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How suitable are Miyawaki forests in 21st century England?

-- The exploration of the perceptions towards the Miyawaki Forest method's application in 21st England.

By

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"The most important thing to do right now is to build native forests which survive thousands of years until the next glacial age arrives… I hope all of the Japanese people plant small saplings with their own hands in order to protect their own lives and those of their loved ones, and to preserve the lush verdure of Japan. I wish to spread the know-how and the results of this ecological reforestation to the whole world."

Akira Miyawaki

"Few of us are in a position to restore the forests… But tens of millions of us have gardens, or access to open spaces such as industrial wastelands, where trees can be planted… and if full advantage can be taken of the potentialities that are available even in heavily built up areas, new 'city forests' can arise."

Robert A. de J.Hart

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All diagrams presented in the thesis are contributed by the researcher unless specified.

Abstracts

Forests play a vital role in mitigating climate change, supporting biodiversity, and improving quality of life. The Miyawaki forest is described as a dense, fast-growing and biodiverse native forest. It is based on afforestation management methods pioneered by Dr Akira Miyawaki in the 1970s. As an innovative urban greening approach, the MFM has garnered increasing attention in Europe recently, particularly in the UK, where hundreds of projects have been initiated since 2020, due to its rapid afforestation claims. This thesis investigates the suitability of implementing the MFM in England through a mixed-method research design, including a field experiment and two comprehensive surveys of 112 experts and professionals and 292 members of the non-professionals. It aims to understand the early-stage growth and survival rates of the MFM plantings compared to conventional planting method, and measure perceptions of the method within the UK context. It assesses awareness, attitudes, concerns regarding its implementation and the composition of native and non-native tree species in MFM planting, in light of the rapidly changing climate in the UK. Key concerns include space requirements, costs, maintenance, ecological consequences, potential conflicts with existing habitats, risks of vandalism, tree species selection, and climate adaptability to future climate conditions. Ultimately, the study reveals that the MFM demonstrates relatively rapid early-stage growth and is generally supported, particularly for application in urban areas, though academic engagement remains limited. It also finds shifting attitudes toward native and non-native species selection especially in relation to climate adaptation. By contributing to the growing body of research on high density urban tree planting, this thesis provides critical insights for urban policymakers, practitioners, and environmental advocates regarding the implementation of urban tree-planting initiatives in UK cities, contributing to a greater understanding of sustainable and resilient urban environments for UK citizens in an evolving climate future.

Key words: Miyawaki Forest Method, Tiny Forest; Urban Forestry; Forest Restoration; Native and Non-native Tree Species; Climate Change; Ecological Innovation; Perceptions

Abbreviations

MF: Miyawaki forest
MFM: Miyawaki Forest method
CF: Conventional forest
CFM: Conventional Forest method
NT: Native tree
NNT: Non-native tree
UF: Urban forests
NS: not significant
FAO: The Food and Agricultural Organisation
CBD: Convention on Biodiversity Diversity

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Ch.1. Introduction

1.1 The status of forests in the UK

Globally, forests cover approximately 31% of the Earth's land area, serving as vital ecosystems that support biodiversity, regulate the climate, and provide resources for millions of people (Abraham, 2022). Forests act as carbon sinks, absorbing around 2.6 billion tonnes of carbon dioxide annually, which plays a crucial role in mitigating the effects of global warming and climate change (Pan *et al.*, 2011). However, increasing human demand for resources has resulted in the deforestation of natural forests for agriculture as well as the degradation of forest through logging for timber, forest fragmentation, pollution and other human impacts (Foley *et al.*, 2005; Song *et al.*, 2018). Globally, forest cover has decreased by approximately 420 million hectares since 1990, and the area of natural forests decreases by some 13 million ha annually (ca. 0.3%) (FAO, 2020; FAO and UNEP, 2020; Igini, 2023). The loss of forests not only threatens biodiversity but also contributes to climate change, as forests play a crucial role in carbon sequestration (Brockerhoff *et al.*, 2008; Pan *et al.*, 2011; Phillips, Newbold and Purvis, 2017; Hill *et al.*, 2019).

Forests in the UK have undergone significant transformations over centuries, from large-scale deforestation for agricultural expansion and industrial development, as agricultural and industrial expansion reduced woodland cover to just 5% by the early 20th century, to modern-day efforts focused on reforestation and biodiversity conservation (Peterken, 1996; Foster *et al.*, 2008). Currently, the UK is planting lots of trees. The area of forest in the UK is 3.25 million hectares, ~13 per cent of the land area (Sing *et al.*, 2018). Nevertheless, it is still one of the countries with the lowest forest cover in Europe, well below the European average of 46 per cent (including the Russian Federation) (Forestry Commission, 2023). Thus, the UK's forests are still facing severe ecological pressures.

Historically, the UK's forests were dominated by native broadleaf species, such as oak (*Quercus robur*) and beech (*Fagus sylvatica*). However, post-war afforestation efforts have led to an increase in conifer plantations, particularly non-native tree (NNT) species like Sitka spruce (*Picea sitchensis*), which now dominate commercial forestry in parts of the UK, particularly Scotland (Forestry Commission, 2023). These plantations, whilst economically valuable, have been criticised for their negative impact on biodiversity and landscape aesthetics (Liu, Kuchma and Krutovsky, 2018).

Meanwhile, climate change poses a particular threat to UK existing forests thorough multiple ways (Doick and Hutchings, 2013). For instance, urbanisation and urban heat island directly stress tree populations, making them more vulnerable to disease (Klapwijk *et al.*, 2013; Hamann *et al.*, 2021; Tabassum, Manea and Leishman, 2024). Agricultural pressures also contribute to forest loss as land is converted for farming to meet food production demands (Bahar *et al.*, 2020). Also, the biological invasions further exacerbate the pressures on UK forests. The introduction of pests like the ash dieback fungus (*Hymenoscyphus fraxineus*) and the oak processionary moth (*Thaumetopoea processionea*) has caused widespread damage to native tree (NT) populations (Urquhart *et al.*, 2017). As temperatures rise and weather patterns become more unpredictable, NT species such as oak (*Quercus robur*) and beech (*Fagus sylvatica*) may struggle to adapt, particularly in the southern regions, where droughts, wet and wind are expected to become more frequent (Hacket-Pain *et al.*, 2016). This could lead to shifts in forest composition that may favour more drought-tolerant tree species, including some NNT species that might be better suited to the

changing climate conditions (Broadmeadow, Ray and Samuel, 2005; Ray, Morison and Broadmeadow, 2010).

Nowadays, with increasing awareness of environmental challenges such as climate change, habitat loss, and declining biodiversity, the role of forests in the UK's environmental strategy is being reconsidered. There have been recent efforts to increase tree cover, improve forest management and conserve biodiversity (Read, 2009). In recent decades, initiatives like the UK Forestry Standard (UKFS) have been introduced to ensure sustainable forest management. Furthermore, the UK government has committed to planting at least 30,000 hectares of trees annually across the UK by 2025 (Gabbatiss and Viisainen, 2024), and also the UK has committed to achieving net-zero carbon emissions by 2050 (Climate Change Committee, 2020b).

These actions reflect growing concerns over climate change and the recognition that forests can play a crucial role as carbon sinks (Defra, 2021). However, the environmental benefits of forests extend well beyond carbon capture. Forests also contribute significantly to flood resilience by managing water flow and reducing surface runoff (Hurtado-Pidal *et al.*, 2022). Additionally, they improve air quality by filtering pollutants and producing oxygen (Isaifan and Baldauf, 2020). Moreover, urban forests and green spaces provide particular benefits for mental well-being, offering residents access to nature that has been shown to reduce stress and improve psychological health (Wilson *et al.*, 2022).

The drive for tree planting in the UK has therefore become a major environmental and political priority (Westaway *et al.*, 2023). Although recent decades have seen progress, ongoing pressures highlight the need to consider new approaches to afforestation and urban greening. The debate is no longer only about planting more trees, but about how to plant the right trees in the right places, using methods that are both ecologically effective and socially supported (Bateman *et al.*, 2023). This is motivated by several interconnected aims: contributing to the legally binding target of net-zero carbon emissions by 2050, enhancing resilience against climate change impacts such as flooding, drought, and the urban heat island effect, and improving public access to nature in urban areas (Isaifan and Baldauf, 2020; Hurtado-Pidal *et al.*, 2022; Wilson *et al.*, 2022).

1.2 The emergence of Miyawaki-style forests in the UK

The Miyawaki Forest Method (MFM) has emerged as a potential way of restoring tree populations. The MFM involves planting dense, fast-growing, and diverse native forests and has been applied in small urban spaces. It is claimed to help address some of the key pressures facing UK forests, particularly in urbanised areas where space is limited (Cárdenas *et al.*, 2022).

MFM was originally developed by Japanese botanist Akira Miyawaki in 1970s, to create 'native forests by native trees' (Miyawaki, 1989). This technique, which emphasises planting dense, native species in small areas to replicate natural forest ecosystems, claims to promise rapid ecological restoration, biodiversity enhancement, and increased carbon sequestration around the world in response to the changing climate (Miyawaki, 1998, 2004; Lu *et al.*, 2011). MFM claims to require a shorter time for forest establishment compared to conventional planting. MFM planting is based on greater species richness which is claimed to be self-sustaining after 2-3 years' growth (Schirone, Salis and Vessella, 2011; Guo, 2018) and is meant to provide a more complete plant community structure than conventional planting. It has been implemented in over 3,000 projects in the last

50 years around the world, with apparently overwhelmingly positive results (Miyawaki, 1989, 1999; Webber, 2022). Over the last decade, this method has seen rising interest beyond Japan, with successful implementations in India and European countries such as the Netherlands. More recently, the MFM has begun to take root in the UK, indicating that its potential for addressing environmental challenges in the 21st century needs to be explored.

The introduction of the MFM in the UK can be traced to collaborative efforts between Earthwatch Europe and IVN Nature Education in Netherlands with Shubhendu Sharma (Beament, 2020) since 2020. In urban areas, MFM planted sites are called 'mini forests' or 'tiny forests' in England, and 'wee forests' in Scotland, 'Pocket forests' by SUGi. Institutional support for the MFM in the UK has been steadily growing, with organisations such as Earthwatch Europe, Department for Environment, Food and Rural Affairs (Defra), Tree Conservation Volunteer (TCV) and SUGi have actively supporting or funding MFM projects. As of 2025, Earthwatch Europe has established 301 Tiny Forests across the UK, while SUGi has established over 240 pocket forests worldwide (Earthwatch Europe, 2025; SUGi, 2025).

The method has attracted substantial interest for its claimed benefits: accelerated forest growth rates, enhanced biodiversity, improved air quality, increased carbon sequestration, and meaningful opportunities for community engagement and environmental education (Cárdenas *et al.*, 2022). These claimed benefits make the MFM particularly attractive in the UK's urban context, where space constraints on forest opportunities, while simultaneously emphasising policy priorities for urban greening, biodiversity enhancement, and community-based climate resilience strategies.

1.3 Research gaps in knowledge

Questions remain regarding the transferability of this method to the UK context, where differences in climate, soil conditions, and people's perception may influence its success (Qi, Dempsey and Cameron, 2024). While the method has demonstrated success in tropical and subtropical regions, its application in the UK's temperate climate requires critical examination, particularly concerning the potential differences in species selection, growth rates, and long-term sustainability (Schirone, Salis and Vessella, 2011). Proponents of MFM, such as Earthwatch Europe (which promotes the Miyawaki-style 'Tiny Forest' in the UK), SUGi, Afforestt as well as Boomforest, advocate for its numerous environmental benefits offered. This include carbon sequestration and storage, rainwater interception, noise abatement, habitat for wildlife, as well as a number of soil-related benefits including pollution abatement and preventing erosion(Lu *et al.*, 2011; Riyas, 2022).

There is however a notable lack of empirical research data on how it is currently being applied across the European and UK contexts, and to what extent these projects are achieving the claimed benefits. As a result, the practice of establishing Miyawaki-style forest is ahead of research in Europe and the UK, resulting in Miyawaki-style forest projects being implemented without a robust research and evidence base. While there are claims that suggest MFM is a cost-effective method of establishing forests (Singh and Saini, 2019), others describe it as an expensive, manually and labour-intensive effort due to the substantial pre-planting soil preparation and large numbers of saplings needed in this dense-placement of this planting method (Vashisth, 2019; Taylor and Lovell, 2021). To date, there is limited research data (with only one study in 2024) comparing costs

of MFM with other tree planting strategies, which further exacerbates uncertainty around its application in the UK context.

In addition, there is almost no research into whether it is acceptable. This question matters because technical success alone will not guarantee widespread adoption (Greenhalgh *et al.*, 2004; Cantiani, 2012). If experts and professionals do not regard the method as feasible or cost-effective, it is unlikely to be supported in urban planning or environmental management strategies. If the non-professionals do not value or identify with these forests, community-based initiatives risk resistance or indifference (Shindler, Brunson and Stankey, 2002). Understanding these attitudes is therefore essential, as they will determine whether the method is scaled up, sidelined, or adapted in the UK context.

For these reasons, the suitability and applicability of the MFM within the UK context remains uncertain. Key questions persist around whether MFM can deliver similar benefits as in tropical regions, whether it will be embraced by the public in the UK, and the use of NT versus NNT species remains vague, especially in light of rapid climate change. While community-led projects and environmental organisations, such as Earthwatch Europe, have initiated the planting of 'Tiny Forests' inspired by MFM principles, limited research has been conducted on assessing whether this intensive planting method will be embraced by both experts/professionals and the non-professionals within the UK context, particularly in urban areas. These uncertainties highlight the necessity to explore the application of this method in the context of urban development in UK. This research therefore will explore the perceptions and challenges associated with the MFM's application in the UK. Understanding the environmental, social, and policy implications of this method is crucial in applying it to the UK.

To address these knowledge gaps, this research explores both professional and non-professionals attitudes toward the MFM within the UK context. Particular focus on the questions outlined below, recognising that technical efficacy alone does not guarantee successful implementation, professional and non-professionals acceptance is equally essential. In addition, this research includes controlled experimental plantings that compare MFM with CFM to assess early growth and survival rates under UK conditions. This experimental component is critical for evaluating the ecological performance of MFM in situ, moving beyond theoretical assumptions.

The MFM offers an alternative approach to afforestation beyond the Conventional Forest method (CFM) of afforestation, which predominantly characterised by monoculture or mixed-species plantations, has historically been the dominant method in the UK (Liu, Kuchma and Krutovsky, 2018). Exploring these knowledge gaps associated with its application will be a critical focus of this PhD, which are also crucial and novel for research and practice. This PhD will offer a comprehensive review of the MFM and compare it with conventional tree planting approaches in the UK, examining how these relate to people's attitudes toward different aspects outlined above. This aspect of the study will make a significant contribution to the literature in terms of the application of MFM in the UK context.

The research into both professionals and non-professionals' attitudes will not only complement ongoing discussions around the NT and NNT species, but also offer a novel investigation into the MFM. Understanding these attitudes is crucial because successful implementation of any forest

management approach depends not only on its technical merits but also on professionals acceptance and non-professionals support. Without professional endorsement, MFM is unlikely to be adopted by local authorities, environmental consultancies, or land managers. Similarly, non-professionals' resistance could undermine community-based projects. This research will provide evidence on the method's perceived feasibility, suitability, and appropriate species choices from both professional and non-professionals perspectives, filling a critical gap in understanding the social dimensions of forest management innovation

In addition, the experiment that compares the growth and survival rates of MFM and CFM is essential because current claims about MFM's effectiveness in the UK are based primarily on theoretical assumptions and overseas evidence. The experiment will offer empirical insights into MFM's performance under UK conditions, providing the evidence base that is currently missing and which professionals and policymakers need to make informed decisions about forest management strategies.

Addressing these gaps through gathering empirical evidence which has not been collected before in this research will be critical to providing the first comprehensive empirical assessment of MFM's potential in the UK. Ultimately, this research will provide valuable insights into professionals' attitudes towards and support for urban greening initiatives. It also offers policymakers and environmental advocates critical information on the challenges of implementing urban tree-planting initiatives in UK towns and cities. By examining professionals' perceptions of how to implement ecological innovation, this study contributes to a greater understanding of sustainable urban environments for UK citizens in an uncertain and evolving future.

1.4 Research aims

This research aims to understand and assess professional and non-professionals attitudes toward the MFM and gather empirical evidence on its early-stage performance compared to conventional methods in UK conditions. Specifically, the main aims are to:

- Explore professional and non-professionals perceptions, knowledge, and attitudes toward MFM implementation in the UK.
- Identify perceived barriers, opportunities, and preferences regarding MFM application in urban contexts.
- Compare early growth and survival performance of MFM versus CFM through controlled experimentation.

By consulting with professionals in the forestry / woodland sectors (especially those involved in urban green infrastructure) and non-professionals (with interest in trees), the research will determine their knowledge and views on the potential of MFM in the UK. Information is sought on where such forests should be sited, their relative advantages and drawbacks over other forest types, cost implications and whether key aspects of the Miyawaki methodology (such as sole use of native plant species) should be adhered to strictly.

In addition, by collecting and comparing the experiments data of MFM and CFM treatments, the research evaluates factors such as tree growth rates, survival rates and stem diameters in MFM versus CFM. By conducting practical experiments, the research provides initial empirical data to assess the early stage performance of the MFM in the UK context.

Ultimately, this research provides valuable insights into how professionals and the non-professionals perceive MFM as an urban greening approach, and initial empirical evidence on MFM's early performance in UK conditions. It will offer policymakers and environmental advocates critical information on stakeholder attitudes and technical performance regarding urban tree-planting initiatives in UK towns and cities. By examining professional and non-professionals perceptions of ecological innovation implementation, this study will contribute to understanding the social and technical factors that influence sustainable urban forestry practices for UK citizens.

The specific questions of the research are as follows:

1.5 Research questions

Three main research questions and sub-questions are addressed in the thesis:

1. **What are the dominant discourses on the MFM both in the UK and around the world from the perspective of experts and professionals?**
    - 1.1 What are experts and professionals' perceptions of the MFM -- and how do they compare to their perceptions of CFM?
    - 1.2 How do experts and professionals' perceive the prioritisation of planting native species in the Miyawaki forest in the UK? To what extent do they think that native species as suitable for future UK climate scenarios, and what role should non-native species play?
    - 1.3 How are experts and professionals re-evaluating species selection for Miyawaki forests in response to climate change?

2. **How much does the non-professionals know about the Miyawaki Forest method?**
    - 2.1 What are non-professionals attitudes towards the MFM and CFM -- and how do they compare to their perceptions of CFM?
    - 2.2 What are the non-professionals attitudes towards the prioritization of planting native species in the Miyawaki forest in the UK? To what extent do they perceive that native species as suitable, and what role do they believe non-native species should play in the UK?
    - 2.3 Are non-professionals perspectives on species selection for Miyawaki forests evolving in response to climate change?
    - 2.4 How do these attitudes differ from those held by professionals?

3. **How do growth rates and survival rates of trees planted using the MFM compared to CFM in the UK?**
    - 3.1 Do Miyawaki forest saplings have a higher growth rates and thicker diameters compared to saplings planted in a Conventional forest?
    - 3.2 Do Miyawaki forest saplings have a higher survival rates compared to saplings planted in a Conventional forest?

1.6 Thesis structure

This thesis is structured into eight chapters:

Chapter 1: Introduction.

This chapter begins by providing an introduction to the context of the study, setting out the significance and relevance of researching the application of the Miyawaki method for urban forestry in 21st-century UK. It explains the gap in knowledge regarding perceptions of MF in urban spaces and their potential for biodiversity and climate change mitigation. The chapter defines the aims and objectives of the research and presents the research questions that will guide the study. The rationale for why this topic matters in the realm of academic study and urban environmental planning is also outlined, followed by an overview of the content to be covered in the subsequent chapters.

Chapter 2: Literature Review.

This chapter presents a comprehensive review of the existing literature, both globally and with a focus on the UK and Europe. It examines the intersections of forests, biodiversity, and urban environments, discussing the broader environmental challenges posed by climate change and the role of urban forests in mitigating these effects. It then emphasises the role of MFM within the UK contexts and exploring its potential applications in urban environments and people's perceptions.

Chapter 3: Methodology.

This chapter outlines the methodology employed in this research. The research design involves a multi-method approach combining surveys, interviews, and experiments. It discusses the process of data collection, detailing the sequential steps of gathering data from experts/professional and the non-professionals through online questionnaire surveys and interviews, along with details on research ethics and integrity. The data analysis process is rigorously explained in the subsequent chapters.

Chapter 4: Findings of professional perceptions of MFM.

This chapter is to answer RQ1. It presents the initial findings in relation to the questionnaire survey one, focusing on the perceptions of a sample of professionals who are involved in urban forestry, landscape planning, and environmental management. The data is presented and organised in alignment with the primary research questions, incorporating both quantitative and qualitative analysis. This chapter also emphasises the diversity of professionals' perspectives tell us which RQ/ sub-questions this will be answering – you can do this for this and other chapters.

Chapter 5: Finding of non-professionals perceptions of MFM.

This chapter is to answer RQ2. It focuses on the non-professionals' perceptions of the MFM which calls on data from a second questionnaire survey, with results analysed quantitatively and qualitatively. The chapter explores non-professionals awareness and preferences of using MF in the urban and rural areas in the UK, and their views on biodiversity and climate action. The findings provide insights into how the non-professionals perceives the benefits and potential drawbacks of the MFM compared to conventional tree planting method. Again, tell us which RQ/ sub-questions this will be answering – you can do this for this and other chapters.

Chapter 6: Experiment results.

This chapter is to answer RQ3. It discusses the experimental data of the research, which involved observing and collecting data from a MF plot and a CF plot conducted in the Hope Valley in Sheffield. It presents the quantitative analysis of the forest's growth, survival and biodiversity changes. The data is analysed based on the primary research questions, providing evidence of the effectiveness of the MFM in a specific setting. Key variables such as species diversity, growth rates and mortality are analysed and discussed.

Chapter 7: Discussion.

The discussion chapter brings together the empirical findings from the professional and non-professionals perception studies (Chapters 4 and 5) and the experimental trial (Chapter 6) to critically evaluate the suitability of the method. The chapter begins by integrating insights from the three empirical strands to explore the MFM's social and ecological viability within the UK context. It is structured thematically, with subsections examining perceptions of awareness and engagement, suitability, benefits and challenges, species selection under climate change and etc.. The limitations of the study are also outlines in this chapter.

Chapter 8: Conclusion.

The conclusion chapter draws together the most significant key findings of the study, presented in the previous chapters, to evaluate the method's viability within UK contexts. The chapter also outlines the study's original contributions to knowledge and recommends future research directions, emphasising the need for long-term empirical monitoring, interdisciplinary collaboration, and comparative studies across Europe, to support the adaptive implementation of the MFM in temperate urban contexts. Together, these reflections offer practical guidance for policy, research, and urban greening practices.

References and Appendices.

References present all the sources cited in the thesis and appendices offer supplementary information to certain chapters, including questionnaires, demographic information and experiment data.

Ch.2. Literature review

2.1 Introduction

This chapter presents a comprehensive review of the existing academic literature, encompassing both global perspectives and a specific focus on the UK and Europe, in order to understand and find out about research gaps in knowledge. It outlines the concept of urban forests in section 2.2. Section 2.3 provides an overview of current understandings regarding the benefits, biodiversity and climate impacts of urban forests. Section 2.4 investigates the interconnections between climate change, forests, biodiversity, and urban environments, as well as the challenges and opportunities of urban forest, while exploring the significant environmental challenges posed by climate change and highlighting the critical role that urban forests play in mitigating these impacts, and also people's perceptions of and preferences for forest landscapes in urban areas. In section 2.5, it further explores the challenges and opportunities of urban forests in the UK in facing of changing climate, from standard, strategy, challenges and opportunities aspects. Section 2.6 focuses on the development and application of Miyawaki Forest method (MFM) around the world, including its technical principle, development, comparison to Conventional Forest method (CFM), global applications, outcomes and challenges. In addition, it highlights the significance of the role of MFM within these contexts, exploring its potential suitability and applicable in urban environments, alongside people's perceptions, particularly in the UK (section 2.6 and 2.7). Through this exploration, the chapter aims to identify key gaps in current research and contribute to a deeper understanding of how urban forestry can be effectively implemented. The chapter concludes with a comprehensive recap of how the literature frames the main research questions (Section 2.8).

2.2 What is forest?

Forests are fundamental components of the Earth's ecosystems. Despite forests' ecological importance, long history and the widespread use of the term, there are over 800 definitions used to describe forests globally, and there remains no universally accepted definition of what constitutes a forest (Adam, 2011; Vila, no date). The origin of the '*forest*' is the late Latin phrase '*forestis silva'*. Here, '*silva'* means "woodland" and '*forestis'* means "outdoor, outside". In time, the phrase became shortened to '*forest'*. Forest was originally used to designate lands set aside for the monarch, denoted the uncultivated land that had been primarily established as a legitimate area where royal hunting was carried out (Fleetwood, 2011; Rackham, 2020). These forests did not necessarily contain trees, as it can be an area preserved in medieval times for deer, which did not usually grow trees in abundance (Goldberg *et al.*, 2007; Fleetwood, 2011). For them and their successors, the 'forest' was an open area of unenclosed countryside consisting of woodland, heathland, scrubland and farmland (Rackham, 2020). Over time, these areas that appear to have been wooded continuously in England since at least 1600 (1750 in Scotland) are widely recognised as ancient woodland (Goldberg *et al.*, 2007). Nowadays, the The Food and Agricultural Organisation (FAO) definition of a forest is: "land spanning more than 0.5 hectares with trees higher than 0.5 meters and a canopy cover of more than 10%, or trees able to reach these thresholds in situ." (Ritchie, 2024). The contemporary definitions of forests generally fall into three broad categories: legal units, land use, and land cover (Lund, 1999; Watson et al., 2000).

There are the following three samples for each category:

Legal units definition is grounded in forest laws and regulations (Ford-Robertson, 1971), i.e. land designated or declared as forest under national or regional law is classified as such (Lund, 1999), which bear no relationship to the vegetation grown and associated carbon storage capacity on the land (Watson *et al.*, 2000).

Land use definition is based on the function or intended purpose of the land (Watson *et al.*, 2000). This includes land suitable and used predominantly for timber production, sand or soil erosion control, or protection of ecological boundaries such as tree lines.

Land cover definition focus on the physical characteristics of vegetation, typically involving type and density of the vegetation that grow on the land. This definition generally classify an area as forest when tree growth exceeds a specified threshold (Watson *et al.*, 2000). For instance, this may include tree-dominated ecosystems with a minimum canopy cover of 10%, as well as cultivated lands or open forests on pasture with canopy closure of at least 20% (Office for Official Publications of the European Communities, 1997). Under this definition, all such areas are recognised as forest.

According to the above definitions of the forest, various relevant international organisations have developed the forest attributes to standardise forest classification, as follows (Morales-Barquero *et al.*, 2014).

Table 2.2.1 Forest attributes that used to define what is classified as "forest" by relevant international policy bodies

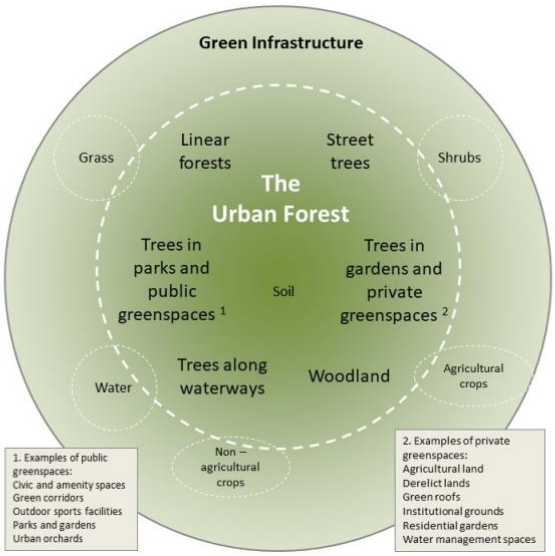
Institution	Minimum crown cover (%)	Minimum area (ha)	Minimum height (m)	Species or vegetation type
IPCC GHG for land use, land-use change and forestry (LULUCF)	Countries can decide on a threshold between 10% -- 30% (or similar stocking level) at maturity	≥ 0.05 – 1.0	Countries can decide on a value above ≥ 2 – 5 (at maturity in situ)	Includes closed or open forest, young natural stands and forest plantations that have the potential to reach 2 -5 m. Includes harvested forest that is below 10% - 30 % canopy over where they are considered to be temporarily unstocked.
FAO	≥ 10% （at maturity）	≥ 0.5	≥ 5 (at maturity in situ)	Does not include areas predominantly under "non-forest" land use such as agriculture or urban
CBD	≥ 10%	≥ 0.5	≥ 5	Only includes "natural" forest. Excludes areas under "non-forest" land use such as agriculture

In summary, the most widely accepted global definition of a forest it as an area predominantly composed of trees, with varying degrees of canopy density (Lund, 1999; Vila, no date). According to this definition, forested land must support trees capable of reaching a minimum height of five metres at maturi*ty in situ,* and a canopy cover of at least 10%. Canopy density is typically measured by estimating the proportion of ground shaded by the tree canopy. In addition, the area must be no smaller than 0.5 hectares. Excluded from this definition are urban parks, orchards, and areas under agricultural or forestry crops; however, land used in agroforestry systems, along with other tree-dominated landscapes, is generally included (DataBank, no date).

The 'urban forest' includes all trees within the urban limits (Fig. 2.2.1) (Doick, no date). It is usually defined as tree-dominated systems including all individual trees groups of trees, and woodlands, and their relevant infrastructural, ecological and social connectivity, that extends from the urban

core to the urban and rural margins, and is becoming a growing field of interest in the urban areas (Rowntree, 1984; Nowak, 1993; Salbitano *et al.*, 2016; Wirtz *et al.*, 2021). Urban forests are considered an essential part of green infrastructure that is crucial for urban sustainability and citizens' health and well-being (Sousa-Silva *et al.*, 2023).

Figure 2.2.1 The urban forest (Doick, no date)



2.3 Understanding Forests: benefits, biodiversity and climate impacts

2.3.1 Forest benefits

The forest ecosystem is one of the most functional and crucial of the life support systems on earth and it delivers enormous benefits (Wang, Kauze and You, 2002; Balderas Torres *et al.*, 2015). The establishment of urban forest is seen as an essential way to enhance the urban environment, providing multiple ecosystem services including beneficial effects on physical and mental health to resolve urban environmental problems (Dwivedi, Rathore and Dubey, 2009; Nowak *et al.*, 2013). Urban forests can improve air quality by filtering pollutants, moderate the hydrological cycle, and support wildlife habitats (Rao *et al.*, 2014; Prather, Eppley and Rosenstiel, 2018; Diener and Mudu, 2021). They can also absorb CO_2, release O_2, cool urban areas, and maintain species and genetic diversity (Weng and Yang, 2006; Harlan and Ruddell, 2011; Nowak *et al.*, 2013; Baró *et al.*, 2014; Hong *et al.*, 2024). For instance, trees in urban forests provide significant cooling effects by reducing surface and air temperatures through shading and evapotranspiration, helping to mitigate urban heat islands (Moss *et al.*, 2019; Hunkeler, 2023).

In addition, urban forests contribute to microclimate regulation, such as reducing temperature extremes and enhancing humidity, creating favorable conditions for species survival (Greiser *et al.*, 2024). They can mitigate against soil erosion, and climate change, and provide resources for humans (Miyawaki, 1999; Wang, Kauze and You, 2002). Additionally, urban forests offer cultural and recreational benefits, promoting mental and physical well-being through reduced air pollution exposure (Nemet, Holloway and Meier, 2010) as well as forest-based environmental services (Elbakidze and McCarl, 2007; Angelsen *et al.*, 2009; Beckmann-Wübbelt *et al.*, 2021; Cheng *et al.*, 2021). These effects are particularly crucial in cities.

2.3.2 Biodiversity conservation and habitat connectivity

Forests play a crucial role in enhancing biodiversity within cities by providing habitats, enhancing ecological connectivity, and fostering species diversity (Dickinson and Ramalho, 2022; Wang *et al.*, 2024). First, forests are important habitats for a variety of species, including birds, insects, mammals, and microorganisms (Paudel and States, 2023). They provide food, nesting sites, and shelter that support both residents and migratory species, offering the resources and conditions necessary for survival, reproduction, and migration in an increasingly developed landscape (Kowarik *et al.*, 2019; Wang *et al.*, 2024). Second, forests act as and can create more ecological corridors that help connect fragmented natural habitats and facilitate wildlife migration and gene flow, forming so-called 'green networks'. This connectivity is important especially to reconnect wildlife populations that have become isolated because of human-mediated habitat fragmentation (Zellmer and Goto, 2022). Green corridors and forests can help alleviate the isolation of urban patches and provide valuable resources and habitat for wildlife in the urban matrix, while offering a way for wildlife and vegetation to move around, thus maintaining biodiversity at the landscape scale (Pirnat, 2000; Nichols-Russell, 2016). Furthermore, forests increase species richness by creating heterogeneous environments that support a wide range of organisms. Mixed-species planting, varying tree ages, and diverse vegetation layers enhance structural complexity are positively correlated with tree species richness (Perles-Garcia *et al.*, 2021). For instance, insects such as bees and butterflies, interacting with trees, providing pollination that is critical for ecosystem functioning (Dylewski, Maćkowiak and Banaszak-Cibicka, 2020).

2.3.3 Climate change response

Forests represent major carbon sinks because both trees and soils have the capacity to store large amounts of carbon over the long-term (Norman, 2023). According to Streiff (2021), forests remove 7.6 billion tonnes of carbon dioxide annually as carbon sinks, and all existing old-growth and regenerating forests together absorb about 2 gigatonnes of carbon per year, which is contributing significantly to terrestrial carbon sinks (Pugh *et al.*, 2019; Waring *et al.*, 2020). In addition, forests, as carbon sinks, can contribute up to 30% of the greenhouse gas emission reductions needed to limit global warming to 2°C at relatively low cost, which is a critical function in the fight against climate change (IPCC, 2023; Kafy *et al.*, 2023).

However, forest ecosystems across the globe have been severely degraded, with temperate forests, tropical rainforests, broadleaf and evergreen forests all experiencing varying degrees of deforestation, degradation, or conversion for urban development (IUCN, 2021). Since 1990, worldwide forest area has continued to decrease, while forest deterioration has also been occurring at an alarming rate (FAO, 2020). For instance, between 1990 and 2015, the total amount of global forests decreased from 4.3 billion hectares to 4.06 billion hectares, representing approximately 31% of the global land area. During this period, an estimated 420 million hectares of forests were affected by deforestation, and a 178 million hectares of forests have been lost, an area equivalent to the size of Libya (FAO, 2016; Freer-Smith *et al.*, 2019). In addition, over two billion hectares of forest landscapes worldwide suffer from forest deterioration that are currently in need of restoration (Minnemayer, Laestadius and Sizer, 2011; Lindenmayer et al., 2012; Stanturf et al., 2014). In addition, in urban areas, shows insufficient number of tree coverage in many cities though urban forest has increased in recent years, with urbanization and city expansion leading to further loss of green space and the associated ecosystem services (Ritchie, 2021).

As urban areas are significant contributors to greenhouse gas emissions, urban forestation is a strategic way of climate change adaptation. Urban forests are vital in combating climate change by storing and sequestrating CO_2, which directly reducing greenhouse gas (Kafy *et al.*, 2023). As urban populations continuously grow and climate change accelerates, urban forests will become increasingly important in ensuring the sustainability, health and resilience of urban areas. Urban forests provide a wide range of ecosystem services that enhance urban resilience and are an integral part of an effective climate adaptation strategy. However, it is necessary to be aware that carbon sequestration in urban forests is long-term, because the net carbon capture by urban forests slows as forests mature (Nowak *et al.*, 2013; Ariluoma *et al.*, 2021).

2.3.4 The importance of forest restoration

The scientific community recognises the need to restore deteriorated forests, particularly in urban areas, through the adoption of appropriate and contextually specific restoration approaches (Lund, 1999; Wong, Delang and Schmidt-Vogt, 2007; Putz and Redford, 2010). These efforts aims to accommodate the present environmental conditions as well as prospective climate challenges (Harris *et al.*, 2006; Stanturf *et al.*, 2014). However, the escalating impacts of global environmental issues, such as global climate change, indicate that there is going to be a much higher requirement for restoration in the future (Steffen, Crutzen and McNeill, 2007; Zalasiewicz *et al.*, 2010; Stanturf *et al.*, 2014).

2.3.5 Challenges and opportunities of urban forest

Despite forests being considered an essential element for mitigating against climate change (Nunes *et al.*, 2020), providing enormous benefits (Wang, Kauze and You, 2002; Balderas Torres *et al.*, 2015). The UK faces challenges in implementing urban forestry policies. These include land-use conflicts, such as competition with housing development and infrastructure projects, limited available space in dense urban areas, and restricted public access due to private land ownership and fragmented green spaces (Morris *et al.*, 2011; Bateman *et al.*, 2013; Jong *et al.*, 2021).

Moreover, research by Tubby and Webber (2010) suggest that urban forests face numerous health threats that require ongoing management. Common pests, such as the oak processionary moth can defoliate trees, while sooty bark disease (Cryptostroma corticale) becomes more active during periods of heat or drought. Climate change further exacerbates these problems by altering temperature and precipitation patterns, potentially increasing the vulnerability of urban trees to existing and emerging pests and diseases.

In addition, in terms of urban forests themselves, they can face challenges to successful establishment as survival rates of newly planted trees can be low (Roman, Battles and McBride, 2014). Urban trees are frequently affected by soil compaction from foot traffic and construction, which restricts root growth and water infiltration, accidental mechanical damage and even deliberate acts of vandalism, such as bark stripping or branch breaking, which can create entry points for pathogens or lead to tree death (Czaja, Kołton and Muras, 2020). Extreme weather events such as prolonged droughts or floods can make it difficult for urban trees to thrive after planting.

2.4 The relationship between climate change, urban environments, forests, humans and their perceptions and preferences.

2.4.1 Impacts of climate change in urban environments

With rapid urbanisation, understanding the impact of climate change on the urban environment has become increasingly crucial. Urban areas are currently home to more than half (54%) of the world's population (Bolay, 2020), and this continues to grow, nearly 70% of people are expected to be living in cities by 2050. Cities consume substantial resources like energy and water, and serve as key transportation hubs, emitting substantial amounts of carbon through extensive road networks, public transit systems and airports. For instance, globally, urban areas are accounting for almost three quarters of total carbon dioxide equivalent emissions (Fujii *et al.,* 2018). which are responsible for current global warming.

Global warming is the main evidence of current climate change, as demonstrated by rising sea levels, rising global average and ocean temperatures, and widespread melting of snow and ice (Van Aalst, 2006; Peñuelas *et al.*, 2013). At present, the global average surface temperature is at the highest level recorded in at least five centuries. During the past 100 years, the global average surface temperature has risen by about 0.74 °C (Nunes *et al.,* 2020). It is conservatively estimated that the future climate change will lead to a global average temperature increase of 2-4 °C, accompanied by a rise in the frequency and severity of extreme events such as droughts, heatwaves, and prolonged periods of high temperatures in a number of areas, posing significant threats to ecosystems worldwide (Seager *et al.*, 2007; Sterl *et al.,* 2008; Allen *et al.*, 2010; Warren *et al.,* 2021).

Cities are significant contributors to climate change due to their rapid growth and high emissions, also making cities central to combating climate change (Sampson *et al.*, 2021; Tong *et al.*, 2021). There is growing evidence indicating that climate change presents unique challenges to urban areas, threatening both their sustainability and the well-being of their populations (Wang and Qin, 2022). Since the IPCC Fifth Assessment Report (AR5), climate change-related disasters have affected all cities in the world, for instance, heatwaves are expected to become more frequent and intense due to the changing climate (Pachauri and Mayer, 2015; IPCC, 2021).

As discussed before, urban areas face compounded risks of climate change, from increased temperatures, rising sea level, urban heat islands, extreme weather events (such as drought and flooding), poor air quality and population increase (Bolan *et al.*, 2024). These changes to climate experienced in urban environments have direct and profound impacts, including economic, environmental and health-related (Mi *et al.*, 2019; Tong *et al.*, 2021; Piracha and Chaudhary, 2022). In addition, population increases in urban areas further strain resources and infrastructure, i.e. increasing the demand for green spaces, clean air, and reliable water sources. These pressures are having a significant impact on urban sustainability. Given these compound risks and challenges, there is an urgent need for effective climate mitigation and adaptation strategies, to enhance the resilience of urban areas (Piracha and Chaudhary, 2022). Strategies include expanding urban green spaces, integrating green infrastructure (e.g. permeable surfaces, green roofs, and urban forests), and improving stormwater management systems. These strategies can mitigate the effects of extreme weather and urban heat while enhancing air quality, water management, and overall urban livability (Feng *et al.*, 2023; Paudel and States, 2023; Kumar *et al.*, 2024). Urban forests, in particular, therefore could play a pivotal role in addressing climate challenges.

2.4.2 Impacts of climate change on forests

The continuing climate change is jeopardising the forest ecosystems of the world (McBride and Laćan, 2018; Ruiz-Ramos *et al.*, 2020). Urbanisation and rapid urban expansion tend to reduce the amount of land available for tree planting and have had a significant impact on urban forests structure (Nor *et al.*, 2017). Globally, from 1992 to 2015, as urban expansion, urban forests lost 3.3 million hectares directly and between 17.8 and 32.4 million hectares indirectly (Indirect loss refers to the degradation or decline of urban forests driven by human-induced pressures associated with urban expansion, such as pollution, altered hydrology, heat stress, and fragmentation, rather than by natural processes) (Mcdonald *et al.*, 2009; van Vliet, 2019; Yang *et al.*, 2020). This is generating disturbances globally by altering forest cover and its connectivity, for instance, through encroachment on native vegetation, and fragmentation of undisturbed forests into small and isolated pockets, which constraining the space available for tree planting and forest connectivity and limiting the capacity of forests to support biodiversity and withstand environmental changes (McKinney, 2002; Gong *et al.*, 2013; Hernando *et al.*, 2017; Zhang *et al.*, 2020). Thus, space constraints present a fundamental challenge for forests, particularly as cities densify to accommodate growing populations.

Climate change specifically threatens the health and survival of urban forests, and nature and urban ecosystems have been affected by climate change (Esperon-Rodriguez *et al.*, 2022). Trees in cities are more vulnerable due to increased extreme heat and drought events, resulting in accelerated tree growth and also accelerated tree senescence, shortening the lifespan of trees (Allen *et al.*, 2010; Pretzsch *et al.*, 2017; Hilbert *et al.*, 2019; Smith, Dearborn and Hutyra, 2019; Brienen *et al.*, 2020). A global survey revealed that more than 50% of the overall plant species in urban forests have already exceeded their current climatic tolerance for mean annual temperature and precipitation (Esperon-Rodriguez *et al.*, 2021). By 2050, an increasing number of plant species are expected to be at risk from projected changes in mean annual temperature and precipitation, which may further jeopardise the function of urban ecosystems (Esperon-Rodriguez *et al.*, 2022).

