costs	-	-	-	-	-
Social costs - real (total £m)	22,937	2%	4,918	-	18,019
Total social costs (discounted £m)	6,240	4%	2,752	-	3,488
Net Present Social Value (discounted £m)	14,663	10%	11,672	-	2,990

Table 8 shows the revised costs and benefits under this sensitivity test and a percentage comparison for each metric compared to the core scenario. The table shows that a higher proportion of rural woodland planting will lead to discounted costs being 4% higher and discounted benefits being 8% higher than the core scenario. Overall, the sensitivity test suggests that achieving the target solely through rural woodland creation would lead to a higher NSPV of £14,633m, but also higher lifetime costs.

Sensitivity 3: Low rural woodland, high uptake of agroforestry

It is also possible that there will be a higher uptake of agroforestry than expected. This would mean that the statutory target can still be achieved with a lower proportion of rural woodland creation.

To test this uncertainty, the third sensitivity assumes that rural woodland creation ramps up to 5,600 ha per year by 2035, maintained to 2050. It is assumed that silvo-pasture planting ramps up to 2,600 ha per year by 2035, maintained to 2050. The per hectare cost and benefit assumptions for rural woodland, agroforestry and trees outside woodland are unchanged from the core scenario.

Under this sensitivity, there would be fewer trees planted than under the core scenario due to the lower stocking density in silvo-pasture. This would result in lower carbon sequestration, which could reduce the likelihood of the target delivering on net zero ambitions.

Table 9 shows the revised costs and benefits under this sensitivity test and a percentage comparison for each metric compared to the core scenario. The table shows that a higher proportion of agroforestry planting will lead to discounted costs being 4% lower and discounted benefits being 8% lower than the core scenario. Overall, the sensitivity test suggests that achieving the target with a higher proportion of silvo-pasture would lead to a lower NSPV of £12,080m, but also lower lifetime costs.

Table 9A: Summary of monetised costs and benefits for Sensitivity Test 3: option 1, with high agroforestry uptake and lower rural woodland planting, 2022 to 2100

	Total	% difference: sensitivity compared to core	Rural Woodland	Agroforestry	Trees outside woodland
Social benefit - Carbon (£m)	48,275	-10%	35,151	2,977	10,146
Social benefit – non-Carbon (£m)	51,059	-3%	8,761	689	41,609
Optimism bias adjustment	-	-	-	-	-
Estimated risk costs	-	-	-	-	-
Social benefits (total) (£m)	99,334	-6%	43,913	3,666	51,756
Total Social benefits (discounted £m)	17,787	-8%	10,558	750	6,478

Table 9B: Summary of monetised costs and benefits for Sensitivity Test 3: option 1, with high agroforestry uptake and lower rural woodland planting, 2022 to 2100

	Total	% difference: sensitivity compared to core	Rural Woodland	Agroforestry	Trees outside woodland
Social cost - Capital (£m)	21,114	-2%	2,895	384	17,835
Social cost - Resource (£m)	836	-13%	652	N/A	184
Optimism bias adjustment	-	-	-	-	-
Estimated risk costs	-	-	-	-	-
Social costs - real (total £m)	21,951	-2%	3,548	384	18,019
Total social costs (discounted £m)	5,707	-4%	2,025	194	3,488
Net Present Social Value (discounted £m)	12,080	-10%	8,534	556	2,990

Sensitivity 4: Per hectare lifetime cost increases to 2050

The core analysis for all options and sensitivities assumes that the real lifetime per hectare cost of woodland creation and agroforestry (once inflation has been accounted for) increases at the historic average rate of 2.85% per year until 2030. From 2030 to 2050, per hectare costs are held constant in the core scenario.

However, it is also possible that the per hectare cost of woodland creation and agroforestry continues to increase all the way out to 2050. This could be due to a continuing strain on land, with such high demand and only limited supply, leading to increasing financial incentives being required by landowners in the future or an unexpected increase in other input costs (e.g., labour, saplings).

This sensitivity shows the value for money of option 1 if per hectare woodland creation and agroforestry costs continue to increase to 2050 at the rate of 2.85% per year.

The costs of relacing trees outside woodland are not subject to the same land pressures, so it is assumed that these will be constant over time, in both this sensitivity and the core scenario.

Table 10 below shows the impact of per hectare costs continuing to increase out to 2050. Under this assumption, total discounted costs have increased from the core scenario in option 1 by £622m over the entire period. This is an increase of 10% in total costs. Despite this the NSPV remains positive at £12,783m, implying that even with increasing costs, social value far outweighs the costs.

Table 10: Summary of monetised costs and NSPV for sensitivity 4: Core scenario with marginally increasing costs for rural woodland and agroforestry, 2022-2100.

	Core Scenario Costs				Expanded Costs Scenario			
	Total	**Rural Woodland**	**Agroforestry**	**Trees outside woodland**	**Total**	**Rural Woodland**	**Agroforestry**	**Trees Outside Woodland**
Capital cost (£m)	21,481	3,455	192	17,835	22,605	4,501	269	17,835
Resource cost (£m)	962	778	-	184	1,198	1,014	-	184
Total costs - real (£m)	22,444	4,233	192	18,019	23,803	5,515	269	18,019
Total social costs (discounted £m)	5,974	2,388	97	3,488	6,596	2,977	130	3,488
Net Present Social Value (discounted £m)	13,371	10,103	278	2,990	12,749	9,514	245	2,990
% difference in Net Present Social Value – Sensitivity compared to core					-5%	-6%	-12%	-

12. Costs and Benefits for Discounted Options

For transparency, option 2 was also analysed in this Impact Assessment, though it is not the preferred option.