Trees continuously engage in interactions with the abiotic environment and other organisms, and unhealthy trees have a higher susceptibility to diseases, pests and insects, e.g. pine wilt disease, beech leaf disease and oak processionary moth (Godefroid *et al.*, 2020; Hartmann *et al.*, 2022; Carta, Li and Mowery, 2023; Ye, Wu and Sun, 2023). Future warmer temperatures and extreme events will expand its spread and reproductive success, have further impeded tree growth, contributing to an increase in poor-performing trees and tree mortality rates (Tubby and Webber, 2010; Haase and Hellwig, 2022; Xing *et al.*, 2024). Furthermore, as the health of trees decreases, their capacity to contribute to ecosystem services will be reduced (Haase *et al.*, 2014). Healthy trees are consequently critically valuable (Lin *et al.,* 2021).

In addition, the selection of appropriate tree species for forests, especially urban forests is becoming progressively increasingly complex, as forests are considered to be particularly vulnerable to climate change and the longevity of trees limits their ability to adapt quickly (Lindner *et al.*, 2010). Also, climate change is causing extensive environmental impacts, most immediately, the geographical locations of species are shifting, for example where we see plants and trees are blooming earlier than in the past (Bojana, 2022). This raises the debate: to what extent will native tree (NT) species adapt to the changing climate? Or will non-native tree (NNT) species better suited?

The validity of the applying dualist classification of species as either native or non-native has increasingly been questioned, which is sparking debates (Warren, 2007).

Despite extensive planting of NNT in commercial forestry plantations in Britain's forests (Ennos *et al.*, 2019) and amenity landscapes (Potter and Mach, 2022), NT species are in general to be preferred in their direct contribution to local ecosystem function (e.g. being the most suitable hosts for native invertebrates) and historically have been well adapted to local conditions (Sjöman *et al.*, 2016). NNT species are argued to bring risks of invasiveness, providing potentially poor ecological fit with existing fauna (Liu and Slik, 2022; Cameron, 2023), and may bring in new pest and pathogens when introduced from elsewhere (Richardson and Rejmánek, 2011; Brundu *et al.*, 2020). To address this challenge, species selection is getting more and more important, and the knowledge of the current range and climatic environmental conditions required by the tree species is necessary for the development of adaptation strategies (Hunter, 2011).

Existing evidence suggests that climate change will further exacerbate these challenges by threatening forests health, increasing mortality and species selection. In addition, rapid urban expansion reduces the land available for planting, fragmenting existing green spaces and hindering forest connectivity. These interconnected challenges highlight the complexity of maintaining healthy forests and its biodiversity under continued environmental and urban pressures. Overall, forests face enormous challenges in the context of climate change and urbanisation.

2.4.3 Impacts of forests on humans

Forests have been described as an indicator of the liveability of a place (Mahmoudi Farahani and Maller, 2018). Forests have been found to reduce psychological stress, improve mental and physical health, strengthen immune systems, reduce crime, provide aesthetics, quiet and tranquillity, and also social, educational, entertainment benefits for children (Grinde and Patil, 2009; Church, 2018; O'Brien, Urbanek and Gregory, 2022; Nuccitelli, 2023). In addition, forests can promote social connectivity, neighbourhood satisfaction and a sense of community ownership (Hur, Nasar and Chun, 2010; Arnberger and Eder, 2012). The forest is distinguished by the nexus between human and forests, i.e. forests deliver benefits to human and humans in turn make decisions that influence the forests (Conway *et al.*, 2024).

However, there are positive and negative perceptions towards forests (Ordóñez Barona *et al.*, 2022). For instance, the meaning of forests varies greatly across different cultural and historical backgrounds. Research has found that people have complex and uncertain 'half-seeking, half-fearing' perceptions of forests (Jim and Shan, 2013). In Western cultures, forests have often been romanticised as spaces of tranquillity and natural beauty (Schama, 1995). However, forests can also evoke negative associations, they may be perceived as places of danger, darkness, or the unknown, drawing on cultural narratives from folklore and fairy tales where forests are sites of threat or mystery (Gross, 2014).

There is varying and sometimes limited understanding of human attitudes towards forests and how they vary by location, tree type and other factors. This includes whether people support tree planting, which types of trees people prefer to plant and where they believe trees should be planted (Ambrose-Oji *et al.*, 2021; Conway *et al.*, 2024). Therefore, understanding people's

perceptions of forests can have a significant impact on future forest planning and public satisfaction (Ordóñez Barona *et al.*, 2022; Kazemi, Hosseinpour and Ebrahimian, 2023).

2.4.4 People's perceptions of and preferences for urban forests landscape

Landscape preference is commonly an important interdisciplinary study subject that explores the interactions between humans and their environment (Kearney *et al.*, 2008; Swanwick, 2009). First introduced in the 1960s, the concept focuses on people's perceptions, attitudes and preferences towards landscapes (Yan, Winterbottom and Liu, 2023). The Biophilia Hypothesis suggests that humans prefer to be in natural environments because of their innate attraction to biological things (Wilson, 1984, p.157). Similarly, the Attention Restoration Theory (ART) suggests that natural environments, including forests, promote mental recovery by providing a sense of distance, a soft attraction, and compatibility with human cognitive processes (Kaplan, 1989). People's preferences for different types of forest landscapes, whether dense, naturalistic woodlands or more open, managed parkland settings, can consciously or unconsciously have a profound impact on how urban green spaces are conserved, reconstructed, and restored (Yan, Winterbottom and Liu, 2023).

Urban forests are valued for their ecological, social, and psychological benefits. For instance, Ordóñez Barona et al., (2022) highlighted that people's perceptions of urban forests are determined by their experiences and expectations of those spaces. People's interaction with nature leads people to have different preferences for their surroundings. While many people are inclined to favour urban forests for their ability to enhance air quality, support biodiversity, and deliver opportunities for recreation and relaxation (Li *et al.*, 2021; Shiraishi, 2022). Others may have concerns about dense woodland areas. Research on woodland preferences shows that some people experience feelings of insecurity in dense forest areas (Pardela *et al.*, 2022).

Research on public perceptions and preferences has played an important role in landscape practice. Moffat *et al.*, (2024) have demonstrated that integrating the design of urban forests with people's preferences can increase users' satisfaction and facilitate long term management. In addition, collaborative planting events, ongoing maintenance and citizen science monitoring can install a deeper connection with nature among humans (Sandifer, Sutton-Grier and Ward, 2015; Roman, Campbell and Jordan, 2018; von Gönner *et al.*, 2024).

Moreover, learning about people's perceptions is also crucial to addressing equity in access to urban forests. However, equitable access involves more than just physical proximity, it requires understanding why some communities may choose not to use urban forest spaces even when they are available. Guaranteeing equitable and inclusive access to urban forests can increase people's willingness to use these spaces, which in turn can promote greater engagement of communities in urban forest stewardship (Maleknia, 2025). Dawes et al., (2018) found that low-income neighbourhoods often have difficulty accessing well-maintained urban forests, due to under-distribution, a lack of cultural representation, and exclusion, which can exacerbate existing disparities and lead to wider patterns of environmental injustice (Maleknia, 2025).

Understanding people's perceptions is not only valuable for improving user satisfaction or ensuring equitable access, it is also fundamental to explaining how and why certain ecological practices are adopted or resisted (Chang, Lin and Bin, 2024). As emphasised by Rogers' theory -- Diffusion of Innovations, the uptake of novel techniques depends on how people are perceived in

terms of relative advantage, compatibility, complexity, and observability (Greenhalgh *et al.*, 2004; Cardol, Mignon and Lantz, 2025). If practitioners perceive a method as too resource-intensive or incompatible with current policy frameworks, or if the public view it as unattractive or inaccessible, widespread implementation is difficult, regardless of its proven ecological benefits (Wüstenhagen, Wolsink and Bürer, 2007; Bullock *et al.*, 2021).

Similarly, Social Acceptance Theory (Wüstenhagen, Wolsink and Bürer, 2007) suggests that successful environmental transitions rely on acceptance across three interconnected domains: socio-political acceptance, community acceptance, and market or practitioner acceptance. These frameworks underline that ecological innovation constitutes both a technical process and a social process. Thus, perceptions are not peripheral, but central to environmental practice and policy adoption.

It is therefore critical to incorporate people's perceptions and preferences towards urban forests into urban forest planning, as social acceptance plays a key role in shaping policy and practice. While a tree planting method may be ecologically superior, its implementation depends critically on how it is perceived by both those who will use it (professionals) and those who will experience or be affected by it (the non-professionals). If either group perceives it as incompatible with existing management frameworks, excessively complex, or lacking observable results within acceptable timeframes, adoption will be limited regardless of its actual merit. Hence, exploring both professionals and the non-professionals perceptions is essential for understanding barriers to adoption, enabling informed decision-making, and advancing more sustainable and inclusive urban forest practice (Özgüner and Kendle, 2006).

2.5 Forestry in the UK

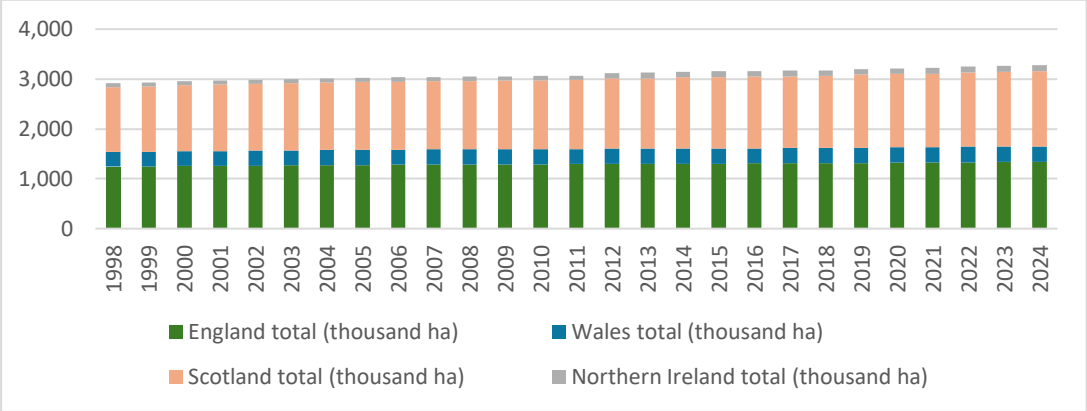
In the face of increasing population and escalating urbanisation, the climate change-induced disturbances have become more frequent and significant in urban areas (Cueva *et al.*, 2022). Forests are argued to be an indivisible component of urban ecosystems (Martens, Gutscher and Bauer, 2011; Ordóñez and Duinker, 2013). At present, urbanisation and land use changes present a significant pressure on UK forests. According to official population projections, the population of the UK will reach 70 million by 2026 (Office for National Statistics, 2024). Thus, there is growing demand for housing, infrastructure, and agricultural land. The pressures surrounding land use form an environmental challenge, which threatens not only existing forests but also opportunities for afforestation and reforestation, as competing land uses make it difficult to allocate space for new forests (King *et al.*, 2023). Given the benefits that forests provide, afforestation and reforestation actions are considered necessary and urgent in the UK.

2.5.1 Forest status in the UK

While global forest cover has decreased, there have been efforts to counter this trend through afforestation. Between 1990 and 2020, planted forests have grown in size from 168 million hectares to 290 million hectares, now representing 7% of the overall area of global forests (FAO, 2016). Forests are increasingly recognised as crucial for addressing contemporary environmental challenges (Freer-Smith *et al.*, 2019). In addition, urban tree planting has demonstrated measurable benefits, with The Nature Conservancy reporting 7% to 24% reduction in particulate matter and temperature decreases of up to two degrees Celsius in areas with tree cover (Singh and Saini, 2019).

In the UK specifically, as of 2024, forest coverage remains notably low at 3.28 million hectares, representing roughly 13% of total land area (Fig. 2.5.1) (Forest Research, 2024b). This places the UK among Europe's least forested nations (Ritchie, 2021), significantly below both the European average of 46% and the global average of 31% (Forestry Research, 2020). Addressing climate change targets, in the UK, the Committee on Climate Change has recommended increasing national forest cover to 19% by 2050 to achieve carbon neutrality (Woodland Trust, 2020).

Figure 2.5.1 Area of forest in the UK (1998-2024) (Forest Research, 2024a)



Approximately a half (51%) of the forested area in the UK is composed of coniferous tree species, 36% of which are non-native such as Cedar, Cypress and Juniper (Barsoum and Henderson, 2016; Forest Research, 2020). The UK's forests are dominated by comparatively low species diversity, with five coniferous species, such as Sitka spruce, Scots pine and Larches, making up 88% of coniferous forests. similarly, five broadleaved species, including Oak, Beech, Sycamore and Ash, account for over 72% of broadleaved forests, with many of these species being planted in monocultures and dominated by fast-growing species (Forest Research, 2017, 2018; Forestry Commission, 2020). In response to the climate crisis, the UK has committed to achieving net-zero greenhouse gas emissions by the middle of the 21st century (Defra, 2021). Therefore, within the UK and elsewhere there is a drive to plant more trees and dedicate more land to forest and woodland cover, for natural climate mitigation (Doelman *et al.*, 2020; Ward *et al.*, 2021) and biodiversity targets. This includes ambitions to increase urban forest cover (Pincetl *et al.*, 2013).

2.5.2 Forestry standards and strategies in the UK

The UK has developed forestry standards and strategies at the national, regional and local levels which emphasise the significance of urban trees and woodlands in alleviating climate change, promoting biodiversity, improving air quality and contributing to public health and well-being.

The UK Forestry Standard (UKFS) (Forest Research, 2023) is the cornerstone of sustainable forest management in the UK, which represents the government's primary mechanism for promoting sustainable forest management across the UK. First published by the Forestry Commission in 1998 and regularly updated, establishes a set of requirements and guidelines for managing forests and woodlands to balance environmental and social benefits for all forest types and management approaches. It is intended to be used by professional foresters, land managers and stakeholders with addressing eight key elements including, forests and biodiversity, climate change, historic

environment, landscape, people, soil and water. This multifaceted approach ensures that forestry practices balance environmental protection with economic viability and social benefits. For urban forests, it mandates considerations such as risk of new pests or disease, reducing the impacts of climate change, supporting a range of ecosystem services, enhancing health, well-being and quality of life and improving perceptions of the area.

In parallel with the UKFS, each devolved administration has developed forestry strategies that reflect their specific regional contexts and priorities. The England Trees Action Plan 2021 -- 2024 (Defra, 2021), which focuses more heavily on urban tree planting and the restoration of ancient woodlands, has outlined the objectives of increasing tree planting, improving canopy cover and enhancing urban forest management, setting out the actions that would be undertaken to expand England's woodland cover and the contribution of woodland to the economy and society. The Government has committed to increasing the rate of tree planting to 30,000 hectares per year throughout the UK. Moreover, the Plan also sets out the Government's long-term vision for the treescape it wants to see in England by 2050, as well as the target of achieving net zero carbon emissions and the economic, environmental and social benefits realised through new trees and woodlands.

Scotland, Wales and Northern Ireland have launched similar strategies, for instance, Scotland's Forestry Strategy 2019 -- 2029 (Environment and Forestry Directorate, 2019) focuses on expanding forests and woodlands areas, improving the adaptability, resilience and environmental benefits of forests and woodlands, as well as increasing their contribution to health and a high quality environment, enabling more people to improve their health, well-being and life quality. Woodlands for Wales Strategy (Woodlands for Wales and Forestry, 2021) aims to increase forest and woodland cover, enhance the health and resilience of forest ecosystems and sustainably manage Welsh woodlands, while improving ecosystem services and biodiversity. Northern Ireland Forestry Strategy (Department of Agriculture and Rural Development, 2006) sets out the vision for sustainable forestry in Northern Ireland, including steady expansion of tree cover to increase different benefits provided by forests and public benefits. This demonstrates how the UK regions are introducing policies for forest planting and management which prioritise forests.

The importance attached to afforestation strategies across the UK emphasises the key role that forests and woodlands play in addressing environmental and social challenges. The increasing incorporation of afforestation initiatives into UK policy frameworks, as outlined in The UK Forestry Standard (2017), reflects growing evidence about forestry's environmental contributions. Current government plans, detailed in the report of Climate Change Committee (2020a), link forestry expansion to emissions reduction targets and nature restoration efforts, though more robust assessments are needed to quantify these potential benefits in the UK context, and continuously adjust forestry standards and strategies to ensure the resilience of UK forests for future generations.

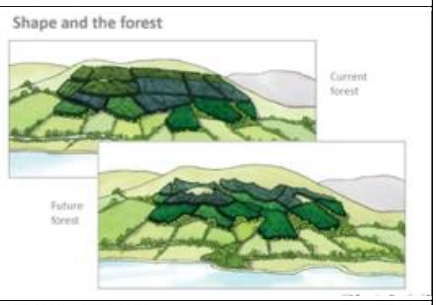
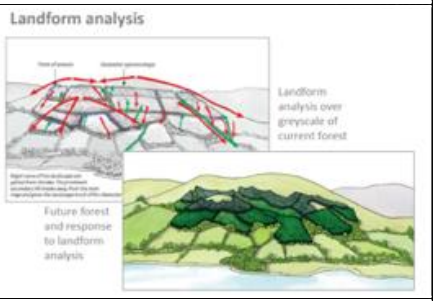
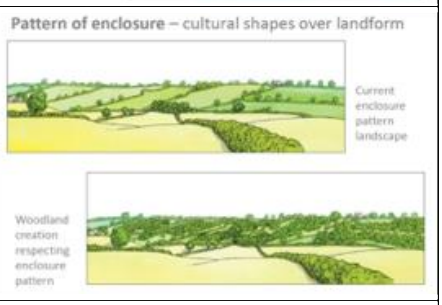
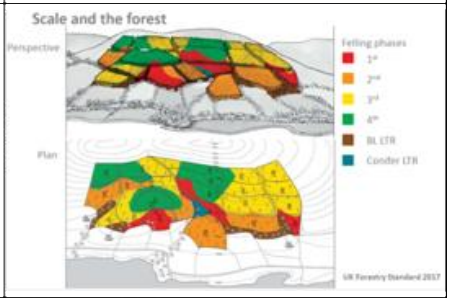
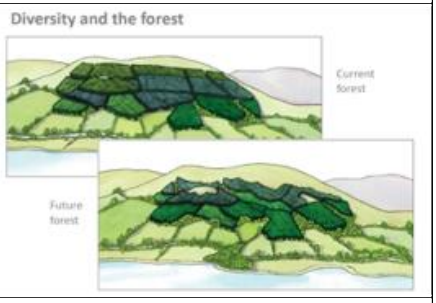
2.5.3 Forest design and tree species selection

Although forests are often thought of as being managed, it is not necessarily the case that people think of them as being designed (Bell and Apostol, 2008). In the UK, a number of early forest design works were applied to large-scale afforestation, particularly in upland areas. Over time, the same principles of design have been developed and adapted to lowland and urban forests (Forest

Authority, 1994). Urban forest design includes ecological, social, and economic considerations to fulfil specified goals for forest ecosystems and the people who will interact with them (Forest Authority, 1994). Different forest designs focus on different aspects, some are more focused on visual and sensory while others are more ecological emphasis (Bell and Apostol, 2008).

Urban forest design is argued to depend on six key design principles, including shape, landform, pattern of enclosure, scale, diversity, unity and spirit of place (Fig. 2.5.2) (Shepherd, n.d.). These design principles can influence the ecological and social benefits that forests can provide (Forest Authority, 1994). Spirit of place being one of the recognised principles in forest design, it imparts a special character to a particular site, making it unique to people (Forest Authority, 1994). In addition, with the cultural perceptions of forests beginning to shift, the forest managers undergoing the transition to ecological forestry felt that in order for forests to be accepted by the public, it would be necessary to perceive aesthetics as an addition (Forest Authority, 1994) (The Global Biodiversity Framework Commission 1991; The Forest Authority, 1994). It is interesting to note research showing that people prefer ‘naturally occurring’ forests to highly modified forests (Bell and Apostol, 2008).

Figure 2.5.2 Key principles of forest design (Shepherd, n.d.)

Forest design principles		
Shape	The shape of forests and woodlands within the landscape can be the most striking visual features: both the overall shape, and the patterns of species and felling coupes within	
Landform	In hilly or mountainous areas, landform is usually the dominant and most obvious landscape influence for forest and woodland design.	
Pattern of enclosure	In lowland areas, where landform is subdued, field patterns are usually the dominant and most obvious landscape influence for forest and woodland design.	
Scale	Scale describes the relative size of visual elements as seen by the viewer. Generally, the scale of forest and woodland shapes should reflect the scale of the landscape.	
Diversity	Diversity refers to the number of different elements in a design. Diverse forests are usually more visually appealing, but the level of diversity should be appropriate to the situation.	
Unity	Unity is achieved when forests or woodlands integrate well with other features and look as though they belong in the landscape. Unity also applies to the integration of the various elements within a forest design.	
Spirit of place	Spirit of place is a term used to describe the intangible qualities, such as wildness, tranquillity and cultural associations, that make a location special or unique.	

In addition, tree species selection is important. Although introduced (non-native) tree species represent an essential part of the urban forests around the world, urban forest programmes tend to focus on the planting of native rather than introduced tree species (Sjöman *et al.*, 2016; Alvarez *et al.*, 2021). As NTs have been part of British ecosystems for thousands of years, establishing complex ecological relationships, hence they are recognised as more secure species to select from. However, the validity of the applying dualist classification of species as either native or non-native has increasingly been questioned, especially under the current rapid changing climate situation, which is sparking many debates (Warren, 2007). The decision-making around tree species selection thus requires careful evaluation of multiple factors (Tubby and Webber, 2010).

When choosing an urban tree, matching species to site conditions and intended functions is critical to determine the type of urban tree that will suit the environment and needs (Miller, 1997; Núñez-Florez, Pérez-Gómez and Fernández-Méndez, 2019). Different urban trees thrive in different climatic and soil conditions (Boughton, n.d.; Worsley, 2018) and tree selection therefore requires careful evaluation of three interconnected factors of tree, place and the wider environment (Boughton, n.d.):

1. **Environmental Conditions:**
    - Climate (temperature range -- minimum and maximum, precipitation and moisture)
    - Site characteristics (soil conditions, altitude)
    - Urban stressors (air pollution, pests, diseases)
2. **Tree Characteristics:**
    - Size at maturity (height, spread)
    - Growth habits (root system, canopy shape)
    - Maintenance needs (pruning, debris management)
    - Deciduous or evergreen
    - Functional benefits (shade, cooling, aesthetics)
3. **Site Constraints:**
    - Infrastructure proximity (buildings, overhead and underground utilities)
    - Limited root zone area
    - place requirements (highways and byways-sight triangle, streetscapes, medians, walkways, courtyards and small urban parks)
    - Property considerations (boundaries, encroachment)

2.5.4 Conventional Forest methods of tree planting

Conventional forest methods (CFM) represent cultivated forest ecosystems developed through planting of native or imported tree species in the course of afforestation or reforestation (Carnol *et al.*, 2014; Nghiem and Tran, 2016). CF types may include commercial silviculture forests (monoculture plantations and mixed-species plantation), farm-woodlands, urban woodland/nature reserve planting schemes (Woudstra, 2004; Kirilenko and Sedjo, 2007; Jansson *et al.*, 2013; Plieninger and Schaich, 2014), where often planting densities are lower (e.g. 1 tree per 2 or 3 m^{-2}) and management over the longer term may involve less intensive weed removal in the early years, lower branch removal and 'stand-thinning' (removing every 2^{nd} or 3^{rd} tree once the forest reaches a set age) (Kerr and Evans, 1993; Cunningham *et al.,* 2015a; Webber, 2022).

Monoculture plantations and mixed-species plantation have been the dominant type of Conventional Forest methods. A number of studies have observed that the majority of the

plantations in the world are monocultures, which have been developed over a long period of time since 1300s (Kelty, 2006; Nichols, Bristow and Vanclay, 2006; Piotto, 2008; Alem *et al.*, 2015). However, mixed-species plantation of two or more tree species tend to achieve higher timber yields and biomass accumulate, while also providing greater benefits in terms of multitude of environmental and societal benefits, maximising the use of resources through species mixing than monocultures (Pretzsch *et al.*, 2010; Löf *et al.*, 2014). Mixed-species plantation is distinguished by low planting density, use of economically or ecologically valuable tree species, and a long growth cycle. It is commonly employed to develop large-scale forest ecosystems for the protection of biodiversity, timber production and ecological restoration. In the UK, commonly planted species include Oak (Quercus robur), Scots pine (Pinus sylvestris) and Birch (Betula pendula) (Forest Research, 2017, 2018). Over the decades, these forests have been planted at lower densities and with less intensive soil preparation.

Mixed-species plantation increases the productivity of the woodland and carbon sequestration, promoting diversification of production between different rotational periods and increasing resilience to disturbances such as storms, pests, or disease outbreaks (Griess and Knoke, 2011; Hartley, 2002; Li *et al.,* 2024; Liu *et al.,* 2018; Lu *et al.*, 2018). However, this approach is not without limitations. In some cases, it can negatively impact biodiversity, and species mixing can reduce soil fertility and overall productivity due to asymmetric competition among species. Establishing and managing mixed species forests can also be complex, challenging and time-consuming, such as complex root interactions and resource competition, unequal species growth rates and differential light and space requirements and so on (Nichols, Bristow and Vanclay, 2006).

Urban tree planting emphasises the introduction of individual trees or small clusters of trees in urban areas. This method can help with air quality improvement, shade provision, urban aesthetics and amenity value and mental well-being (Wolf *et al.*, 2020; Woodland Trust, no date). Trees are often planted individually or in rows and spaced widely (4-10 metres apart) to allow for individual growth and public access. Tree species are selected based on their ability to withstand urban stresses such as pollution, soil compaction and limited water supplies (Yang, Chang and Yan, 2015).

2.5.5 Miyawaki Forest Method of tree planting

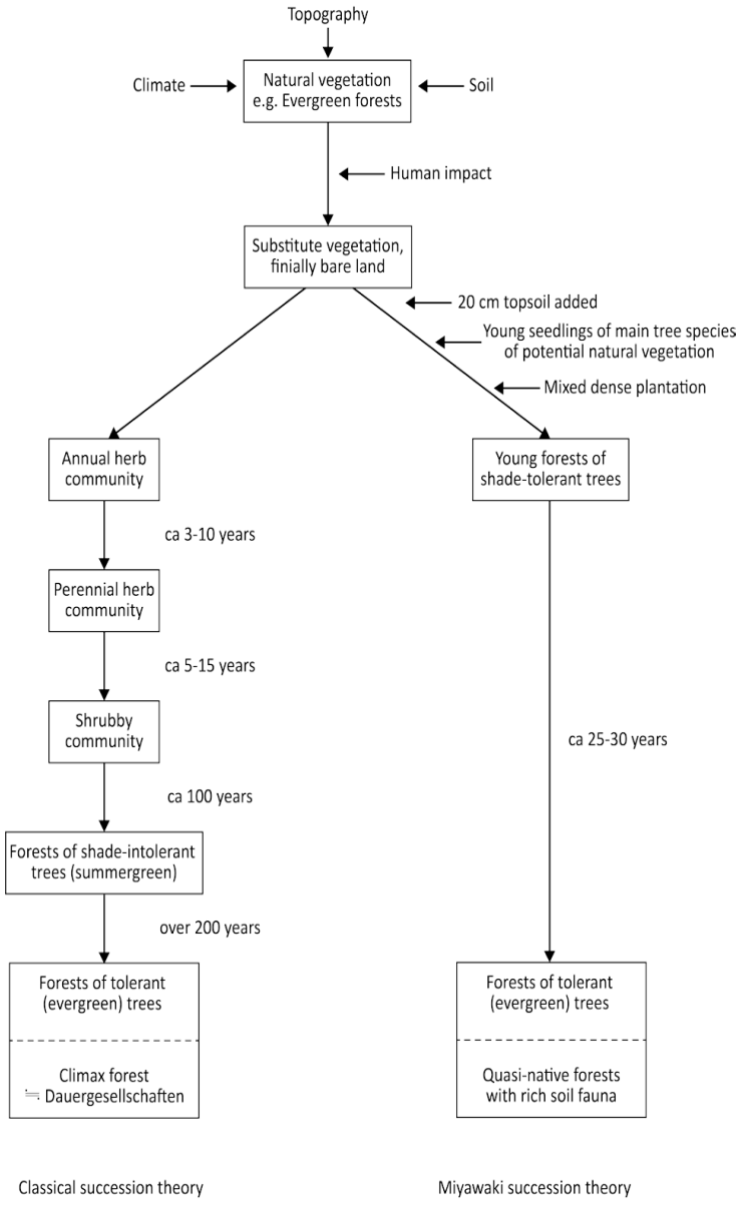
The Miyawaki Forest method (MFM) is a method that relies on principles of native species and high density plantations. It is founded on the theory of succession and potential natural vegetation (PNV), which refers to the cultivation of native species that would naturally occur in a specific area in the absence of human influence. This theory, developed in Europe by Tüxen (1956), emphasis the use of indigenous tree species. The MFM applies this concept alongsidenatural sucession principples and simulation techniques, such as propagating container seedlings to create a dense forest. These apporaches allow trees to grow and mature more quickly than conventional tree planting method (Tüxen, 1956, Saliba et al., 2024).

Through an ideal combination of the natural growth of plants in prepared soil, it is claimed to rapidly establish a stable, self-sustaining forest ecosystem with minimal human intervention. Such forests is characterised by a complete community structure, a high species diversity and high biomass, and ultimately close to the dynamics of a natural forest cycle at a later stage, without going through all the usual successional stages (Miyawaki & Golley, 1993, Da, 2003; Chen et al.,

2004). The strategy is claimed to go directly to achieve the 'climax stage forest', i.e. those that will provide the permanent structure of the new forest.

MFM is claimed to create a dense forest in 15–20 years in Japan and 40–50 years in Southeast Asia through this ecological reforestation based on natural forest systems compared to conventional forest planting, which can take 200–300 years for a dense forest to occur (Miyawaki, 1992; Schirone, Salis and Vessella, 2011). The MFM is based on several key technologies that together form an effective planting system. Fig. 2.5.3 provides a comparison.

Figure 2.5.3 Comparison between Miyawaki forest method and classical theory (Miyawaki, 1992)



MFM has demonstrated effectiveness in forest restoration outside the UK. The MFM is claimed to be suitable for urban and degraded areas, with rapid ecological restoration and high biodiversity benefits(Miyawaki, 1998; Webber, 2022).

2.6 Introduction to the MFM

The Miyawaki Forest Method (MFM) is a tree planting method developed by Japanese botanist Akira Miyawaki in the 1970s (Miyawaki, 1999). It is inspired by the traditional Japanese concept of shrine forestry that Prof. Akira Miyawaki has initiated and implemented first in Japan (Miyawaki and Golley, 1993; Padilla and Pugnaire, 2006). It is innovative and claimed to be relatively rapid and effective tree planting methods for afforestation and reforestation, which is based on potential natural vegetation (PNV) (Tüxen, 1956), and succession theory combined with knowledge of ecology and phytosociology, i.e., using trees native from the area and replicating the natural forest regeneration processes (Miyawaki and Golley, 1993; Miyawaki, 1999; Webber, 2022). PNV is a concept he encountered while working with the German ecologist Reinhold Tüxen. Initially applied in Japan to coastal forests restoration. PNV has since gained popularity around the world due to its adaptability and effectiveness in urban and degraded environments.

2.6.1 History of MFM

In the 1970s, deforestation across Japan caused an environmental crisis. The Japanese botanist Prof. Akira Miyawaki introduced an innovative method of afforestation and reforestation, based on ideas from Germany and the Netherlands, where he had studied the PNV principle: i.e. where vegetation occurs in a specific area naturally, largely without human interference (Tüxen, 1956; Chiarucci *et al.*, 2010). Miyawaki added his agricultural experience to the idea of PNV, and developed a forest planting method for stable topography, based on rich soil and good drainage. MFM is claimed to imitate natural processes to rapidly create diverse forests which survive for millennia through dense planting, mixed and random planting (Miyawaki, 1999). MFs are high density, multi species forests created with an emphasis on soil enhancement and selection of native tree (NT) species (Miyawaki, 1999; Padilla and Pugnaire, 2006). The method claims to address the challenge of reforestation, restoring native ecosystems, as well as conserving the global environment, including disaster prevention and carbon dioxide reduction (Praveen, 2022). In 1972, Prof. Akira Miyawaki first used this method to plant forests at the Nippon Steel Corporation. To date, the technique has been used at more than 900 sites in Japan, including coastal forests (Suzuki, 2022).

Although MFM was initially implemented in Japan, Prof. Akira Miyawaki applied the methodology overseas in collaboration with Japanese multinationals, such as Yokohama Rubber Company Limited, Aeon Environmental Foundation, and Mitsubishi Corporation. With the contributions of these globally influential Japanese multinational corporations, the MFM has rapidly become international in scope. During his career, Miyawaki guided the creation of more than 1,700 MFs around the world. To date, the MFM has been applied in Japan and beyond. As of the end of 2024, over 3,700 MFs have been planted in 62 countries and regions globally (summarised by author, available from open sources). There are 2,307 sites in Asia, 1,168 in Europe, 52 in South America, 155 in North America, 55 in Africa and 46 in Oceania (Table 2.6.1).

Table 2.6.1 Distribution of Miyawaki Forests around the world (summarised by author)

Continent	Country	Starting time	Number	Continent	Country	Starting time	Number
Asia (2,307)	Oman	2014	1	Europe (1,168)	Norway	2021	1
	South Korea	2015	1		Estonia	2023	1
	Iran	2016	1		Austria	2022	1
	Bahrain	2021	1		Greece	2022	2
	Kazakhstan	2024	1		Denmark	2022	2
	Sri Lanka	2021	2		Luxembourg	2023	2
	Tajikistan	2022	2		Romania	2019	3
	Singapore	2016	2		Switzerland	2021	4
	Israel	2023	4		Hungary	2021	4
	Saudi Arabia	2020	4		Czechia	2017	6
	Turkey	2011	6		Poland	2021	6
	Vietnam	2010	7		Finland	2021	6
	Jordan	2018	10		Spain	2019	9
	Lebanon	2014	13		Russia	2013	9
	Philippines	2008	14		Italy	2000	15
	Indonesia	2015	32		Sweden	2020	17
	Afghanistan	2022	32		Portugal	2021	49
	Malaysia	1990	34		Germany	2019	59
	Nepal	1999	61		Belgium	2016	86
	Thailand	1991	60		France	2017	191
	China	1998	107		Netherlands	2015	300
	Pakistan	2014	136		U.K.	2020	395
	India	2009	876	Oceania (46)	New Zealand	2021	2
	Japan	1972	900		Australia	2019	44
Africa (55)	Zambia	2019	2	North America (155)	Nicaragua	2017	1
	South Africa	2021	6		Mexico	2014	2
	Cameroon	2019	8		Bermuda (area)	2021	20
	Kenya	2007	20		USA	2009	56
	Tanzania	2022	19		Canada	2021	76
South America (32)	Colombia	2023	1				
	Ecuador	2021	1				
	Chile	1992	9				
	Brazil	1991	21				
Total	62 countries						3,763

Beginning in Japan, MF has spread around the world (Fig. 2.6.1). It first reached China, India, Malaysia, Chile, Brazil and Italy by Prof. Akira Miyawaki. In December 2009, Shubhendu Sharma met Prof. Miyawaki and worked as a volunteer on his first forest creation project in India. In January 2011, Sharma set up Afforestt, a company that dedicated to the creation of MFs in India.

Sharma adapted the technique, and is therefore considered the successor to the MFM, making it more procedural and standardised. After testing it in India, Sharma and NGO Afforestt began to program and standardise the cultivation of MFs in Oman, Mexico, Kenya and South Africa. Afforestt has since undertaken projects in Singapore, the Middle East, Western Europe and South America (Christopher, 2024; Afforestt, no date). In 2014, Shubhendu Sharma's TED talk made MFM famous in the English-speaking world (TED talks, 2014). Under Sharma's influence, the MFM for restoring native urban forests received interest in Europe, with an increasing number of MFs created around the continent. Since then, MFM has been spreading fastest in Europe, often in an urban, rather than a rural context (Ames, 2023) via IVN Nature Education brought the Indian experience to Europe in 2015. The methodology has attracted attention from a broad range of non-governmental stakeholders. For instance, organisations such as SayTrees, Forest creators, Green yatra, Acacia Eco, Crowd foresting, EcoSattva, and Alaap. In addition, IVN Nature Education has assisted Belgium, the Czech Republic, Denmark, the UK, Germany, Portugal, and Spain to establish their own Miyawaki style forests. France helped Luxembourg to establish the MF. Now, it has expanded to Saudi Arabia and the United Arab Emirates by theOtherForest founded in Lebanon. Table 2.6.1 shows that Japan has the largest number of MFs, followed by India and the UK. In addition, Figure 2.6.2 illustrates how internet interest in the term "Miyawaki Forest" has evolved over time.

Figure 2.6.1 Timeline of the movement of the Miyawaki style forest to England (made by author)

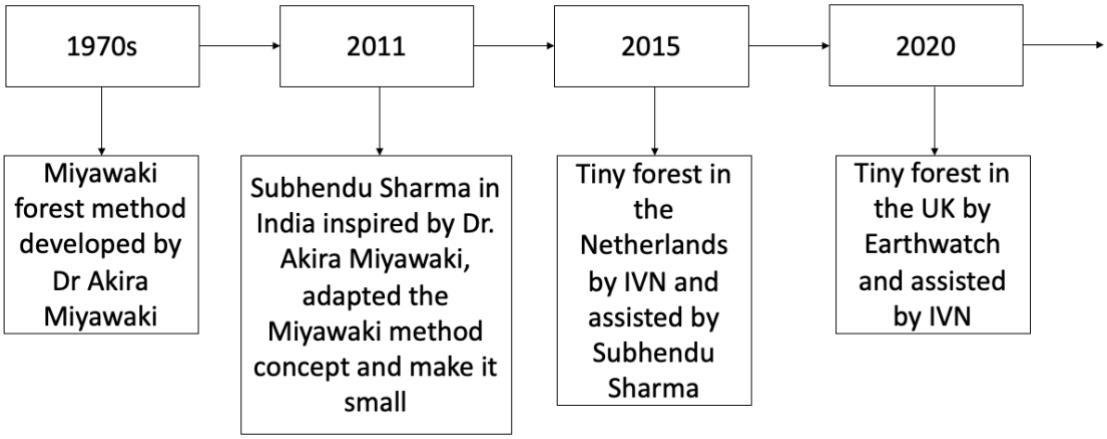
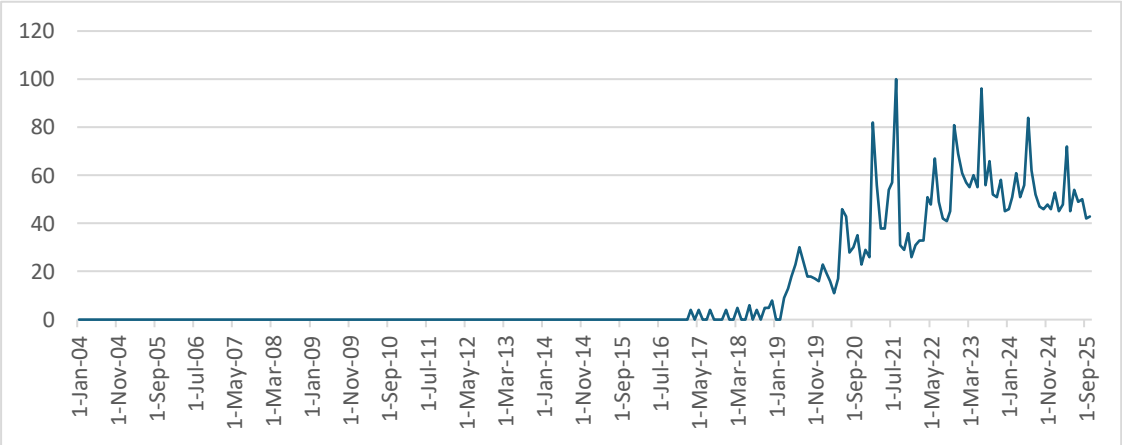


Figure 2.6.2 Timeline of the internet interest of the MF (Google Trends)



2.6.2 Development of MFM

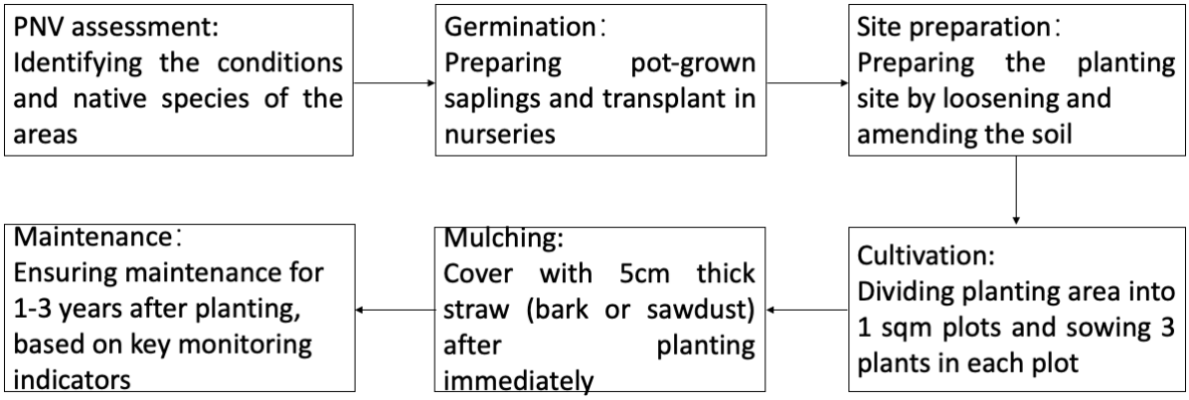
Today, practitioners and researchers of MF in many countries have established networks. Also, it has rapidly become popular and has spread to different parts of Europe as a way to combat against urbanisation and facilitate ecological conservation in small spaces (Lewis, 2020a). Currently, there is an international group named Miyawaki Research Network (MiRN) exploring the development and usage of tree planting using the MFM and its variations. Earthwatch Europe is a founder member of the MiRN, and coordinates the MiRN with practitioner and academic partners including the UK, France, Netherlands, USA, Canada, India and Australia (Earthwatch Europe, no date). Currently, other MFM practitioners (e.g. SUGi) are not part of this network.

In addition, there are more than 50 professional organisations around the world applying Miyawaki method for tree planting. For instance, urban regeneration research on the growth and ecological impact of MFs in Belgium, which has demonstrated their effectiveness in retaining soil moisture and reducing temperatures in urban areas (Urban Forests, no date). Forest restoration using the MFM in Kenya, that highlighted its effectiveness in biodiversity conservation (Okoth, 2025). MFs in Thailand have contributed to ecological outcomes, with activities focused on carbon sequestration and biodiversity enhancement, while also supporting environmental education by raising students' awareness through school-based planting activities (Hanpattanakit *et al.*, 2022) MFs were serving as community spaces for post-disaster healing and social restoration in Lebanon (Gibson, 2020).

Moreover, in recent years, IVN Nature Education has already created more than 170 MFs in the Netherlands, and Afforestt have planted 285 MFs around the world (Thiagarajan, 2020; Chaudron, 2022). Since 2019, SUGi has created more than 230 MFs in 52 cities on 6 continents (SUGi, 2024b). 294 MFs were established by Earthwatch Europe in UK (Earthwatch Europe, 2024) (these are the data as of writing this chapter). NGOs have proved to be an important driving force in the development of MFs around the world these have highlighted the significant contributions of the Miyawaki method to environmental conservation and ecosystem restoration in both urban and suburban settings.

2.6.3 Overview of MF underpinning principles and technique

Figure 2.6.3 illustrates the different stages of MF planting, from initial PNV assessment to post-planting maintenance. Each step is explained in detail in the following sessions (made by author)



2.6.3.1 Selection of suitable native species

In planting MFs, it is first necessary to identify the native vegetation that is most suitable for the planting area, known as PNV. Native species are recognised as having the best ecological resilience in their native environments and the greatest potential to enhance biodiversity. The species selection from stable indigenous forests that are best suited to the local ecosystem is considered to be crucial to MFM technique, and this method particularly emphasises the use of native tree species that are well-adapted to the local climate and soil conditions (Meguro, 2023). For example, in Japan, when establishing urban forests, Miyawaki investigated large primary forests in areas such as the Shrine Forest (Chinju no Mori) first, as well as the overgrown satoyama forests and secondary forests in rural areas (Suzuki, 2022). When selecting tree species for MFs (or TFs the MFM planted forests in European context), it is necessary to carefully consider the differences in conditions, such as climate, topography and soil, and a variety of native plant species occupying different forest strata (Suzuki, 2022).

A typical MF ranges from 100 square metres to 100 hectare in size and have as many as 40 species (Suzuki, 2022). When selecting tree species, priority should be given to native species that are already growing in the area without human intervention (Parikh and Nazrana, 2023). Native trees can be difficult to find because human impacts are almost inevitable in every place. Prof. Miyawaki suggested looking for clues within a 20 km radius of the area that is selected for afforestation. Before planting, it is important to consider the size, topography, soil, climate, and available tree and plant species. Trees in MFs are planted very close to each other (usually 3-5 saplings per square metre). This density promotes competition for sunlight, leading to rapid vertical growth and a thriving tree canopy (Boyden *et al.*, 2009).

If planted in the spring, the saplings may need more attention. In temperate and mountainous climates, the best planting season is autumn. In tropical environments, the best planting season is at the beginning of the monsoon or rainy season. It is best to select 3-year-old saplings with well-developed root systems that are 30 to 50 cm tall, and make sure they show no signs of pests, diseases or malnutrition to ensure growth and survival (Miyawaki, 1999; Suzuki, 2022). Saplings need support in the first few months to avoid sagging or bending. This can be through support sticks slightly taller than the sapling into the soil near the sapling and tie the stick to the sapling with thin twine (News Desk, 2019).

2.6.3.2 Soil quality improvement

Soil preparation is a critical step in the MFM process. It is claimed that the soil condition should be close to natural forest (Domingues, 2025). It is important to identify the type of soil and carry out a soil analysis to determine its characteristics, such as composition, fertility, drainage rate and pH value… A variety of finished composts or dry manures such as cow, goat or chicken can be used to improve soil fertility (usually 5 to 10 kg/m^2) (Kotamraju, 2018, Maarten, et al., 2019). The type and amount of soil improvement depend on the original soil's quality and texture, permeability and water retention (Śpitalniak, Bogacz and Zięba, 2021). To improve aeration and encourage root growth in compacted soils, incorporating dry, fibrous biomass such as chopped straw, wheat straw, or wood chips is recommended (Magdoff, 1993; Weil and Brady, 2017; Davis and Whiting, 2024).

Topsoil is high in organic matter, but urban soils often have a lack of topsoil (Craul, 1985; Winwood, 2023; Beniston, 2024). In MFM, before planting, the soil needs to be made suitable for saplings,

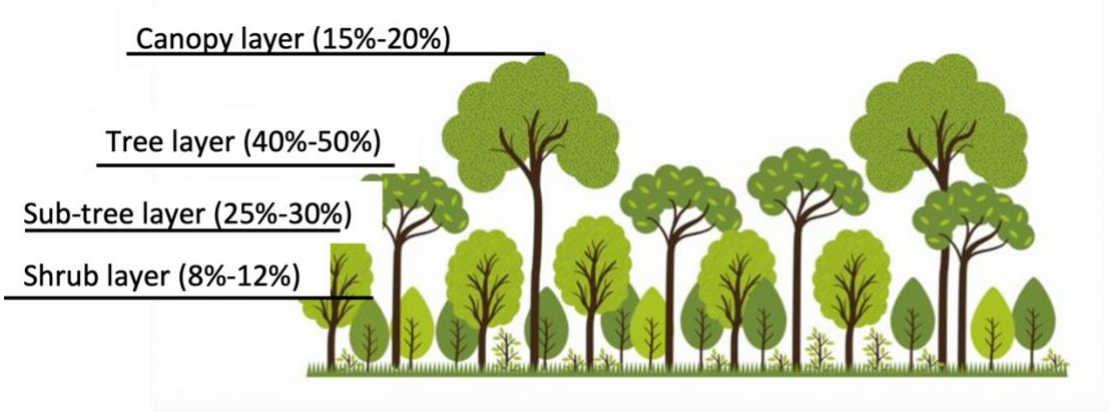
and it is recommended that the topsoil should be 20 to 30 cm by mixing fallen leaves, cut grass and other organic matter into compost (Miyawaki, 1999). This is because the topsoil is where the saplings receive water and nutrients and is vital for their growth (Sheer, 2020). Depending on the degree of compaction, the ground should usually be dug loose to 30 cm to 1 metre to ensure proper root development and water infiltration (Forest Research, no date).

2.6.3.3 Mixed planting at high density

Before planting a Miyawaki forest, it is necessary to identify the local dominant tree species, the quality of the soil and the range of indigenous tree species (Wang, Kauze and You, 2002). Prof. Miyawaki appealed for intensive planting of saplings to simulate a mature natural forest with rapid plant growth, which is encouraging competition and coexistence among saplings, and is encouraging early growth. MFM requires high density and mixed planting. The standard density is 3 plants/m^2 with a spacing of about 60 cm. Digging holes 1.5 times deeper and wider than the pot to add the air in soil and do not plant too deep for breathing (detailed procedure in Fig. 2.6.4). The topsoil should be well-drained, and it is planted with saplings with well-developed root systems, which are 30–50 cm in height, preferably with 5–8 leaves (Wang and Xu, 1998; Wang, Kauze and You, 2002). However, the planting density can be 2-7 trees/m^2 depending on the specific situation, local conditions and actual needs (Boer, 2022). This is all claimed to contribute to considerably shortening the establishment time-period.

A mix of saplings of different sizes will be planted in a place. Strive for grouping all four forest layers in each square metre of planted seedlings, as in a random mix of natural forest[1] (Orchard of Flavours, 2023). These four layers are the canopy, tree, sub-tree and shrub layers (Fig. 2.6.4), with layer ratios typically ranging from 15% to 20% for the canopy layer, 40% to 50% for the tree layer, 25% to 30% for the sub-tree layer and 8% to 12% for the shrub layer. The forest using MFM will have structural diversity, accelerated forest growth and enhanced ecological resilience. It is important to allow the forest to grow into a diverse layers - the shrub layer (which grows to about two metres in height), the sub-tree layer (about eight metres in height), the tree layer (about 12 metres) and the canopy layer (more than 12 metres) (Eiche, 2021).

Figure 2.6.4 Different layers of Miyawaki forest (Eiche, 2021)



1. I visited Japan and planted trees using the MFM in 2024.

2.6.3.4 Mulching

After the planting, mulching is carried out using materials such as dry leaves, straw, or bark chips to reduce evaporation, prevent soil erosion, add nutrients, foster soil organisms, and suppress weeds (Oliwia, 2024). The thickness of the mulch depends on the aridity of the soil and the conditions of the planting site, but a thickness of 5-7 inch mulch is usually recommended, and it should be maintained for at least the first three years (twice a year) (ICLEI South Asia, 2022). The straw should be spread evenly on top of the soil. To ensure the mulch stays on the ground and does not spread around, stakes can be pinned around the forest area and tied together with twine, pressing the straw firmly to the ground. Additionally, fences can be installed to protect the site from grazing by domestic and wild animals, such as sheep and deer (Connaughton, 2024; McCoy, 2024).

2.6.3.5 Maintenance after planting and mulching

The first three years after planting are critical and require regular maintenance, including regular weeding before and after the summer season each year (Nargi, 2019). In most cases, after three years of consistent maintenance, MFs become self-sustaining and require no further intervention (Rashid, Rashid and Ali, 2023). Once the trees grow to a size that they blocks direct sunlight from reaching the ground, they are stable and independent (The Tree Council and Shallcross, 2024).

2.6.4 Costs

There is some available information about actual costs of MFM but it is unclear when compared to other forestation methods (Kaboro, 2022; Stonecraft Group, 2023). In a limited number of studies on the application of MFM in some parts of the world, the overall cost of reforestation using MFM is lower and less maintenance is required after the reforestation period compared to CFM (Miyawaki, 2004; Singh and Saini, 2019). However, other studies have shown that MFM is more costly (Vashisth, 2019; Crowd Foresting, 2022). Preliminary research conducted by the author indicated that MFM costs are higher than CFM in terms of sapling purchase, soil preparation and maintenance (Qi, Dempsey and Cameron, 2024). In that study, interviewed respondents generally compared up-front tree establishment costs and did not consider the results in terms of survival rates (one of the common indicators of early success) and the resulting non-monetary benefits, which are also critical to the economic and environmental success of reforestation (Le *et al.*, 2012; Preece, van Oosterzee and Lawes, 2023).

Table 2.6.2 provides a summary of the reported costs across different countries. However, as the available costs data are quite limited and inconsistent, it highlights the lack of robust information on MF establishment costs. So far, more than 500 MFs have been planted in India and the costs are variable. The average cost of planting a MF is about 4 million rupees/acre (£9.26/m^2). Afforestt, an international company specialising in MF, has a low-cost afforestation model that costs about Rs. 150/sq. ft. (£15.18/m^2) (Kapoor, 2021). In the United States, it is about $20/sq ft (£171.25/$m^2$) (Uteuova, 2024), in France, it is €30 euros/m^2 (£24.95/m^2) and in the UK, it is £10.2/m^2 (The Tree Council, 2024) and so on. It is more expensive in Jordan, Portugal and Canada. Overall, it is widely recognised that the price of MF varies depending on location, size, soil type and ease of use, make it difficult to assess the economic viability of MFM in the UK context.

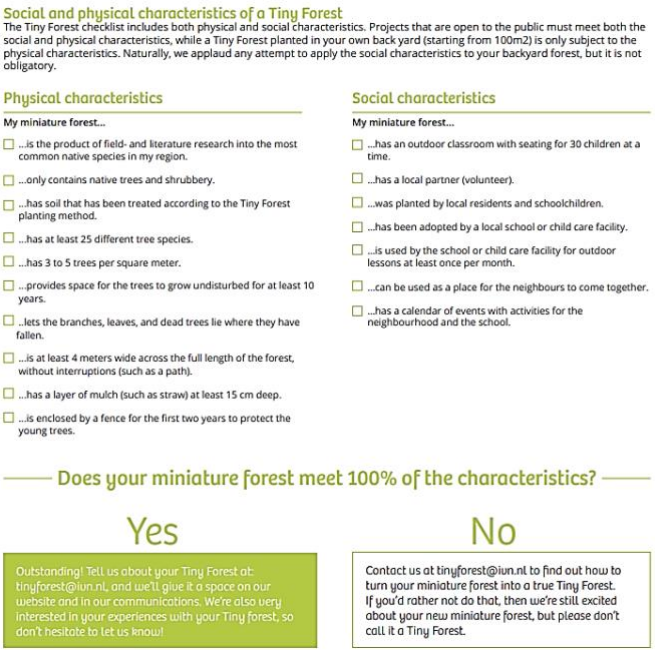
Table 2.6.2 Planting Costs of the Miyawaki Forest planting (summarised by author)

Country	Initial Cost（£/m^2）
Thailand	0.88 – 13.44 (Saraf, Pawar and Bhopale, 2012; FAO/RECOFTC, 2016)
Malaysia	1.18 (Madurapperuma *et al.*, 2009)
India	2.82 – 35.36 (Parikh and Nazrana, 2023; Crowd Foresting, no date)
UK	4.00 – 30.0 (Dream For Trees, 2023; Natural England, 2024)
Indonesia	16.00 – 20.12 (Junglo, 2023)
France	23.06 – 24.90 (AFP, 2021; Yeung, 2023)
USA	43.42 – 173.30 (Thach, 2021; Uteuova, 2024)
Jordan	78.89 (Vidal, 2021)
Portugal	83.00 (Orchard of Flavours, 2023)
Canada	103.98 (Sustainable Waterloo Region, 2022)

2.6.5 Adaptation of MFM in the UK

In the UK and Europe, MFM was largely developed as the Tiny Forest® (TF) concept via IVN Nature Education (Ottburg *et al.*, 2018; Egerer and Suda, 2023). The TF employs the Miyawaki method on a small scale in urban areas. This is unlike the 'original' MF which can be diverse in size as mentioned above. A TF is typically created in an area equivalent to that of a tennis court area, about 100 -- 200 square metres that can accommodate around 600 trees. It claims to be not only an attractive location for flora and fauna; it is a pleasant place for human wellbeing as well (Fig.2.6.5) (Maarten, et al., 2019).

Figure 2.6.5 Tiny Forest checklist (Maarten, et al., 2019)



Social and physical characteristics of a Tiny Forest

The Tiny Forest checklist includes both physical and social characteristics. Projects that are open to the public must meet both the social and physical characteristics, while a Tiny Forest planted in your own back yard (starting from 100m2) is only subject to the physical characteristics. Naturally, we applaud any attempt to apply the social characteristics to your backyard forest, but it is not obligatory.

Physical characteristics

My miniature forest...

- ☐ ...is the product of field- and literature research into the most common native species in my region.
- ☐ ...only contains native trees and shrubbery.
- ☐ ...has soil that has been treated according to the Tiny Forest planting method.
- ☐ ...has at least 25 different tree species.
- ☐ ...has 3 to 5 trees per square meter.
- ☐ ...provides space for the trees to grow undisturbed for at least 10 years.
- ☐ ..lets the branches, leaves, and dead trees lie where they have fallen.
- ☐ ...is at least 4 meters wide across the full length of the forest, without interruptions (such as a path).
- ☐ ...has a layer of mulch (such as straw) at least 15 cm deep.
- ☐ ...is enclosed by a fence for the first two years to protect the young trees.

Social characteristics

My miniature forest...

- ☐ ...has an outdoor classroom with seating for 30 children at a time.
- ☐ ...has a local partner (volunteer).
- ☐ ...was planted by local residents and schoolchildren.
- ☐ ...has been adopted by a local school or child care facility.
- ☐ ...is used by the school or child care facility for outdoor lessons at least once per month.
- ☐ ...can be used as a place for the neighbours to come together.
- ☐ ...has a calendar of events with activities for the neighbourhood and the school.

Does your miniature forest meet 100% of the characteristics?

Yes

Outstanding! Tell us about your Tiny Forest at: tinyforest@ivn.nl, and we'll give it a space on our website and in our communications. We're also very interested in your experiences with your Tiny forest, so don't hesitate to let us know!

No

Contact us at tinyforest@ivn.nl to find out how to turn your miniature forest into a true Tiny Forest. If you'd rather not do that, then we're still excited about your new miniature forest, but please don't call it a Tiny Forest.

More recently, the TF is also sometimes referred to as a 'mini forest', 'micro forest', 'wee forest', 'miniature urban forests' and 'pocket forest' (Knuijt, 2020; Kurian, 2020; Mukherjee *et al.*, 2022). These small-scale forests have been planted in a range of urban locations, including roadsides, school grounds, public parks, brownfield sites, and even private gardens (Bleichrodt et al.2017). The TFs are commonly found in densely populated urban centres, where they are specifically designed to fit within spatially constrained urban environments and contribute to the greening of cities (Fig. 2.6.6, Fig 2.6.7 and Fig 2.6.8).

The overarching objective of these initiatives is to expand green space and increase forest cover within urban areas. As such, they serve as a valuable complement to the objectives of all urban areas to reclaim the natural forests, and help to strengthen human -- nature connections through the establishment of locally embedded TFs in urban areas (Bleichrodt et al.2017).

Figure 2.6.6 Tiny Forest in Barnsley (taken by author)



Figure 2.6.7 Tiny forest in Witney (Earthwatch Europe, 2023)



Figure 2.6.8 Tiny Forest in Chelsea, London (SUGi, 2024a)



In 2015, two TFs with a density of 2.4 trees/m^2 were created in Zaanstad with two control plots (Fig 2.6.9) (Ottburg *et al.*, 2018). In France, Boomforest, as the emerging forestry organization, planted the first MF in 2018. The planting density was 3 trees/m^2 and in total 1,200 trees were planted (Boomforest, 2023). In addition, the Boomforest has been organizing participatory tree planting action with citizens in French cities for the past five years. Their goal is to re-create mini natural forests with the help of local residents in dense urban environment such as Paris or Lyon to help cope with the effects of climate change and foster citizen commitment to nature. To make this happen, they experimented with the MFM six years ago when they planted the very first MF in France.

Figure 2.6.9 Miyawaki forest example in the Netherlands (Charkow, 2022)



Example Miyawaki forest in the Netherlands, photographed in 2016 and 2021

Parsloes Park (10,000 m^2) in Dagenham is, at the moment, the oldest example of publicly accessible MF in the UK, with a density of 3 trees/m^2 and 24 native species, established in 2020 by The Conservation Volunteers (TCV) (Walker, 2022; Forest of Thanks, 2023). Earthwatch Europe have created many small-scale TFs in the UK and the first TF they planted was at Tychwood in Witney in 2020 (Earthwatch Europe, 2020).

Earthwatch Europe's Tiny forests focus on the design that are claimed to offer opportunities, such as a unique outdoor classroom that provide educational opportunities for students, teachers, and community members to learn, observe and connect with nature (Earthwatch Europe, 2023). Citizen science at the heart of the suite of activities aimed at schools and community volunteers, by involving citizens in the monitoring and maintenance of these small bushland habitats, the Earthwatch Europe programme design fosters a connection to nature and promotes environmental literacy, citizens engagement, and promote positive, long-term conservation behaviour change (Roy *et al.*, 2012).

In addition, there is a growing number of local councils and community groups in the UK turned out in support of this tiny forest revolution (Qi and Dempsey, 2024). For instance, Kent County Council have trailed the Miyawaki methodology as an innovative solution to establishing urban trees with potential to withstand multiple challenges. They have planted 16 MFM plots next to control plots (Fig.2.6.10), in urban settings in four English local authorities, to determine the relative cost of tree survival (Natural England, 2024).

Their findings show that significantly greater survival in MFM plots (an average of 79%) than in the control plots (less than 50%) so far. This was achieved during a drought in summer 2022 (Natural England, 2024). The higher initial cost of creating a MFM plot appears to have been outweighed by higher tree survival by the authors, with the experimental plots showing a lower cost per surviving tree than the control plots. Their data suggest that this method offers a rapid, reliable, and cost-effective way to establish trees in UK urban settings. The findings suggest the MFM enables newly planted trees to have greater resilience to the challenges prevalent in urban locations, such as drought, soil degradation, damage and vandalism. However, this Kent County Council's trail represents only on study. There is insufficient empirical evidence about MFM performance across different UK contexts, soil types, and urban environments.

Figure 2.6.10 Paired experimental (left) and comparison (right) plots in Kent (Natural England, 2024)



2.6.6 Claimed benefits and challenges of the MFM

MF is claimed to help to control the carbon, contain water, reduce noise, reduce soil pollution, hold the soil, prevent floods and increased the biodiversity (species groups and individuals), and

produce a habitat for birds, insects, and other wildlife (Lu *et al.*, 2011; Ottburg *et al.*, 2018; Riyas, 2022; Boomforest, 2023). This form of a near-natural multi-layered compound forest structure is claimed to offer high ecological efficiency and contributes to the mitigation of natural disasters (Niu, 2014). In addition, it claims to have possible to support the restoration of indigenous green environments, multi-storey forests and natural biomes. It is also claimed to maintain a richer species, have a higher level of biodiversity, and a more complete plant community structure. As such, it could help to explore the reconstruction of forests in areas where native forests have been lost, as well as enhancing the protection of the existing natural forest in the UK. More broadly, it presents an opportunity to advance forest restoration and governance, while contributing to national and global efforts to address climate change.

However, there is a lack of empirical data on the research of MFM in the UK, and many of the ecological claims associated with the method remain untested and unsubstantiated by robust experimental data in this context. Firstly, many claims regarding the benefits of the Miyawaki method, such as enhancing biodiversity or improving ecosystem, have yet to be substantiated through robust experimental designs that demonstrate significant ecological effects in the UK, such as biodiversity enhancement or carbon sequestration. Second, the literature claims that MFM is a cheap method of establishing forest (Singh and Saini, 2019), but there is no research data to date that compare the costs of MFM and other tree planting approaches. And because MFM requires a dense plantation with relatively high costs of initial soil enrichment, it is considered to be expensive (Singh and Saini, 2019; Vashisth, 2019; Taylor and Lovell, 2021). In addition, there were some other concerns including the potential for high mortality rates due to dense planting, and uncertainty regarding the long-term sustainability of such forests (Heuch and Thurman, 2024). Within the context of rapid climate change, while there is some evidence finding that NNTs positively contribute to the ecosystems services of forests, the evidence about survival rates of NT species, or if NNT species will be better suited as the climate changes is unclear (Castro-Díez *et al.*, 2019; Galwey, 2021). Moreover, there is criticism of using trees of the same age, considered to create a monotonous looking forest (Webber, 2022; Waddington, 2022).

2.7 People's perceptions of the application of the MFM in the UK

People's attitudes towards new tree planting schemes are influenced by a number of factors, including ecological benefits, aesthetic appeal, accessibility and perceived trade-offs with other land uses (Wang *et al.*, 2019). Research demonstrates that urban residents in the UK generally favour initiatives that significantly improve the quality of the environment and deliver tangible social benefits, such as improved air and water quality, recreational opportunities, biodiversity and progress against the impacts of climate change, as these contribute to a better quality of life (Office for National Statistics, 2023). However, acceptance can vary based on demographic and socio-economic characteristics. For instance, communities in densely populated urban areas may prioritise functional green spaces, such as parks, over denser forest patches (Zhu *et al.*, 2022).

MFs have shown significant potential, in terms of their rapid growth and transformation of degraded spaces into robust and viable ecosystems that provide ecological restoration (Kavana, 2023; Rewilding academy, 2024). By promoting hands-on involvement in the creation and maintenance of forests, MFs can install a deeper connection with nature among urban residents. Whilst the MFM is relatively new in the UK, the increasing emphasis on climate resilience, biodiversity enhancement, and community well-being has catalysed potential interest in

innovative urban greening initiatives (Lewis, 2022b). However, acceptance of the application of MFM in the UK is varied (Qi, Dempsey and Cameron, 2024). To date, there has been no systematic research examining how professionals and non-professionals view the MFM compared with conventional methods, or how their perceptions of dense, naturalistic forests differ from traditional forest aesthetics in the UK.

2.8 Knowledge gaps and research aims

Whilst the MFM has been successfully established in multiple places, it is relatively new in the UK and Europe (Miyawaki, 1989, 1999; Webber, 2022). Furthermore, over 3000 MF projects that have been planted in the UK and around the world are only using native species in this method (Miyawaki, 1999, 1989; Webber, 2022). However, Though the MFM has been successfully established in multiple places (Miyawaki, 1989, 1999), it raises a number of questions around Miyawaki style forest – Tiny forest in the UK, because there hasn't been enough studies to prove that TF could offer the benefits that MF claims it could bring, as these TFs are still quite young. For instance, the idea of using only native plantations has attracted some criticism because ecosystems are not stationary, so as the climate changes, will native vegetation continue to be suitable? Whether MFM has similar benefits in the UK as in other regions? What is their profile in the wider woodland/urban green space/natural environment community? How are MFs/TFs viewed by relevant professionals and are these seen as a genuine novel urban forestry type, or something whose benefits and advantages are still to be proven, especially compared against more CF types and practices. There is no answer about these questions for the UK context.

In addition, social acceptance and cultural perceptions present significant challenges for innovative forestry methods like the MFM in the UK, i.e. whether people will embrace this method in the UK, is another question to be explored. The potential for social resistance stems from unfamiliarity with novel ecological restoration approaches, highlighting the critical need for targeted education and advocacy. Consequently, there remains considerable scope for research into the MFM in the UK context. At present, the practice of MFM is ahead of research in the UK, resulting in a number of Miyawaki style forest having been planted without comprehensive scientific validation of their effectiveness in the specific ecological contexts to the UK. Explore these knowledge gaps are crucial and novel in terms of research and practice, and it will be a critical focus of this PhD. Thus, this research is aimed to explore how suitable the MFM is in the UK for natural multi species forests created.

Ch.3. Methodology

3.1 Introduction

As stated in Chapter 1, this research aims to explore the Miyawaki Forest method and its application in the UK context. To achieve the aim of this research, different methodological techniques were undertaken. And in this chapter, an overview of the methodological approach taken and its scope will be discussed, specifically with a focus on the following areas: (a) research questions; (b) research design, including an explanation of the different stages of the research; (c) sample population; (d) data collection and collation; (e) data analysis; (f) ethics approval; and (g) limitations of the research method. It concludes with a summary of the strategy and process of data analysis for producing the results, which are presented in Chapters 4 to 6.

3.2 Research approach – mixed methods.

This research adopted a mixed methods approach, integrating both quantitative and qualitative research methods for primary data collection. Methods employed include a review of relevant literature, questionnaires comprising both closed questions and open questions, and experiments, in order to construct a more comprehensive understanding of the research (George, 2022). The combination of quantitative and qualitative methods is well established in social sciences research (Cadena-Iñiguez *et al.*, 2017). These diverse methods enabled triangulation, that incorporates the use of multiple approaches to develop a more comprehensive understanding of the research phenomena, thereby reducing potential bias and enhancing the validity and reliability of the study (Jonsen and Jehn, 2009; Bhandari, 2022).

Qualitative methods provide a rich, contextual depth that enables a nuanced understanding of a more complex perspectives that cannot be fully captured through quantitative data alone (Lim, 2025). In contrast, quantitative methods offer breadth through larger sample sizes and statistical generalisation, often providing more surface-level data across a wider range of populations (Sharp, 2021). When combined, qualitative work can help to explain the findings of quantitative work improving the accuracy of data, providing more comprehensive information, and minimise single-method bias, allowing for a sequential explanatory strategy (Denscombe, 2008; Baškarada and Koronios, 2018).

This mixed-methods approach was chosen after careful consideration of alternative methodological frameworks. A purely quantitative approach, while providing statistical power and generalisability, would not have captured the depth of people's perceptions that is needed to understand the complex social dimensions of implementation of the Miyawaki method. Conversely, an exclusively qualitative approach would have provided rich contextual insights but lacked the broader measurement of attitudes among populations required for comprehensive assessment.

An experimental approach to plant control and experimental plots is also included in the research design. However, because tree growth takes a long time, experimental data was limited and could not provide a foundation for this initial research itself. In addition, a case study approach was considered but rejected as only a small number of Miyawaki-style forests had been planted by the start of this PhD research project in 2021 and it was therefore impossible to rely solely on case study to collect adequate data. The chosen mixed-method approach aimed to explore

professionals and non-professionals, in terms of their general attitudes (by quantitative method) and in-depth perceptions (by qualitative method) of the Miyawaki planting method, as well as the growth conditions of Miyawaki-style plots (by quantitative method) (Table 3.2.1).

Table 3.2.1 Research questions and methods

Research Questions	**Sub Questions**	**Research Approaches**	**Why this approach**	**Methods**
RQ1 **What are the dominant discourses on the MFM both in the UK and around the world from experts and professionals perspective?**	What are experts and professionals' perceptions of the MFM -- and how do they compare to their perceptions of CFM? What is the knowledge that supports their perceptions?	Mixed-methods (Quantitative and Qualitative)	Need to collect standardised data from large sample to establish general patterns and prevalence of respondents' attitudes at scale. It also requires in-depth understanding of complex perspectives and reasoning that cannot be captured through closed-ended questions.	Questionnaire 1
	How do experts and professionals' perceive the prioritization of planting native species in the Miyawaki forest in the UK? To what extent do they think that native species as suitable for future UK climate scenarios, and what role should non-native species play?			
	How are experts and professionals re-evaluating species selection for Miyawaki forests in response to climate change?			
RQ2 **How much do non-professionals know about the Miyawaki Forest method?**	What are non-professionals' attitudes towards the MFM and CFM -- and how do they compare to their perceptions of CFM?	Mixed-methods (Quantitative and Qualitative)	Need to collect standardised data from large sample to establish general patterns and prevalence of respondents' attitudes at scale. It also requires in-depth understanding of complex perspectives and reasoning that cannot be captured through closed-ended questions.	Questionnaire 1 Questionnaire 2
	What are the non-professionals' attitudes towards the prioritization of planting native species in the Miyawaki forest in the UK? To what extent do they perceive that native species as suitable, and what role do they believe non-native species should play in the UK?			
	Are non-professionals' perspectives on species selection for Miyawaki forests evolving in response to climate change?			
	How do these attitudes differ from those held by professionals?			
RQ3 **How do growth rates and survival rates of trees planted using the MFM compared to CFM in the UK?**	Do Miyawaki forest saplings have a higher growth rates and thicker diameters compared to saplings planted in a Conventional forest?	Quantitative	Tree growth metrics require objective measurement and controlled comparison to establish empirical differences between methods.	Experiment
	Do Miyawaki forest saplings have a higher survival rates compared to saplings planted in a Conventional forest?			

3.3 Questionnaire survey

The questionnaire survey is widely used as a method of data collection by academia in various fields (Regmi et al., 2016). Administering the questionnaire survey online was chosen in this research after evaluating several distribution alternatives. This was decided in 2021, when pandemic restrictions and concerns were still prevalent, and this was a national scope survey, making face-to-face data collection challenging and potentially unsafe, thus online questionnaire was effective necessitated.

The online administration provided several practical advantages for this national scope survey. It offered the most convenient and cost-effective means of reaching respondents across the entire UK without regional sampling bias, allowing the collection of large numbers of respondents' opinions efficiently and economically within a relatively short period of time regardless of geographic location (Punch, 2014, p.242). Online surveys also made participation more accessible for busy people, allowing them to complete the questionnaire at their convenience rather than requiring scheduled appointments.

However, this approach also presented challenges, including potential digital exclusion of some demographics, lower response rates compared to face-to-face methods, and the inability to clarify questions or probe responses in real-time. Despite these limitations, the online approach was deemed most appropriate given the research context, geographic scope, and the need to reach both professional and non-professional audiences efficiently during a period when traditional survey methods were constrained by health and safety considerations.

Thus, two online questionnaires were designed to assess the perceptions and attitudes of the Miyawaki Forest method from experts and professionals (Questionnaire 1) and non-professionals (Questionnaire 2). As different groups of respondents were targeted, the separation of questionnaires was essential, as each group required differently structured questions reflecting their expected backgrounds, knowledge levels and engagement with forestry practices. Understanding people's perceptions and attitudes can help to better promoting people-oriented forestation, they could also reveal underlying values and knowledge frameworks that drive both professional practice and non-professionals support for forest initiatives (Huang *et al.*, 2023). Both questionnaires were included quantitative (closed questions) and qualitative (open questions) data. The online questionnaires lasted for eight months (08.2022-03.2023).

3.3.1 Questionnaire survey design

The design of the online questionnaire surveys was based on the research gap in knowledge and questions, aimed to explore the two cohorts of respondents' perceptions and attitudes towards the Miyawaki forest method. The structure and turn of phrase of the questionnaire were refined according to questionnaire design principals in the existing literature. For instance, according to McColl et al., (2001) and King, Pealer and Bernard, (2001), researchers are encouraged to consider using a respondent-friendly-questionnaire structure to minimise the occurrence of non-response errors and to increase response rates and answer accuracy of the questions, thus enhancing the validity of the questionnaire collected. Consequently the questions should be worded neutrally to reduce bias and enable free expression of opinion in greater detail (Lietz, 2010) which underpinned the approach taken here.

For more comprehensive completion and more effective collection of the questionnaire data, this study conducted a pilot test before the official questionnaire distribution (Perneger *et al.*, 2015). This pilot test demonstrated that respondents were able to understand the questions (Bickman and Rog, 2008, p. 378-379), and to check that questions were not of a sensitive nature. Additionally, it helped identify and resolve issues related to content, wording, and order of the questionnaire (Murray, 1999). The sample for the pilot surveys included 22 professionals, specifically PhD students from the then Department of Landscape Architecture at the University of Sheffield, and 11 non-professionals respondents from the Miyawaki Research Network (MiRN, an international group of Miyawaki researchers, practitioners and interested decision-makers, and University of Sheffield is one of the partner organisations), to test the points listed above. The questionnaires were subsequently adjusted and refined according to the feedback from these pilot questionnaire surveys.

Given that the aim of this research is to understand a broad spectrum of people's perception and attitudes, online questionnaires to a relatively large sample of people were deemed most appropriate. This approach allows for targeting respondents from all over the UK without regional restrictions (Vicente and Reis, 2010). Additionally, online questionnaires are arguably more environmentally friendly, cost-effective, and time efficient than physical copies as they do not require printing or mailing. The data comes already in an e-format, which can be collected continuously, 24 hours a day, resulting in significant cost and time savings for dataset preparation (Vicente and Reis, 2010).

Therefore, the questions in the two questionnaires were designed and organised to facilitate coherent and easy responses from respondents. The primary aim of the two questionnaires was to obtain data on people's perceptions and attitudes towards the Miyawaki Forest method and Conventional Forest method in the UK, addressing research questions 1 and 2, and both questionnaires were similar in design. However, there were differences in the content of the two questionnaires, with more specialised questions included in the professional questionnaire (Questionnaire 1). For instance, professionals were asked questions about costs and what species recommendations for the Miyawaki forest, which were not included in the non-professionals questionnaire (questionnaire 2).

For professionals, questions were asked relating to factors such as familiarity with the Miyawaki Forest method; attitudes and interests; potential locations; costs; potential environmental benefits and problems; climate change and the selection of native and non-native tree species in the UK in general (Questionnaire 1). Socio demographic information from the respondents was also collected. For the non-professionals, similar factors were investigated through questionnaire 2 but excluding questions on costs and species recommendations.

In both questionnaires, the majority of questions were closed-ended, posed using attitude and rating scales. Depending on the specific perceptions constructure (agreement vs. suitability vs. support) being measured, and to keep the respondent interested and engaged in the questionnaire, some questions followed a ten-point Likert scale from 1 (do not agree/not at all supportive/completely unhelpful) to 10 (strongly agree/very supportive/very helpful), some questions used a four-point Likert scale from 'not suitable at all' to 'very suitable', and also a seven-

point Likert scale from 'strongly disagree' to 'strongly agree' for evaluation specific statements (Taherdoost, 2019).

Additionally, there were a number of optional open-ended questions included after each closed-ended question to explore the detailed reasons behind the respondents' answers regarding their perceptions and attitudes. This approach allowed respondents to elaborate on their responses, provide context for their ratings, and express nuanced perceptions that might not have been fully captured through the structured response options alone. As the findings chapters will show, the qualitative data collected through these open-ended responses provided valuable insights into the underlying reasoning behind respondents' perceptions and attitudes toward Miyawaki forests.

A research ethics review application for this research project was approved for this project by the Department of Landscape's Research Ethics Committee at the University of Sheffield (Appendix 1). The questionnaires can be found in Appendix 2 and 3.

3.3.2 Sampling strategy

The rationale for selecting these groups is multifaceted. In the context of this research, professionals' perceptions are crucial as they are the primary stakeholders involved in tree planting, and their perceptions inform decisions made about public spaces, therefore they have considerable influence over whether a tree planting method like Miyawaki could gain broader adoption in the UK (Nam and Dempsey, 2019). Professionals' understanding are essential for the implementation and scaling of innovative methods, as they possess the expertise and decision-making power required to initiate and sustain such projects (Lang *et al.*, 2012).

Equally important is the examination of understanding non-professionals attitudes, because non-professionals acceptance is key to the implementation of environmental initiatives being successful (Lang *et al.*, 2012). Without their adequate agreement, tree planting projects using the Miyawaki method may encounter resistance, leading to potential challenges in community engagement, such as opposition to changes in land use, concerns about aesthetic, and increased perceived safety risks or anti-social behaviour associated with densely planted areas, as noted in our interview findings (Kirkpatrick, Davison and Daniels, 2012; Qi, Dempsey and Cameron, 2024). Consequently, comparing the perceptions of professionals with those of the non-professionals can provide a comprehensive understanding of the feasibility and potential reception of the Miyawaki Forest method in the UK.

Eligibility criteria for participation in this research stipulated that respondents must be at least 18 years of age and able to answer all the compulsory questions on the questionnaire. This criterion ensures that respondents have the necessary maturity and cognitive ability to provide informed responses.

3.3.2.1 Questionnaire 1 -- Professionals

In Questionnaire 1, respondents were recruited from a spectrum of experts, professionals and practitioners involved in tree planting. A total of 112 respondents from professional organisations participated in the survey. This included academics from 20 universities around the UK. The inclusion of academics ensured that perspectives from research were captured, providing insights into the scientific and educational implications of the Miyawaki method.

Decision-makers from government bodies and councils (e.g., Defra, local authority tree officers) were also identified as respondents. These individuals play a pivotal role in policy formulation and implementation, and their perceptions are critical for understanding the regulatory and policy-related challenges and opportunities associated with the Miyawaki method (Munzhedzi, 2020).

Representatives from NGOs (e.g., TreesEve, Earthwatch, Tree Conservation Volunteer (TCV), Wild Urban Spaces, Acacia Eco, IVN) were also targeted. These organisations are often at the forefront of environmental advocacy and implementation of innovative planting methods. Their practical experiences and on-the-ground insights are helpful from an implementation perspective that complemented the academic viewpoints and decision maker perspectives. The inclusion of practitioners alongside academics and decision-makers ensured a comprehensive understanding of the method from practical, theoretical, and policy dimensions (Laustsen *et al.*, 2021).

3.3.2.2 Questionnaire 2 -- Non-professionals

Questionnaire 2 targeted members of the non-professionals with an active interest and involvement in tree planting (not representative of all general public). This includes tree wardens, members of relevant charities (e.g., Woodland Trust), students studying related subjects at the University of Sheffield (e.g., landscape architecture, animal and plant science, geography and architecture students etc.), and members of 'friends of' community organisations throughout England.

Tree wardens and members of charities are typically engaged in voluntary activities and community-based initiatives, providing grassroots perspectives on tree planting (Harper *et al.*, 2018). Their views are helpful for understanding community-level support and potential challenges.

Students, as future professionals and advocates, represent an important demographic for assessing the long-term educational potential of the Miyawaki method. Engaging with students studying relevant subjects, familiarises them with novel knowledge, stimulates their interest, increases their focus on relevant areas of scientific research, and also ensures that the research captures emerging trends and knowledge within academic circles (Punzalan and Balanac, 2020). Students were contacted through official university email distribution lists, in accordance with institutional data protection and communication policies.

The inclusion of members from 'friends of' organisations, which often consist of local community members passionate about green spaces, were helpful, as these community groups play an important role in the stewardship and advocacy of urban green spaces (Dennis and James, 2016; Papastavrou, 2019).

To distribute the questionnaire, I utilised networks with organisations such as MiRN, TCV, and Earthwatch. The Tree Wardens network and the National Federation of Parks and Green Spaces, along with local and regional networks (e.g., Sheffield Green Spaces Forum, Leeds Parks Forum), were instrumental in reaching a wide audience.

Emails were sent to potential respondents through these niche networks, facilitating broad distribution and helping to ensure comprehensive coverage of the target demographic (Regmi *et al.*, 2016). To date, the final sample of non-professionals respondents comprises 292 individuals. The demographic information of both professionals and the non-professionals is included in Table 4.2.1 and 5.2.1.

3.3.3 Administration of the quantitative surveys

Links to the online questionnaire surveys were disseminated by email in August 2022. This method was chosen for its ability to reach a broad audience efficiently and cost-effectively, particularly in a post-pandemic context where in-person interactions were not always desirable (Regmi *et al.*, 2016; Ni and Jia, 2023). A total of 404 valid questionnaires were completed by respondents who fulfilled the selection criteria, comprising 112 professional and 292 non-professionals questionnaires. The response rates were 23.59% for professionals and 35.92% for the non-professionals.

The administration process was carefully planned to ensure clarity and ease of participation. Online questionnaires included project information, and assurances of confidentiality and anonymity, adhering to ethical standards approved by the Department of Landscape at the University of Sheffield. To further enhance the response rate and ensure data validity, a follow-up reminder was sent two weeks after the initial invitation and a second reminder two weeks after that (Van Mol, 2016). This step was implemented to maximise participation (Socol and Large, 2022).

3.3.4 Data preparation

Both quantitative and qualitative data were processed and prepared for analysis in SPSS and NVivo coding following established procedures to ensure accuracy and reliability.

The quantitative data came from questionnaire surveys and experiments. First, the missing values, outliers or inconsistencies in the raw data were cleaned up. In addition, categorical variables were adjusted and coded appropriately for analysis, for instance, for the data in questionnaire 1 (experts and professional), due to the very small sample in the 18-24 age group, the age groups were recoded and merged into the 25-34 age group, resulting in a new code of 18-34 age group. Coding and construction of data files, is essential for good survey analyses, at the same time, being aware of the need to maintain a meaningful interpretation (Kulzy and Fricker, 2015). And sometimes, for consistent and avoids misinterpretation, variables that need to be recoded to maintain data integrity, for instance, there was a need to recode Likert scale responses (Kulzy and Fricker, 2015).

The questionnaires permitted respondents to include freehand text in their answers, which constituted the qualitative data for this research. The required word processing to facilitate data analysis, which included correction of typographical errors without changing the original meaning (Jamieson, 2016). In addition, answers were systematically coded using a combination of deductive and inductive methods. Deductive method created codes before the data is analysed and apply these codes to the data, providing a structured framework aligned with the research questions; inductive method complemented this approach by reading through the data and identify new codes or themes that emerge directly from respondents' responses, ensuring that all perspectives were captured. (Miles, 2020; Vanover, Mihas and Saldana, 2021).

Coding was carried out using qualitative data analysis software (e.g. NVivo) to organise and manage the data effectively. NVivo was chosen because of its power in handling complex qualitative datasets, facilitating systematic coding, efficient retrieval of coded fragments, and supporting the identification of patterns and relationships between different responses (Zamawe, 2015).