The planting trajectory for option 2 (**17.5% tree canopy and woodland cover by 2050**) is equivalent to raising planting rates to 16,700 ha per year by 2035, maintained to 2050.

Table 11 shows the monetised costs and benefits for option 2. A higher tree canopy and woodland cover target would deliver an increased NPSV of £16,420m compared to the core scenario. However, total social costs would also be higher at £6,629m, reflecting the increased difficulties in delivering the higher target.

Table 11A: Summary of monetised costs and benefits for option 2 compared against the baseline, 2022 to 2100.

Year	Total	Rural Woodland	Agroforestry	Trees outside woodland
Social benefit - Carbon (£m)	70,187	52,368	7,672	10,146
Social benefit – non-Carbon (£m)	54,865	11,481	1,775	41,609
Optimism bias adjustment	-	-	-	-
Estimated risk costs	-	-	-	-
Social benefits (total) (£m)	125,052	63,849	9,447	51,756
Total Social benefits (discounted £m)	23,049	14,637	1,933	6,478

Table 11B: Summary of monetised costs and benefits for option 2 compared against the baseline, 2022 to 2100

Year	Total	Rural Woodland	Agroforestry	Trees outside woodland
Social cost - All Capital (£m)	22,937	4,113	989	17,835
Social cost - Resource (£m)	689	505	N/A	184
Optimism bias adjustment	-	-	-	-
Estimated risk costs	-	-	-	-
Social costs - real (total £m)	23,626	4,618	989	18,019
Total social costs (discounted £m)	6,629	2,641	500	3,488
Net social benefits (discounted £m)	16,420	11,996	1,433	2,990

Total cost benefit range

Table 12 shows the total costs, benefits and NSPV for options 1 and 2 and the sensitivity tests, which are based around option 1, the 16.5% tree canopy and woodland cover target. The overall cost range is £5,707m to £6,629m and the overall benefits range between £16,116m and £23,049m. The NSPV range is between £10,143m and £16,420m indicating that any of the tree canopy and woodland cover targets is likely to represent good value for money.

Table 12: Summary of monetised costs and benefits for core scenario and sensitivities, option 1 compared to the baseline, 2022 to 2100

	Option 1: 16.5% tree canopy and woodland cover ***Preferred***	**Option 2: 17.5% tree canopy and woodland cover**	**Sensitivity 1: Reduced non-market benefits**	**Sensitivity 2: Zero agroforestry**	**Sensitivity 3: Low rural woodland**	**Sensitivity 4: Increasing marginal costs**
Social benefits (total) (£m)	**105,977**	125,052	69,003	112,620	99,334	105,977
Total Social benefits (discounted £m)	**19,345**	23,049	16,116	20,903	17,787	19,345
Social costs - real (total £m)	**22,444**	23,626	22,444	22,937	21,951	23,803
Total social costs (discounted £m)	**5,974**	6,629	5,974	6,240	5,707	6,596
Net Present Social Value (discounted £m)	**13,371**	16,420	10,143	14,663	12,080	12,749

13. Direct costs and benefits to business calculations

Direct costs to business and income forgone

The target places a duty on government and does not itself lead to any direct costs to business. However, it is likely that some of the costs of meeting the target will be borne through the private sector, through private finance and landowners deciding to plant trees without grant funding. Private finance could be in the form of co-financing or green finance, such as through BNG or carbon markets. It has not been possible to split total social costs between government and business, as these costs will be dependent on how the target is implemented in the future and the extent to which private finance markets develop.

Nevertheless, it is useful to examine the current cost split between government and private finance to get an indicative estimate of the proportion of costs that might fall to each group in the future. Under the NCF, private finance through co-financing of schemes and carbon markets is estimated to reach between 8% and 25% of total funding for tree planting by 2025. If this breakdown is applied to the 16.5% tree canopy and woodland cover target, then discounted lifetime costs to business would be approximately £0.5 to £1.5 billion. However, it is likely that an increasing amount of tree planting will be financed by the private sector in the future, which could mean that businesses contribution towards meeting this target could be higher. There is a high degree of uncertainty regarding the overall potential for private investment, particularly as private finance markets are relatively novel. Given this uncertainty, costs have been presented as total social costs within this Impact Assessment rather than providing a quantified breakdown between government and private sector costs.

It is assumed that costs to business will predominantly fall on private individuals or organisations that want to invest in financing woodland, rather than landowners themselves. Landowners will incur tree planting and woodland management costs, as well as opportunity costs through giving up income when using their land for planting trees rather than the next best alternative use (such as agriculture, renewable energy generation or development). However, it is assumed that most landowners would not actually bear these costs as they would seek financial compensation through government payment rates and additional private revenue streams (such as timber, carbon or green finance).

The main government grant schemes for tree planting in the future will be the environmental land management schemes. Future grant payment rates have not yet been set. As such, this Impact Assessment uses the current grant scheme EWCO to inform the analysis. EWCO grant payments cover 100% of the standard costs of tree planting, as well as providing woodland maintenance payments for 10 years. EWCO also provides additional contribution payments for woodland creation that delivers certain public benefits.

This suggests that government grant payments are currently covering the full costs to landowners of planting, as well as part of the opportunity cost from lost agricultural revenues. Landowners may also be able to generate additional timber, carbon and ecosystem service revenues, which would be costs to the private sector. It is unclear the extent to which private investors would pass through the costs of investing in woodland to consumers in the form of higher prices for their products or services.

Given the unprecedented scale of annual planting required, the government will require additional policy levers beyond grants and existing green finance initiatives to encourage more landowners to change land use in favour of woodland. Potential options could include future regulatory or spending measures. It is not yet possible to determine which of these options may be required to achieve the statutory target. It is possible that some regulatory options may lead to reduced costs for businesses, such as any changes to streamline or reduce administrative burdens for woodland creation. However, other changes may lead to increased costs for business, such as requiring landowners to plant trees. Given the uncertainty around the future policy mix, it has not been possible to quantify or estimate these costs. A full regulatory Impact Assessment would be produced for any future regulatory measures, should they be deemed necessary.

14. Risks and assumptions

General assessment assumptions

The following assumptions have been used in the analysis:

- The assessment takes place over the period 2022 to 2100 due to the long timeframes for the costs and benefits to accrue in tree planting.
- In accordance with the Green Book a 3.5% discount rate is used for the first 30 years, and this then drops to 3% from years 31 to 100.
- Where applicable, values have been deflated in line with HMT GDP deflator guidance. All values are in 2019 prices.
- All benefits and costs are **for option 1, the 16.5% tree canopy and woodland cover target**, and are additional compared to the baseline (option 0).
- The assessment assumes the following stocking densities (with rural woodland based on NCF stocking densities and agroforestry stocking based on the Scottish Government agroforestry grant offer[67]):
    - Rural Woodland (assumes 70% broadleaf, 30% conifer split which is the current policy assumption on planting mix to best balance biodiversity benefits and rates of carbon sequestration):
        - Conifer – 2500 stems /ha
        - Broadleaf – 1600 stems /ha
    - Agroforestry:
        - Silvo-pasture– 400 stems /ha
        - Silvo-arable – less than 100 stems/ha

Cost Assumptions

While cost assumptions are varied across the different elements, the majority are based on already established tree planting projects, particularly those carried out by the Forestry Commission. As the Forestry Commission has carried out many similar projects in the past and made full assessments of the actual costs, these estimates are robust and thus not requiring any cost or optimism bias adjustment. Additionally, the cost estimates already include an assumption of tree mortality which acts indirectly as a form of optimism bias. For example, for trees outside woodland, by 2100 there is only an average survival rate of 30%, implying that although 100% of trees are costed, benefits are not achieved over the whole assessment period for a large proportion of those trees planted. This indirectly creates a form of optimism bias adjustment. For woodland trees, up to 15% of losses in the first two years following establishment is considered normal, but landowners would be expected to replace those trees. In the longer term, natural mortality (shade leading to self-thinning) or management would be expected to reduce tree numbers. This is incorporated into the data.

[67] Agroforestry (ruralpayments.org)

For this analysis, the per hectare costs of woodland creation and agroforestry are assumed to increase in the short run. The increase is set at a 2.85% increase yearly between 2020 and 2030, with constant marginal costs from 2031 onwards. The evidence supporting this approach for agroforestry and rural woodland creation has been set out previously in the 'Monetised and non-monetised costs and benefits of preferred option' section of this Impact Assessment.

Rural Woodland

Costs for rural woodland planting are predominantly based on the woodland creation elements of the NCF outlined in Table 13.

Table 13: Per hectare cost assumptions for rural woodland creation

Category	Lifetime costs per hectare	Evidence Source
Capital cost	£15,882 in 2020, rising to £21,038 in 2030 onwards	Based on the NCF. This includes various projects, such as EWCO, Community Forests and planting on public land, amongst others. The per hectare cost is the average across the whole NCF. Resource costs include administration costs for running planting schemes.
Resource cost	£3,578	

Considering the scale of planting required under the tree canopy and woodland cover target, it is reasonable to assume that several delivery mechanisms will be required, including environmental land management grant schemes, but potentially also other government funded schemes and private finance. As the costs of these delivery mechanisms are not yet known, the analysis uses the average per hectare cost across all existing NCF schemes as a proxy for the likely future costs.

The primary delivery mechanism for woodland creation under the NCF is EWCO. EWCO provides funding for capital items and activities to create a new woodland up to an average maximum of £8,500/ha. The cost of each capital item is based on a wealth of evidence on the actual costs of delivering different types of woodland. These costs are set out in the EWCO grant manual[68]. These items and activities include supplying and planting trees (£1.60 per tree), tree shelters (£2.00 per tree), and various boundary, flood and vegetation management options.

EWCO also offers additional contributions of up to £8,000/ha based on the location and design of the woodland. These payments are determined by whether the woodland contributes to nature recovery, water quality, flood mitigation, recreational access and air

68 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1019930/EWCO_Grant_Manual_-_Appendix_1_-_Standard_cost_items_v1.1.pdf

quality, as well as locational considerations such as proximity to population centres or rivers. In addition to capital payments, EWCO also offers annual maintenance payments for 10 years at a rate of £300/ha.

Forestry Commission analysis has been used to estimate the average expected per hectare payment rate across all EWCO applications, based on predictions on the location and design of future applications.

Other delivery mechanisms under the NCF include Community Forests and planting on public land. These delivery mechanisms are usually higher on a per hectare basis as they include additional costs such as land acquisition.

The per hectare cost for each delivery mechanism has been combined into an average cost per hectare across the NCF, weighted by the number of hectares that each delivery mechanism contributes.