3.3.5 Quantitative statistical analysis

All data from questionnaires were analysed using IBM SPSS (Statistical Package for Social Sciences) version 29.0.2.0. Statistical analysis was conducted to explore quantitative data about descriptive statistics, mean comparisons and relationship among variables from the questionnaires (Kaur, Stoltzfus and Yellapu, 2018). It was carried out according to background factors such as age, gender, level of education, occupation and familiarity of MFM. This explored respondents' perceptions towards the application of the MFM in the UK, including support for the use of the MFM, potential locations, perceived potential problems, costs and potential funding sectors, environmental benefits, and the selection of native and non-native tree species under changing climate conditions, hypothesis such as: (1) Respondents' level of familiarity with the MFM would positively correlate with their support for its implementation in the UK. (2) experts and professionals with environmental science backgrounds would show higher support for the MFM compared to others.

This section is divided into two parts: (1) Mean comparison tests, which examine whether there are statistically significant differences between the responses of different groups. (2) Variable relationship exploration, which investigates how different variables relate to one another. The techniques employed are listed and explained in Appendix 4.

A mean comparison test was carried out, it is a statistical technique that is frequently used in the social sciences, to assess the differences between two or more groups of data. Depending on the properties of the data set (e.g. normality or equal variance), the techniques used differ and they are categorised as parametric and non-parametric statistics, respectively (Orcan, 2020).

3.3.5.1 Parametric tests

Independent sample t-test

Independent sample t-test was carried out, these compare the equality of means between two independent groups to assess the difference of (Kim, 2019), for instance, the perceptions of male and female groups on their willingness to pay for Miyawaki forest planting in the UK. In this research, we used Levene's Test for Equality of Variances, which is frequently used with independent sample t-test, to test whether the variances of two groups or variables were different.

Paired-sample t-test

Paired-sample t-tests were used to compare the difference between the means of two related groups twice, producing paired observations (Kim, Park and Wang, 2018). This test was used frequently in this research to compare respondents' perceptions. For instance, this was used to analyse responses before and after giving respondents information about climate change, in the question: 'Please select the percentage of native and non-native tree species in the Miyawaki forests/ Conventional mixed forest planting, if planted in the UK'. It was also used in the experiment to compare the survival rates of saplings in the MF and CF plots at three separate time points: 2023, 2024, and 2025.

One-way Analysis of Variance (ANOVA)

This test compared the means of three or more independent categorical variable groups, such as different age groups, education level groups or occupation groups, to ascertain if the mean of at least one group is significantly different from the others (Hesamian, 2016). This technique was often used in this research to compare respondents' perceptions. For instance, ANOVA was used to compare the extent to which different age groups agree that the MFM is a suitable tree planting method in urban or rural areas. Post hoc comparisons were mainly conducted in one-way AVOVA, using Tukey's test. If Tukey's test result was not available, least significant difference (LSD) was employed instead.

Two-way repeated measures Analysis of Variance (ANOVA)

This technique was used to compare changes in different groups when the same respondents answered multiple times under different conditions to the same question. For instance, this test was used to assess changes in responses regarding preferred species composition, i.e. comparing answers about the most suitable percentage of native and non-native tree species in the MF and CF before and after providing information about climate change. As a subsequent step in the ANOVA, the Sidak correction is a technique used to address the multiple comparison problem. It is a technique for modifying the significance level (P-value) to take into account the fact that multiple comparisons are being undertaken.

3.3.5.2 Non parametric tests

In some cases, the use of tests that estimated means and therefore used parameters (means are parameters) was not appropriate. In these instances, non-parametric tests were used instead.

Friedman's two-way analysis of variance by ranks

Friedman's test is a non-parametric alternative to repeated-measures ANOVA, used to two or more comparable quantitative variables are measured from the same sample (usually at the same time) (Siegel, 1988). It is appropriate when data in the variable of interest are ordinal or continuous. In this study, Friedman's test was used to compare respondents' rankings of different suitable locations for MFM implication.

Cochran's Q test

Cochran's Q test is a non-parametric method used to compare the consistency of three or more related binary outcomes (Aslam, 2023). It is suitable to determine whether the proportions of a specific outcome are consistent across the different groups. In this study, Cochran's Q test was applied to assess whether there were statistically significant differences in respondents' perceptions on the suitability of the MFM in urban, suburban, and rural contexts in the UK. This allowed the analysis of whether the same individuals had consistent or varying attitudes across different landscape types.

Cross-Tabulation with Pearson's Chi-squared test analysis

Cross-tabulation is a technique for displaying the distribution of frequencies and examining the relationship between two categorical variables at the same time (Dass, 2010). The Pearson's Chi-squared test was then applied to determine the relationship between the variables. For instance, cross-tabulating gender and the frequency of visiting Miyawaki forest can show if there are

different patterns for men and women. This helped identify whether distributions of responses differed significantly between subgroups in the sample, providing insight into demographic influences on perception.

Spearman's bivariate correlation

Spearman's bivariate correlation was used to assess the strength and direction of monotonic relationships between two continuous or ordinal variables (Schober, Boer and Schwarte, 2018). For instance, it was applied to explore the relationship between respondents' interest in trees and their attitude toward MF planting.

3.3.6 Qualitative analysis

The qualitative data collected from questionnaires were analysed using NVivo 1.7.2 software, which facilitated the organisation and management of the large volume of qualitative data. Open questions were used to better understand perceptions and attitudes (Bazeley, 2013; Saldaña, 2013). Thematic analysis approach was employed to explore meaningful themes that illuminated respondents' understanding and interpretation to the Miyawaki Forest methods and its application in the UK. Thematic analysis is rapidly developing into one of the most widely used methods of qualitative data analysis, and is used in almost every sub-discipline and field of the social sciences that deals with general qualitative research questions (Willig, 2017; Ahmed *et al.*, 2025).

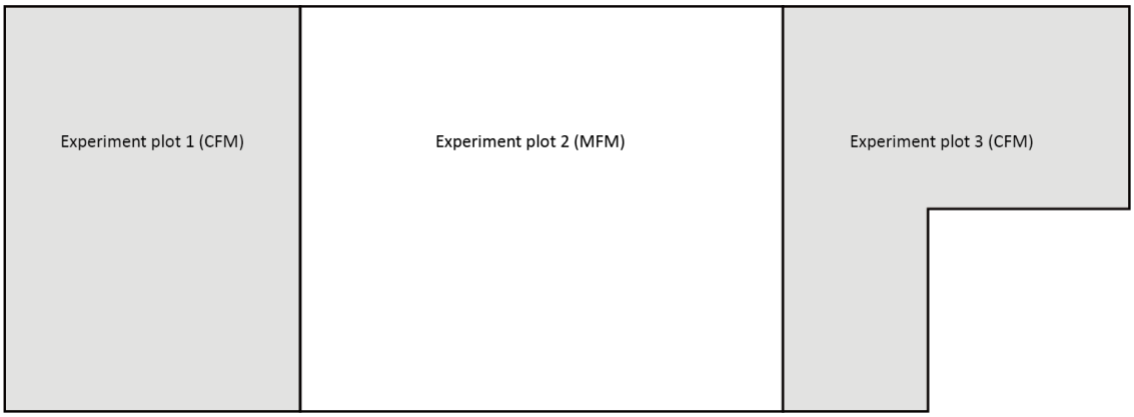
This analysis followed Braun and and Clarke's (2006) six-phase thematic analysis framework. The first stage of data analysis was the familiarisation to the responses, to capture initial impressions of the content. Then, the data were coded. Initial codes were generated according to the most frequently occurring words in respondents' answers to each question in the questionnaire (Miles, 2020). Additionally, potential themes for the codes were searched, reviewed and named. Words and synonyms (words with a very close meaning) were counted together as one theme. For instance, 'quick-growing', 'grow quickly', 'less time' and faster were all counted as 'quick-growing'. Through these processes, overall themes arise from the categories of codes that have been created. By following this framework, the qualitative data analysis provided rich, contextualised insights that assistant the quantitative findings.

3.4 Experiment

3.4.1 Experiment site selection

The site for this experiment (Fig. 3.4.1) was provided by a private landowner who approached the supervisory team a couple of years ago, indicating a willingness to provide land for a physical experimental test to compare the Miyawaki Forest planting method with Conventional Forest planting. At that time, there had been no experimental studies comparing these methods within the UK context, which presented a unique research opportunity for this PhD.

Figure 3.4.1 Experiment site



3.4.2 Experiment design

The experiment was designed for three plots:

Experimental plot 1 and plot 3: These plots were designated for tree planting following the Conventional Forest method (Fig. 3.4.2). This conventional method typically involves digging the soil, planting trees at wider and regular spacing, and using lower planting density with limited or no soil amendments (Cunningham *et al.*, 2015b; Woodland Trust, 2023). Specifically, at this particular site, plots 1 and 3 were left pristine. Trees were planted following the procedure described above: the soil was ripped, and one sapling was planted every two metres without any additional digging, soil preparation, or mulching. Each sapling was protected with a tree guard and a total of 300 saplings were planted across these two plots.

Experimental Plot 2: This plot was designated for tree planting following the Miyawaki Forest method (Fig. 3.4.3). The Miyawaki method involves the high-density planting of a diverse mix of native species, combined with soil enhancement techniques to mimic the natural forest soil conditions, promoting rapid growth of forest (Schirone, Salis and Vessella, 2011). At this site, plot 2 was excavated to a depth of 50 cm approximately. Manure was mixed into the upturned soil when prepare the soil. Saplings were planted at a density of 3.5 per square metre. After planting the saplings, the plot 2 was covered with a mulch layer about 5 cm thick, then tree guards were placed, with a total of 1800 saplings planted in plot 2 (Riyas, 2022; SUGi, 2024c).

Only three plots were established due to the physical constraints of the site. The study area is privately owned land with limited available space, characterised by a long, narrow, and sloping form. It is bordered by existing woodland along the back edge and an open field on the opposite side. The site also experiences wet with drainage conditions worsening toward the bottom of the slope. These characteristics made it difficult to get additional areas suitable for creating more comparable plots within the same site.

The chosen 24 saplings are all native species (Earthwatch advised), sourced locally, to ensure they are well-adapted to the regional climate and soil conditions. These trees/species were randomly planted on the site. The species list, along with the number of saplings for each species, is provided in Table 3.4.1. This approach claims to replicate natural forest ecosystems as closely as possible, fostering resilience and sustainability in the planted forests (Schirone, Salis and Vessella, 2011).

Figure 3.4.2 Conceptual diagram of CF experiment plots

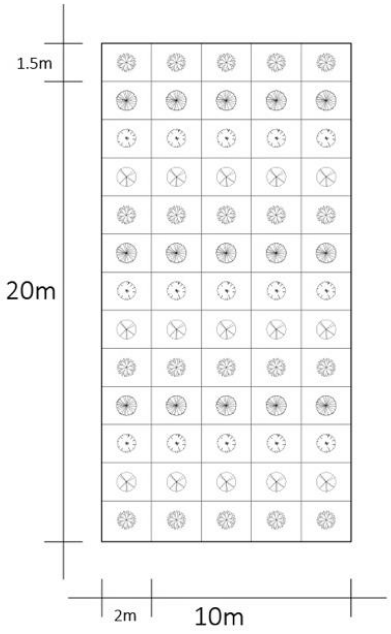


Figure 3.4.3 Conceptual diagram of MF experiment plots

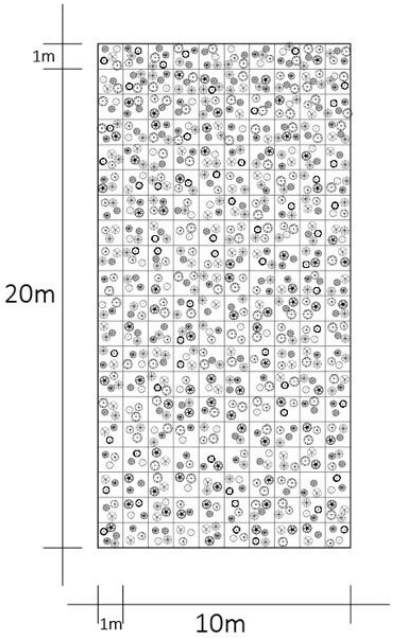


Table 3.4.1 Tree species list and number of trees

Forest layer	**Common name**	**Scientific name**	**MF number to be planted**	**CF number to be planted**	**number of trees**
Canopy	Alder	Alnus glutinosa	35	10	45
Canopy	Beech	Fagus sylvatica	40	10	50
Canopy	Cherry, bird	Prunus padus	90	10	100
Canopy	Cherry, wild	Prunus avium	90	10	100
Canopy	Hornbeam	Carpinus betulus	105	/	105
Canopy	Oak, English	Quercus robur	180	20	200
Canopy	Oak, sessile	Quercus petraea	180	20	200
Sub-canopy	Birch, downy	Betula pubescens	65	10	97
Sub-canopy	Birch, silver	Betula pendula	65	10	97
Sub-canopy	Wild Service tree	Sorbus torminalis	30	/	
Sub-canopy	Yew, English	Taxus baccata	95	10	122
Understory	Crab apple	Malus sylvestris	90	/	142
Understory	Dogwood	Cornus sanguinea	65	10	94
Understory	Hawthorn	Crataegus laevigata	90	15	162
Understory	Hazel	Corylus avellana	85	5	94
Understory	Holly	Ilex aquifolium	80	10	142
Understory	Rowan	Sorbus aucuparia	60	10	102
Understory	Spindle	Euonymus europaea	65	5	94
Understory	Whitebeam	Sorbus aria	60	/	142
Understory	Willow, goat	Salix caprea	10	/	12

Forest layer	Common name	Scientific name	MF number to be planted	CF number to be planted	number of trees
Understory	Willow, grey	Salix cinerea	20	5	102
Shrub	Dog Rose	Rosa canina	80	10	
Shrub	Guelder Rose	Viburnum opulus	60	10	94
Shrub	Wayfaring tree	Viburnum lantana	60	10	102
Total			1800	200	

3.4.3 Administration of the experiment

This is an experiment which involves multiple institutions and organisations, including the University of Sheffield, University of Leeds, University of Derby, Earthwatch and Hope Valley Climate Action Group etc. These partners are collaborators and oversee the execution and maintenance of the experiment. The design, preparation, planting and overall management of the experiment has been done by this team (i.e. not only the PhD researcher). I have collected data on-site about the saplings growth rate, survival rate, and stem diameter on a regular basis to address Research Question 3.

Following planting, weeding and watering were scheduled for April and August in the first three years to support sapling growth and minimise competition from weeds. Data collection has been undertaken either once or twice a year (depend on the growth condition) for each plot to monitor sapling survival and growth rates.

While maintenance was standardised across all plots, this study acknowledges several variables that may have influenced the results and limited experimental control. Site-specific differences such as drainage patterns, sunlight exposure, and microtopography varied between plots and could have affected sapling establishment and growth rates. Additional external environmental factors, including seasonal weather fluctuations, pest and disease pressure, human interference, and wildlife browsing, also posed potential influences beyond the control. In addition, although saplings were sourced from the same nursery at the same time and planting procedures were standardised, these factors could not be completely eliminated as potential confounding variables.

To address these limitations, data collection protocols were standardised. Measurements were conducted by the same research team using consistent tools and methodologies to minimise observer bias. Nevertheless, the real-world conditions of this forest establishment study means that the findings should be interpreted as exploratory, offering baseline insights for understanding the short-term performance of the Miyawaki method under practical implementation contexts in the UK. Future research incorporating more controlled experimental designs, larger sample sizes, and long-term monitor would help strengthen the validity and robustness of findings about the effectiveness of Miyawaki forest establishment in the UK.

3.4.4 Quantitative statistical analysis

Data have been inputted in the Excel and undergone rigorous quantitative statistical analysis. Firstly, the means, medians and standard deviations of growth rates, survival rates and stem diameter were calculated for these three plots. In addition, statistical tests such as linear mixed

models and paired sample t-test were applied to establish if there are significant differences between the growth and survival rates of saplings in the CF plots and MF plot. In combination, these statistical methods will provide initial insights into early establishment patterns and short-term performance differences between the Miyawaki Forest method and the Conventional Forest method.

Linear Mixed Models

Linear Mixed Models (LMMs) is a statistical approach with widespread applications in longitudinal data analysis, that account for both fixed effects (e.g. treatment type) and random effects (e.g. year), making them suitable for repeated measures and nested data structures (Schielzeth *et al.*, 2020). In this study, LMMs were applied to analyse sapling growth and diameter data collected from three plots (two CF and one MF) over multiple time points. By incorporating both fixed effects (e.g. forest type: MF vs CF) and random effects (e.g. year), the model allowed for a more accurate estimation of treatment effects while addressing temporal and spatial variation.

3.5 Conclusion

This chapter has provided a thorough examination of the methodology used to conduct the primary research and generate results for analysis. It provides details of the design and implementation plan for both the online questionnaires survey and experiments. These methods were selected to explore the perceptions from both professionals and non-professionals towards the acceptability and feasibility of the Miyawaki Forest method in the UK and how Miyawaki forest performs in the UK context, in order to reveal the fundamental reasons behind their responses to the Miyawaki Forest method and application on the experiment site. The following chapters present the specific data collected and the results from these surveys.

Ch.4. Perceptions of experts and professionals on Miyawaki Forest Method (MFM) and Conventional Forest Method (CFM)

4.1 Introduction

This chapter addresses the first research question:

1. What are the perspectives of experts and professionals on the MFM in the UK?

1.1 What are experts and professionals' perceptions of the MFM, especially in comparison to their views on CFM?

1.2 How do experts and professionals' perceive the prioritisation of planting native species in the Miyawaki forest in the UK? To what extent do they think that native species as suitable for future UK climate scenarios, and what role should non-native species play?

1.3 How are experts and professionals re-evaluating species selection for Miyawaki forests in response to climate change?

This chapter presents the findings of the online questionnaire survey that was carried out primarily in the UK, but that also targeted a worldwide sample (professionals from other countries with knowledge and experience of the UK context). There was limited prior research on MFM to draw upon before launching this questionnaire, so many aspects of the questionnaire were exploratory in nature. The gaps in knowledge led to a number of hypotheses to be addressed in the research:

- Awareness: Relatively few professionals would be aware of the MFM, and academics would demonstrate higher levels of awareness compared to other professional groups.
- Support: The overall support from professionals would be limited as MFM had just emerged in the UK.
- Perceived suitability: Professionals would rate the method's suitability for the UK context as neutral, reflecting the novelty of the method and existing uncertainties.
- Knowledge of costs: There were limited understanding of the costs associated with implementing the MFM.
- Willingness to pay: Only a few professionals would express willingness to pay for or invest in MF projects due to the perceived high initial costs.
- Perceived problems/challenges: Most experts and professionals would identify various potential problems associated with MFM.
- Species preference: Experts and professionals would show a preference for incorporating NNT species in response to climate change in the MFs.

Primary data of this study derived from the response of survey respondents which captures the perceptions of experts and professionals towards the Miyawaki forests in the UK context. The data was summarised based on experts and professionals' perspectives and the similarities and differences among the respondents were identified. This chapter is organised into the following sections:

- Attitudes towards, and interests in, the Miyawaki Forest method, and comparison with Conventional Forest method (section 4.3).
- Potential locations for planting Miyawaki Forests in the UK (4.4).
- Perceived potential problems of the Miyawaki Forest method (4.5).

- Perceived costs of the Miyawaki forest planting, and comparison with Conventional Forest method (4.6).
- Potential environmental benefits of Miyawaki forest planting, and comparison with Conventional Forest method (4.7).
- Tree species for Miyawaki forest planting, and comparison with Conventional Forest method (4.8).

4.2 Demographic characteristics of the sample

This section outlines the demographic characteristics of the survey sample, providing a foundation for interpreting the responses. The sample consist of respondents who were experts and professionals in tree planting, and it was categorised by age, gender, education level, occupation and frequency of visiting greenspace. The most respondents identified as British (74%) and they did not necessarily have prior knowledge of MFM. Young (age group 18 to 34, 40.2%, Table 4.2.1) and high educated (academic, 53.6%) respondents were the most dominate group in the study and comparatively more females (55.4%) answered the questionnaire than male respondents (42.0%). The respondents had a diverse range of occupations related to ecology, forestry, and environmental management. The majority of respondents (91%). visited a greenspace at least once a week (Table 4.2.1).

The sample comprised a relatively high proportion of academic respondents, which could potentially influence the results. To evaluate the robustness of the findings, exploratory sensitivity testing was undertaken, excluding academic respondents from the analysis (results not presented). This procedure revealed no significant differences to the core outputs, indicating that the inclusion of academics did not materially affect the overall findings.

Table 4.2.1 Demographic profile of the expert and professional questionnaire respondents

Age	**Number**	**Percentage**
18-34	45	40.2%
35-44	26	23.2%
45-54	20	17.8%
55+	21	18.8%
Gender		
Male	47	42.0%
Female	62	55.4%
Prefer not to say	3	2.6%
Level of education		
Bachelor and below	23	20.6%
Masters	38	33.9%
PhD	51	45.5%
Occupation		
Academic (e.g. university, college)	60	53.6%
Public (e.g. local authority)	19	17.0%
Voluntary community (e.g. charity)	10	8.9%

Private (e.g. landowner, consultant)	23	20.5%
Frequency of visiting greenspace		
Daily	46	41.1%
Weekly	56	50.0%
Monthly	9	8.0%
Less than monthly	1	0.09%

Respondents were assigned unique identification codes for reference in the findings chapter. It incorporated key demographic and relevant factors in the survey, i.e., respondents are identified in the findings according to education level – age – gender – occupation – have been involved in Miyawaki method planting or not, e.g. (MA-35-44-F-AC-MY-77), the last number is the serial number of respondents (Appendix 5). These codes protect the anonymity of respondents while allowing for consistent identification throughout the analysis.

4.3 Experts and professionals' attitudes towards, and interests in, the Miyawaki forest method, and comparison with CFM.

Table 4.3.1 Summary table for research question 1.1 and questionnaire integration

Research questions	**Themes**	**Indicators (questions in the questionnaire)**
RQ 1.1 What are experts and professionals' perceptions of the MFM -- and how do they compare with their perceptions of CFM?	4.3 Experts and professionals' attitudes towards, and interests in, the Miyawaki forest method, and comparison with CFM.	**Q5** Are you familiar with the Miyawaki Forest method? (i.e. familiarity with MF) **Q6** Have you been involved in any Miyawaki Forest (also called Tiny Forest) projects? (i.e. involvement of MF) **Q7** Have you ever visited a Miyawaki forest before?
		Q11 To what extent would you support using the Miyawaki Forest method to plant a forest rather than using the Conventional Forest method?
		Q13 Do you agree that the Miyawaki Forest method is a suitable tree planting method in the UK?

4.3.1 Respondents' awareness of the MFM in the UK

The first set of questions were designed to analyse how familiar and engaged the questionnaire respondents are with MFM in the UK (Table 4.3.1). A mixed level of familiarity on the MFM was observed (Table 4.3.2), with over half of the respondents (54.5%) were familiar with the MFM in the UK. There were fewer respondents (only 28.6%) who had been involved in MF projects, and 25.0% of respondents had previously visited MF projects. Among the respondents familiar with MF, half (50.8%) of them were directly involved in MF, compared to only 2% who were not familiar with it ($P < 0.001$). 44.3% of those who were familiar with MF have also visited a MF, compared to only 2% of those who have not visited a MF ($P < 0.001$). Data presented in Table 4.3.3 were analysed using Chi-square test in crosstabulation, according to factors based on all respondents' characteristics. Factors that influenced the responses to the questionnaire and levels of significance were outlined in full in Appendix 7. The only characteristics found to have significant associations/significant trends were occupation and education level.

Table 4.3.2 Respondents' awareness of MFM (n = 112).

Are you familiar with the Miyawaki Forest method?	Number	Percentage
Yes	61	54.5%
No	51	45.5%
Have you been involved in any Miyawaki Forest (also known as Tiny Forest) projects?		
Yes	32	28.6%
No	80	71.4%
Have you ever visited a Miyawaki forest before?		
Yes	28	25.0%
No	84	75.0%

Table 4.3.3 Summary of factors affecting responses at a significant level (level of probability P) and trends for that factor.

Question	**Factor**	**P value**	**Trend / relationship within the factor group**
Q5 Are you familiar with the Miyawaki Forest method?	Age	P = 0.945	
	Gender	P = 0.759	
	Education level	P = 0.069	
	Occupation	**P < 0.001**	**Academics have the least familiarity with MF than other disciplines.**
	Frequency of visiting greenspace	P = 0.380	
Q6 Have you been involved in any Miyawaki Forest (also called Tiny Forest) projects?	Age	P = 0.984	
	Gender	P = 0.538	
	Education level	P = 0.060	
	Occupation	**P = 0.000**	**Academics have the least involvement of MF than other disciplines.**
Q7 Have you ever visited a Miyawaki forest before?	Age	P = 0.477	
	Gender	**P = 0.050**	**There were more men visited MF than women.**
	Education level	P = 0.077	
	Occupation	**P < 0.001**	**Academics have the least visited MF than other disciplines.**

The only significant demographic factor that influencing familiarity with MF was occupation (P < 0.001, Table 4.3.3, Fig. 4.3.1). Academic respondents have the least (36.7%) familiarity with MF, followed by the respondents from private sector (69.6%) and local authority (73.7%). The respondents who primarily work in voluntary sector, including charities, have the greatest familiarity with MFM (90.0%). In addition, there was a significant trend between familiarity and education level (P = 0.069, Table 4.3.3, Fig. 4.3.2). Respondents with a Master's degree level or

lower education are more likely to be familiar with the MFM, whereas respondents with PhD education level exhibits the lowest familiarity (43.1%).

Figure 4.3.1 Are you familiar with the Miyawaki Forest method by occupation?

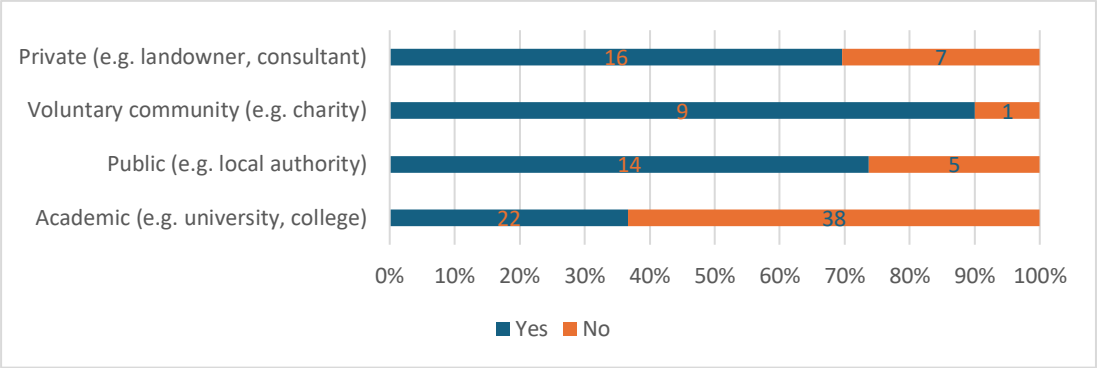
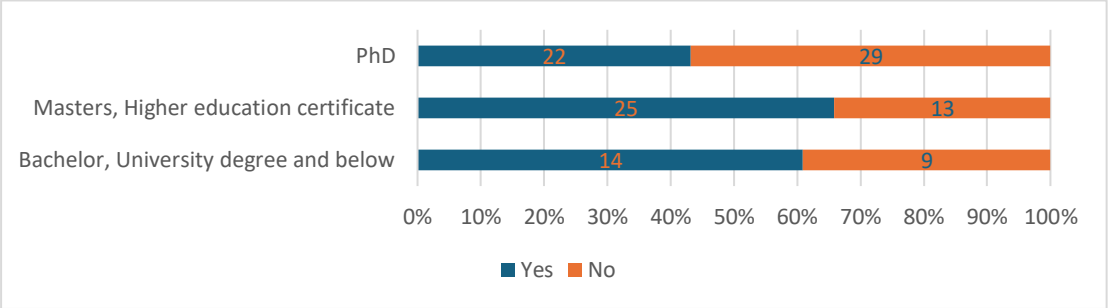


Figure 4.3.2 Are you familiar with the Miyawaki Forest method by education level?



The findings of the question 'Have you been involved in the MF project' and 'Are you familiar with the MFM' demonstrate a similar pattern. Once again, occupation influenced the level of involvement amongst respondents (P = 0.000, Table 4.3.3, Fig. 4.3.3), with respondents working in academia having the lowest level of involvement (8.3%) in MF projects, whilst those working in the voluntary community had the highest (80.0%). Moreover, education level was significantly associated with people's involvement in MF (P = 0.060, Table 4.3.3, Fig. 4.3.4). Those with education up to the undergraduate level were more likely to be involved in MF project, while those with advanced education (i.e. PhD) were generally the least involved. This was consistent with the findings of familiarity question that reported above.

Figure 4.3.3 Have you been involved in any Miyawaki Forest (also known as Tiny Forest) projects by occupation?

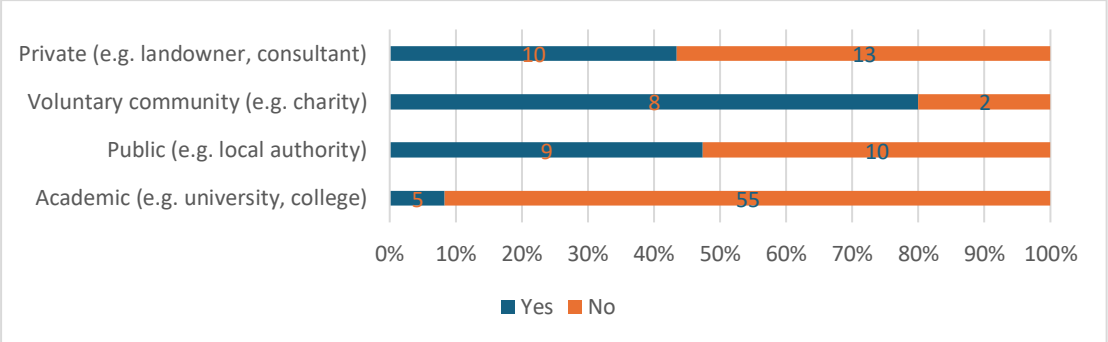
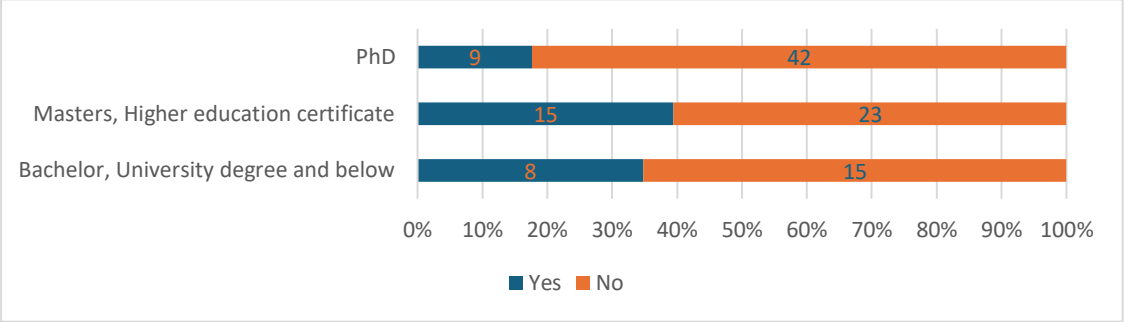


Figure 4.3.4 Have you been involved in any Miyawaki Forest (also known as Tiny Forest) projects by education level?



Among all other demographic factors, occupation and gender were the prominent factor that demonstrate significant variation in whether or not respondents visited to MFM ($P < 0.001$, Table 4.3.3, Fig. 4.3.5). The academic group had made the fewest visits (13.3%), whilst the voluntary community had made the most (70.0%). In addition, gender had a significant influence ($P = 0.05$, Table 4.3.3, Fig. 4.3.6) on whether an individual had ever previously visited MF projects before, with more males (36.2%) than females (17.7%) having done so. Moreover, level of education also showed a significant trend ($P = 0.077$, Table 4.3.3, Fig. 4.3.7), with the proportion of those having visited an MF project being greater for those with relatively lower levels of education.

Figure 4.3.5 Have you ever visited a Miyawaki forest before by occupation?

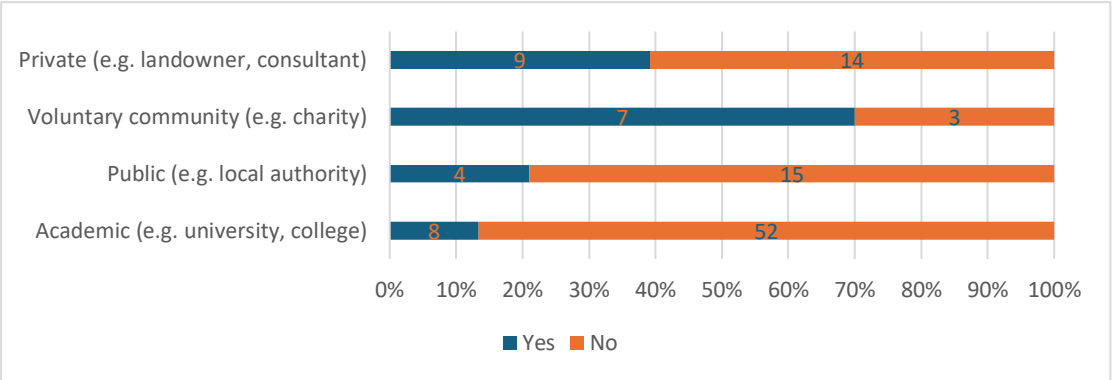


Figure 4.3.6 Have you ever visited a Miyawaki forest before by gender?

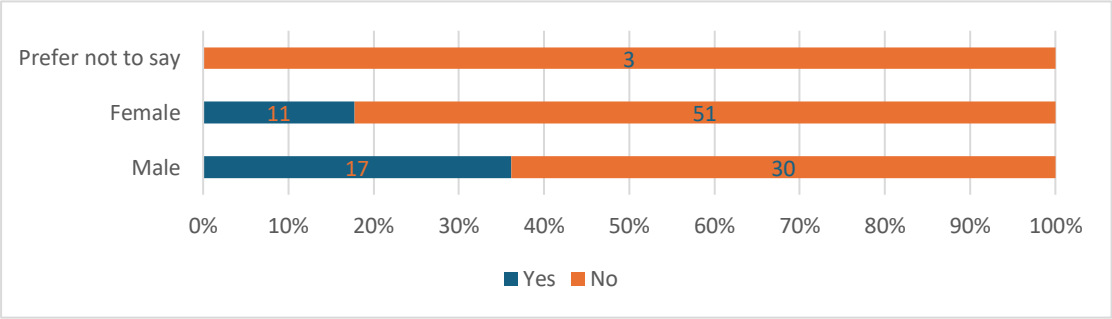
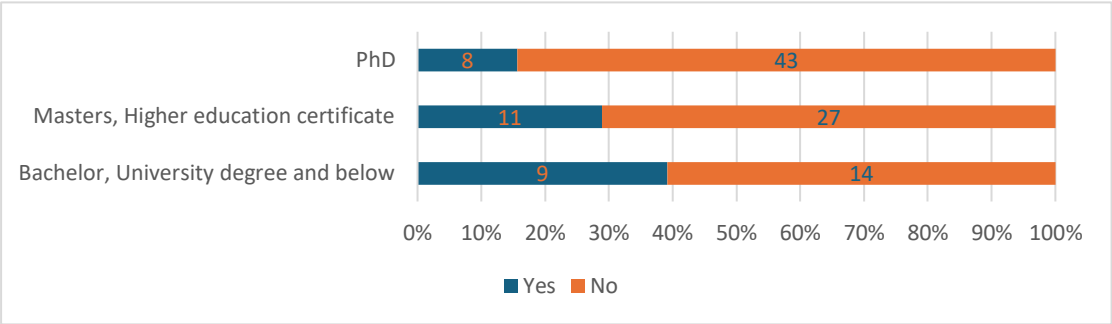


Figure 4.3.7 Have you ever visited a Miyawaki forest before by education level?



Overall, more than half of the experts and professionals involved in this survey were familiar with the concept of the MFM, but very few had actually visited (25%) or been involved in MF projects (29%).

4.3.2 Did the respondents support the use of MFM as a method of tree planting compared to CFM?

Respondents were requested to answer the following question (based on the UK context):
Q11 To what extent would you support using the Miyawaki Forest method to plant a forest rather than using the Conventional Forest method?

Table 4.3.4 Summary of factors affecting responses at a significant level (level of probability P) and trends for that factor.

Question	Factor	P value	Trend / relationship within the factor group
Q11 To what extent would you support using the Miyawaki Forest method to plant a forest rather than using the Conventional Forest method?	**Age**	**P = 0.046**	**18-34 and 55+ year groups were more supportive on MF than other disciplines.**
	Gender	**P = 0.047**	**Females were more supportive on MF than males.**
	Education level	P = 0.426	
	Occupation	P = 0.911	
	Familiarity with MF	P = 0.540	
	Involvement of MF	P = 0.235	

Respondents predominantly support the MFM over CFM for tree planting (mean = 6.69, Fig. 4.3.8). A total of 76 respondents (67.9%) supported the use of MFM in the UK context. Chi-square tests through crosstabulation showed that the significant demographic factors affecting the tree planting preference was age (P = 0.046) and gender (P = 0.047) of the respondents (Table 4.3.4). Overall, elderly group (aged above 55) showed greatest support for the use of MFM (mean = 7.24, Fig. 4.3.9), whilst the middle aged (between 45 and 55) group reported the lowest (mean = 5.9). Women (mean = 7.03) had a higher level of support for MFM than men (mean = 6.45).

Figure 4.3.8 To what extent would you support using the Miyawaki Forest method to plant a forest rather than using the Conventional Forest method?

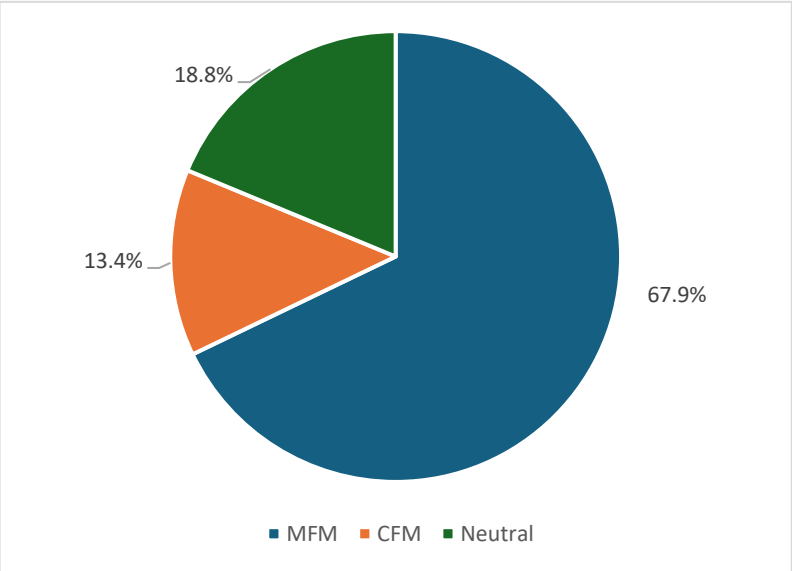
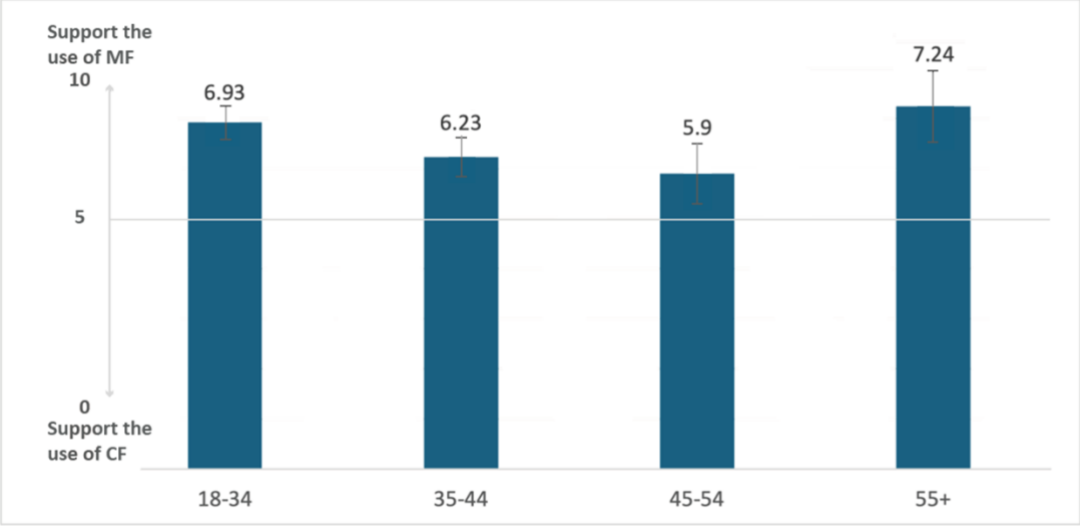


Figure 4.3.9 Would you support using the Miyawaki Forest method to plant a forest rather than using the Conventional Forest method by age?



4.3.2.1 Respondents in support of the use of the MFM

Respondents provided further information to explain the reasons for their previous answers (n = 97, representing 86.6% of the overall sample). They typically gave reasons for their support of MFM.

According to respondents (67.9%), the reasons for supporting MFM as follows:

Firstly, MFM provides some environmental benefits, such as useful for eco-restoration, mitigating the climate change, higher nature value, and very close practice to natural selection etc.

> *'It seems an overall method closer to how nature itself would approach forest management, namely: healthy natural selection, mother trees and saplings growing in*

shade, native tree species, as little human maintenance as possible.' (PhD-18-34-F-AC-MN-52)

'With the Potential Natural Vegetation (PNV) generation behind Miyawaki's method, we are really closely studying and mimicking the existing mature forest ecosystem and allowing natural selection to establish the forest that will survive in the new context [degraded urban...]. Nature is our mentor.' (MA-35-44-M-PR-MY-77)

Secondly, about 23 respondents described MF as high in diversity compared to CF, thus it provide diversity in forest planting, in terms of species diversity, biodiversity and structural diversity.

'I have personally seen comparison between a conventionally planted forest and a Miyawaki forest - the latter is so much faster and more effective in terms of encouraging biodiversity.' (MA-18-34-F-VOL-MY-109)

Thirdly, 8 respondents thought MF was better for community engagement and suitable in urban areas than rural.

'For community engagement and social engagement, Miyawaki method is far more engaging and provides great learning resource for the younger generation. So both [MF and CF] have their merits and shouldn't be looked at as one or the other.' (MA-18-34-M-PR-MY-32)

'Planting a Miyawaki forest should mainly be planted in urban areas where there is a need for a fast method to protect population and biodiversity from higher temperatures..' (MA-45-54-F-VOL-MY-78)

Finally, respondents considered MF to have the advantages of being quick-growing (n = 8), using native species (n = 5), being more cost-effective way to establish forest (n = 2), to have low maintenance requirements (n = 7), and to follow science (n = 1).

4.3.2.2 Respondents in support of the use of the CFM

Additionally, 13.4% of respondents expressed support for the CFM, suggesting that it was more representative of natural forest and *'would thus be more likely to achieve greater diversity.'* (GAV-45-54-M-PR-MN-45), and one respondent noticed that '*The Conventional Forest Method seems more rooted in 'productive' forest creation rather than high nature value forests.' (PhD-18-34-F-AC-MN-52).*

But it was noticeable that majority respondents who support the use of CFM often described them in relation to the perceived disadvantages of MFM or why they did not support MFM. Firstly, MF might have unclear side-effects.

'It seems that fast growth is enabled by extra stress (dense planting) to trees. For urban trees already stressed in growth in urban areas, we are not yet sure about side effects for their health and sustainability.' (PhD-45-54-F-AC-MN-28)

Secondly, MF was not considered a viable option over large scales and soil preparation of MF is important and difficult to implement in large scale.

'My main concern with the Miyawaki method is the soil preparation. It seems that it's a very important step of the project but also difficult to actually implement in large size areas.' (MA-18-34-F-AC-MN-61)

Thirdly, MF fails to allow for any contribution from natural regeneration and cannot claim carbon credit.

> *'MF is not an approved approach under the woodland carbon code, so [landowners] unable to claim credits from them.' (MA-18-34-M-PR-MY-32)*

Fourthly, MF is considered to be very expensive, and its low survival rate means that more young trees will die compared to CF.

> *'It seems like for larger areas this is a wasteful approach. Planting at extremely high density with the expectation or even requirement that most will die seems profligate.' (BA-35-44-M-PR-MN-36)*
>
> *'It sounds expensive to plant so many saplings so close together.' (MA-55+-F-AC-MN-55)*
>
> *In larger areas or in or near a natural forest, the Miyawaki method is too expensive and labour intensive.' (MA-45-54-F-VOL-MY-78)*

Moreover, according to some respondents, MF were typically over-crowded and they don't believe the fast growth of trees in the MF.

> *'I cannot believe for a moment that the Miyawaki method makes trees mature as fast as you suggest. And also I suppose there is limited evidence that trees grow that quick in the UK using MF.' (BA-45-54-M-PR-MN-41)*
>
> *'I am not convinced that self-selection would occur to a sufficient extent to prevent overcrowding and a closed canopy, with trees not having the space to mature into large specimens.' (MA-55+-F-AC-MN-55)*

Finally, respondents considered how the use of MFM or CFM would depend on the specific context (MA-55+-M-LA-MN-83) or on client objectives (MA-18-34-M-PR-MY-32). Additionally, five respondents indicated that further research and examples are needed.

> *'I think more research is needed to distinguish the benefits of the Miyawaki method….' (MA-18-34-F-VOL-MY-106)*
>
> *'Seeing more examples of how this method has been used in the UK and the benefits of it might improve the amount of support.' (MA-18-34-F-LA-MN-85)*

4.3.3 Did respondents consider the MFM to be a suitable tree planting method in the UK, compared to the CFM?

Table 4.3.5 Summary of factors affecting responses at a significant level (level of probability P) and trends for that factor.

Question	Factor	P value
Q13 Do you agree that the Miyawaki Forest method is a suitable tree planting method in the UK?	Age	P = 0.354
	Gender	P = 0.139
	Education level	P = 0.232
	Occupation	P = 0.100
	Familiarity with MF	P = 0.396
	Involvement of MF	P = 0.060

To the above question, respondents suggested a relatively high suitability score (mean = 7.27). According to the mean value, most respondents agreed that, MFM was considered a relatively suitable tree planting method in the UK context. despite the poor correlation of any associated demographic factors, respondents involved in MF were more likely to rate it as suitable method (P = 0.06, n.s., Table 4.3.5). Comparatively, people who have been actively involved in MF practices (mean = 8.19) gave a higher score than people who haven't been involved (mean = 6.9).

Detailed questions were given to the respondents who thought MFM was a suitable tree planting method in the UK (n = 97). Respondents primarily cited species, climate, specific (geographical) areas, successful examples, transferability of this principle and widespread suitability as a primary reason for their views. More specifically, respondents considered that MFM is a suitable method for the UK as long as UK native species are selected.

> *'It uses native species that are regularly planted successfully in the UK. Evidence from other temperate locations (European countries), shows good results of planting Miyawaki forests in temperate climates.' (PhD-35-44-F-VOL-MN-101)*

Second, respondents thought MFM is suitable but only in small urban areas or spaces with limited green areas, *'where there would be benefits from establishing a mixed woodland quickly.' (PhD-55+-M-AC-MN-23).* Moreover, some respondents have seen successful projects in the UK or elsewhere, so they thought it is suitable.

> *'I have seen some evidence of its successful implementation.' (PhD-18-34-F-AC-MN-54)*
> *'... [We planted Tiny Forests in the UK] It doesn't grow as fast as in tropical climate but it is definitely successful'(MA-18-34-F-VOL-MY-109)*

Third, respondents considered the ecological principles of MFM as transferable to the UK context.

> *'It needed to be adapted slightly for UK to be applicable for temperate forests and not tropical, but the basic principles are suitable.' (MA-18-34-F-VOL-MY-106)*

Some respondents considered MF as suitable for diverse climatic conditions.

> *'… Based on data I have analysed from Miyawaki forests around the world, the forests perform well under a variety of climatic conditions.' (PhD-45-54-F-AC-MY-79)*
> *'As far as I have seen, the Miyawaki method is working wonderfully in all sorts of climates, also temperate Europe.' (BA-18-34-M-PR-MY-80)*

There were some other reasons mentioned by a few, such as MFM mimics nature:

> *'It mimics natural recovery of woodlands effectively and uses cheaper, younger stock effectively.' (PhD-55+-F-AC-MY-65)*

It can bring benefits:

> *'I think its new approach that could give a good environment positive result to our future.' (MA-18-34-M-AC-MN-91)*
> *'Due to space availability and increasingly urbanised areas in the UK, MF is suitable.' (BA-18-34-F-LA-MY-47)*

Also they thought it was because of the amount of UK rainfall:

> *'It rains enough to sustain the development of a new forest in the UK.' (MA-18-34-M-AC-MN-92)*

Respondents who disagree with the suitability of MFM for tree planting in the UK provided following reasons. The main reason was water resources.

> *'Because most of Miyawaki Forest method was conducted in heavy rainy regions. UK is becoming nearer to Mediterranean climate which would impact negatively on fierce competition on water resources.' (PhD-45-54-F-AC-MN-28)*

Some respondents were concerned about the seasonal climate conditions in the UK:

> *'I am quite doubtful of it during the winter in UK. Because the winter in UK is much longer than in Japan.' (MA-18-34-F-AC-MN-96)*

Additional reasons were also provided by respondents. And there were some other reasons given. For example, more than 20 respondents thought that further research and evidence are needed in MFs.

> *'I think we just don't know yet ! We need more research on it, especially the species mix and how different mixes affect the development of the woodland …' (PhD-18-34-F-VOL-MY-3)*

And they felt it mainly depends on the context, objectives or vision of projects.

> *'… but the site and the objectives should shape the delivery / planting approach.' (MA-45-54-M-VOL-MN-2)*

Moreover, they recognised MFM not been popular in the UK.

> *'… as it has not been applied widely in the UK, I am not sure it will be suitable in the UK.' (MA-18-34-F-AC-MN-93)*

Last, they raised their concerns on overcoming the people's perception against the MFM.

> *'[It is] more about overcoming people's perceptions.' (MA-35-44-F-PR-MN-38)*

4.4 Potential suitable places for planting Miyawaki forests in the UK

Table 4.4.1 Summary table for research question 1.1 and questionnaire integration

Research questions	**Themes**	**Indicators (questions in the questionnaire)**
RQ 1.1 What are experts and professionals' perceptions of the MFM -- and how do they compare to their perceptions of CFM?	4.4 Potential places for Miyawaki forests in the UK.	**Q9** To what extent do you agree that the Miyawaki Forest method is a suitable tree planting method in urban/rural areas? **Q15** In the following areas where do you think the Miyawaki forest planting would be suitable in the UK (urban/suburban/rural)? **Q18** Which of the following specific locations do you think Miyawaki forest planting would be suitable?

4.4.1 Perceptions of the suitability of the MFM for urban, suburban and rural contexts

Table 4.4.2 Summary of factors affecting responses at a significant level (level of probability P) and trends for that factor.

Question	Factor	P value	Trend / relationship within the factor group
Q9 To what extent do you agree that the Miyawaki Forest method is a suitable tree planting method in urban areas and in rural areas?	Age	P = 0.692	
	Gender	P = 0.113	
	Education level	P = 0.315	
	Occupation	**P < 0.001**	**Academic respondents had the lowest level of agreement regarding urban areas but the highest for rural.**
	Familiarity with MF	**P < 0.001**	**Respondents who were familiar with/ have been involved in the MFM showed a higher level of agreement regarding its suitability in urban areas, but the opposite trend was observed in rural areas.**
	Involvement of MF	**P < 0.001**	

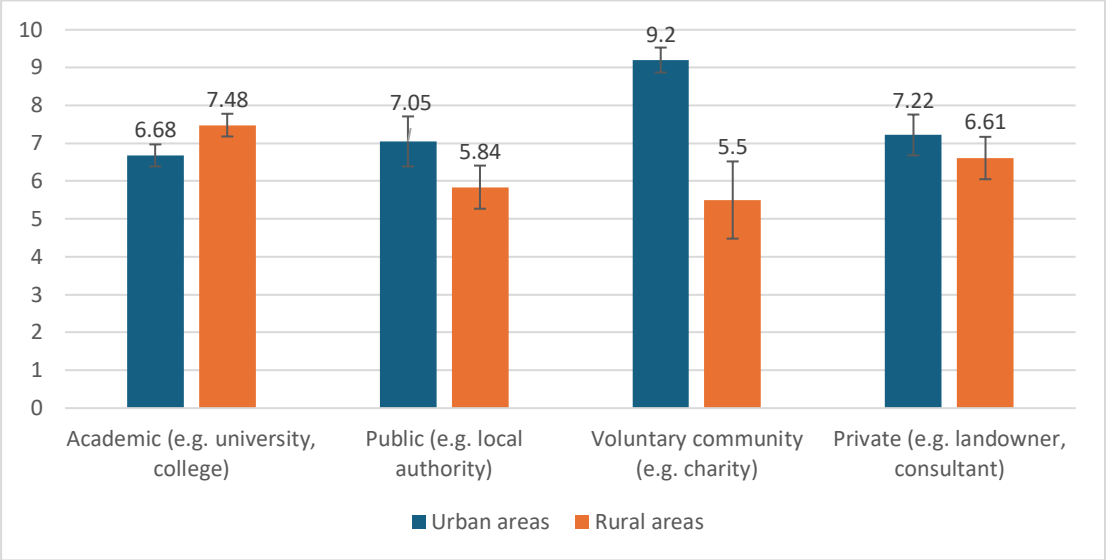
Respondents agreed that the MF was a suitable tree planting method in both urban areas (mean = 7.08) and rural areas (mean = 6.85). They considered the use of MF in urban areas to be a slightly more suitable than in rural areas, however there was no significant difference between urban and rural areas (Fig. 4.4.1, P = 0.468). Data from these questions (Q9: To what extent do you agree that the Miyawaki Forest method is a suitable tree planting method in urban areas and in rural areas? and Q15: In the following areas where do you think the Miyawaki forest planting would be suitable in the UK?) was analysed using Chi-square test in crosstabulation, one-way ANOVA, Repeat Measure ANOVA and Paired t-test to compare urban versus rural, and also within different factors. Occupation, familiarity with MFM and involvement in MFM were highly significant factors (P < 0.001) in urban vs rural areas in term of the suitability of using MFM (Table 4.4.2).

Figure 4.4.1 To what extent do you agree that the Miyawaki Forest method is a suitable tree planting method in urban/rural areas (mean scores)?



Academic respondents had the lowest level of agreement regarding urban areas (mean = 6.68) but the highest for rural (mean = 7.48). Conversely, findings for the third sector show the highest level of agreement that MFM is suitable for urban areas (mean = 9.20) but the lowest for rural (mean = 5.5). The public and private sector respondents were between these two extremes and tended to agree more that urban areas were more suitable than rural areas (P < 0.001, Fig 4.4.2).

Figure 4.4.2 To what extent do you agree that the Miyawaki Forest method is a suitable tree planting method in urban/rural areas by occupation?



In addition, respondents who were familiar with MFM had a higher level of agreement (mean = 7.51) as to the suitability of the use of MF in urban areas than respondents who were not familiar with it (mean = 6.57). In contrast, for rural areas the opposite was true: respondents who were not familiar with MFM positively towards rural areas (mean = 7.67) compared to respondents who had heard of it (mean = 6.16) ($P < 0.001$, Fig 4.4.3). A similar pattern was observed when comparing responses based on respondents prior involvement, i.e. respondents who had been involved in MF were more likely to agree (mean = 8.72, Fig. 4.4.4) that MF was suitable for use in urban areas than people who had not been involved in it (mean=6.43). However, for rural areas the opposite was true, i.e., respondents who had not been involved in MF had a lower level of agreement (mean = 5.66) as to the suitability of the use of MF than people who had been involved in it (mean = 7.33).

Figure 4.4.3 To what extent do you agree that the Miyawaki Forest method is a suitable tree planting method in urban/rural areas by familiarity?

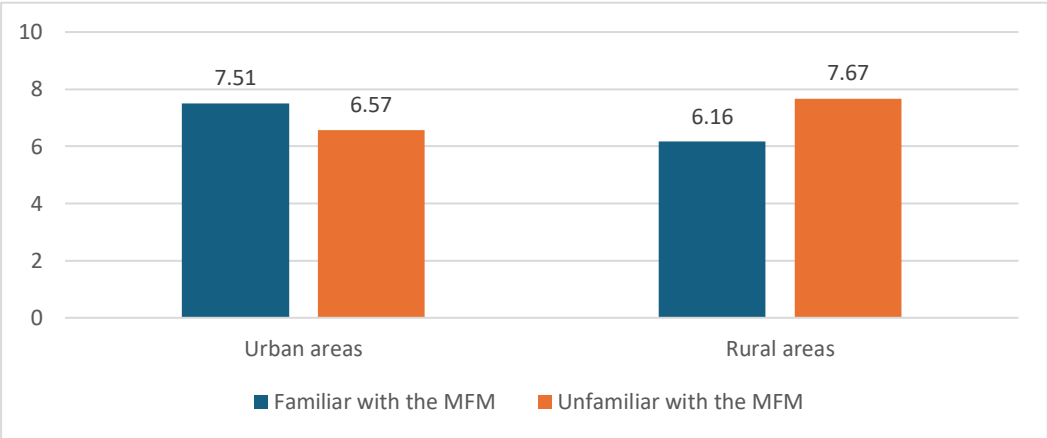
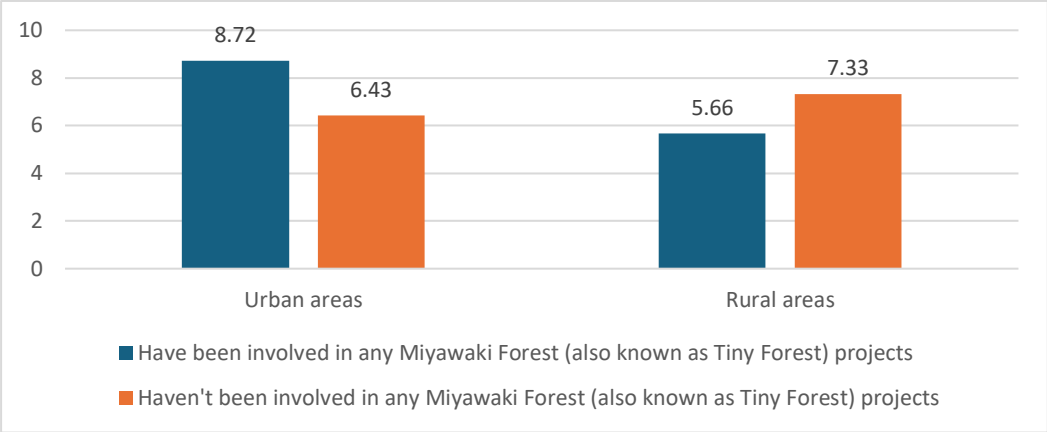
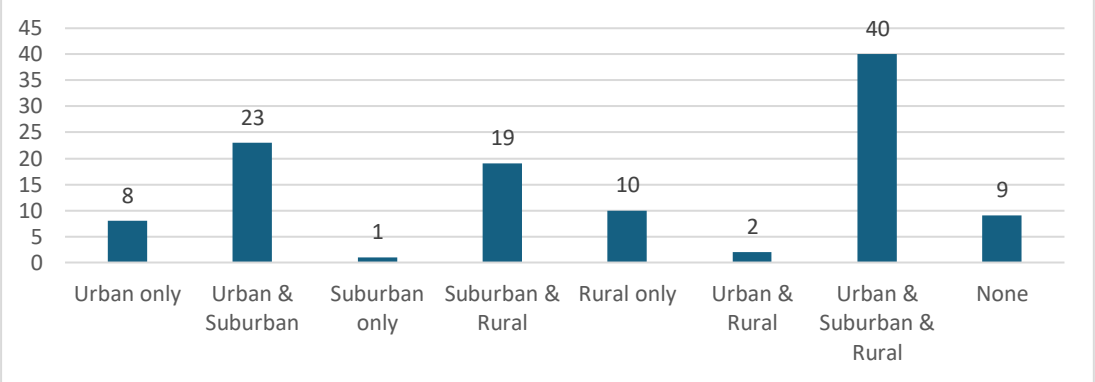


Figure 4.4.4 To what extent do you agree that the Miyawaki Forest method is a suitable tree planting method in urban/rural areas by involvement?



Respondents who were very positive about MFM's suitability in urban, urban & suburban areas (Q15 In the following areas where do you think the Miyawaki forest planting would be suitable in the UK?), also gave higher score (Q9 To what extent do you agree that the Miyawaki Forest method is a suitable tree planting method in urban areas and in rural areas?) for urban areas. This also held for rural areas: respondents who were very positive about MFM's suitability in rural, suburban & rural settings (Q15), gave higher score (Q9) for rural areas. It is not necessary to go into the details of the findings of Q15 as respondents were consistent when answering both questions.

Figure 4.4.5 In the following areas where do you think the Miyawaki forest planting would be suitable in the UK?



There were many follow-up answers given by the respondents (n = 98) with regard to the suitability of planting MF in urban or rural areas. For instance, those respondents who were positive about the MFM suitable for planting in urban areas, point out the necessity of small-scale, densely planted, and fast-growing trees in urban areas due to the limited space available.

> *'…fast growth will make people think tree planting is worthwhile, as being able to see change helps people feel supportive.' (BA-18-34-F-AC-MN-69)*

These respondents also mentioned how MF can bring ecological benefits to the urban areas, such as improve air quality, mitigate the urban heat island effect, facilitate better health and wellbeing, provide biodiversity hotspots and diversity etc.

'It is a brilliant method for quickly increasing the biodiversity and ecosystem services provided in an urban area.' (BA-18-34-F-LA-MY-110)

For some respondents, their positive answers were based on their own experience in existing project in practice work:

'I have been a Miyawaki forest maker for ....., and I am convinced it is perfect for urban areas.' (MA-35-44-M-PR-MY-77)

Respondents who viewed the MFM planting as unsuitable for urban areas felt that there is an increased competitions and limited space availability. Moreover, there would be challenges in soil preparation, water and plant management, and access due the density of forests prevent it in urban areas.

'…There is also more competition for space from other uses in urban areas - residential, commercial for example.' (PhD-55+-F-AC-MN-5)

'It is not easy to achieve the level of soil preparation, … management … and etc. the method demands particularly in urban areas.' (PhD-35-44-F-LA-MN-7)

Furthermore, they thought the speed is an issue, as '*urban schemes require instant impact and this method may not provide sufficient impact until year 5+' (MA-35-44-M-PR-MN-44).* And it might result in a single tree species dominating the area. And also they thought MFM is not suitable because:

1) There are some cultural issues (e.g. a lot of British people still like 'tidy' landscapes, particularly in urban areas) that need to overcome.
2) The need for the shade tolerant trees.
3) Uncertainty about the actual benefits.

Respondents with the positive attitude towards MFM planting in rural areas gave the followed reasons. They described rural areas as unlimited space, therefore fewer competing pressures on the land.

'It seems like it's a good and efficient way to grow big scale of green space in relatively short time. I think rural areas would have enough space also needs for this method.' (MA-18-34-F-AC-MN-99)

They also considered MFM to have great value as part of rewilding, stating that there is less of an issue in terms of weed control in rural areas (compared to urban).

'Possibly more justified in a rural location if there is less weed control available and the quick canopy cover can keep the weeds down.' (PhD-55+-M-AC-MN-102)

However, some respondents questioned the necessity of MFM planting in rural areas, where land resources are abundant. They suggested cheaper and simpler method with more spaced tree planting and described small-scale, dense MFM planting as unsuitable for rural areas. Besides, it might cause competition from agriculture. Alongside MFM being considered an expensive method, 'profitable' species were preferred in rural settings as rural residents primarily rely on the land to produce income to their livelihood in a form agriculture, livestock farming and agro-forestry:

'The Miyawaki method is quite expensive and rural people might prefer to reforest bare land with profitable species (i.e. selling timber, fruit or non-timber forest products),

rather than considering native or exotic species that eventually bring wildlife (often detrimental for livestock).' (MA-18-34-N-AC-MN-59)

Other respondents considered rural areas akin to more 'natural' areas, so a more 'natural method' would be more appropriate for rural areas – i.e. not MFM.

'I think rural environments should be restored using more natural approaches (e.g. assisted natural regeneration).' (PhD-35-44-M-AC-MY-27)

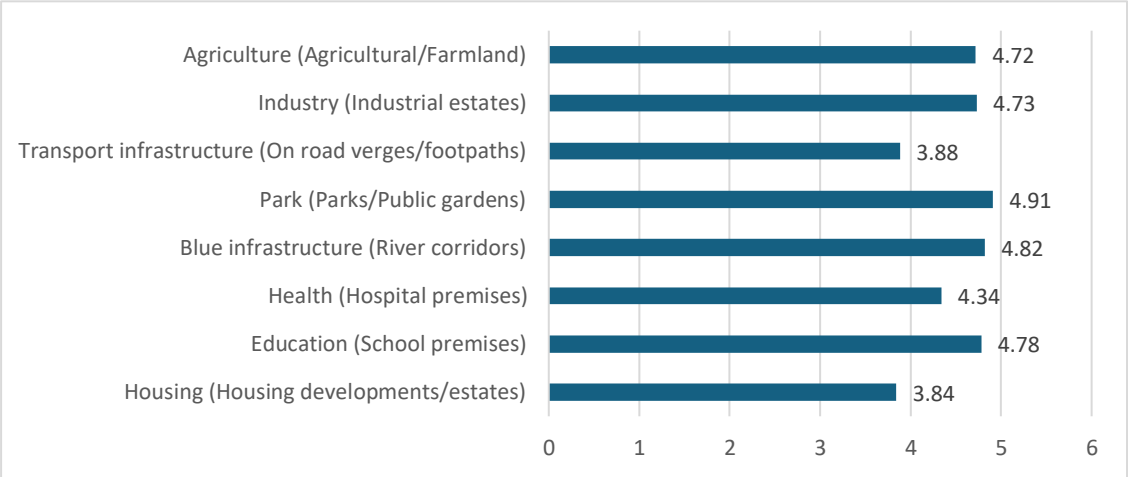
In addition, there were negative comments related to MFM planting in rural areas because of its threat to wildlife (rabbits, deer), the obstacles to land ownership, the lack of access to irrigation and the concern on 'rich soil'.

'The introduction of native but not autogenous material in especially rural areas however, especially in combination with so-called 'rich soil' (=bringing outside nutrients not native to the site) seem like a way to create a disbalance in especially rural areas.' (PhD-18-34-F-AC-MN-52)

4.4.2 Perceptions of the suitability of the MFM for urban, suburban and rural contexts

Respondents were provided with a selection of specific site types and asked for their perceptions on the suitability of these sites for planting Miyawaki forests (Q18). To analyse the related responses, Friedman's two-way analysis of variance by ranks was employed. In general, respondents chose the 'suitable to some extent' or 'very suitable' option in most cases. Overall, respondents identified park (parks/public gardens), blue infrastructure (river corridors), and education (school premises) as the three most suitable locations for MF, housing as the least suitable location for MF, and the other four locations as in between ($P < 0.001$, Fig. 4.4.6).

Figure 4.4.6 Which if the following specific locations do you think Miyawaki forest planting would be suitable (by ranking from 1, least suitable to 8, most suitable)?



Respondents were also encouraged to provide any other locations that they thought were suitable for MF (n = 48; Table 4.4.3).

Table 4.4.3 Summary table of other potential locations for planting Miyawaki forest (in no particular order, places highlighted in red were mentioned more than once)

Other potential locations for MF tree planting	
Category	Detailed information
Brownfields	Brownfields
	Reclamation site
	Reclaimed industrial site
	Reclaimed landfills
	Former mineral
Mountainous area	Semi mountainous areas
	Hilly areas
	Remote 'wilderness' areas
	Deforested uplands
Remote areas	Natural reserves
	National parks
	Nature restoration
Forestry land	
Heritage site	National Trust
Post-industrial site	
Commercial areas/retail	Shopping malls
	Supermarket parking
Zoos	
Interstitial greenspace	
Refugee camps	
Any small area	

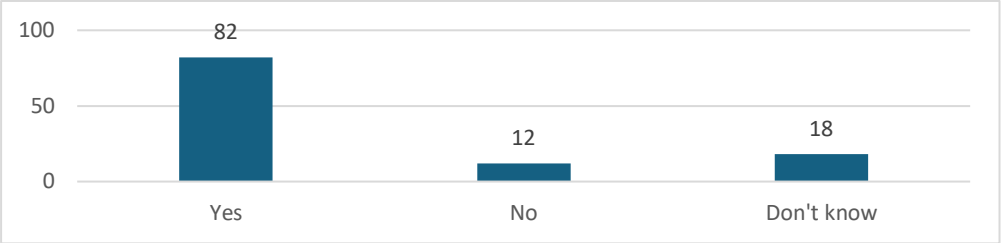
4.5 Perceived potential problems with application of MFM in the UK

Table 4.5.1 Summary table for research question 1.1 and questionnaire integration

Research questions	**Themes**	**Indicators (questions in the questionnaire)**
RQ 1.1 What are experts and professionals' perceptions of the MFM -- and how do they compare to their perceptions of CFM?	4.5 Perceived problems with Miyawaki forest.	**Q17** Do you think there are any potential problems with planting in these areas?

Among the questionnaire respondents (n = 112), 73.2% of them agreed on probability of potential problems with planting using the Miyawaki forest method. A small group (10.7%) denied the chances of any challenges, while some others (16.1%) expressed lack of awareness about any complications related to MF (Fig. 4.5.1). There was no significant difference between answers in terms of the demographic factors.

Figure 4.5.1 Are there any potential problems with Miyawaki planting in the UK?



Respondents perceived many potential problems, as listed below (n = 83), including vandalism, environmental issues, relatively high cost, space requirement, maintenance and management, competition, and social issues, amongst others (Table 4.5.2).

Table 4.5.2 Summary of perceived potential problems with Miyawaki forest (in no particular order, problems highlighted in red were mentioned more than once)

Question	Category	Detailed information	Quote
Do you think there are any potential problems with Miyawaki planting in the UK?	Anti-social behaviour (4/84)		*'In urban/suburban areas a dense forest, however small, can provide cover for illegal or antisocial activities.'*
	Vandalism (10/84)	Littering	*'Possible vandalism in densely planted areas.'*
	Safety and growing unease among people		*'Dense forest can make some people nervous due to a loss of sightlines.'*
	Damage by animals	Deer and rabbit damage as vulnerability of saplings (rural)	*'Browsers such as deer and rabbits.'*
	Ecological consequences	Impact of air and soil pollution impact	*'Air & soil pollution impacts - primarily urban but not exclusively.'*
		Heat and water stress (primarily in urban)	*'Heat & water stress (urban but also elsewhere).'*
		Detrimental to the local ecosystem (urban)	*'Particularly in sensitive habitats, it could be detrimental to the local ecosystem. Moreover, longitudinal data would be really useful - to see how the Miyawaki system evolves and supports biodiversity over longer periods.'*
		Detrimental to the wildlife (rural)	*'Rurally - you have to think about the current ecosystems there. For example, would planting a forest harm the wildlife there?'*
		Possible impacts on infrastructure	*'Urban: possible impacts on infrastructure.'*
		Effect on biodiversity	*'In the long term Miyawaki forest might be limited the tree species diversity and then cause low tolerance of disease and biodiversity lost .... So more data to see how the M system evolves and supports biodiversity over longer periods in the UK is very useful.'*
	Costs (8/84)	Costs to maintain the planting in the initial years may be expensive	*'Management in the first few years may be costly.'*
		Is there long-term funding for Miyawaki forest?	*'Is this an allocated project from council, or foundation? Do they have funding for long term?'*

Question	Category	Detailed information	Quote
	Competition and conflict	Competition for space (11/84)	*'There is insufficient space in urban and suburban areas for tree planting so this might be a potential problem for Miyawaki plantation.'*
		Competition from other users	
		Competition on water resources	*'Most of Miyawaki Forest method was conducted in heavy rainy regions. UK is becoming nearer to Mediterranean climate which would impact negatively on fierce competition on water resources.'*
		Conflict with other priority areas or habitats	*'Conflicts with other priority areas/habitats e.g. chalk grassland and limited urban opportunities where conflict is in the area of open space required for sport and recreation.'*
	Maintenance and management	Ongoing management and watering (urban)	*'Ongoing management and watering also might be more of an issue in urban settings.'*
		Maintenance of internal paths and benches	*'Future maintenance of internal paths, benches etc.'*
		lack of community management	*'It may suffer from a lack of community management.'*
	Undesirable social impacts	Cultural resistance	*'Social issues, .eg. cultural incompatibility/ resistance,'*
		Lack of understanding/engagement/support from local people, community and landowners	*'Lack of public / landowner understanding/support.'*
		Likelihood of poor public perception of the value of Miyawaki planting	*'Likelihood of poor public perceptions of the value of such planting.'*
		Public/local community access and use	*'It is also important to think about social impacts and how local communities will use and access the forest.'*
	Others	Stakeholders' engagement	*'Good stakeholders is also a key, particularly in urban / suburban areas to ensure local people and communities support tree planting, and ideally can help shape it and even volunteer to help do the planting. '*

Question	Category	Detailed information	Quote
		Distrustful of land manager	*'Land manager will not be familiar and might be distrustful of the method (so need a relatively skilled workforce).'*
		Residents' objections	*'Some residents will object to them for things such as being homes for vermin or for blocking out their "view".'*
		Public necessities	*'This must be made according to the public necessities rather than just having woodlands in the city.'*
		Need for signage to explain	*'There would probably need to be signage to explain what was being done to public.'*
		Green gentrification	*'In urban areas we need to consider inequality in access to green space.'*
		Visual aesthetic value	*'The visual aesthetic value should be taken into account.'*
		Policy	*'The UK landscape is almost entirely privately owned, even in national parks. This requires complex, collaborative governance and appropriate resources, incentives, and policy frameworks.'*
		Permits	

4.6 Perceived costs of Miyawaki forest in the UK, and comparison with CFM.

Table 4.6.1 Summary table for research question 1.1 and questionnaire integration

Research questions	Themes	Indicators (questions in the questionnaire)
RQ 1.1 What are experts and professionals' perceptions of the MFM -- and how do they compare to their perceptions of CFM?	4.6 Perceived costs of Miyawaki forest in the UK, compared to CFM.	**Q20** On average how much do you think the Miyawaki forest planting/'Conventional' mixed forest planting costs in the UK? (per square metre) **Q26** Which method do you think is more expensive in urban/rural areas?
		Q21 Would you be willing to pay for Miyawaki forest planting in the UK? **Q22** How much could you (or your organisation) afford to pay for Miyawaki forest planting in the UK? (per square metre) **Q23** Do you think Miyawaki forest planting should be funded by the public sector?
		Q24 What is the relative cost percentage you would expect to pay for soil preparation/ tree purchases/ ongoing maintenance for the Miyawaki forest planting in per square metre?

4.6.1 Perceived costs of MF in the UK

This section reports the findings for Q20 and Q26 (Table 4.6.1).

Table 4.6.2 Summary of factors affecting responses at a significant level (level of probability P) and trends for that factor.

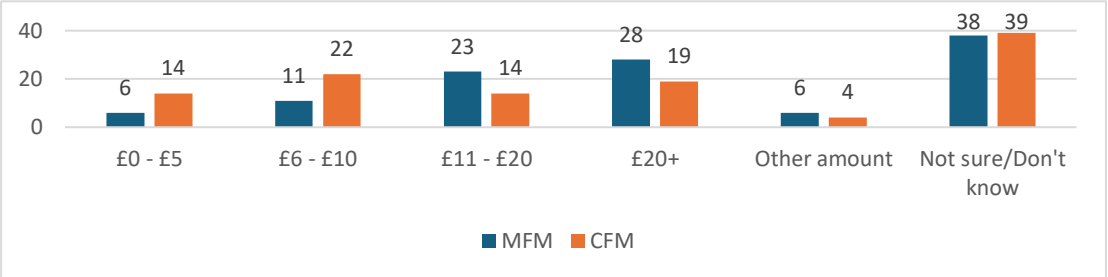
Question	Factor	P value	Trend / relationship within the factor group
Q20-1 On average how much do you think the Miyawaki forest planting costs in the UK?	Age	P = 0.280	
	Gender	P = 0.262	
	Education level	P = 0.082	
	Occupation	**P = 0.050**	**Academics were least aware of the costs.**
	Familiarity with MF	**P < 0.001**	**Respondents who were familiar with MF were more likely to select a range closer to the right expenditure of MF.**
	Involvement of MF	P = 0.068	
Q20-2 On average how much do you think the 'Conventional' mixed forest planting costs in the UK?	Age	P = 0.095	
	Gender	**P = 0.006**	**Females perceived the costs higher than males.**
	Education level	P = 0.097	
	Occupation	P = 0.577	
	Familiarity with MF	**P = 0.006**	**Respondents who were familiar with/ have been involved in the MFM perceived the costs lower than who were not familiar with/ haven't been involved in MF.**
	Involvement of MF	**P = 0.046**	
Q26-1 Which method do you think is	**Age**	**P = 0.004**	**18-34 year group thought MF were more expensive, 55+ year group thought CF were more expensive.**
	Gender	P = 0.517	

Question	Factor	P value	Trend / relationship within the factor group
more expensive in urban areas?	**Education level**	**P = 0.050**	**Masters group thought MF were more expensive, other groups don't know.**
	Occupation	P = 0.782	
	Familiarity with MF	**P = 0.022**	**Respondents who were familiar with MF thought MF were more expensive, respondents who were not familiar thought CF were more expensive or don't know.**
	Involvement of MF	P = 0.278	
Q26-2 Which method do you think is more expensive in rural areas?	**Age**	**P = 0.007**	**18-34 year group thought MF were more expensive.**
	Gender	P = 0.626	
	Education level	P = 0.103	
	Occupation	P = 0.491	
	Familiarity with MF	**P = 0.027**	**Respondents who were familiar with MF thought MF were more expensive, respondents who were not familiar thought CF were more expensive or don't know.**
	Involvement of MF	**P = 0.015**	**Respondents who have been involved MF thought MF were more expensive, respondents who haven't been involved thought CF were more expensive or don't know.**

The majority of respondents who were familiar with MF (41.0%) chose the £0-£10 ranges, whilst the majority of those not familiar with MF (33.3%) chose the £11+ options (Fig. 4.6.5). Respondents who have been involved (43.8%) in MF planting before were more likely to perceive the costs as £0-£10 per square metre and respondents who have not been involved in the MF planting (33.8%) selecting £11+ (Fig. 4.6.6).

Over one-third of respondents were unaware of the potential costs of both planting methods (33.9% for MF, 34.8% for CF) (Fig. 4.6.1). For MF, a notable 25% of respondents perceived it would cost more than £20/m^2, while CF was viewed as more affordable practice with majority of respondents (32.1%) chose the estimated cost less than £10/m^2 (Fig. 4.6.1). In general, 37 respondents regarded MF as a more expensive method than CF, and 22 respondents regarded MF as expensive as CF. However, there were 15 people still thought CF would be more expensive than MF.

Figure 4.6.1 On average how much do you think the Miyawaki forest planting/'Conventional' mixed forest planting costs in the UK (per square metre)?



Data presented in Table 4.6.2 were analysed using Chi-square test in crosstabulation. Perceptions of MF costs significantly varies among respondents from different occupation (P = 0.05) and different levels of familiarity (P < 0.001) of MF (Table 4.6.2). Academic respondents considered costs to be lower than other sectors (public, voluntary community and private sectors), i.e. academics mostly chose £0-£10, while other sectors estimated the cost to be above £11+ (Fig. 4.6.2). In addition, the majority of choices for those respondents who were familiar with MF felt that the costs would be polarized to higher amount (£20+/m^2), which aligned with the reported costs received from NGOs (Fig. 4.6.3).

Figure. 4.6.2 On average how much do you think the Miyawaki forest planting costs in the UK (per square metre) by occupation?

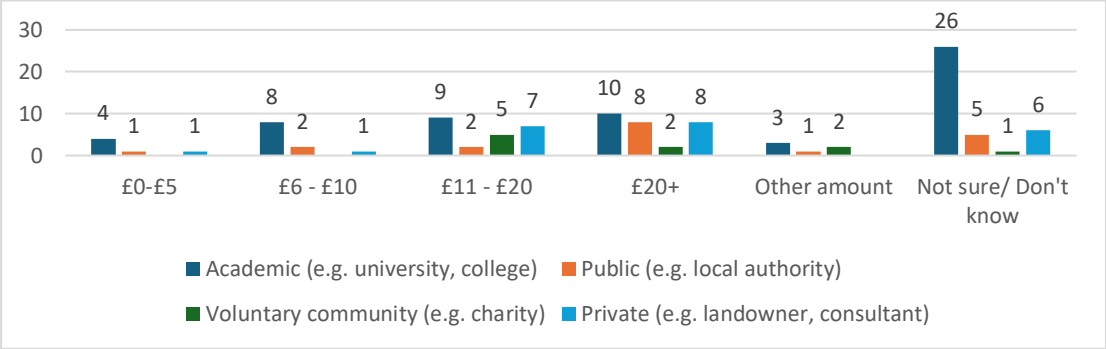
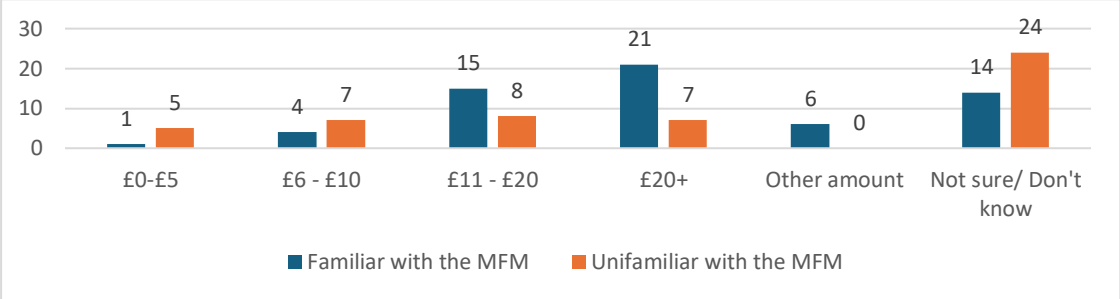
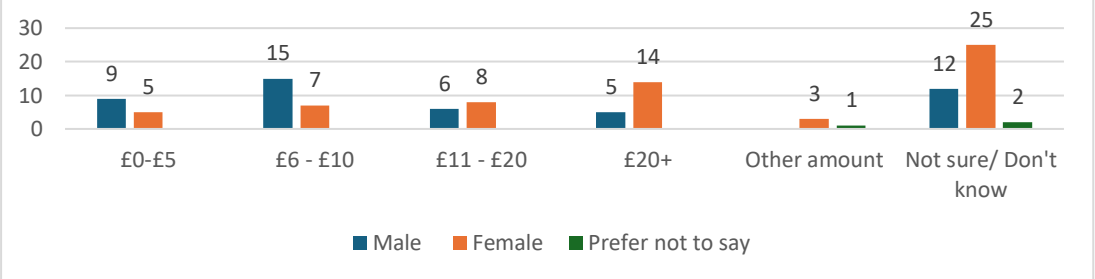


Figure. 4.6.3 On average how much do you think the Miyawaki forest planting costs in the UK (per square metre) by familiarity?



For CF, gender (P = 0.006), familiarity with MF (P = 0.006) and involvement of MF (P = 0.046) were found to be significant variables (Table 4.6.2). There were more males (31.9% of males) perceived the costs as £6-£10 and more females (22.6% of females) perceived the costs as £20+ (Fig. 4.6.4). It appears that female respondents were closer to the reported cost range than males.

Figure. 4.6.4 On average how much do you think the 'Conventional' mixed forest planting costs in the UK by gender?



The majority of respondents who were familiar with MF (41.0%) chose the £0-£10 ranges, whilst the majority of those not familiar with MF (33.3%) chose the £11+ options (Fig. 4.6.5). Respondents who have been involved (43.8%) in MF planting before were more likely to perceive the costs as £0-£10 per square metre and respondents who have not been involved in the MF planting (33.8%) selecting £11+ (Fig. 4.6.6).

Figure. 4.6.5 On average how much do you think the 'Conventional' mixed forest planting costs in the UK by familiarity?