The NCF also includes supporting activities such as R&D, monitoring and evaluation and investment in additional nursery capacity and skills. As future supporting activities will likely be needed to deliver the tree canopy and woodland cover target, the analysis uses the cost of NCF supporting activities as a proxy for future costs. The costs of all NCF supporting activities were added together and then divided by the number of hectares. These costs were then added to the average per hectare delivery costs. This assumes that total spending on supporting activities will increase proportionately with hectares. This is a conservative assumption, as in reality it is expected that fewer supporting activities would be required on a per hectare basis as afforestation scales up, due to economies of scale.

Agroforestry

Cost assumptions for agroforestry are based on Defra analysis on the standard costs for establishment, planting and maintenance of agroforestry schemes, as well as data from the Forestry Commission. The marginal costs for agroforestry are assumed to increase at the rate of 2.85% up to 2030, at which point they are held constant. The cost assumptions are outlined in Table 14.

Table 14A: Cost assumptions for agroforestry creation

	Lifetime cost per tree	Lifetime cost per hectare in 2020	Assumptions
Tree protection costs	£7.26	£2,903	Per tree costs include: Tree shelters costing £2 (EWCO standard costs[69]). A 3 foot stake costing £1.53 and a half round stake costing £1.95[70]. 3.15mm wire, Ground prep and labour – 0.16 hours per tree at £14.76[71] per hour.
Tree supply	£1.60	£640	£1.60 per tree (EWCO standard costs)
Fencing	-	-	Assumes farmer already has standard livestock fencing around field boundary, as the farmer is converting from pasture to silvo-pasture.

69 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1019930/EWCO_Grant_Manual_-_Appendix_1_-_Standard_cost_items_v1.1.pdf
70 Based on real world costs of tree protection required for a recent Northern Ireland agroforestry scheme.
71 John Nix Farm Management Pocketbook 2021 (51st Edition). Page 161. Median Labour Cost, total employer costs for all hours

Table 14B: Cost assumptions for agroforestry creation

	Lifetime cost per tree	Lifetime cost per hectare in 2020	Assumptions
Maintenance	£4.76	£1,904	Cost spread over 10 years. Includes: Replacement of up to 20% of newly planted trees which have died, costing £1.60 per tree (EWCO standard costs) Weeding at 8p per application per tree (2 applications annually for three years) Fence maintenance and repairs of 1 day per year costing £180 per day72 Forestry agent supervision costing £100/ha[73] Removal of tree shelters at £120/ha – based on 1 full day of labour costing £14.76 per hour.
Total	£13.62	£5,447 in 2020 rising to £7,215 in 2030 onwards	

[72] Defra estimate based on quotes from contractors
[73] Defra estimate based on quotes from agents

Trees outside woodland

Costs assumptions for trees outside woodland are derived from the LATF model and are outlined in Table 15.

Table 15: Cost assumptions for trees outside woodland

	Lifetime cost per tree
Admin and delivery (resource)	£1.00
Management (resource)	£5.96
Total resource	£6.96
Planting (capital)	£8.68
Establishment and pruning (capital)	£681.74
Total capital	£690.42

15. Carbon Assumptions

Carbon sequestration rates are based on the growth rate of trees, with presumed mortality and different sequestration rates for each section of the assessment. The monetised carbon values are derived using the new undifferentiated BEIS carbon prices, which combine traded and non-traded values. The analysis uses the central carbon value. This is in line with the latest BEIS guidance on carbon values[74] (August 2021).

Rural Woodland

For rural woodland, carbon emissions/removals are estimated using output from Forest Research's CSORT model (see Morison et al., 2012) published in Matthews and Broadmeadow (2009)[75], an off-line version of Carbine, the greenhouse gas accounting model used to calculate the forestry contribution to the UK greenhouse gas inventory. Three indicative woodland types are represented in the model: productive conifer, productive broadleaf, and unmanaged. Carbon sequestration modelling is based on conventional forestry growth and yield models which apply an s-shaped growth function. This accounts for the fact that many forestry systems, particularly broadleaf woodland, commonly have slower growth during the establishment phase (the period after planting). As such, carbon sequestration in the early years is conservative before accelerating as the trees begin to reach maturity.

Agroforestry

As agroforestry has not been commonly practised in the UK, to date, there is uncertainty in how agroforestry systems will be implemented and planted; in particular, spacing, stocking densities and the timing of thinning interventions. There is limited information for agroforestry systems on which to base robust models.

The agroforestry carbon emissions/removals are estimated using the same model source as rural woodland but scaled down to reflect the lower stocking density of silvo-pasture. Modelling assumes silvo-pasture systems will have approximately 470 stems per hectare with 7.4m spacing.

Trees outside woodland

Carbon sequestration rates for trees outside woodland are based on estimates used for urban trees in Defra's UTCF modelling, which uses individual tree growth models based on data from iTree eco surveys[76].

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[74] https://www.gov.uk/governent/publications/valuing-greenhouse-gas-emissions-in-policy-assessment/valuation-of-greenhouse-gas-emissions-for-policy-assessment-and-evaluation
[75] Matthews R.W. and Broadmeadow M.S.J. (2009). The potential of UK forestry to contribute to government's emissions reduction commitments. In: Read, D.J., Freer-Smith, P.H., Morison, J.I.L.
[76] An open access public version of the iTree eco tool can be found here: https://www.itreetools.org/tools/i-tree-eco

16. Non-market benefit assumptions

Rural Woodland

The benefit assumptions are aligned with Enabling a Natural Capital approach (ENCA) guidance[77]. The Green Book supports the use of ENCA for natural capital assessment. The application of these benefit values for the woodland target has been checked for consistency with ENCA. This provides a high level of confidence in the non-market benefit valuations below:

- **For recreation**, a value of £969/ha (2019 prices) is applied for all woodland. This value comes from the currently unpublished August 2021 Outdoor Recreation Valuation Insights project (ORVal)[78], which values various aspects of outdoor recreation in England and Wales. The value provided is based on the estimated marginal welfare value of an average woodland hectare for outdoor recreation, which is £1939/ha (2019 prices). However, this value can only be applied to woodland that has public access. It is uncertain the proportion of woodland that will be planted in public areas under the tree canopy and woodland cover target. As the NCF suggests that 50% of woodland planted will be accessible to the public, this assumption is continued for the tree canopy and woodland cover target. Therefore, the applied value (£969/ha) is half of the total recreation value provided in the ORVal report to account for the value of publicly accessible woodland provided under the target only. The applied value is for rural woodland, which provides lower recreation benefits than woodland created in urban or peri-urban areas. However, it is not possible to split out woodland creation under the target across different area types. Therefore, as some planting is likely to be in peri-urban areas, the applied value is likely to underestimate the true recreational value of woodland provided under the target.
- **Air quality** benefits use a marginal value derived from the Jones et al (2017)[79] report for the ONS. Using the value of £278/ha (in 2019 prices) for 2020 for rural woodland, minus the £16/ha (in 2019 prices) for enclosed farmland, giving a marginal value of woodland creation at £262/ha. This is the price for rural woodland and will likely underestimate the value of air removal by peri-urban woodland. However, as national air pollution is expected to decrease over time, the value of air quality benefits through tree planting is also expected to reduce. The analysis assumes that air quality benefits reduce linearly to a value of £141.70/ha in 2019 Prices by 2030. The 2030 value is derived from the ENCA services data book, converted to 2019 prices.
- **Biodiversity** benefits will depend on the species and location of planting. Benefit values are based on a split between conifers and broadleaf derived from an area-

[77] Enabling a Natural Capital Approach (ENCA): Guidance - GOV.UK (www.gov.uk)
[78] An open access public version of the ORVAL tool can be found here: https://www.leep.exeter.ac.uk/orval/
[79] Developing Estimates for the Valuation of Air Pollution Removal in Ecosystem Accounts. Available at: N524081RE.pdf (nerc.ac.uk)

based breakdown from Willis (2003)[80]. This approach denotes an annual value of £223/ha for conifer and £588/ha for broadleaves (2016 prices) (£232 and £614 respectively in 2019 prices) and is based on a non-use value of biodiversity. This means that the benefits to the whole population are captured, even those who do not utilise the forests directly or indirectly.

- **Landscape** values come from Willis (2003)[81] and are estimated at £80.72/ha/year (£102 in 2019 prices). This is based on the value which households receive from having a view of woodlands from their houses or on their commutes.
- **Flooding regulation service values** are based on the Forest Research (2018)[82] report on valuing this service from existing forest cover. The average annual value across all English forests is used, £117.36/ha (in 2019 prices), as it is not known what proportion of sites will be in flood risk catchments and thus provide a higher value of flooding regulation

The benefits are monetised and then multiplied by the number of hectares to be planted. The inputs to the model are the planting profile, in terms of hectares per year, and the woodland type. For this analysis it is assumed 20% Managed Conifer, 40% Managed Broadleaf and 40% Biodiversity Broadleaf. Non-market benefits are 'phased in', scaling up by 1/20th of the full value each year, reaching full value at 20 years and retaining this value for the lifetime of the woodland.

Agroforestry

As for rural woodland, the benefit assumptions have been kept aligned with ENCA guidance[83], although a number of additional assumptions have been made to scale the rural woodland values for use in agroforestry systems:

- Our analysis assumes **no recreation benefits**, as agroforestry schemes are unlikely to have any public access.
- **Air quality** benefits are the same as for rural woodland. This is because silvo-pasture is likely to generate similar canopy coverage as rural woodland by the time the trees reach full size.
- **Biodiversity** benefits are based on the broadleaf value used for calculating the biodiversity benefits of a rural woodland but scaled to reflect the lower stocking density of an agroforestry system. This gives a value of £153.40/ha. There is no existing per hectare value for the biodiversity benefits of an agroforestry system. Therefore, our approach reflects that agroforestry is likely to deliver some biodiversity benefits, but not at the scale of a full hectare of rural woodland.
- **Landscape** values are based on the same values as for rural woodland but scaled down to reflect the lower stocking density of an agroforestry system. This gives a

[80] The area based breakdown is based on Defra and Forestry Commission analysis of *The Social and Environmental Benefits of Forests in Great Britain.* Available at: Social & Environmental Benefits of Forestry
[80] The area based breakdown is based on Defra and Forestry Commission analysis of The Social and Environmental Benefits of Forests in Great Britain. Available at: Social & Environmental Benefits of Forestry
[82] Valuing flood regulation services of existing forest cover to inform natural capital accounts - Forest Research
[83] Enabling a Natural Capital Approach (ENCA): Guidance - GOV.UK (www.gov.uk)

value of £25.26/ha. This is a conservative approach by assuming some landscape benefits but not to the same extent as a hectare of rural woodland.

- As per rural woodland, **flooding regulation service values** are assumed to be at £117.36/ha, as it is not known what proportion of agroforestry sites will be in flood risk catchments and thus provide a higher value of flooding regulation.

Non-market benefits are 'phased in', but over 40 years instead of 20 (as was assumed for rural woodland). This is because the trees are likely to take a longer time to reach full maturity in an agroforestry system. This means benefits are scaled up by 1/40th of the full value each year, reaching full value at 40 years and retaining this value for the lifetime of the agroforestry system. This is likely to be a conservative assumption to reflect that the overall non-market benefits are likely to be lower in for agroforestry compared to rural woodland.