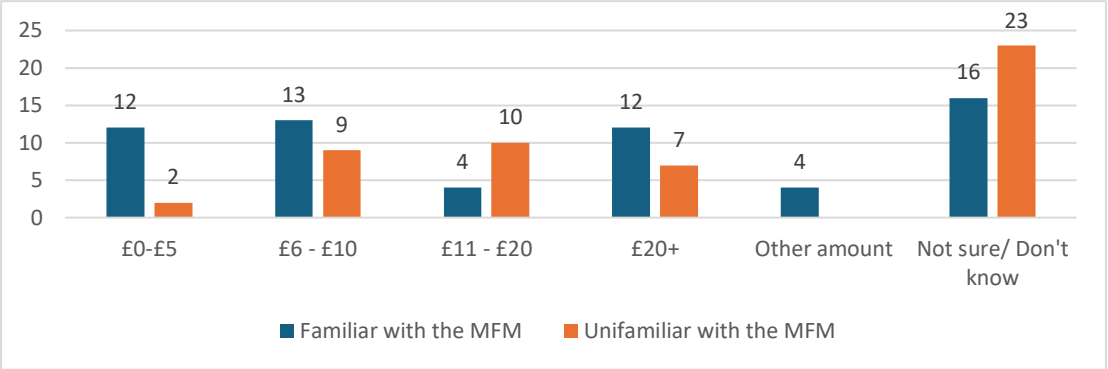
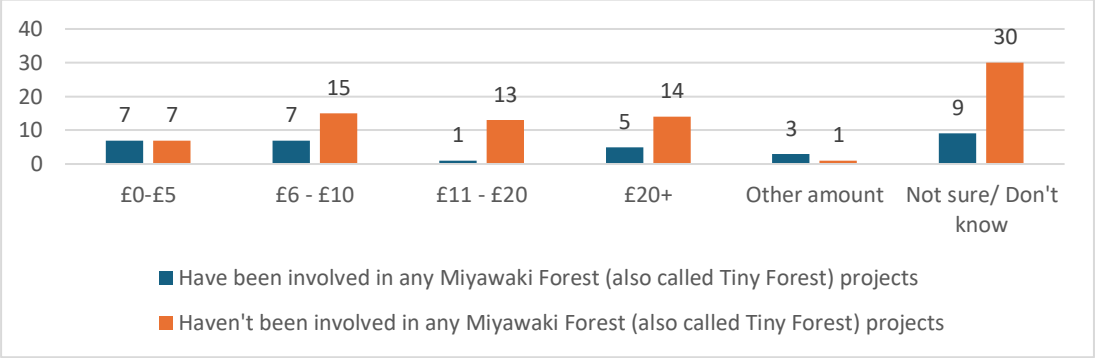
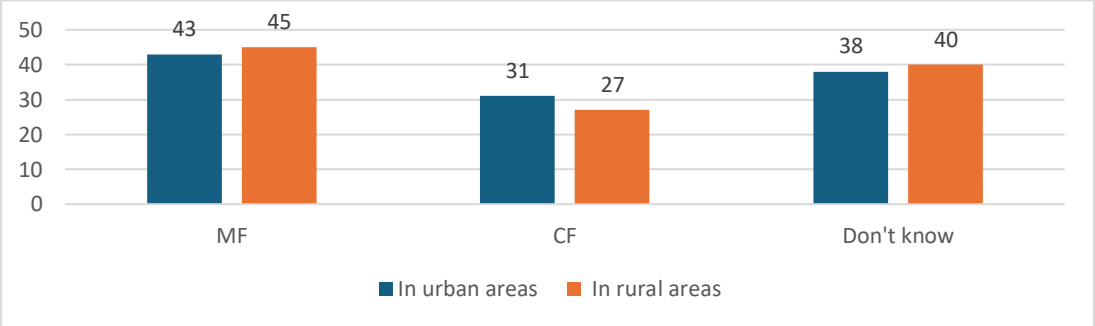


Figure. 4.6.6 On average how much do you think the 'Conventional' mixed forest planting costs in the UK by involvement?



Subsequently, respondents were requested to choose one method (MFM and CFM), which they believed is more expensive in urban or rural environments (Q26). The results were similar to those discussed above. Overall, respondents implied that in urban areas MF was similar expensive to CF, while in rural areas MF was more expensive than CF (Fig. 4.6.7).

Figure 4.6.7 Which method do you think is more expensive in the urban and rural areas?



In urban areas, answers differed significantly according to age (P=0.004), education level (P = 0.05) and familiarity with MF (P = 0.022) (Table 4.6.2). Most of young respondents (age group 18 - 34 and 45-54) regarded MF is more expensive, while other age groups thought CF is more expensive. A large portion of respondents (33.9%) were unable to provide a comparison in terms of which method is more expensive (Fig. 4.6.8). Respondents of all levels of education unanimously perceived MF to be more expensive than CF (Fig. 4.6.9). In addition, respondents who were familiar with MF believed that MF would be more expensive than CF, whilst those not familiar with MF, cost perception was evenly split between MF and CF (Fig. 4.6.10).

Figure 4.6.8 Which method do you think is more expensive in urban areas by age?

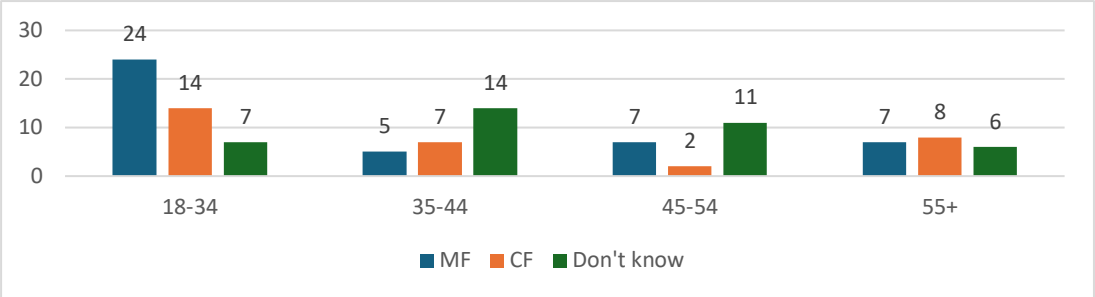


Figure 4.6.9 Which method do you think is more expensive in urban areas by education?

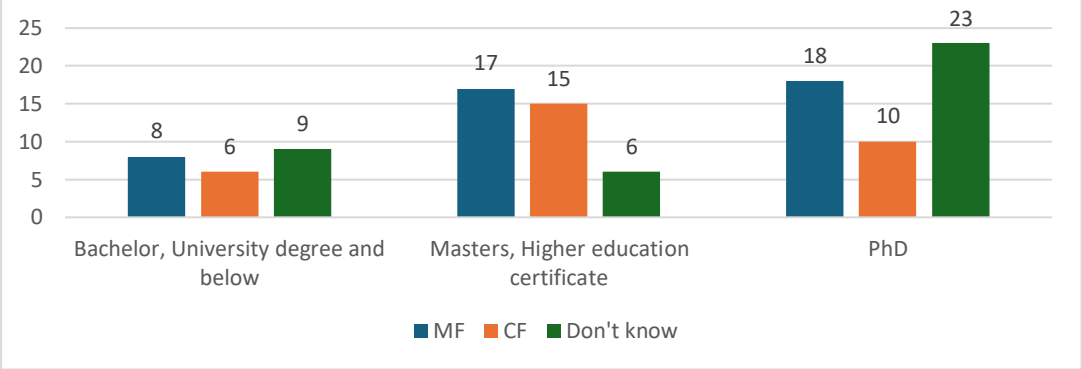
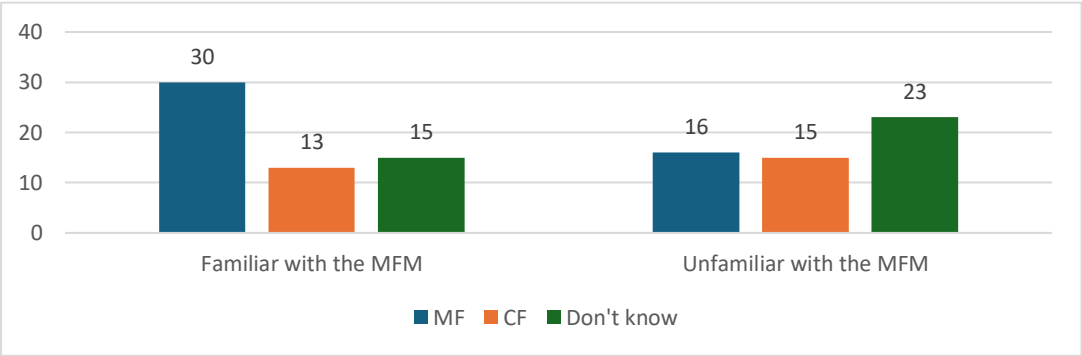


Figure 4.6.10 Which method do you think is more expensive in urban areas by familiarity?



In rural areas, answers differed significantly according to age (P = 0.007), familiarity with MF (P = 0.027) and involvement of MF (P = 0.015) (Table 4.6.2). Despite the age group differences, most respondents regarded MF is more expensive, and 35.7% of respondents didn't know which method is more expensive (Fig. 4.6.11). consistent perception pattern across urban and rural areas related to respondents' familiarity with MF: respondents who were familiar with MF thought it

would be more expensive, whilst the perceptions of those who were not familiar with MF were evenly distributed between MF and CF (Fig. 4.6.12). Also, respondents who have been involved in MF perceived it would be more expensive, but those who have not been involved in MF, almost as many people thought MF would be as expensive as CF (Fig 4.6.13).

Figure 4.6.11 Which method do you think is more expensive in rural areas by age?

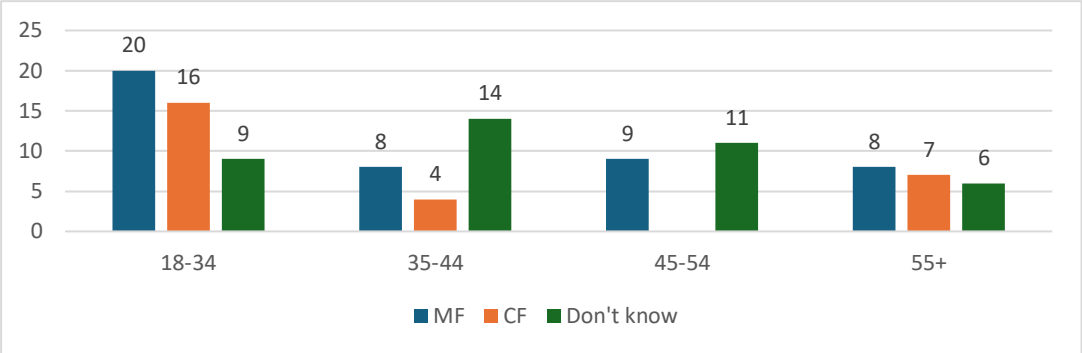


Figure 4.6.12 Which method do you think is more expensive in rural areas by familiarity?

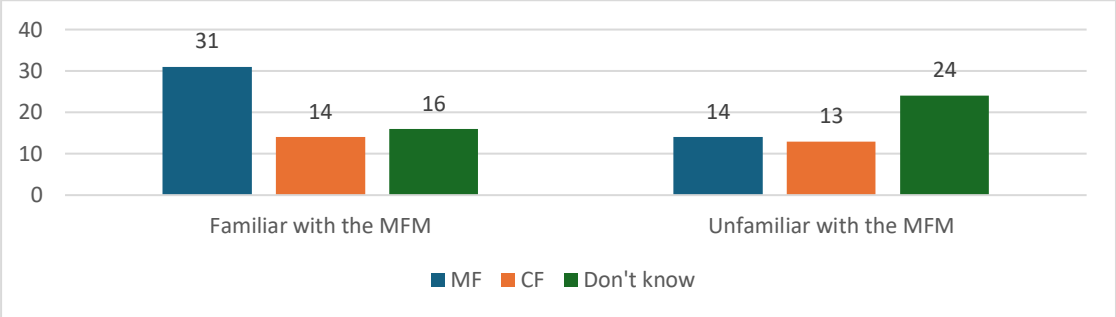
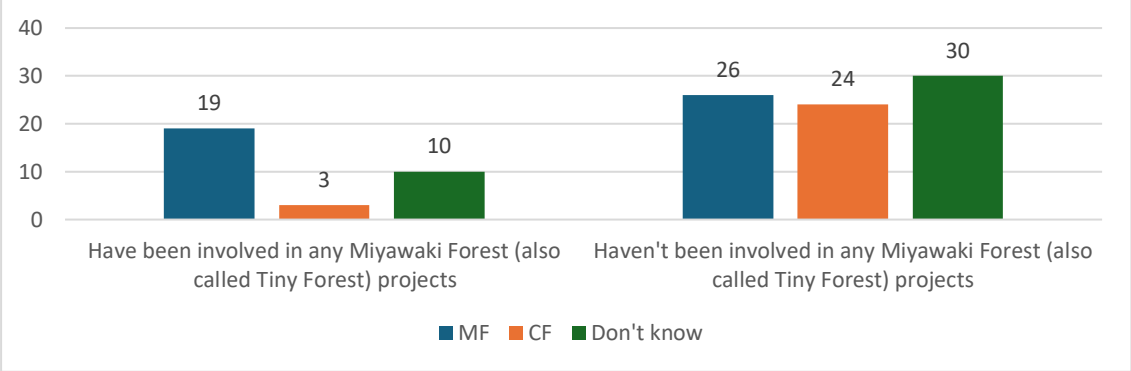


Figure 4.6.13 Which method do you think is more expensive in rural areas by involvement?



To explain which method they considered more expensive, respondents provided a variety of answers regarding the preparation, maintenance and cost (Table 4.6.3). The comparison results of costs exhibited similar pattern in both urban and rural areas.

Table 4.6.3 Respondents' perceptions of which tree planting method is more expensive in urban environments (n=29, reasons highlighted in red were mentioned more than once)

Type of tree planting method	Reason
MF	Costs high
	More expensive in all cases
	Costs of materials
	Costs of trees/saplings
	Costs for preparation (pre-planning)
	It is an expensive method
	Soil/ground preparation
	Intensive preparation
	Ongoing maintenance
	Costs of fencing
	Mulch
	Research involved
CF	More management and maintenance
	Planning and precise labour
	Large stock costs
	Soil preparation
	Watering (maintenance)

4.6.2 Willingness to pay for MF projects in the UK

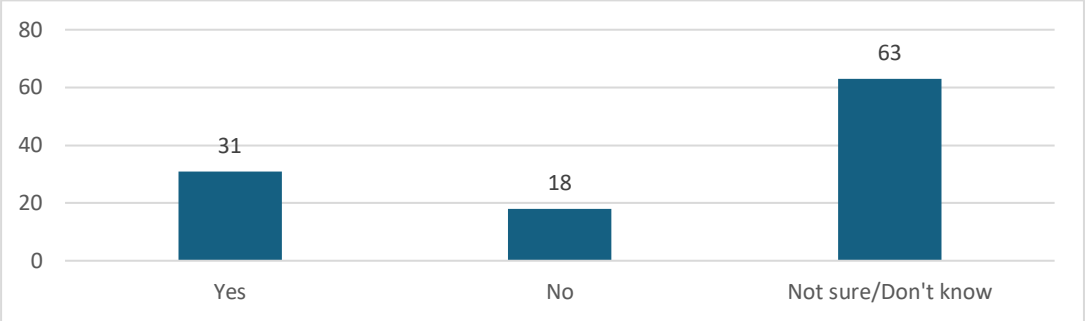
Questions 21, 22 and 23 (Table 4.6.1) were designed to enquire the respondents' willingness to pay and the actual amount they or their organisations could possibly afford. More than half of the respondents (56.3%) were unsure if they would invest in MF projects, while 27.7% of respondents showed their willingness to pay (Fig. 4.6.14). Table 4.6.4 shows the results from Chi-square tests in crosstabulation and independent T-test.

Table 4.6.4 Summary of factors affecting responses at a significant level (level of probability P) and trends for that factor.

Question	Factor	P value	Trend / relationship within the factor group
Q21 Would you be willing to pay for Miyawaki forest planting in the UK?	Age	P = 0.817	
	Gender	**P < 0.001**	**Males were more willing to pay for MF than females.**
	Education level	**P = 0.027**	**Masters degree respondents were more willing to pay for MF than others. (Bachelor not willing to, master willing to, PhD don't know).**
	Occupation	**P = 0.035**	**Public and private sectors were more willing to pay for MF than others.**
	Familiarity with MF	**P = 0.002**	**Respondents who were familiar with MF were more willing to pay for MF than others.**
	Involvement of MF	**P = 0.009**	**Respondents who have been involved in MF were more willing to pay for MF than others.**
	Age	P = 0.132	

Question	Factor	P value	Trend / relationship within the factor group
Q23 Do you think Miyawaki forest planting should be funded by the public sector?	Gender	P = 0.107	
	Education level	P = 0.233	
	Occupation	**P = 0.035**	**Academics and private sector were most supportive of public sector for funding.**
	Familiarity with MF	P = 0.271	
	Involvement of MF	P = 0.466	

Figure 4.6.14 Would you be willing to pay for Miyawaki forest planting in the UK?



Willingness to pay for MF initiatives showed significant variation across all the demographic groups gender ($P < 0.001$), education level ($P = 0.027$), occupation ($P = 0.035$), familiarity with MF ($P = 0.002$) and involvement of MF ($P = 0.009$) (Table 4.6.4). A total of 56.3% respondents was not sure about this, with more than 66% of female respondents were unsure about their spending intention (Fig. 4.6.15). Similarly, academic respondents (Fig. 4.6.16), especially PhD group (Fig. 4.6.17) were not sure if they willing to spend on MF planting. Respondents familiar with MF and those who were involved in MF demonstrated significantly higher willing to pay (Fig. 4.6.18 and 4.6.19). This suggested the prior knowledge of MFM's benefits may positively influence their paying intention.

Figure 4.6.15 Would you be willing to pay for Miyawaki forest planting in the UK by gender?

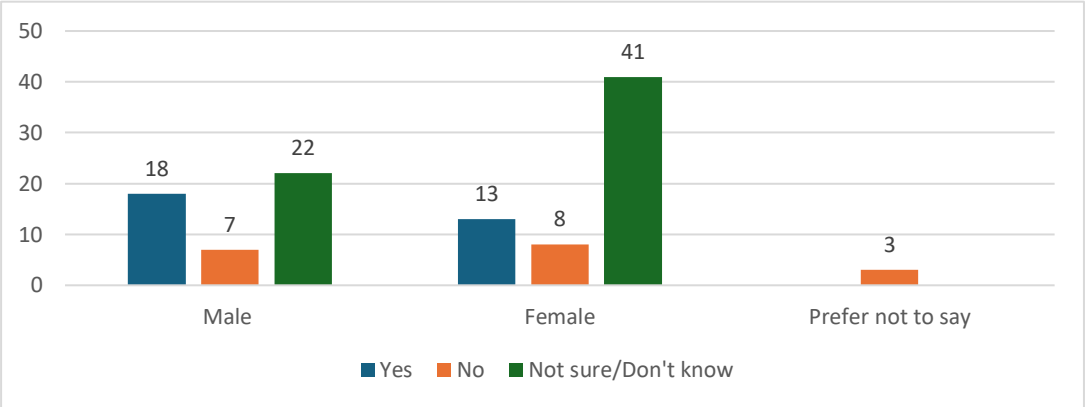


Figure 4.6.16 Would you be willing to pay for Miyawaki forest planting in the UK by occupation?

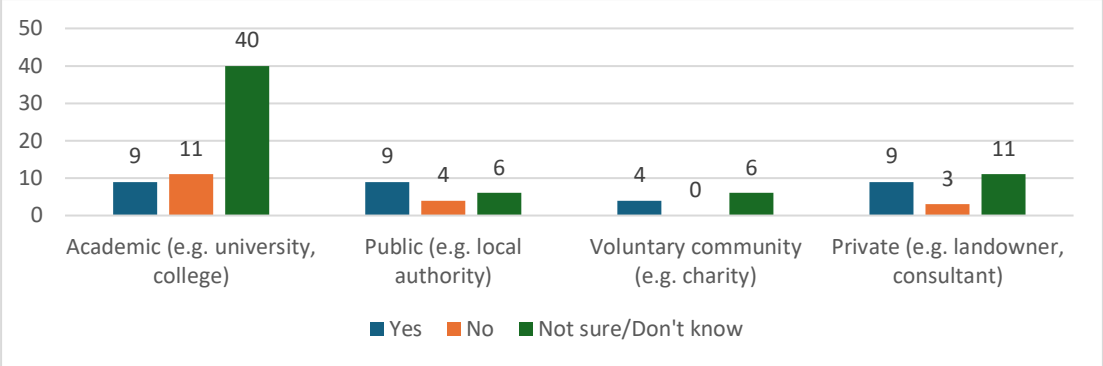


Figure 4.6.17 Would you be willing to pay for Miyawaki forest planting in the UK by education level?

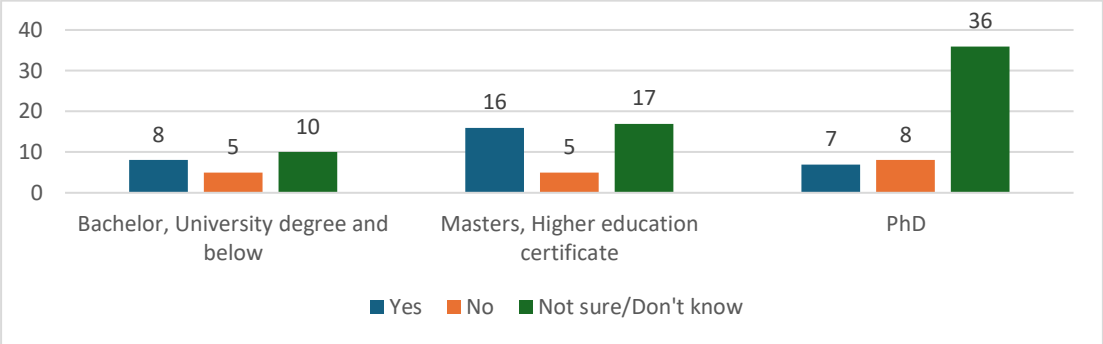


Figure 4.6.18 Would you be willing to pay for Miyawaki forest planting in the UK by familiarity?

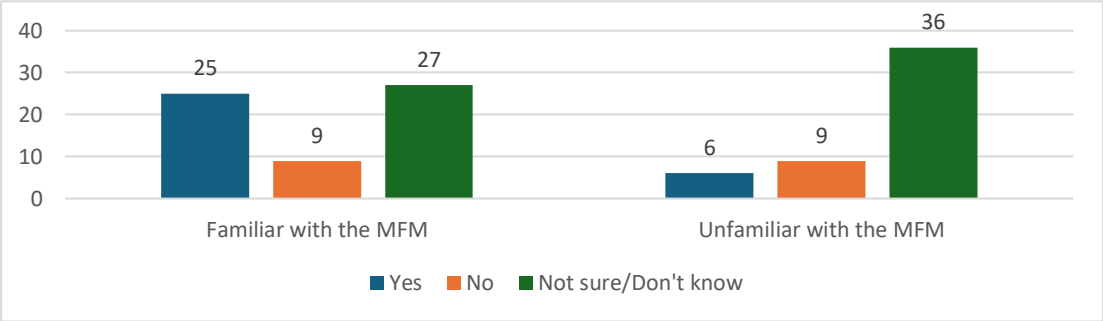
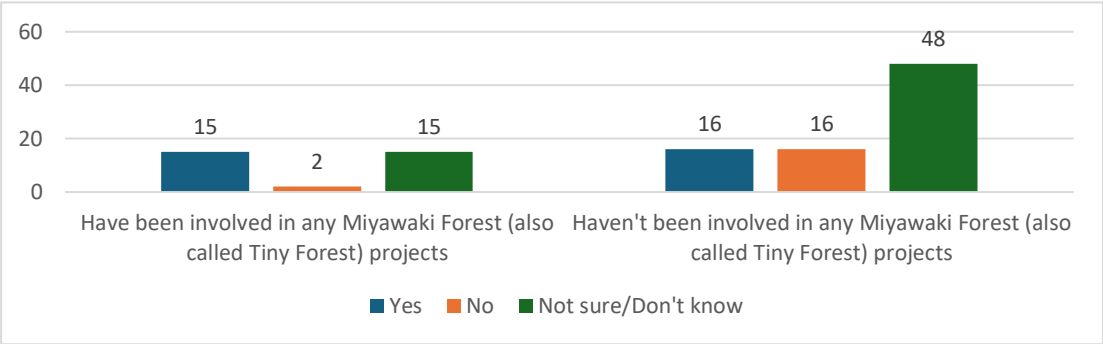


Figure 4.6.19 Would you be willing to pay for Miyawaki forest planting in the UK by involvement?



Questions were raised on respondents' or their organisations affordability to pay for MF in the UK. Among the 63 respondents, 12 of them were willing to pay less then £20/m^2, and 13 chose more than £20/m^2. While the remaining 25 respondents provided some comments rather than specify an exact amount. Some common amounts of money that could be afforded in the answers are reported in Table 4.6.5, and detailed reasons were reported in the Table 4.6.6.

Table 4.6.5 Common amounts of how much could they/their organization afford to pay for MF in the UK (per square metre).

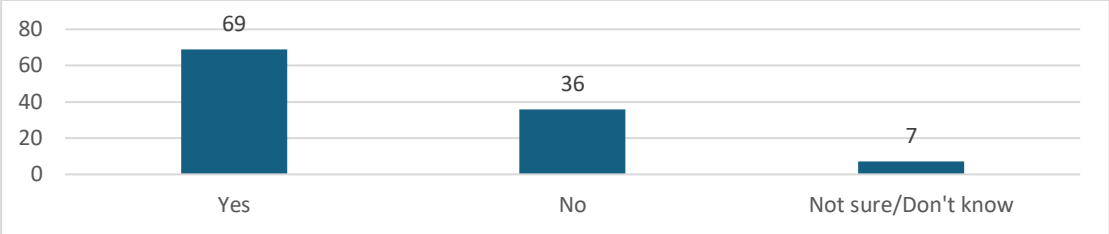
Amount of money	Number of people
£1	1
£5	5
£10	5
£15	1
£20	7
£40	3
£100	2
£150	1
Don't know	13

Table 4.6.6 Detailed reasons of how much could they/their organization afford to pay for MF in the UK (per square metre).

Amount of money	Number of people	Quote
There are also some respondents didn't give an amount of money but provided some other comments.	DEFRA have budget to pay for MF project.	
	Council will fund MF project.	
Some respondents think it depends on specific situation.	Costs	Depends on grant conditions, staffing costs, accessibility of site etc. Too many variables to give a ballpark figure.
	Benefits	If the science showed positive benefits in terms of functional and cultural ecosystem services I would contribute some funding.
	Client	This would be more client focused.
	Labour and resources	depends on the costs of labour and resources required to plant a Miyawaki forests in the UK.

69 respondents (61.6%) thought that MF should be funded by the public sector, with 36 respondents (32.1%) refused to MF should be funded by the public sector, and seven respondents (6.3%) who didn't know (Fig. 4.6.20).

Figure 4.6.20 Do you think Miyawaki forest planting should be funded by the public sector?



Respondents supported public sector funding to pay for MF planting, as of the direct benefits of MF tree planting. The majority view was '*because the public benefit, the public should pay*'. At the same time, respondents also gave some suggestions of specific organisations that could distribute the funding, e.g., DEFRA, Forestry Commission (n = 75).

Respondents who agreed that the public sector should pay (n = 69), some listed out various reasons for their decision. First, they elaborate the responsibility of governmental bodies to protect green spaces, therefore they should pay for it. Additionally, they believed that planting scheme incentives are able to bring lots of benefits to the public. For instance, it will provide public benefits on social, economic and environmental levels, and it could combat large scale issues, such as climate change and biodiversity loss issues more quickly. Moreover, it is described as efficient, and can help maintain city viability.

> *'It has a lot of benefits for local environment and community building.' (BA-18-34-M-PR-MY-80)*
>
> *'It is a very effective way to combat climate change and biodiversity loss.' (MA-18-34-F-VOL-MY-107)*
>
> *'Because it is efficient - especially with community plantings and public-sector supporting stock purchase and materials.' (PhD-55+-F-AC-MY-65)*

Second, respondents linked tree planting to improved public health and wellbeing, thus reduces the burden of healthcare costs.

> *'Tree planting and raising awareness is incredibly important. Plus it could eventually end up costing other sectors (e.g. healthcare) less as there are health benefits to being active and in nature.' (MA-18-34-F-VOL-MY-108)*

Third, they thought public sector has funded many tree planting schemes why not MF, and they already do fund MF.

> *'There are many tree planting schemes that are funded by the public sector, why not Miyawaki method as well? Indeed, grants have been obtained to plant Miyawaki forests through funding schemes aimed at tree planting.' (PhD-35-44-F-VOL-MN-101)*

Last, many of them only supported the funding of pilot trials by government to test first, to see how trees actually perform. And some respondents advocated for mixed financial approach.

> *'A proportion should be funded [by public sector], and with private financing supplementing.' (MA-35-44-F-PR-MN-38, PhD-55+F-AC-MN-50)*

Respondents who were against the idea of public sector funding for MF expressed that '*there was barely the budget available in the public sector to maintain trees as well' (BA-55+-F-LA-MY-20)*. They described how MFM hasn't proved its advantages in the UK.

> *'Benefit-cost basis required. WHAT (benefit or benefits) will it deliver and IS it proven/comfortably clear that the benefits will be delivered. If the risk is too high then public money would be better spent or more certain methods.' (PhD-45-54-M-LA-MN-33)*

In addition, they argue that many aspects should be considered before making decisions, such as planting objectives, the benefits of having these forests, and how MFM would be useful for public interest. Thus, they disagreed with that the public sector should pay for it.

> *'The Vision/objectives for any tree planting / woodland creation have to come first …' (MA-45-54-M-VOL-MN-2).*

4.6.3 Perceived components of expenditure in the MF in the UK

Respondents were asked (Q24): What is the relative cost percentage you would expect to pay for soil preparation/ tree purchases/ ongoing maintenance for the Miyawaki forest planting per square metre? The components of soil preparation, tree purchases, and ongoing maintenance are widely recognised as the main expenses involved in tree planting projects. This question aimed to assess the willingness of respondents to allocate costs across these three categories. To statistically examine differences in cost expectations among the three categories, a related samples Friedman's two-way analysis was conducted. This non-parametric t-test was chosen to determine whether significant differences exist in how respondents distribute costs across the three expenditure areas and the differences was not significant (P = 0.85).

The findings indicate that on average, tree purchases constitute the highest expected expenditure, accounting for 36.7% of the total cost per square metre. This is followed closely by soil preparation at 35.1%, while ongoing maintenance accounted for 28.2% (Fig 4.6.21). The detailed cost of expenditure is listed in fig. 4.6.22. The relatively high allocation to tree purchases may reflect the dense planting approach characteristic of the Miyawaki method, based on a diverse selection of native species to achieve rapid forest development. Similarly, the significant cost assigned to soil preparation aligns with the method's emphasis on soil enrichment to support accelerated plant growth. In contrast, the lower percentage attributed to ongoing maintenance suggests that professionals anticipate reduced long-term management costs once the forest is established, consistent with the self-sustaining nature of Miyawaki forests after the initial years of intervention.

Figure 4.6.21 What is the relative cost percentage you would expect to pay for soil preparation/ tree purchases/ ongoing maintenance for the Miyawaki forest planting in per square metre?

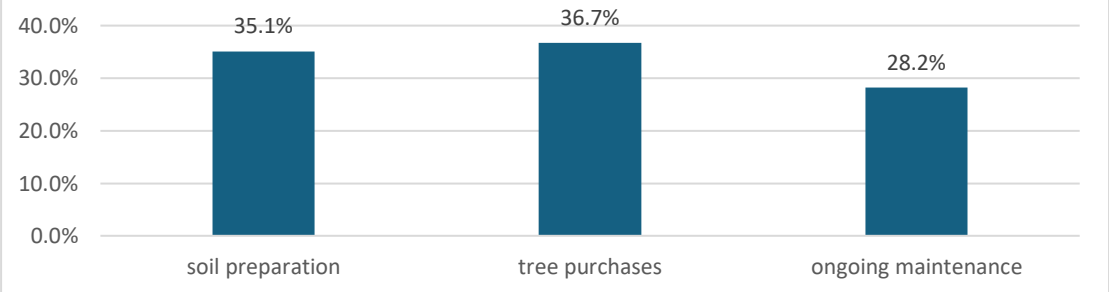
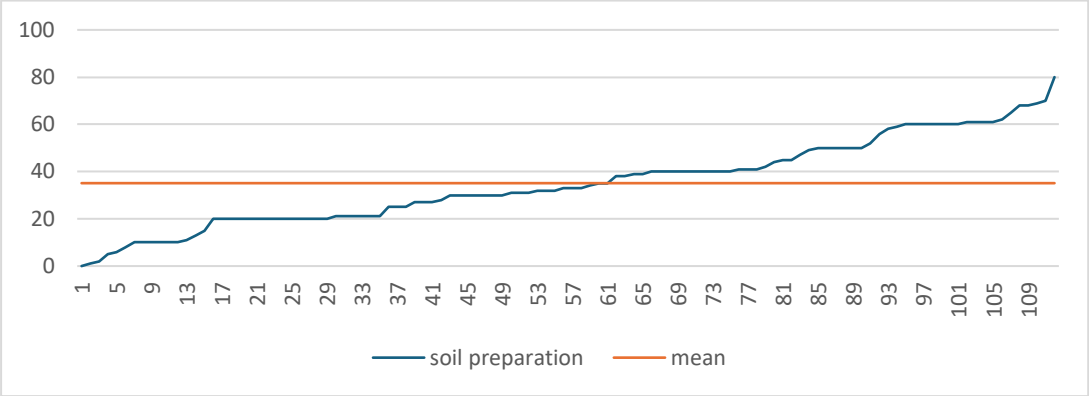
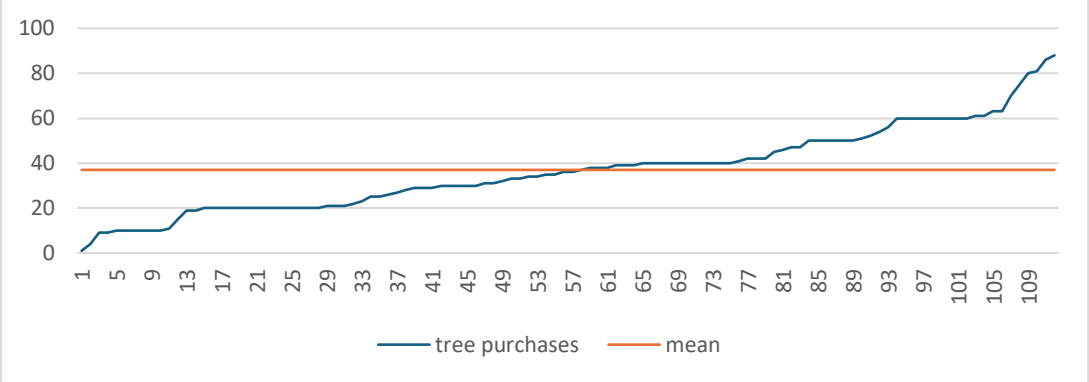
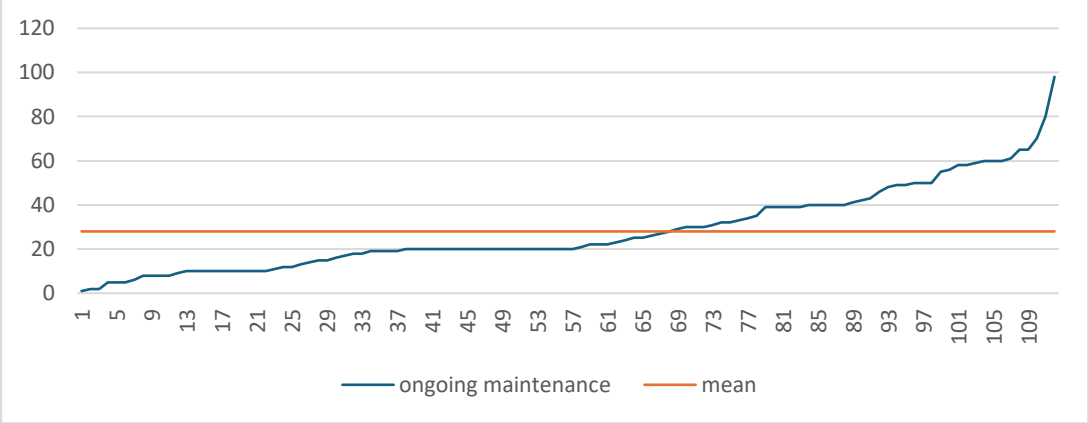


Figure 4.6.22 Detailed cost by expenditure







4.7 Perceived potential environmental benefits of MFM, and comparison with CFM

Table 4.7.1 Summary table for research question 1.1 and questionnaire integration

Research questions	Themes	Indicators (questions in the questionnaire)
RQ 1.1 What are experts and professionals' perceptions of the MFM -- and how do they compare to their perceptions of CFM?	4.7 Perceived environmental benefits of MFM, and comparison with CFM.	**Q27** To what extent do you think Miyawaki forest planting could help mitigate the following aspects. (1 = completely unhelpful, 10 = very helpful) **Q29** To what extent do you think Conventional mixed forest planting could help mitigate the following aspects. (1 = completely unhelpful, 10 = very helpful)

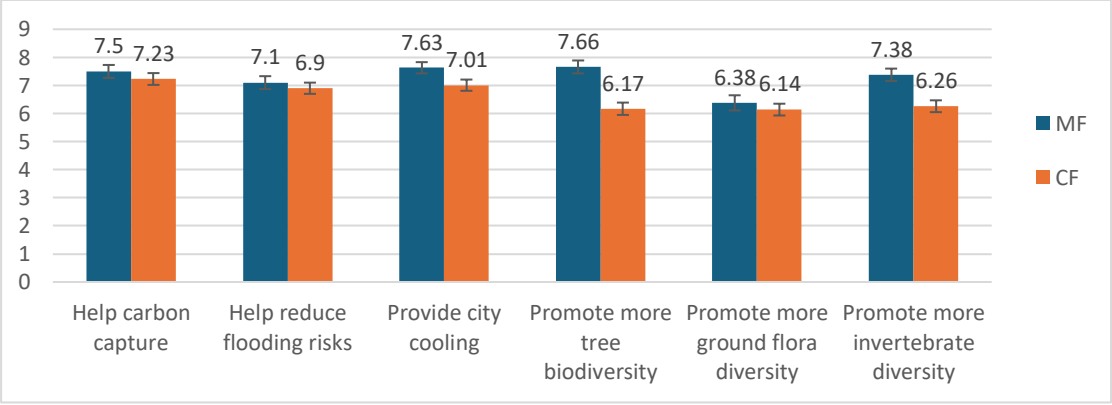
Table 4.7.2 Summary of factors affecting responses at a significant level (level of probability P) and trends for that factor.

Question	Factor	P value	Trend / relationship within the factor group
Q27 and Q29 To what extent do you think Miyawaki forest planting could help mitigate the following aspects vs Conventional mixed forest planting.	**Provide city cooling**	**P = 0.004**	**Respondents indicated that MFM was more helpful in providing city cooling, in promoting tree biodiversity, and invertebrate diversity compared to CFM.**
	Promote more tree biodiversity	**P < 0.001**	
	Promote more invertebrate diversity	**P < 0.001**	

Comparing the data of Q27 and Q29, the perceived effectiveness of MFM and CFM in mitigating various environmental challenges, including carbon capture, flood risk reduction, city cooling, and biodiversity promotion (tree, ground flora, and invertebrate diversity) is assessed. Respondents rated the extent to which each method contributes to these aspects, and the mean values were compared between MFM and CFM. To determine whether these differences are statistically significant, further analysis using Repeated Measures ANOVA was conducted. The findings indicate that MFM is generally perceived as more effective than CFM across all of the six categories (Fig. 4.7.1), This suggests that respondents generally perceived that MFM was better than CFM in all aspects of helping to improve the environment.

Specifically, the respondents indicated that MFM was more helpful in providing city cooling compared to CFM (P = 0.004, Table 4.7.2, Fig. 4.7.1), in promoting tree biodiversity (P < 0.001), and invertebrate diversity (P < 0.001). However, the differences were not significant for carbon capture, flood risk reduction, and ground flora diversity promotion, though MFM received slightly higher ratings than CFM for these three categories (Fig. 4.7.1). This suggests that respondents possibly recognise its similar potential for rapid biomass accumulation and carbon sequestration, and in enhancing urban hydrology and mitigating surface water runoff. The perceptions for ground flora diversity were low for MFM, which may be attributed to the dense tree canopy in MF, which limits light penetration and subsequently reduces the establishment of understory vegetation.

Figure 4.7.1 To what extent do you think these methods (MFM and CFM) could help mitigate the following aspects (mean value).



They then elaborated on the reasons for giving this score to each category, in detail, as reported in Table 4.7.3

Table 4.7.3 Respondents' perceptions of the reasons for supporting the environmental benefits of MF (n = 67) and CF (n = 58) (in no particular order, places highlighted in red were mentioned more than once)

Category	**Reason**	
	MF	CF
Carbon capture	**Small scale** equals limited ability to store carbon.	Large trees equal more carbon capture.
	Soli prep cause carbon losses on organic rich soils.	Perhaps less carbon capture since less trees initially.
	Young trees equal not storing carbon as effective as older trees.	Since they are not as dense they may not help as much with biodiversity and carbon capture.
	The Miyawaki approach may provide enhanced carbon capture capacity.	
Reduce flooding risk	Root network not substantial enough.	It is location specific.
	It is not helpful on reduce flood risk as it is too small.	
	Dense leaf cover and trunks would slow the flow.	They [rural areas] are large areas so help more with reducing flood risk.
	More complex vegetation good for flood avoidance.	
City cooling	**Small scale** equals not good at city cooling.	It is location specific.
		Bigger trees, so better for cooling and shading.
		Large area so help with enabling city cooling.
Tree biodiversity	Fierce competition = just a few will thrive = low tree biodiversity.	Fewer species equal less opportunity to increase tree species diversity.
	Faster growing species will dominate these tightly spaced forests and limit the extent of tree diversity that is achieved.	
Ground flora diversity (14)	**Densely planting** = shade = reduce ground flora diversity.	**Less dense planting/more light and space**, so promote more ground flora.
Invertebrate diversity	Densely planting, forest might not be suitable for invertebrate diversity.	Less dense /more light and space, so greater invertebrate diversity
	More complex vegetation = increase invertebrate diversity.	Fewer species = less opportunity to increase insect diversity.
Other	It uses local species, bring more biodiversity.	**Depends on species used,** location, age of trees, size of the fields, planting scheme.

Category	Reason	
	MF	CF
	Context/species dependent.	Less dense planting reduces some benefits on all of the aspects.
		Less layers and less shelter due to distance in planting encourage less biodiversity.