Given the uncertainty around the non-market benefit assumptions for agroforestry, sensitivity testing has been conducted where all the non-market benefits for agroforestry are excluded from the assessment. Results from this test are outlined in the 'Monetised and non-monetised costs and benefits' section of this Impact Assessment.

Trees outside woodland

The key monetised benefits for trees outside woodland are from the ecosystem services which trees provide and are calculated using street trees. The LATF and large tree benefits in the UTCF are based entirely on single tree delivery of ecosystem services.

The ecosystem services valued for the individual planted trees are **air pollutant removal, rainfall interception and carbon sequestration**. The **amenity value** of the trees is also valued. This is based upon a residual value in the final year of the assessment period and is derived from CAVAT. The CAVAT system provides a method for managing trees as public assets rather than liabilities, and accounts for the contribution of location, social value and appropriateness. However, it should be noted that the CAVAT calculation creates an extremely high value in the final year of assessment. This is because the amenity value of the tree is included as a benefit in the final year, as a residual value for its ongoing provision of amenity for the years following the end of the assessment period. This is in line with Green Book best practice for asset values. However, this methodology creates a per hectare benefit much higher than other methodologies. Given the uncertainty around this assumption, sensitivity testing has been conducted to remove CAVAT values from the assessment. Results from this test are outlined in the 'Monetised and non-monetised costs and benefits' section of this Impact Assessment.

The other ecosystem services benefits are derived from iTree eco[84] which quantifies the structure and environmental effects of individual urban trees and calculates their value to society. The values captured here are based on Norway Maple being planted. This is because there are the most data available for the benefits of Norway Maple compared to

[84] An open access public version of the iTree eco tool can be found here: https://www.itreetools.org/tools/i-tree-eco

other tree types. As three different size trees are part of the fund, the rate at which the benefits are derived are based on the age at which the tree is planted. Whips are assumed to be planted at age 2, feathers at age 6 and large trees at age 10. The values derived from each of the benefits are identified and monetised on a per tree basis, then multiplied by the number of trees to be planted.

17. Gaps and uncertainty in the evidence

As previously discussed, there is inherent uncertainty in modelling land use change so far into the future. It should be noted that what has been modelled here is a hypothetical scenario and should not be considered an expectation of how government will deliver the target.

There are also key evidence gaps in our analysis, particularly on the level of deforestation, the level of tree canopy loss outside woodland associated with pest and diseases and urban tree management, the nature of future agroforestry schemes, uptake of agroforestry and future changes in the extent of orchards. Agroforestry carbon sequestration rates are also uncertain. There is also uncertainty in some of the non-market environmental benefits used in the analysis, particularly for agroforestry schemes. Finally, there is uncertainty on how the real per hectare costs will change in the future, and how these costs will be split between the private sector and government.

The sensitivity tests outlined in the ‘Monetised and non-monetised costs and benefits’ section of this Impact Assessment help to test some of this uncertainty. Further analysis will also be produced to address these evidence gaps ahead of the final stage Impact Assessment.

The chosen woodland target is designed to be robust to future policy uncertainty. Having an expansive, undifferentiated target which includes different trees beyond conventional woodland will allow for more flexibility in meeting the target, whilst still delivering on net zero ambitions.

18. Impact on small and micro businesses

As discussed in the 'Direct costs and benefits to business calculations' section, the target places a duty on government and does not itself lead to any direct costs to business.

Any landowner could plant trees in support of the target, including small and micro businesses. Landowners with one hectare of land are currently eligible for EWCO grants and similar eligibility criteria could be used for future grant schemes. As such, many small and micro businesses would technically be able to apply. These businesses would be fully re-imbursed for any actual tree planting costs through grant payments.

However, there is some evidence to suggest that larger farms are more likely to increase tree cover than small farms[85]. For smaller farms the need to maximise agricultural output from the available land to keep the farm viable can be a barrier to tree planting[86].

As a result, larger farms are more likely to be impacted by the tree canopy and woodland cover target, with a lesser impact on small and micro farm businesses.

[85] NEER020 Edition 1 Encouraging woodland creation regeneration and tree planting on agricultural land (1).pdf

[86] Mills, J., Gaskell, P., Jones, N., & Boatman, N. (2013). Farmer attitudes and evaluation of outcomes to on-farm environmental management. Aspects of Applied Biology 118, 209-216.

19. Wider impacts

Non-monetised benefits

There are several benefits from a 16.5% tree canopy and woodland cover target that it has not been possible to monetise. There may be some overlap between these benefits and those that have been monetised, so these benefits should not be viewed as entirely additional to those set out in the monetised section of this Impact Assessment.

- **Water quality improvements, noise, and heat reductions** – these are all positive externalities associated with tree planting but have not been monetised due to a lack of robust data. Planted trees increase water filtration rates, helping to reduce water pollution. Woodland expansion will, in most circumstances, lead to a reduction in agricultural diffuse water pollution through (a) replacing intensive agricultural land use/practice and (b) providing a barrier/interception function to reduce the quantity of sediment and associated nitrate/phosphate from entering water courses. Riparian woodland will also help to stabilise the banks of water courses reducing sedimentation. Trees also act as natural noise barriers, therefore having a mainly positive impact on noise pollution in peri-urban areas. The planting of trees can also reduce heat through providing shade and evapotranspiration. Planting on certain sites, such as vacant and derelict land, may also have the positive effect of removing current negative externalities. For example, the disamenity impacts associated with old landfill sites which are somewhat removed with the planting of trees[87]. These types of benefit will be very location dependent and therefore are harder to quantify at this stage.
- **Health benefits:** Planting trees contributes to societal wellbeing through improving both physical and mental health. Providing increased public access to woodland has shown to improve individual's mental health, with a study by the University of Wollongong[88] finding that people who are exposed to areas with canopy cover have been shown to experience a third less psychological stress. It was also estimated that physical inactivity costs the NHS more than £450m a year[89]. Planting woodland has been shown to increase physical activity if made accessible. Therefore, through tree planting the health and wellbeing of individuals can be improved and the costs to the NHS reduced.
- **Jobs:** There is large uncertainty on the number of jobs that may be required to support such an unprecedented increase in afforestation. Calculations based on the August 2021 Forestry Skills Forum 'Forestry Workforce Research' report[90] suggest

[87] https://www.sciencedirect.com/science/article/pii/S0921800912003680
[88] 2019: Urban trees found to improve mental and general health - University of Wollongong – UOW
[89] Public Health England: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/524234/Physical_inactivity_costs_to_CCGs.pdf
[90] The report estimates that 2019 jobs will be supported by 2025, if planting rates reach 10,000 ha of new woodland per year. This accounts for attrition in the workforce and does not include indirect jobs such as tourism. The full report is here: https://www.lantra.co.uk/sites/default/files/2021-08/Forestry%20Workforce%20Research%20Final%20Report%2013.08.21.pdf

that total projected labour demand to support increased afforestation is estimated to be approximately 2000 jobs by 2025 and 2500 jobs by 2035. The figures are for woodland creation, harvesting and restocking only. This is based on achieving 10,000 ha of planting by 2025 and 16,700 ha of planting by 2035. When scaling these job projections to account for the afforestation rates of the 16.5% tree canopy and woodland cover target, increased tree planting will support an additional 1,400 jobs by 2035. This equates to approximately one job being supported for every 5 ha of new woodland creation. The job figures are for England only and are conservative as they exclude potential jobs created in fencing, public sector advisers, deer control and social foresters. Indirect job creation such as in tourism or local farming is also excluded. It is also uncertain whether these will be new net jobs or a movement from other sectors as land use changes towards forestry.

- **Economic productivity:** Timber and biomass sales are private benefits to the seller of the tree and feed into the economy through multipliers associated with the processing and logging supply chain. The GVA multiplier related to forestry planting is 1.6, taken from Scottish Government's Input-Output tables[91]. This demonstrates that there is positive additional value to the economy from greater economic activity because of forestry planting.
- **Educational benefits:** Educational benefits are derived from engaging people in the planting and maintenance of trees, particularly young people. These benefits are maximised when planting trees in or near educational institutions (e.g. schools).

Non-Monetised Costs

Given the unprecedented scale of planting required, the government will require additional policy levers beyond grants and existing green finance initiatives to encourage more landowners to change land use in favour of woodland in the future. Potential options could include changes to future regulatory or spending measures. It is not yet possible to determine which of these options may be required. Whilst some regulatory options may reduce costs to businesses, others may lead to increased costs. Given the uncertainty around the future policy mix, it has not been possible to quantify or estimate these costs. A full regulatory Impact Assessment would be produced for any future regulatory measures once these policies have been determined.

Domestic sustainable food production continues to be a high priority and it's important to consider any potential impacts the targets may have on it. The tree canopy and woodland cover target is achievable without requiring the use of the most productive agricultural land, as tree planting is most likely to occur on less productive land. This limits the likely consequences on UK food production. Modelling has identified 3.2 million hectares of low-risk land suitable for afforestation[92], excluding best and most versatile agricultural land, designated landscapes (all National Parks and Areas of Outstanding Natural Beauty) and a range of other sensitivities. In total, the 16.5% tree canopy and woodland cover target

[91] https://www.gov.scot/publications/input-output-latest/
[92] https://www.forestresearch.gov.uk/documents/6955/FCPG012.pdf

would require ~262,000 hectares of this land (~8%) to be converted to woodland and agroforestry by 2050.

Skills and Workforce

UK nursery production would need to increase substantially to deliver option 1 and to increase domestic timber supply for increased use in construction. The current forestry workforce is considered as ‘aging’ and would be insufficient to enable such an increase in planting rates without substantial investment in skills and workforce.

Regional and Sectoral Impacts

Uplifts in afforestation rates are likely to largely be delivered in rural areas, providing diversified income generation and business opportunities for rural communities, particularly in the forestry, timber and tourism sectors. Planting also boosts the UK wood products sector. Opportunities for afforestation will also be delivered in areas close to people, for example near cities and urban conurbations, providing regional employment opportunities as well as benefits to society such as landscape and sense of place improvements. Cheaper land tends to be in the North and West, but this land generally has greater environmental constraints on it, providing a likely balance on where the woodland is created.

Private Finance markets

Private finance models are expected to develop to support planting in the future. The forestry sector is well-placed to develop private/green finance models, with the WCC a relatively mature standard, having been piloted more than a decade ago. The HMT-funded Woodland Carbon Guarantee and announcement of the Climate Emergency by businesses and government bodies has resulted in a recent upturn in new project registrations. BNG is also expected to support development-funded woodland creation, while there is ongoing work to develop a Woodland for Water Code to capture private finance for water quality improvement and flood resilience. These models could generate revenue streams for landowners in the future. However, such markets are still relatively novel, and as such the overall potential of private investment is uncertain.