4.8 Tree species selection for the MFM and CFM in the UK

Table 4.8.1 Summary table for research question 1.2 and 1.3 and questionnaire integration

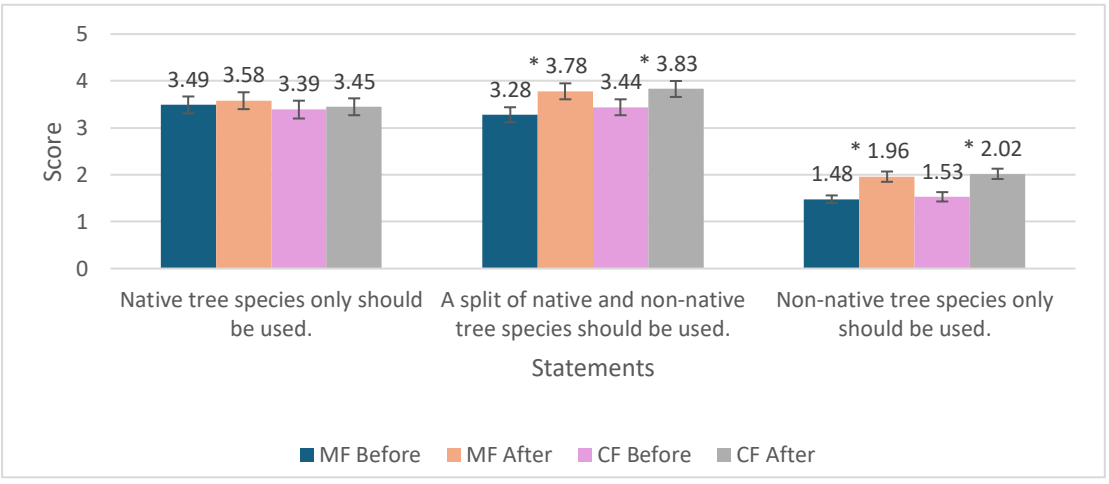
Research questions	Themes	Indicators (questions in the questionnaire)
RQ 1.2 How do experts and professionals' perceive the prioritization of planting native species in the Miyawaki forest in the UK? To what extent do they think that native species as suitable for future UK climate scenarios, and what role should non-native species play? RQ 1.3 How are experts and professionals re-evaluating species selection for Miyawaki forests in response to climate change?	4.8 Tree species selection for the MFM in the UK: comparison with CFM, climate adaptation, and recommended species.	**Q31** Do you agree with the following statements: Native tree species only should be used in the Miyawaki Forest method. A split of native and non-native tree species should be used in the Miyawaki Forest method. Non-native tree species only should be used in the Miyawaki Forest method. Native tree species only should be used in the Conventional Forest method. A split of native and non-native tree species should be used in the Conventional Forest method. Non-native tree species only should be used in the Conventional Forest method. **Q36** In light of rising temperatures, do you agree with the following statements:
		Q33 Please select the percentage of native and non-native tree species in the Miyawaki forests, if planted in the UK. **Q34** Please select the percentage of native and non-native tree species in the Conventional mixed forest planting, if planted in the UK. **Q38** In light of rising temperatures, please select the percentage of native and non-native tree species in the Miyawaki forests, if planted in the UK. **Q39** In light of rising temperatures, please select the percentage of native and non-native tree species in the Conventional mixed forest planting, if planted in the UK.
		Q35 What non-native tree species might you consider in the UK and why?

4.8.1 The focus on planting native species in the MFM vs CFM, and attitudes shift amid climate change issue.

Repeated measure ANOVAs and Paired sample t-tests were conducted to compare the data of Q31 and Q36. Respondents' perceptions towards NT and NNT were explored. Before providing information to the respondent about the changing climate (see questionnaire in Appendix 2). Respondents generally preferred the use of either exclusively native species or a mix of native and non-native species in both MF and CF situations, as these options consistently received higher ratings compared to the use of non-native species alone. Interestingly, respondents showed a stronger preference for the exclusive use of native species in MF, whereas they were more likely to agree with the use of a mixture of native and non-native species in CF, as reflected in the respective scores (Fig. 4.8.1, P = 0.229, N.S.).

After informing respondents about the impacts of climate change (which might promote the use of NNT due to assumptions about these being better adapted to the UK climate in the future), marginally more (N.S.) people thought that natives alone should be used (in both MF and CF). Adding more information increased the number of people who thought mixes of NT and NNT were appropriate (with both MF* [P < 0.001] and CF* [P = 0.007], Fig. 4.8.1). There were also more respondents in favour of using non-native alone (Fig. 4.8.1) with MF* (P < 0.001) and CF* (P < 0.001) after the additional climate information had been disclosed. The fact that respondents were in favour of planting more trees (irrespective of nativeness, i.e. all the values increase in Fig. Fig. 4.8.1 when comparing the 'after' to the equivalent 'before' number) might indicate that tree planting in general was deemed a positive response to climate change.

Figure 4.8.1. Do you agree with the following statements (before and after they had been told climate change-related information)



Nevertheless, when climate change was taken into consideration, respondents were more likely to agree with the use of mixed NT and NNT species in MF rather than NT only. Native trees were generally preferred which can been seen in the respondents detailed answers (n = 65). After informing respondents about the potential impacts of climate change, their detailed reasons toward NT and/or NNT did not change (n = 54), remaining similar to their previous answers. But there was still resistance to the sole use of NNT, and respondents suggested that southern English

or European species could be considered in the selection. The following are the detailed reasons for the results (Table 4.8.2, n = 119).

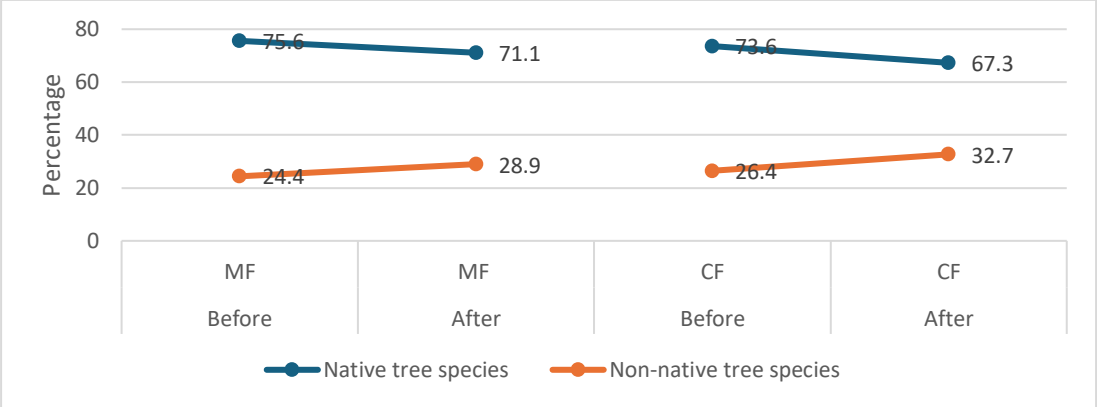
Table 4.8.2. Professionals' perceptions of native and non-native tree species selection (in no particular order, places highlighted in red were mentioned more than once)

Statements	**Category/Reason**
Native tree species only	Support and enhance native genetic diversity.
	Survive better in long-term.
	Support more biodiversity.
	For landscape quality.
	Better adapted to the environment where they will be planted.
	More suitable (for allowing native flora and fauna thrive).
	Offer ecological benefits.
	As MF is about reviving native forest.
	Provide the greatest benefit for native wildlife.
	More resilient to extreme weather events.
	Less biosecurity risks.
The use of non-native tree species and reasons (i.e. a mix of NT and NNT)	Good for climate mitigation and adaptation.
	Increase (species) diversity.
	Increase benefits.
	Better climate change adaptation, Offer more resilience to climate change and disease.
	Good effects of urban heat island.
	Adding interest in urban areas.
	Mix but NT should be prioritised/dominant
	Tolerant to higher temperatures, better adapted to the warming/drying climate.
	As a supplement to maximise the full range of benefits of woodland.
	Mix but need to be aware of invasive NNT.
Other	Community preference should be taking into account.
	Policy.
	Depends on aim/purpose.

4.8.2 The specific percentage of native species in MFM and CFM, and attitudinal shifts regarding climate change

In terms of the respondents' perceptions of the proportion of NT and NNT appropriate to tree planting, respondents selected a similar percentage of NT in both the MF (75.6% on average) and CF (73.6% on average) tree planting methods (Fig. 4.8.2, no significant difference based on forest type, P = 0.312). Paired sample T-tests and repeat measure ANOVAs were conducted. After being presented with the climate change-related information, respondents perceived different proportions of NT to be appropriate in both the MF (71.1% on average) and CF (67.3% on average) tree planting methods (Fig 4.8.2, P = 0.006). Respondents' perceptions of the percentage of NT in MF scored significantly higher than their perceptions on the percentage of NT in CF.

Figure 4.8.2 Respondents' percentage of native and non-native tree species in the forests (MF and CF and before and after they had been told climate change-related information)



Comparing data of the percentage of NT before and after obtaining information on climate change shows that professionals' perceptions of the percentage of NT in MF decreased from 75.6% to 71.1% ($P = 0.001$), while their perceptions of the percentage of NT in CF decreased more sharply, from 73.6% to 67.3% ($P < 0.001$). Despite these reductions, NT remains the dominant options in both forest types.

4.8.3 Recommended species

Respondents were asked to recommend potential tree species for planting MF in urban and rural areas in the UK, as summarised in Table 4.8.3. Insights from professionals and practitioners highlight the need for a context-driven approach that considers native biodiversity, climate adaptation, and ecological interactions.

As such, respondents emphasise the importance of selecting species according to different criteria:

- Drought resistant and heat tolerant species: Given the warming climate, species originating from drier regions, such as Mediterranean oaks (Quercus spp.) and southern European pines (Pinus pinea), are recommended.
- Non-native but resilient species: While the Woodland Trust advocates for native species, some professionals suggest including non-native trees with demonstrated resilience to urban stressors, such as the London plane (Platanus × acerifolia), known for its pollution tolerance.
- Ornamental Species: Certain ornamental trees, such as Katsura (Cercidiphyllum japonicum), Styrax spp., and Halesia spp., are considered suitable due to their aesthetic appeal and climate change.

Respondents described how tree species selection must also take into account site-specific factors such as local microclimate, soil conditions and ecological interactions. Respondents emphasised that tree species should be non-invasive and compatible with local biodiversity to avoid unintended ecological consequences.

In rural settings, tree species selected prioritised native biodiversity, long-term ecological resilience, and economic value. However, in light of changing climatic conditions, professionals suggest incorporating drought-resistant species that do not disrupt native ecosystems.

Overall, respondents indicated that tree selection for both urban and rural Miyawaki Forests should align with climate resilience, local ecological suitability, and long-term sustainability. While

native species remain a priority, integrating carefully assessed non-native species that provide ecological and climate adaptation benefits may be necessary to ensure forest resilience in a rapidly changing climate.

Table 4.8.3 Tree species recommended for use in MF in urban and rural areas

Tree Species	
Urban (n = 43)	Rural (n = 40)
Acacia dealbata	*Acer pseudoplatanus*
Acer monspessulanum	*Aesculus hippocastanum*
Acer opalus	*Castanea sativa*
Acer pseudoplatanus	*Castanea spp.*
Aesculus hippocastanum	*Cedars spp.*
Aesculus indica	*Eucalyptus spp.*
Araucaria araucana	*Juglans nigra*
Castanea sativa	*Larix decidua*
Cedrus spp.	*Malus X domestica*
Cercis canadensis	*Picea abies*
Eucalyptus spp.	*Picea sitchensis*
Fagus spp.	*Pinus sylvestris*
Ginkgo biloba	*Platanus spp.*
Gleditsia triacanthos	*Prunus avium*
Koelreuteria paniculata	*Prunus domestica*
Magnolia grandiflora	*Prunus spp.*
Malus baccata	*Pseudotsuga menziesii*
Malus x domestica	*Quercus spp.*
Malus trilobaca	*Quercus (any non-native types)*
Paulownia tomentosa	*Robinia pseudo acacia*
Planatus x hispanica	*Sequoioideae*
Platanus spp.	*Sequoiadendron giganteum*
Prunus domestica	*Taxus baccata*
Prunus serrulata	*Thuja plicata*
Prunus spp.	*Tsuga heterophylla*
Quercus ilex	*Ulmus spp.*
Quercus spp.	
Robinia pseudoacacia	
Taxus baccata	
Ulmus spp.	
Zelkova serrata	

Ch.5. Non-professionals' attitudes towards the MFM and CFM

5.1 Introduction

This chapter addresses the second research question:

2. How much does the non-professionals know about the Miyawaki Forest method?

2.1 What are non-professionals' attitudes towards the MFM and CFM, and how do they compare to their perceptions of the CFM?

2.2 What are the non-professionals' attitudes towards the prioritisation of planting native species in the Miyawaki forest in the UK? To what extent do they perceive native species as being suitable, and what role do they believe non-native species should play?

2.3 Are non-professionals' perspectives on species selection for Miyawaki forests evolving in response to climate change?

2.4 How do these attitudes differ from those held by professionals?

This chapter presents the findings of the second online questionnaire survey, administered primarily to UK-based respondents but with some responses from outside the UK (non-professionals from other countries with knowledge and experience of the UK context). as mentioned in Section 4.1, there was very limited prior research so only some hypotheses discussed in advanced (where prior knowledge allowed some degree of prediction), as follow:

- Awareness: Very less non-professionals would be aware of the MFM.
- Support: The overall support from non-professionals would be limited as MFM had just emerged in the UK.
- Perceived suitability: Non-professionals would rate the method's suitability for the UK context as neutral, reflecting the novelty of the method and existing uncertainties.
- Perceived problems/challenges: Most non-professionals might not know potential problems associated with MFM.
- Species preference: Non-professionals would show a preference for incorporating NNT species in response to climate change in the MFs.

The survey collected primary data on non-professionals perceptions of Miyawaki forests in the UK context, focusing on awareness and attitudes toward their implementation in urban and rural settings in the UK, and compared to CFM, examining non-professionals perspectives on perceived environmental benefits, preferences for tree species selection in the context of the climate change, and perceived limitations of the MFM. The data is synthesized according to non-professionals perspectives to outline the similarities and differences among respondents, ultimately contributing to a deeper understanding of non-professionals engagement with the MFM and its potential perceived suitability within the UK landscape.

- Awareness of, and interest in, the Miyawaki Forest method, and comparison with the Conventional Forest method (section 5.3).
- Support and willingness to engage with Miyawaki Forests, and comparison with the Conventional Forest method (5.4).
- Perceived suitability of the Miyawaki method and potential locations for planting Miyawaki Forests in the UK (5.5).
- Perceived potential problems of the Miyawaki Forest method (5.6).

- Potential environmental benefits of Miyawaki forest planting, and comparison with the Conventional Forest method (5.7).
- Tree species for Miyawaki forest planting, and comparison with conventional forest planting (5.8).
- The differences between the attitudes of the non-professionals and those of professionals (5.9)

5.2 Demographic characteristics of the sample

Participants were not required to have prior knowledge of the MFM. The respondents (87.3%) predominantly identified as British, with the largest proportion of respondents aged 65 and over (31.8%, Table 5.2.1), followed by those aged 55–65 (24.7%). The sample included a slightly higher proportion of male respondents (51.7%) compared to females (43.5%). In terms of level of education, 55.1% of respondents held a bachelor's degree or lower, while 44.9% had a master's degree or higher. The majority of respondents lived in urban (41.4%) or suburban (40.4%) environments, while 18.2% resided in rural areas. Additionally, 51.0% of respondents expressed the highest level of interest in trees (10 on a 10-point scale). Most participants reported frequent engagement with greenspaces, with 95.5% visiting daily or weekly, indicating a strong affinity to greenspaces. Furthermore, the same coding process has also been undertaken for the non-professionals data (Appendix 6).

Table 5.2.1 Demographic profile of non-professionals questionnaire respondents (n = 292)

Age	Number	Percentage
18-34	47	16.1%
35-44	31	10.6%
45-54	49	16.8%
55-65	72	24.7%
65+	93	31.8%
Gender		
Male	151	51.7%
Female	127	43.5%
Prefer not to say	14	4.8%
Level of education		
Bachelor's and below	161	55.1%
Master's and above	131	44.9%
How frequently do you spend time in greenspace now (i.e., Frequency in green space)		
Daily	166	56.8%
Weekly	113	38.7%
Monthly	10	3.4%
Less than monthly	3	1.1%
How would you describe where you live now (i.e., Living environment)		

Urban	121	41.4%
Suburban	118	40.4%
Rural	53	18.2%
How would you describe yourself and your interest in trees (i.e., interest in trees) (1 to 10 = low to high interest)		
10	149	51.0%
9	50	17.1%
8	40	13.7%
7	26	8.9%
6	8	2.7%
5	7	2.4%
4	4	1.4%
3	2	0.7%
2	4	1.4%
1	2	0.7%

Respondents were assigned unique identification codes which incorporated key demographic and relevant factors in the survey, i.e., respondents are identified in the findings according to education level – age – gender – frequency in greenspace – living environment – interest in trees – have heard of Miyawaki method planting or not, e.g. (BA-18-34-F-D-URB-9-MY-29), the last number is the serial number of respondents (Appendix 6). These codes protect the anonymity of respondents while allowing for consistent identification throughout the analysis.

5.3 Non-professionals' awareness of, and interest in, the Miyawaki Forest method, and comparison with the CFM

Table 5.3.1 Summary table for research question 2.1 and questionnaire integration

Research questions	Themes	Indicators (questions in the questionnaire)
RQ 2.1What are non-professionals' attitudes towards the MFM and CFM, and how do they compare to their perceptions of the CFM?	5.3 Non-professionals' awareness of, and interest in, the Miyawaki Forest method, and comparison with the CFM	**Q4** Have you ever heard of the Miyawaki Forest method before? (i.e., have heard of it or not)
		Q5 Have you ever visited a Miyawaki forest before? (i.e., have visited of it or not) **Q12** Have you ever visited a conventional forest/woodland before?

The first set of questions were intended to assess the level of non-professionals' engagement with the MFM in the UK (Table 5.3.1). The findings indicated a varied level of awareness, with only 79 respondents (27.1%) having previously heard of the MFM and just 26 (8.9%) having visited a Miyawaki Forest. In contrast, 280 respondents (95.9%) had visited a Conventional Forest ($P < 0.001$), suggesting that the majority were not aware of the MFM at the time of the survey.

25.3% of the respondents who had heard of the MFM had also visited a Miyawaki Forest, compared to only 2.8% of those who had not previously heard of the MFM ($P < 0.001$). The data presented in Table 5.3.2 were analysed using Chi-squared tests and Cohen's kappa in

crosstabulation, Spearman's bivariate correlation, independent t-tests and paired sample t-tests, considering factors related to respondents' characteristics. A detailed breakdown of factors influencing questionnaire responses and levels of significance is provided in Appendix 8. The key factors significantly associated with responses in this set of questions included age, frequency of greenspace visits, living environment, interest in trees, and prior awareness of the MFM (have heard of it or not) in this set of questions.

Table 5.3.2 Summary of factors affecting responses at a significant level (level of probability P) and trends for that factor.

Question	Factor	P value	Trend / relationship within the factor group
Q4 Have you ever heard of the Miyawaki Forest method before?	**Age**	**P = 0.010**	**Respondents aged 45–54 have the greatest awareness of MF.**
	Gender	P = 0.832	
	Level of education	P = 1.00	
	Frequency in greenspace	**P = 0.044**	**Respondents who visited greenspaces more frequently were more likely to be aware of MF.**
	Living environment	**P = 0.010**	**Respondents who live in rural areas exhibited higher levels of awareness.**
	Interest in trees	**P = 0.008**	**Respondents who expressed a strong interest in trees being more likely to be aware of MFM.**
Q5 Have you ever visited a Miyawaki forest before?	Age	P = 0.196	
	Gender	P = 0.877	
	Level of education	P = 0.410	
	Frequency in greenspace	P = 0.788	
	Living environment	P = 0.199	
	Interest in trees	P = 0.113	
	Have heard of MFM or not	**P < 0.001**	**Respondents who had heard of MF were more likely to have visited a MF.**

72.9% questionnaire respondents had not heard of MFM. Awareness of MFM varied across age groups, with the greatest awareness observed among respondents aged 45–54, of whom 38.8% had heard of MF. This was followed by the 18–34 age group, where 34.0% reported awareness. In contrast, the lowest awareness was recorded among those aged 65+, of whom 86% had not heard of MFM (P = 0.01, Table 5.3.2, Fig. 5.3.1). Additionally, frequency of greenspace visits was also a significant factor; respondents who visited greenspaces more frequently were more likely to be aware of MF, as 53.5% of respondents who visited greenspaces daily or weekly had heard of MFM, compared to only 10% of those who visited monthly (P = 0.044, Table 5.3.2, Fig. 5.3.2).

Figure 5.3.1 Have you ever heard of the Miyawaki Forest method before, by age.

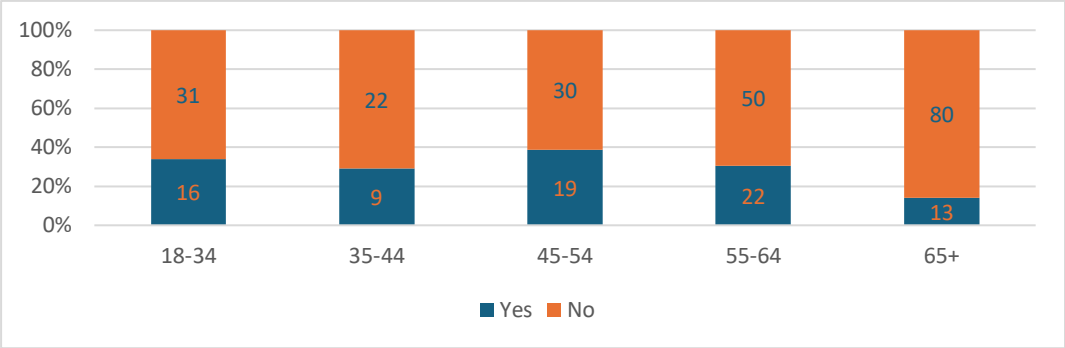
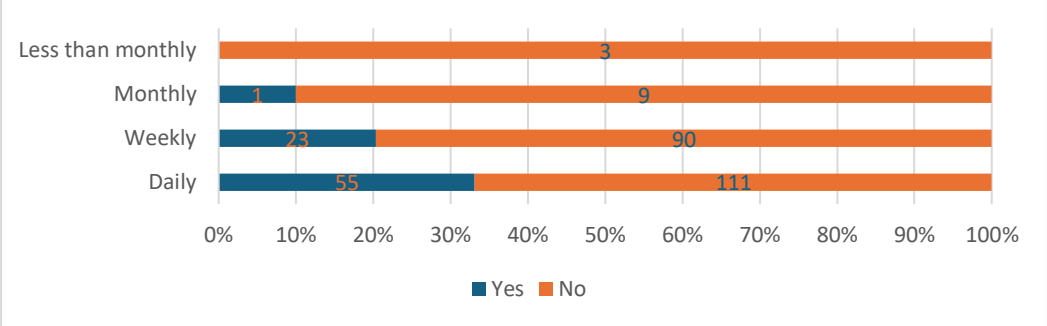
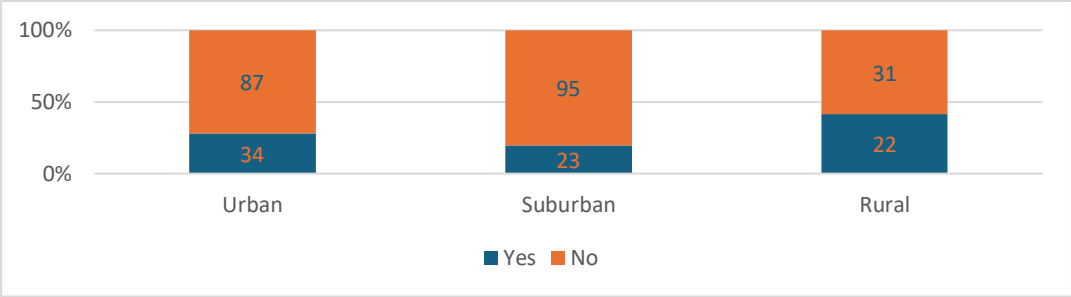


Figure 5.3.2 Have you ever heard of the Miyawaki Forest method before, by frequency in greenspace.



A similar trend was observed regarding living environment, as individuals living in rural areas exhibited higher levels of awareness. Specifically, 41.5% of rural residents had heard of MFM, a significantly higher proportion than those in urban and suburban areas (P = 0.01, Table 5.3.2, Fig. 5.3.3). Interest in trees was also a significant factor influencing awareness, with respondents who expressed a strong interest being more likely to have heard of MFM (P = 0.008).

Figure 5.3.3 Have you ever heard of the Miyawaki Forest method before, by living environment.



Moreover, respondents' prior awareness of MFM was significantly associated with whether they had previously visited one (P < 0.001). Those who had heard of MF were substantially more likely to have visited a MF, with 76.9% having done so, compared to only 23.1% of those who had not previously heard of MFM.

5.4 Supporting the use of, and willingness to engage with, the MFM for tree planting compared to the conventional method.

Table 5.4.1 Summary table for research question 2.1 and questionnaire integration

Research questions	Themes	Indicators (questions in the questionnaire)
RQ 2.1What are non-professionals' attitudes towards the MFM and CFM, and how do they compare to their perceptions of the CFM?	5.4 Support the use of and willingness to engage with MFM compared to the CFM	**Q9** To what extent would you support using the Miyawaki Forest method to plant a forest in your area?
		Q11 Would you visit a Miyawaki forest if there was one in your local area?
		Q16 Would you be in favour of using the Miyawaki Forest method to plant a forest rather than using the conventional forest method in your area?

Respondents were then asked to answer the questions listed in the Table 5.4.1, to indicate their level of support for the MFM. Data in Table 5.3.2 were analysed using Chi-squared tests in crosstabulation, independent t-tests, one-way ANOVA and Spearman's bivariate correlation, considering factors related to respondents' characteristics.

Table 5.4.2 Summary of factors affecting responses at a significant level (level of probability P) and trends for that factor.

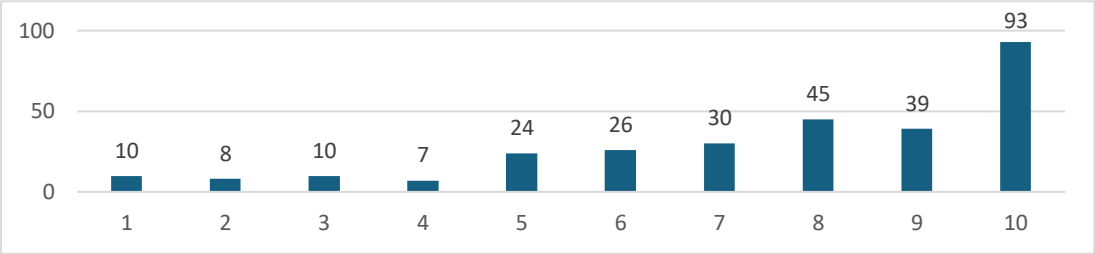
Question	Factor	P value	Trend / relationship within the factor group
Q9 To what extent would you support using the Miyawaki Forest method to plant a forest in your area?	Age	P = 0.439	
	Gender	**P = 0.004**	**Female expressed a stronger supportive attitude than male.**
	Level of education	P = 0.833	
	Frequency in greenspace	P = 0.631	
	Living environment	P = 0.317	
	Interest in trees	P = 0.925	
	Have heard of MFM or not	**P = 0.007**	**Respondents who had not previously heard of MF were more supportive of using MF than those who had previously heard of it.**
	Have visited or not	P = 0.501	
Q11 Would you visit a Miyawaki forest if there was one in your local area?	Age	P = 0.355	
	Gender	P = 0.302	
	Level of education	P = 0.275	
	Frequency in greenspace	**P = 0.039**	**Respondents who visited greenspaces more frequently were more likely to visit a MF near their neighbours.**
	Living environment	P = 0.340	
	Interest in trees	**P<0.001**	**Respondents who expressed a strong interest in trees being more likely to visit a MF near their neighbours.**
	Have heard of MFM or not	**P = 0.036**	**Respondents who had not previously heard of/ visited MF were more likely to visit a MF near their neighbours.**
	Have visited or not	**P = 0.050**	

Q16 Would you be in favour of using the Miyawaki Forest method to plant a forest rather than using the Conventional Forest method in your area?	Age	P = 0.356	
	Gender	**P = 0.007**	**Females were more likely to prefer the MFM to plant forests over CFM than males.**
	Level of education	P = 0.483	
	Frequency in greenspace	P = 0.251	
	Living environment	P = 0.368	
	Interest in trees	P = 0.961	
	Have heard of MFM or not	**P = 0.005**	**Respondents who had not previously heard of MF were more supportive of its use than CF to plant forests compared to those who had previously heard of it.**
	Visited or not	P = 0.627	

5.4.1 Support for the use of the MFM compared to CFM

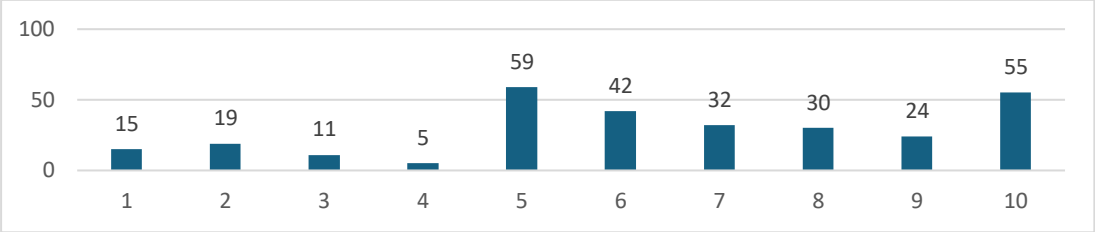
In terms of the extent to which respondents would support using the MFM, respondents were generally in favour of the use of MFM (mean = 7.57, Fig. 5.4.1), with 93 respondents (31.8%) rating their support as 10 out of 10. Gender (P = 0.004), and whether they have heard of it or not (P = 0.007), were very significant factors influencing a supportive attitude (Table 5.4.2). Generally speaking, female respondents (mean = 8.08) expressed a stronger supportive attitude than male respondents (mean = 7.07), as well as those respondents who preferred not to report their gender (mean = 6.64). Interestingly, the respondents who had not previously heard of MF (mean = 7.84) were more supportive of using MF than those who had previously heard of it (mean = 6.84).

Figure 5.4.1 To what extent would you support using the Miyawaki Forest method to plant a forest in your area (1 = not at all supportive, 10 = very supportive)?



When comparing to CFM in the question: '*Would you be in favour of using the Miyawaki Forest method to plant a forest rather than using the Conventional Forest method in your area?*', respondents were more in favour of using MFM than CFM to plant forests (mean = 6.45, Fig. 5.4.2). Again, gender (P = 0.007) and whether they had heard of it or not (P=0.005) were very significant factors. Females (mean = 6.88) were more likely to prefer the MFM to plant forests over CFM than males (mean = 6.08), and much higher than respondents who preferred not to report their gender (mean = 5.14). Similarly, respondents who had not previously heard of MF (mean = 6.71) were more supportive of its use than CF to plant forests compared to those who had previously heard of it (mean = 5.73).

Figure 5.4.2 Would you be in favour of using the Miyawaki Forest method to plant a forest rather than using the Conventional Forest method in your area (1 = not at all in favour, 10 = greatly in favour)?



5.4.1.1 Respondents in support of the use of the MFM

Respondents (n = 265) provided additional information to elaborate on their earlier responses. Overall, 79.8% of respondents expressed support for the use of the MFM, while the rest of the respondents did not support its use. Among those who supported it, several key themes emerged regarding the perceived advantages of the method from the respondents. 17 respondents expressed general support for more tree planting across the UK.

> *'We urgently need to plant a lot more trees across the UK (MA-55-64-F-D-URB-10-MY-226)'*
>
> *'Any means of planting trees is good.' (BA-65+-M-D-RUR-10-MN-138)*

Firstly, about 41 respondents believed that the potential for rapid establishment is a key reason for supporting the use of the MFM. They valued the method's ability to create densely planted, fast-growing green spaces, with one respondent noting that *'… having a nearly instant forest which does not take a long time to fully establish is a good thing. (GAV-55-64-F-D-URB-10-MN-123).*' This theme was particularly evident among respondents who emphasised the urgency of addressing environmental and urban challenges. For instance, one respondent stated that:

> *'[It is] important to obtain a quick result in some towns and cities.' (MA-65+-M-W-SUB-10-MN-9)*

While others highlighted the method's potential contributions to climate action:

> *'We need quick results for carbon capture' (MA-65+-F-D-SUB-9-MN-41)*
>
> *'We need trees that grow quick to help with climate change' (BA-65+-F-W-SUB-10-MN-51)*

Secondly, 35 respondents reported being intrigued by the method but indicated a desire for further information and clarification, in terms of better understanding of how the method has been tested in the UK, its potential to support native biodiversity, and its anticipated short- and long-term impacts, etc.

> *'I would require more information before committing, but in theory this is appealing.' (BA-55-64-M-D-RUR-10-MN-164)*
>
> *'… Would be worth trying on an experimental basis first.' (GAV-65+-F-W-SUB-10-MN-18)*
>
> *'I would need to know … particularly how it would benefit native wildlife.' (BA-55-64-F-W-URB-10-MN-69)*

'I would want more information about the short- and long-term impact…' (MA-45-54-F-W-URB-8-MN-67)

Thirdly, 16 respondents supported the use of MFM due to its perceived benefits, including ecological contributions and biodiversity, climate change mitigation, human well-being, and the provision of ecosystem services.

'It has good ecological value' (MA-18-34-F-W-URB-8-MN-96)

'…[It] is good to help combat climate change and would be very beneficial for the local population in terms of mental health …' (MA-45-54-F-D-SUB-10-MN-203)

'It should provide a good habitat for wildlife quickly.' (MA-65+-M-D-SUB-9-MN-166)

'It sounds like a cheaper and more efficient way of achieving a green space with the potential of providing a healthy habitat for various ecosystems, …' (BA-18-34-M-W-SUB-10-MN-95)

In addition, there were 11 respondents who expressed their interest in the method and thought it was worth trying.

'I think it is very interesting. People have more opportunities to get closed to the nature and know their native tree species. It also enriches their outdoor activities.'(MA-18-34-F-D-URB-10-MN-110)

Finally, 10 respondents highlighted that the appropriateness of the location chosen as a key factor influenced their support for the use of the MFM.

'In the right location, i.e., amenity grassland, they can be a very worthwhile addition.' (MA-35-44-F-W-URB-2-MY-287)

5.4.1.2 Respondents in support of the use of the CFM

20.2% of respondents expressed support for the use of the CFM, primarily because *'it is what is familiar to me.' (GAV-55-64-F-D-URB-10-MN-123)* and they perceived that *'Conventional forestry is likely to deliver and economic return from timber and other, non-forestry uses of the site (Forest schools, shooting, recreation, etc.). Miyawaki projects will likely not deliver this.' (MA-18-34-M-W-URB-10-MY-258)* difficult to access

In contrast to what some respondents perceived as the high-density planting and limited accessibility of MFs, 12 respondents cited the more open and easily accessible CFs as a key reason for their support for their use.

'The forest [CF] would not be as densely planted and would be more accessible.' (GAV-65+-F-W-URB-8-MN-34)

'Density of the woodland may not be conducive with being able to walk through it easily.' (GAV-55-64-F-D-SUB-10-MY-200)

'Miyawaki forests are not accessible.' (MA-45-54-M-D-RUR-10-MY-163)

In line with the above concern, respondents were also unsure about the efficiency of the MFM's dense planting configuration, particularly in terms of resource efficiency and residents' experiences.

'Not sure whether *dense planting would work everywhere.' (BA-65+-F-D-URB-7-MN-39)*

'… but it may be too dense to walk into and experience.' (MA-18-34-F-W-URB-8-MN-96)

'Seems like a waste of saplings as the spacing seems to me to be unnecessarily dense …' (MA-55-64-F-W-URB-10-MN-217)

There were also some potential concerns about MFM raised by respondents that show why they support the use of the CFM instead. Early-stage maintenance and initial costs of MFM were critical issues for the respondents to support the use of CFM. This issue was raised by eight respondents.

'It may require too much looking after in the first few years since labour is expensive.' (BA-65+-F-D-SUB-9-MN-42)

'I think initial cost is prohibitive.' (MA-55-64-M-D-RUR-3-MY-288)

Specific potential challenges such as weed control in fertile soils and competition in the early stages of establishment were also mentioned:

'… however, the management within the first three years would be very involved due to high fertility soils encouraging dominating weed species to take over and out shade the seedlings and saplings.' (BA-18-34-F-M-URB-5-MN-102)

In addition, a small number of respondents (n = 7) expressed scepticism regarding the rapid growth associated with the MFM. While quick establishment is often promoted as a strength of the method, these respondents worried it might compromise long-term ecological resilience and sustainability, which was another reason for their support of the use of CFM.

'… quick results don't often go hand in hand with good quality.' (BA-18-34-M-W-SUB-10-MN-95)

'… but I would be dubious with how sustainable it is in the long run when it's executed so quickly in comparison to conventional forestry.' (BA-18-34-M-W-SUB-10-MN-95)

'… worried that fast-growing will lead to the simplification of local ecosystems, thus affecting the resilience of ecosystems after disasters.' (MA-18-34-F-W-URB-4-MY-128)

'If the trees mature more quickly, how do they cope with strong winds - we have lots of problems with stronger storms as a result of climate change across the UK. ' (MA-45-54-F-W-SUB-8-MN-282)

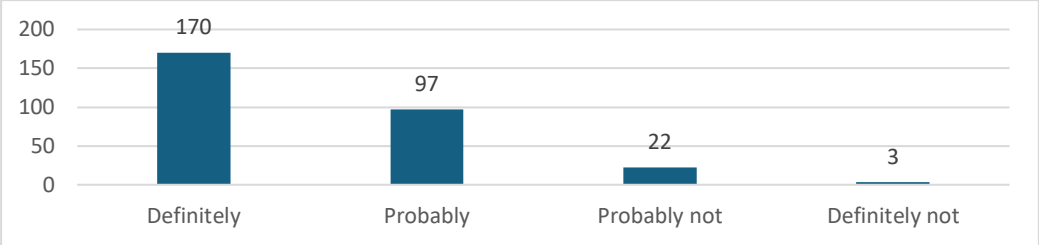
Finally, two respondents raised the issue of space requirements for ground flora and other organisms, suggesting that the more spaced layout of CFM may provide better conditions for diverse understorey development:

'… greater ground space between trees will provide more space for ground flora.' (BA-18-34-F-D-SUB-10-MY-284)

5.4.2 Willingness to visit a Miyawaki forest

A substantial proportion of respondents (91.4%, n = 267) indicated that they would "definitely" (58.2%) or "probably" (33.2%) visit a MF if there was one in their local area (Fig. 5.4.3). This high level of interest suggested a more open public receptivity towards the use of MFM in the UK. Frequency in greenspace ($P = 0.036$), interest in trees ($P < 0.001$), have heard of it or not ($P = 0.036$), and have visited it or not ($P = 0.050$) were very significant factors in this regard.

Figure 5.4.3 Would you visit a Miyawaki forest if there was one in your local area?



Respondents who frequently visited greenspaces were more likely to express a willingness to visit a nearby MF. A similar trend was observed with regard to interest in trees, i.e., those with greater interest would be more inclined to visit an MF. Prior awareness of the MFM also played a role: 67.1% of those who had previously heard of the MF expressed a definite willingness to visit, compared to 54.9% among those without such knowledge. A similar trend was observed regarding previous visitations to MF, with 76.9% of those who had visited an MF before expressing a strong willingness to visit again.

To further understand the motivations and concerns that influenced non-professionals' interest and willingness to visit an MF, 142 participants provided further responses to the question: *Would you visit a Miyawaki Forest if there was one in your local area?*

26 respondents explained that their interest stemmed from a general interest in trees, nature, and walking in greenspaces, which naturally extended to interest in MFs.

> *'Forests can be so interesting … people enjoy for recreation, so these forests [MFs] could provide a similar recreational space and help people relax and connect with nature.' (BA-45-54-F-W-URB-9-MN-29)*
>
> *'I like to walk through woodlands and practise my identification skills, enjoy nature - they are where I go to unwind.' (MA-18-34-F-D-RUR-10-MY-240)*

Apart from that, the most prominent motivation, cited by 60 respondents, was pure curiosity or professional/personal interest in the method itself. These respondents were keen to observe its look, development, management, and the ecological outcomes of MFs, which could further their knowledge and understanding.

> *'Because I'm curious and open to new methods of tree planting.' (MA-35-44-F-D-SUB-10-MY-44)*
>
> *'I would be interested to see what it looks like and how it is managed.' (BA-45-54-M-D-SUB-10-MN-26)*
>
> *'To observe the growth of tree species and the benefits for biodiversity.' (MA-18-34-F-W-URB-8-MN-97)*
>
> *'I enjoy being in nature, I would visit to see how well it was establishing and what works and doesn't, so out of professional interest too…' (MA-55-64-F-W-URB-9-MY-145)*

In addition, a small group (n = 5) indicated willingness, depending on certain conditions, such as distance and accessibility.

> *'If it's in walking distance and accessible to the public.' (BA-55-64-M-D-URB-10-MY-33)*

'If there were clear walking pathways through the forest.' (GAV-65+-F-W-URB-8-MN-34)

Conversely, 25 respondents indicated that they would not be willing to visit an MF. Their concerns focused primarily on the dense planting structure of MFs, which some associated with a lack of accessibility, reduced human-friendliness, and feelings of insecurity.

'… too dense trees can also give me a feeling of insecurity.' (MA-18-34-M-W-SUB-9-MN-100)

'The fact that they are densely packed makes them less human-friendly and more wildlife-friendly. I see these forests as a measure in our fight against climate change not as a green space for humans to enjoy.' (BA-45-54-F-W-SUB-10-MY-71)

Other respondents also questioned the recreational value of MFs, citing their even-aged structure and limited amenity potential.

'Not as interesting as mature forests as they will be all equal age.' (MA-55-64-M-D-SUB-10-MN-77)

5.5 Perceived suitability of the Miyawaki method and potential locations for planting Miyawaki Forests in the UK

Table 5.5.1 Summary table for research question 2.1 and questionnaire integration

Research questions	Themes	Indicators (questions in the questionnaire)
RQ 2.1 What are non-professionals attitudes towards the MFM and CFM, and how do they compare to their perceptions of the CFM?	5.5 Perceived suitability of the Miyawaki method and potential locations for planting Miyawaki Forests in the UK	**Q18** Do you agree that the Miyawaki Forest could be a suitable tree planting method in the UK?
		Q20 In the following areas, where do you think the Miyawaki forest planting would be suitable in the UK?
		Q22 Which of the following specific locations do you think Miyawaki forest planting would be suitable?

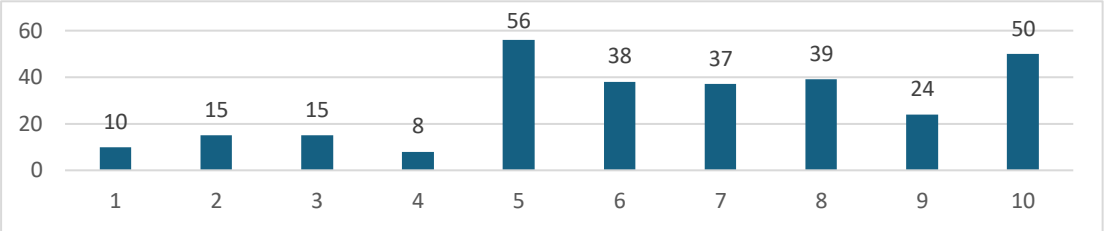
5.5.1 Perceived suitability of the MFM as a tree planting method in the UK

Generally speaking, according to the mean value, respondents agreed that MFM was considered a relatively suitable tree planting method in the UK context (mean = 6.55, Fig. 5.5.1). Data from this question (Q18) was analysed using one-way ANOVA and Spearman's bivariate correlation. All associated demographic factors were independent of suitability (Table 5.5.2), which means that no significant associations were found between respondents' demographic characteristics and their perceptions of the MFM's suitability as a tree planting approach in the UK.