Trees planted through BNG funding may not have full benefit values if biodiversity is being lost in other places. Similarly, if trees are lost elsewhere to development, there may only be marginal carbon benefits from trees planted through BNG. The net impact of planting must be considered where BNG is applied. However, as stated previously, the split between private and public financing is currently uncertain, and so the degree to which this may impact the benefits is not possible to estimate at this stage.

Crossover with other Environment Act targets

Due to the nature of the Environment Act targets setting process there is inevitable overlap between some of the statutory target impacts. Through modelling an array of non-market benefits in the tree canopy and woodland cover target there is potential overlap with the following target areas: Air Quality, Water, and Biodiversity. Through the quantification of our benefits, our analysis provides per hectare figures for each of these areas. This creates the potential for double counting if these other target areas assume that a proportion of their benefits accrue through tree planting. Therefore, the boundaries of these benefits have been assessed to minimise double counting in each of the following target areas:

- **Air Quality**: In this Impact Assessment, the assessment includes a value for air quality benefits provided by tree planting. This marginal figure of £262/ha in 2020 scaling down to £142/ha in 2030. The value is based on the removal of a range of pollutants through tree planting, including: coarse particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$), sulphur dioxide (SO_2), ammonia (NH_3), nitrogen dioxide (NO_2) and ozone (O_3). This value is applied across both rural planting and agroforestry. The air quality targets focus on $PM_{2.5}$. Within the context of the air quality targets, tree planting only has a marginal impact on overall pollutant removal. The contribution of the tree canopy and woodland cover target to air quality targets is location and species dependent. Therefore, the air quality benefits provided by trees will be quantified within the tree canopy and woodland cover target Impact Assessment and will not be accounted for within the air quality targets Impact Assessment.
- **Water:** Incentivising targeted woodland expansion could lead to a reduction in agricultural diffuse water pollution by reducing the quantity of sediment and associated nitrate/phosphate from entering water courses[93]. The benefits of this are counted under the water target rather than the tree canopy and woodland cover target. The tree canopy and woodland cover target contains a quantified value for the benefit of flood regulation, but these benefits are not accounted for in the water target. There might be some double counting of non-water benefits from trees. It is not possible to quantify the level of double counting between the two Impact Assessments, as they use different methodologies.
- **Biodiversity:** The tree canopy and woodland cover target Impact Assessment values biodiversity benefits of woodland creation based on a split between conifers and broadleaves derived from an area-based breakdown from Willis (2003). This approach denotes an annual value of £223/ha for conifer and £588/ha for broadleaves (2016 prices) (£232 and £614 respectively in 2019 prices) and is based on a non-use value of biodiversity. Woodland creation also contributes to the biodiversity habitats target, as deciduous woodland is a priority habitat. Only deciduous woodland created outside of Sites of Special Scientific Interest (SSSI) areas counts towards the wider habitats target. A total of approximately 163,000 ha of woodland creation is estimated to occur by 2042 under the 16.5% tree canopy

[93] ibid

and woodland cover target. The target assumes that 70% of woodland creation will be broadleaf, which implies a total of 114,000 ha of deciduous woodland will be created by 2042. It is not known how much deciduous woodland creation will occur outside of SSSIs, but 88% of current deciduous woodland is outside SSSIs. As a simplification, the analysis therefore assumes that this same percentage will apply to new woodland creation. If the target is realised, this would result in approximately 100,000 hectares of priority woodland habitat being created outside protected sites by 2042. To avoid double counting, the monetised costs and benefits of this woodland creation are only included in the tree canopy and woodland cover target and not in the wider habitats target Impact Assessment.

20. A summary of the potential trade implications of measure

The tree canopy and woodland cover target is unlikely to have any direct trade implications, but it is likely there will be some indirect impacts from an increase in tree planting. The UK currently imports 80% of its timber and wood products, making it the 2nd biggest importer after China[94]. An increase in tree planting is likely to reduce the UK's reliance on import by providing an increase in domestically supplied timber for construction and other uses.

[94] Forest Research 2019. Forestry Statistics 2019. https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2019/

21. Monitoring and Evaluation

The Environment Act creates a new statutory cycle of monitoring, planning and reporting. Long-term targets will be supported by interim targets, which will set a five-year trajectory towards meeting the long-term targets. The Act requires Government to set interim targets in the Environmental Improvement Plan. This will ensure that there is always a shorter-term goal Government is working towards, as well as the long-term target and will allow for an ongoing assessment of whether the government is on track to meet its long-term target ambitions.

The canopy cover metric will measure woodland, small woods, groups of trees and individual trees (including urban). Tree canopy and woodland cover is currently measured by National Forestry Inventory and administrative records are used to monitor and report net increase in tree canopy and woodland cover with a robust dataset stretching back to 1971. Small woods, groups of trees and individual trees (including urban) will be measured by remote sensing published by National Forestry Inventory Assessment of Tree Cover Outside Woodland, established in 2017 and due to be updated in 2022 and every five years after. Remote sensing data will need to be analysed to augment administrative data for woodland creation and deforestation to calculate canopy cover during the target.

Through this it is possible to determine whether the policy objectives are being met or whether there have been any unintended effects which need to be addressed.

Extra data may need to be collected on the carbon uptake of any woodland planted in its early years to determine whether the policy is on track to meet its objectives. Data on the impact of agroforestry systems will also need to be collected as their potential impact has been modelled on the limited data available in England.

If there is substantial uptake in biomass the policy may need to be reviewed. Under these circumstances the SI may need to be replaced or reviewed depending on the changes that are required.