Table 5.5.2 Summary of factors affecting responses at a significant level (level of probability P) and trends for that factor.

Question	Factor	P value
Q18 Do you agree that the Miyawaki Forest could be a suitable tree planting method in the UK?	Age	P = 0.202
	Gender	P = 0.304
	Level of education	P = 0.092
	Frequency in greenspace	P = 0.122
	Living environment	P = 0.928
	Interest in trees	P = 0.416
	Have heard of it or not	P = 0.627
	Visited or not	P = 0.171

Figure 5.5.1 Do you agree that the Miyawaki Forest could be a suitable tree planting method in the UK (1 = do not agree, 10 = strongly agree)?



Among the respondents who believed the MFM could be a suitable tree planting method for the UK, several key themes emerged (n = 252). These centred around compatibility with UK climate conditions, species selection, specific areas where space is limited, successful examples, and the speed of growth and establishment.

33 respondents suggested that the climate in the UK shares similarities with Japan, making it potentially compatible with the conditions required for successful application of the MFM. As respondents noted: *'If it works in the temperate climate of Japan, I see no reason why it wouldn't work here in the UK.' (BA-35-44-M-W-URB-9-MY-256).* An additional five respondents specifically highlighted the UK's temperate maritime climate as conducive to MFM: *'in the UK you get a lot of rain, with good soil that method would work perfectly.' (BA-18-34-M-W-SUB-8-MN-103)*.

Six respondents emphasised that the MFM could be suitable for the UK as long as appropriate native tree species were selected.

> *'Provided suitable native trees for the Miyawaki method were chosen…' (GAV-65+-F-D-SUB-10-MY-150)*

Seven respondents believed the method could be suitable particularly in areas with limited space, primarily urban environments, as *'planting lots of different species densely in places where space is at a premium, like cities, has to be a good idea!' (MA-45-54-M-W-URB-10-MY-81)*. Additionally, five respondents cited examples in the Netherlands and elsewhere as supporting evidence for the method's applicability in the UK:

> *'I think I've read some information about it being used in the Netherlands and it was successful.' (MA-55-64-F-W-URB-9-MY-145)*

'Evidence from Japan and Netherlands suggests it will work here.' (MA-35-44-F-W-URB-2-MY-287)

Twelve respondents valued the perceived ability to deliver rapid results through the MFM, particularly in light of the climate crisis. These respondents expressed its capacity to accelerate forest establishment and biodiversity outcomes:

'It's a way of planting more trees to mature quickly, which is essential in the current climate crisis.' (MA-55-64-F-D-SUB-10-MY-179)

'It has the potential to create biodiverse habitats faster than other methods…' (MA-55-64-M-D-URB-10-MN-59)

Conversely, respondents who were sceptical of the MFM's suitability for the UK offered a range of concerns. The most frequently cited issue was the lack of robust evidence supporting the method's long-term success in the UK context (n = 39). Respondents highlighted the need for further research, particularly considering climate change and species resilience:

'[I would need to see more research] to be able to assess its suitability especially with climate change meaning that some native species will not offer a long-term sustainable option.' (GAV-45-54-M-D-RUR-10-MN-5)

'I don't think there has been enough research done to see if this method works … But that being said I personally think it is possible when the right species are planted.' (BA-18-34-F-D-SUB-10-MY-284)

Nine respondents questioned whether MFM could cope with specific regional climate conditions, particularly in harsher areas in the UK.

'I live in the northwest which has a quite harsh climate in winter. We suffer some loss … so I am unsure whether the Miyawaki method would work unless the trees were very hardy.' (GAV-55-64-F-D-URB-10-MN-123)

Seven respondents were concerned that the rapid growth associated with the MFM might compromise forest health or ecological resilience:

'I am not convinced it will produce a healthy strong woodland…' (GAV-65+-M-D-SUB-10-MY-21)

'… a dense, single aged stand could be great for short-term carbon uptake but not too resilient.' (MA-45-54-F-D-URB-10-MN-221)

Finally, four respondents raised concerns about high mortality rates and the economic inefficiency of the method:

'… we are paying for trees that will soon die due to competition.' (MA-55-64-M-D-RUR-3-MY-288)

5.5.2 Potential places for planting MFs in the UK?

Table 5.5.3 Summary of factors affecting responses at a significant level (level of probability P) and trends for that factor.

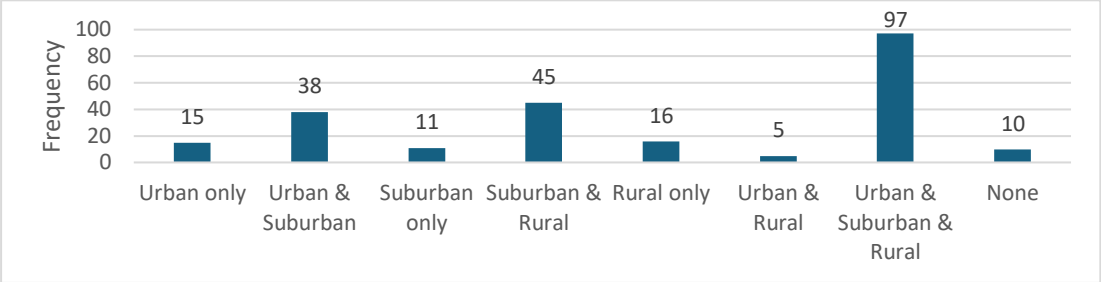
Question	Factor	P value	Trend / relationship within the factor group
Q20 In the following areas, where do you think Miyawaki forest planting would be suitable in the UK?	Age	P = 0.240	
	Gender	**P = 0.002**	**The majority of both male and female respondents considered urban, suburban, and rural areas to be suitable for MFM. However, female respondents were more likely to support the suitability of the MFM in suburban and rural areas, whereas male respondents showed stronger support for its suitability in urban and suburban areas.**
	Level of education	P = 0.279	
	Frequency in greenspace	P = 0.428	
	Living environment	P = 0.851	
	Interest in trees	P = 0.404	
	Have heard of it or not	**P < 0.001**	**Respondents who had not previously heard of MF expressed higher levels of support for its suitability across urban, suburban, and rural contexts.**
	Have visited or not	P = 0.122	

The majority of respondents (33.2%) agreed that the MFM is a suitable tree-planting method for urban, suburban, and rural areas (Fig. 5.5.2). Responses to this question (Q20) were analysed, using Pearson's Chi-squared test in crosstabulation, one-way ANOVA with Tukey HSD post-hoc and Cochran's Q test analysis, to assess differences between urban and rural contexts and across different factors. Gender (P = 0.002) and have heard of it (P < 0.001) were highly significant factors influencing perceptions of suitability across different areas (Table 5.5.3).

Among male respondents, 38.3% considered urban, suburban, and rural areas to all be suitable for Miyawaki forest planting, while 16.8% indicated that only urban and suburban areas were appropriate. In comparison, 44.6% of female respondents supported the suitability of all three areas, while 24.8% favoured suburban and rural areas only.

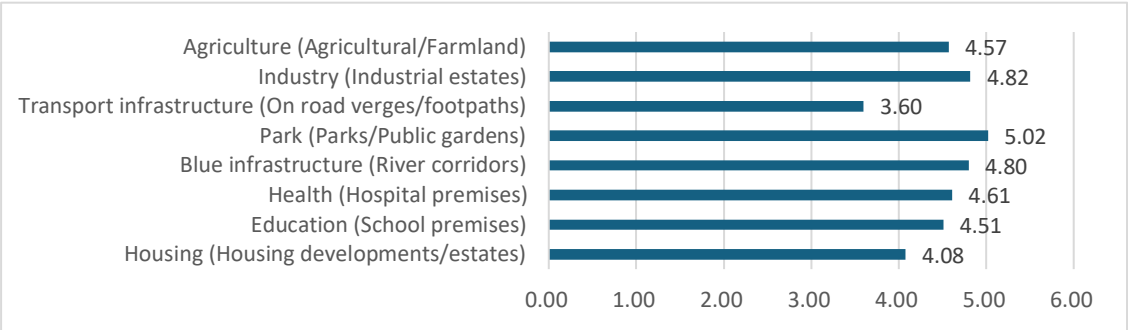
A similar pattern was observed with respect to prior awareness of the MFM. Among those who had previously heard of the method, 51.5% identified urban, suburban, and rural areas as suitable for Miyawaki forest planting, while 25.0% identified just urban and suburban areas. Conversely, only 36.7% of those who had not heard of MF considered all three areas suitable, while 26.6% supported its use solely in suburban and rural areas.

Figure 5.5.2 In the following areas, where do you think Miyawaki forest planting would be suitable in the UK?



Respondents were subsequently provided with a selection of specific site types and asked for their perceptions of the suitability of these sites for planting Miyawaki forests (Q22). A related samples Friedman's two-way analysis of variance by ranks was conducted for this question. In most cases, respondents selected either the 'suitable to some extent' or 'very suitable' options. Overall, park (parks/public gardens), industry (industrial estates), and blue infrastructure (river corridors) were considered the most suitable locations, while transport infrastructure (on road verges/footpaths) and housing were rated as the least suitable. The remaining three locations were perceived as moderately suitable ($P < 0.001$, Fig. 5.5.3).

Figure 5.5.3 Which of the following specific locations do you think Miyawaki forest planting would be suitable (by ranking from 1, least suitable to 8, most suitable)?



Additionally, respondents were also encouraged to provide any other locations that they thought were suitable for MF (n = 136; Table 5.5.4).

Table 5.5.4 Summary table of potential locations for planting Miyawaki forest (in no particular order, places highlighted in red were mentioned more than once)

Other potential locations for MF tree planting	
Category	Detailed information
Brownfields	Brownfields
	Industrial wasteland
	Opencast mining sites
	Contaminated land
	Post-operation landfill site
	Waste ground
Abandoned places	Derelict and vacant land
	Over disused refuge tips

Cemeteries	Churchyards
	Burial sites
	Graveyard edges
	Public cemeteries and memorial grounds
Moorland	Moorland bordering on arable
	Denuded moorland
Countryside	Rural uplands
	Open countryside
	Hill and mountain sides
Remote areas	National parks
	Nature reserves
Commercial areas/retail	Shopping centres
	Individual large business sites
Government sites	MOD barracks
	Military ranges
Heritage site	National Trust Land
Near the airports	
Golf course edges	
Sports grounds	
Unused small pockets	

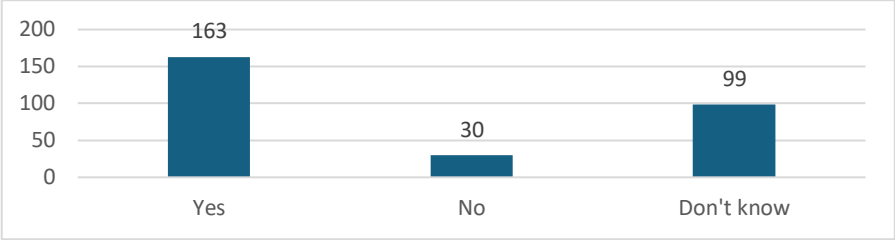
5.6 Perceived potential problems with the MFM's application in the UK

Table 5.6.1 Summary table for research question 2.1 and questionnaire integration

Research questions	**Themes**	**Indicators (questions in the questionnaire)**
RQ 2.1 What are non-professionals attitudes towards the MFM and CFM, and how do they compare to their perceptions of the CFM?	5.6 Perceived potential problems with the Miyawaki Forest method	**Q21** Do you think there are any potential problems with planting in these areas?

Of the 292 questionnaire respondents, 163 (55.8%) indicated that they perceived there to be potential challenges associated with implementing the MFM in the UK. In contrast, 10.3% reported no concerns, while 33.9% were uncertain (Fig. 5.6.1).

Figure 5.6.1 Do you think there are any potential problems with planting in the UK?



Respondents perceived many potential problems, as listed below (n = 195), including vandalism, environment, competition and conflict, maintenance, and social issues, amongst others (Table 5.6.2).

Table 5.6.2 Summary of perceived potential problems with Miyawaki forest (in no particular order, problems highlighted in red were mentioned more than once)

Question	Category	Detailed information	Quote
Do you think there are any potential problems with Miyawaki planting in the UK?	Antisocial behaviour (9/195)	Fly tipping	'Antisocial behaviour due to lack of understanding, particularly in urban areas.'
	Vandalism (22/195)		'In built-up urban areas, this could invite vandalism.'
	Safety		'People may worry about feeling safe whilst walking in densely planted areas.'
	Damage by animals	Animals damage to saplings (rural)	'In very rural areas, the young saplings may require protection from browsing animals.'
	Ecological consequences (24/195)	Disease (5/195)	
		Drought and fire risk (4/195)	'Likelihood of drought and possibility of arson.'
		Pollution	
		Quality and durability of trees	'Rapid growth resulting in weaker trees.'
		Harsher growing conditions (urban)	

		Impoverished ground flora	
		Detrimental to the wildlife habitats	
		Watering	
	Costs (5/195)	Soil preparation might be more expensive	'The soil preparation sounds more complicated and probably a lot more expensive.'
		Labor-intensive and more expensive	
	Competition and conflict (21/195)	Competition of land use (10/195)	'Conflict with other land uses such as growing food or other biodiversity/rewilding objectives.'
		Competition from housing (5/195)	'Space in the city centre, land is more likely to be used to build flats.'
		Competition from leisure	'But areas for playing and sport are needed too.'
		conflict with infrastructure	
	Maintenance (21/195)	Poor management	
		Effective maintenance of leaf fall in urban areas	
		Lack of maintenance	'No designated volunteers/organization to monitor the planting or carry out the maintenance.'
	Undesirable social impacts (15/195)	Community apathy	
		Lack of support from community/public	'[Its] success would rely on community support.'
		Likelihood of poor public awareness	

		Public access (5/195)	'Closely planted trees will inhibit human visitors if there are no paths.'
	Others	Finding suitable land for planting trees (18/195)	
		Landowners' willingness (6/195)	
		Landownership and planning permission (5/195)	
		Overcoming the entrenched ideas of forestry experts (number?)	
		Too wild (urban) (number?)	'Possible perception that in an urban situation it might feel too wild/unmanaged. People can be a bit scared/worried by trees that grow 'too big' next to (their) houses!'
		Interconnections with neighbouring habitats (urban and suburban areas) (number?)	
		Nuisance issues (such as shade, encroachment into people's gardens) (number?)	

5.7 Perceived potential environmental benefits of MFM and CFM

Table 5.7.1 Summary table for research question 2.1 and questionnaire integration

Research questions	Themes	Indicators (questions in the questionnaire)
RQ 2.1 What are non-professionals attitudes towards the MFM and CFM, and how do they compare to their perceptions of the CFM?	5.7 Potential environmental benefits of Miyawaki forest planting, and comparison with the Conventional Forest method	**Q24** To what extent do you think the Miyawaki forest planting could help mitigate the following aspects.
		Q26 To what extent do you think the Conventional forest planting could help mitigate the following aspects.

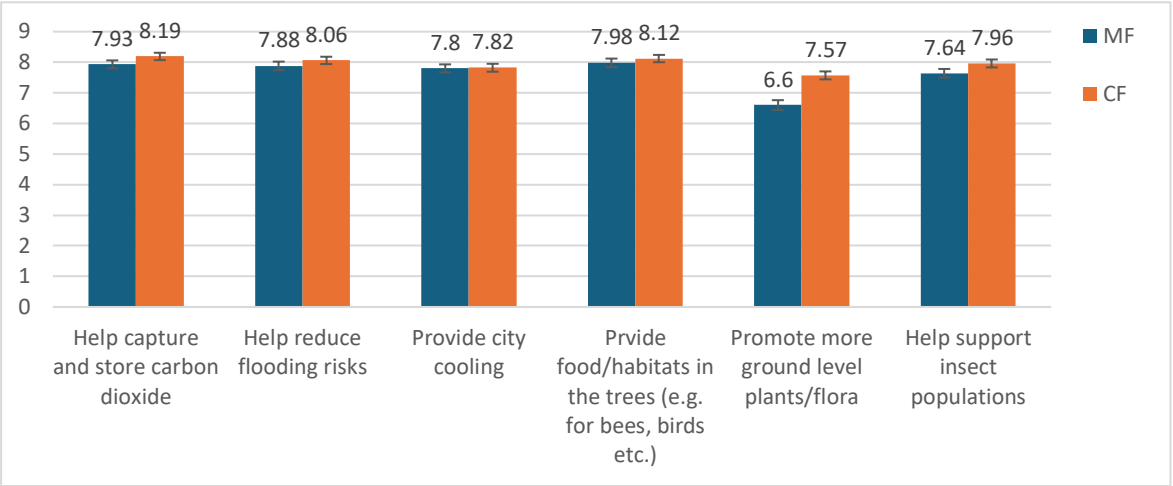
Table 5.7.2 Summary of factors affecting responses at a significant level (level of probability P) and trends for that factor.

Question	Factor	P value	Trend / relationship within the factor group
Q24 and Q26 To what extent do you think Miyawaki forest planting or Conventional mixed forest planting could help mitigate the following aspects.	**Provide more ground level plants/flora?**	**P < 0.001**	**Respondents perceived the CFM to be significantly more beneficial for promoting ground-level plants/flora diversity and supporting insect populations compared to CFM.**
	Help support insect populations?	**P = 0.019**	

A comparison of responses to Q24 and Q26 allowed the perceived effectiveness of the MFM and the CFM in addressing various environmental challenges to be assessed, including carbon capture and storage, flood risk reduction, urban cooling, and biodiversity enhancement (tree, ground flora, and insect population diversity). Respondents rated the extent to which each method contributed to these aspects, and mean values were compared for MFM and CFM. To determine the statistical significance of these differences, a repeated measures ANOVA was conducted. The results indicate that the CFM was generally perceived as more effective than the MFM across all six categories (Fig. 5.7.1), suggesting that respondents viewed the CFM as superior in its ability to improve environmental conditions.

Specifically, respondents perceived the CFM to be significantly more beneficial for promoting ground-level plants/flora diversity ($P < 0.001$, Table 5.7.2, Fig. 5.7.1) and supporting insect populations ($P = 0.019$) than the MFM. However, differences in perceptions of carbon sequestration, flood risk reduction, urban cooling, and habitat provision were not statistically significant, although the CFM received slightly higher ratings than the MFM in these categories (Fig. 5.7.1). These findings suggest that respondents recognized comparable potential between the MFM and CFM in terms of carbon storage, urban cooling, and hydrological benefits. The lowest perceived effectiveness of the MFM in supporting ground flora diversity may be attributed to its dense tree canopy, which limits light penetration and subsequently reduces understory vegetation establishment.

Figure 5.7.1 To what extent do you think these methods (MFM and CFM) could help mitigate the following aspects (mean value)



Respondents further elaborated upon the reasons behind their ratings for each category, providing detailed justifications for their perceptions of the environmental benefits of the MFM (n = 198) and CFM (n = 185). These responses are summarised in Table 5.7.3, which presents the key themes identified.

Table 5.7.3 Respondents' perceptions of the reasons for supporting the environmental benefits of MF and CF (in no particular order, places highlighted in red were mentioned more than once)

Category	Reason	
	MF	CF
Capture and store carbon dioxide	The high density would be good for carbon sequestration.	More space between the trees, less carbon capture.
	If the trees grow quickly then they will sequester carbon rapidly.	
Reduce flooding risk	More dense complex vegetation will help water capture.	N/A
	Flood risk is reduced where planting replaces porous surfaces.	
	Close proximity planting and quick canopy cover will help secure riverbanks and increase in interception to prevent floods.	
City cooling	A mixed variety of trees will provide a cooling canopy.	Forest at reduced density could allow larger trees that would provide more shade and cooling effect.
	City planning and economics does not allow enough room for trees to provide cooling.	
Food/habitats in the trees (e.g., for bees, birds, etc.)	A mixed variety of trees will provide habitat opportunity.	

Category	Reason	
	MF	CF
Ground level plants/flora diversity	Close planting would crowd out most ground level plants and flora (27).	Traditional planting allows for open spaces and increased diversity of ground flora (11).
Insect populations diversity	The canopy might inhibit insect populations (4).	More select/specific for certain insects.
Other	All tree planting will provide these benefits (22).	Conventional planting provides a limited number of species.
	Encourage fungal networks.	Take longer to become established (15).
	Tree planting is more likely to damage existing habitats, rather than increasing biodiversity.	

5.8 Tree species selection for the MFM and CFM in the UK

Table 5.8.1 Summary table for research question 2.2 and 2.3 and questionnaire integration

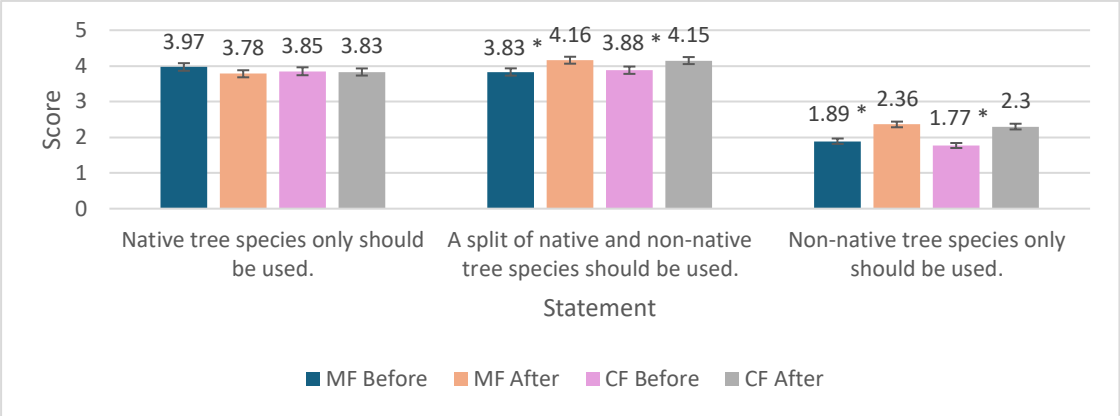
Research questions	**Themes**	**Indicators (questions in the questionnaire)**
RQ2.2 What are the non-professionals' attitudes towards the prioritisation of planting native species in the Miyawaki forest in the UK? To what extent do they perceive native species as being suitable, and what role do they believe non-native species should play? RQ2.3 Are non-professionals perspectives on species selection for Miyawaki forests evolving in response to climate change?	5.8 Tree species for Miyawaki forest planting, and comparison with the Conventional Forest method	**Q28** Do you agree with the following statements: Native tree species only should be used in the Miyawaki Forest method. A split of native and non-native tree species should be used in the Miyawaki Forest method. Non-native tree species only should be used in the Miyawaki Forest method. Native tree species only should be used in the Conventional Forest method. A split of native and non-native tree species should be used in the Conventional Forest method. Non-native tree species only should be used in the Conventional Forest method. **Q30** In light of rising temperatures, do you agree with the above statements?

Repeated measures ANOVAs and paired sample t-tests were conducted to compare responses to Q28 and Q30, examining respondents' perceptions of NT and NNT. Before receiving information on climate change (see questionnaire in Appendix 3), respondents generally believed the use of either exclusively native trees or a mix of native and non-native trees in both MF and CF settings, as these options consistently received higher ratings compared to the use of non-native species only (Fig. 5.8.1).

After respondents were provided with information on climate change—highlighting potential reasons for incorporating NNT due to their assumed adaptability to future UK climatic conditions—

there was a slight decrease in support for native species alone (in both MF and CF), but an increase in support for mixed planting strategies (in both MF* [P < 0.001] and CF* [P < 0.001], Fig. 5.8.1). Additionally, support for the exclusive use of NNT increased significantly for both MF* (P < 0.001) and CF* (P < 0.001) after the climate change information was disclosed (Fig. 5.8.1).

Figure 5.8.1. Do you agree with the following statements (before and after respondents had been told climate change-related information)



Nevertheless, when climate change was taken into consideration, respondents were more likely to support the use of a mix of NT and NNT species in MF, rather than NT species alone, although NT species remained the preferred choice, as reflected in the respondents' detailed answers (n = 184). After being informed about the potential impacts of climate change, their detailed reasons toward NT and/or NNT did not change (n = 146), with the majority of responses (Q31) remaining consistent with their previous responses (Q29). However, notable resistance persisted regarding the exclusive use of NNT species. Respondents suggested that the inclusion of selected European species could be considered in the species selection. The detailed reasons underpinning these preferences are summarised in Table 5.8.2 (n = 330).

Table 5.8.2. Professionals' perceptions of native and non-native tree species' selection (in no particular order, places highlighted in red were mentioned more than once)

Statements	**Category/Reason**
Native tree species only (65)	Native trees best suit the UK climate.
	More beneficial to native wildlife (27).
	Native is best (35).
	Planting more native trees could slow down/combat the increase in temperature.
	Trees have the ability to adapt to climate changes.
The use of non-native tree species and reasons (i.e., a mix	Mix will better support resilience to climate and diseases (19).
	Due to advancing northerly climate movement so will species move with it.
	It adds to the interest and diversity of a forest.
	Climate change forces us to look to new tree species .
	A mix of trees is always going to be a healthier forest.

of NT and NNT) (76)	The number of native trees in the UK is too small to rely upon entirely.
	Using resilient and non-invasive non-native replacement trees to sustain fuller biodiversity.
Non-native tree species only (14)	Upset ecological balance (4).
	Issue of pests and diseases.
Other (40)	With the need for species diversity with a warming climate, we have to accept that we will need diversity.
	The best strategy should be to plant more trees.
	Non-native species are needed to survive climate change, but native species are still culturally important.
	Depends on locations/areas (12).
	A small percentage of proven non- natives in a species mix.

5.9 How do the non-professionals' attitudes differ from those held by professionals

Finally, to answer RQ 2.4, an independent t-test was conducted to compare responses to identical or similar questions across both questionnaires, allowing for an assessment of differences in perceptions between experts and professionals and the non-professionals. Significant differences exist between professionals and non-professionals. Professionals rated MFM as more suitable for the UK (7.27 vs 6.55) and perceived more potential problems (73% vs 56%). Moreover, professionals perceived MFM as more suitable specifically for urban areas than the non-professionals did. In contrast, non-professionals rated CFM more highly across all environmental benefit categories whereas the professionals held the opposite view. Non-professionals also showed stronger preferences for native-only species. These perceptual differences are further explored and critically discussed in Chapter 7.

Table 5.9.1 Comparison of responses to same/similar questions on perceptions of experts/professional and the non-professionals.

Questionnaire 1 (Experts and professionals)	**Questionnaire 2 (Non-professionals)**	**P value**	**Findings**
Q11	Q16	P = 0.351	Both experts and professionals (mean = 6.70) and non-professionals (mean = 6.45) were more supportive of the use of MF to plant a forest rather than CF.
Q13	**Q18**	**P = 0.004**	**Experts and professionals (mean = 7.27) agreed more than the non-professionals (mean = 6.55) that MFM is a suitable tree-planting method in the UK.**
Q15 (Urban)	**Q20 (Urban)**	**P = 0.03**	**Experts and professionals thought that Miyawaki forest planting is more suitable in urban areas than the non-professionals.**
Q15 (Suburban)	Q20 (Suburban)	P = 0.110	Both experts and professionals and the non-professionals thought that Miyawaki forest planting is suitable in suburban and rural areas.
Q15 (Rural)	Q20 (Rural)	P = 0.228	
Q17	**Q21**	**P = 0.000**	**There were more professionals (73.21%) who believed that MF has potential problems than the non-professionals (55.82%).**
Q18	Q22	n.s.	Both experts and professionals and the non-professionals similarly perceived that these locations are suitable for MF. Sorted from highest to lowest: parks/public gardens, industrial estates, river corridors, school

			premises, agricultural/farmland, hospital premises, housing development/estates, on road verge/ footpaths.
Q27 (carbon capture)	Q24(carbon capture)	P = 0.058	Both experts and professionals and the non-professionals similarly perceived that MF can help capture carbon.
Q27 (reduce flood risk)	**Q24 (reduce flood risk)**	**P = 0.003**	**Non-professionals thought MF would be more helpful than experts and professionals in flood risk reduction.**
Q27 (city cooling)	Q24 (city cooling)	P = 0.503	Both experts and professionals and the non-professionals similarly perceived that MF can help cool the city, and promote biodiversity in all aspects.
Q27 (tree biodiversity)	Q24 (habitat in the trees)	P = 0.233	
Q27 (ground flora diversity)	Q24 (ground level plants/flora)	P = 0.465	
Q27 (invertebrate diversity)	Q24 (insect populations)	P = 0.326	
Q29	**Q26**	**P < 0.001 in all six aspects**	**Non-professionals perceived that CF is more helpful in all aspects than experts and professionals.**
Q31 (MF NT only)	**Q28 (MF NT only)**	**P = 0.001**	**Non-professionals were more likely than experts and professionals agree that native tree species only should be used in the MF.**
Q31 (MF NT and NNT)	**Q28 (MF NT and NNT)**	**P = 0.005**	**Non-professionals were more likely than experts and professionals agree that a split of native and non-native tree species should be used in the MF.**
Q31 (MF NNT only)	**Q28 (MF NNT only)**	**P < 0.001**	**Non-professionals were more likely than experts and professionals agree that non-native tree species only should be used in the MF.**
Q31 (CF NT only)	**Q28 (CF NT only)**	**P = 0.028**	**Non-professionals were more likely than experts and professionals agree that native tree species only should be used in the CF.**
Q31 (CF NT and NNT)	Q28 (CF NT and NNT)	P = 0.49	Non-professionals, experts and professionals were in agreement that a split of native and non-native tree species should be used in the CF.

Q31 (CF NNT only)	Q28 (CF NNT only)	P = 0.163	Non-professionals, experts and professionals were in agreement that non-native tree species only should be used in the CF.
Q36 (MF NT only)	Q30 (MF NT only)	P = 0.118	Non-professionals, experts and professionals were in agreement that non-native tree species only should be used in the CF.
Q36 (MF NT and NNT)	**Q30 (MF NT and NNT)**	**P = 0.04**	**Non-professionals were more likely than experts and professionals agree that that a split of native and non-native tree species should be used in the MF.**
Q36 (MF NNT only)	**Q30 (MF NNT only)**	**P = 0.003**	**Non-professionals were more likely than experts and professionals agree that non-native tree species only should be used in the MF.**
Q36 (CF NT only)	Q30 (CF NT only)	P = 0.059	Non-professionals, experts and professionals were in agreement that native tree species only should be used in the CF.
Q36 (CF NT and NNT)	Q30 (CF NT and NNT)	P = 0.112	Non-professionals, experts and professionals were in agreement that a split of native and non-native tree species should be used in the CF.
Q36 (CF NNT only)	**Q30 (CF NNT only)**	**P = 0.049**	**Non-professionals were more likely than experts and professionals agree that non-native tree species only should be used in the CF.**

Ch. 6. Experiment findings

6.1 Introduction

This chapter addresses research question 3:

3. How do growth rates and survival rates of trees planted using the MFM compared to CFM in the UK?

3.1 Do Miyawaki forest saplings have a higher initial growth rates and thicker diameters compared to saplings planted in a Conventional forest?

3.2 Do Miyawaki forest saplings have a higher survival rate compared to saplings planted in a Conventional forest?

This chapter presents the experimental findings of the research, conducted on the Knowlesgate farm, Hope Valley in Sheffield. The site is owned by a private landowner and the experiment was designed to align with the site's specific conditions. The area was divided into three plots: plots 1 and 3 were planted using the CFM, while plot 2 followed the MFM (Fig. 3.3). Saplings were purchased from a nursery in Scotland and planted randomly across the designated plots by volunteers in November 2022. All selected saplings consisted of native species, as detailed in Table 3.2.

The hypotheses for the experiment were that saplings in the MF plots would exhibit faster height growth, greater stem diameter, and higher survival rates compared to those in the CF plots. This expectation was based on results from previous studies, mainly from Shubhendu Sharman, IVN and Wageningen university (their work in the Netherlands) and Earthwatch (their work in the UK), which reported that the dense planting and soil enrichment characteristic of the Miyawaki method can enhance competition for light, stimulate rapid vertical growth, thereby supporting better overall sapling performance and survival.

Data collection took place across five time points: 25.11.22, 08.06.23, 06.10.23, 29.05.24 and 15.05.2025. It should be noted that the same individual trees were not measured at each time point. Instead, data were collected from different representative subsets of saplings within each plot during each data collection period (similar random subsampling approaches are commonly employed in ecological and forestry studies). This approach was adopted due to the high planting density, the close spacing of individuals, and restricted accessibility within the plots, which made consistent tagging and tracking of individual trees impractical.

Measurements focused on key variables included growth rates, stem diameter and survival rates, facilitating a comparative analysis of the performance of the MFM (experimental plot) against the CFM (control plots). The analysis is structured according to the primary research questions, providing empirical evidence concerning the effectiveness of the MFM within this specific context. It should be noted that the results report only for the first two and half years after planting.

Between 2022 and 2025, Sheffield experienced generally warmer and drier conditions than the long-term average, with notable seasonal variability. Maximum temperatures were typically 1–3 °C above average, particularly in spring and summer, while winters remained relatively mild with few air frost days. These climate deviations may have influenced local soil moisture dynamics, subsequently influencing sapling growth and establishment processes observed during the study

period. A detailed summary of general weather conditions for 2022–2025 is provided in Appendix 9.

- Growth rate and diameters of the Miyawaki forest plot and comparison with Conventional forest plots (section 6.3).
- Survival rates of the Miyawaki forest plot and comparison with Conventional forest plots (6.4).

6.2 Introduction to the experimental site and data collection process

The experimental site is located at Knowlesgate, Hope Valley, Sheffield. Prior to planting, the three plots were clearly delineated to accommodate the two planting methods. Plot 2, designated for the MFM, covered approximately 600 m², while plots 1 and 3, assigned to the CFM, collectively spanned 550 m² (Fig. 6.2.1). The site is dominated by a combination of silty clay loam, clay loam, silty clay and clay soils. Notably, the terrain slopes, resulting in plot 3 being positioned much lower than plots 1 and 2, which subsequently created drainage challenges during the early phases of the project.

The control plots (1 and 3, using conventional tree planting method) were left in the natural state with minimal intervention to reflect conventional forestry practices. No soil preparation, digging, or mulching was undertaken, with existing soil structure and composition remained undisturbed. In addition, several pre-existing trees within the plots were retained, with a buffer zone established around them where no additional planting was carried out.

The CFM planting was established in two phases due to site-specific topographical challenges. Plot 1 was planted in November 2022 with selected native tree species. Tree tags were installed simultaneously for a sub-sample of saplings, to allow for individual monitoring. Owing to severe waterlogging caused by the sloped terrain in the lower area of the site (plot 3), planting was delayed. To address this, a drainage ditch was dug in January 2023, to alleviate standing water. Following this intervention, planting in plot 3 was completed in March 2023, with tree tags installed as well.

The CFM plots utilising conventional forestry spacing of one sapling every spaced at 2 m apart, with a total of 200 saplings planted across both plots. 19 native species were planted in the CFM plots. Five species (*Carpinus betulus, Sorbus torminalis, Malus sylvestris, Sorbus aria, Salix cinerea*) were exclusive to the MF plot, and thus not planted in the CFM. After planting, every sapling was sapling was protected with an individual tree guard to prevent herbivore damage predominately, which is common practice in rural areas.

In contrast, the experiment plot (MFM-plot 2) was prepared and planted in accordance with Miyawaki Forest principles, which emphasise intensive soil preparation and high-density, multi-layered planting. The preparation involved several stages. First, extensive soil preparation was conducted. The plot was excavated to a depth of approximately 50 cm to break up compacted soil layers and facilitate root penetration. This was followed by the incorporation of well-rotted organic manure, thoroughly mixed with the existing soil matrix to enhance nutrient availability, improve soil structure, and increase water retention. This enriched soil aims to provide optimal growing conditions for early plant establishment.

In addition, a path bisecting the MFM plot was covered with straw prior to planting. Saplings were then planted at a density of approximately 3.5 per m^{-2}, with tree tags attached to a sub-sample of saplings to enable individual tracking of saplings development throughout the monitoring period. Planting was carried out by volunteers on community planting days, and saplings were distributed randomly across the site to mimic natural forest distribution. In total, 1,800 saplings from 24 native species were planted. After planting, the entire plot 2 area was covered with straw mulch to a depth of approximately 5 cm around each sapling tube, creating a continuous mulch cover, to regulate soil moisture and temperature. Consistent with the CFM plots, all saplings were protected with individual tree guards.

Initial sapling height measurements were recorded at the time of planting across all plots to provide baseline data for subsequent analysis.

Figure 6.2.1 Experiment site preparation and saplings planting (25.11.2022)

(Before planting)



(After planting (MFM-plot 2))



(After planting (CFM-plot 1))



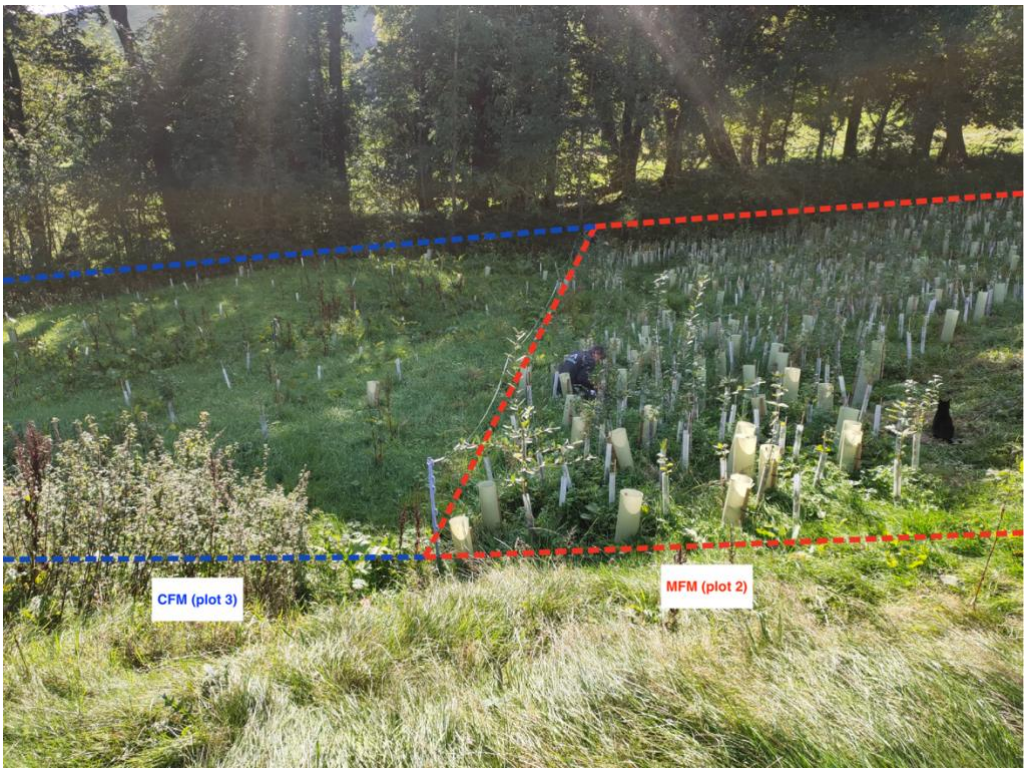
Approximately six months after planting (08.06.2023), a follow-up data collection was conducted to monitor the early stage survival rates of saplings and overall site conditions (Fig. 6.2.2). It should be noted that no height measurements were recorded at this stage, as the saplings remained too small and the presence of tree guards made accurate measurement more difficult.

Figure 6.2.2 Experiment site (08.06.2023)



In September 2023, a subsequent visit was undertaken. Weeding was carried out to reduce competition from unwanted vegetation (Fig. 6.2.3).

Figure 6.2.3 Experiment site weeding (21.09.2023)







During the third round of data collection, heights and diameters of saplings were recorded on 06.10.23. both MFM and CFM plots were showing early establishment (Fig.6.2.4).

Figure 6.2.4 Experiment site (06.10.2023)

(MFM-plot 2)



(CFM-plot 1)



(CFM-plot 3)



By late May 2024, one and half years after planting, the fourth round data collection about heights, diameters and survival of saplings was recorded at this stage (Fig.6.2.5).

Figure 6.2.5 Experiment site (29.05.2024)

(CFM-plot 3)



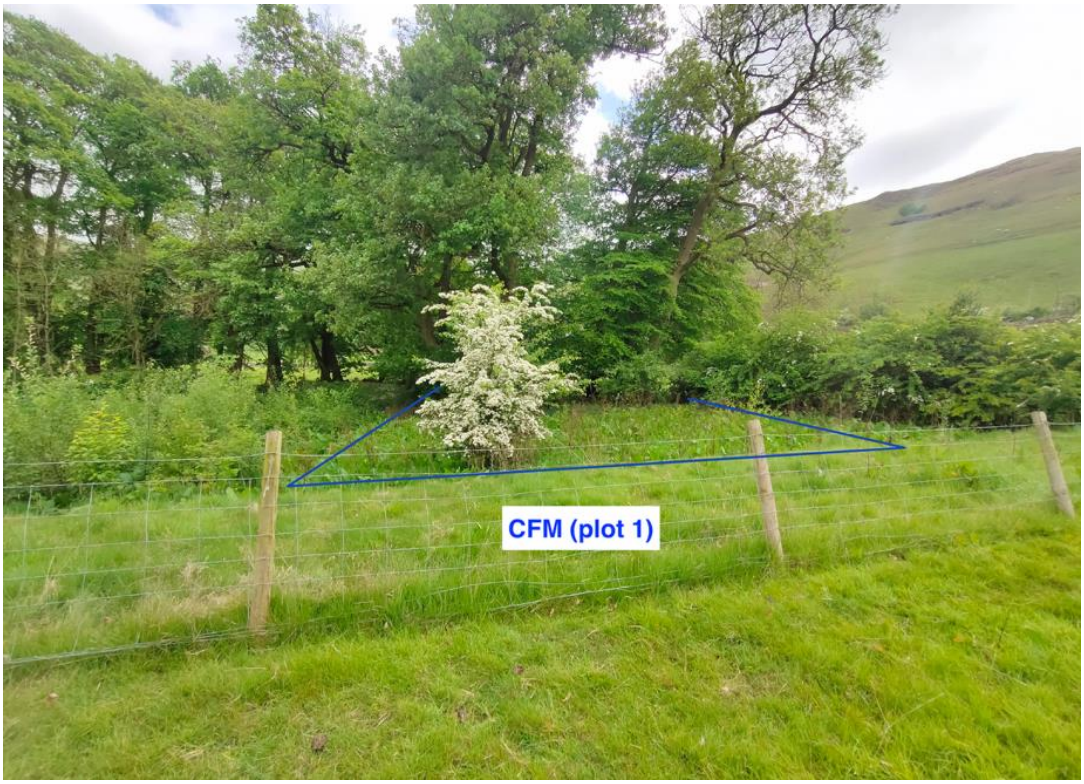
(MFM-plot 2)



Finally, on 15.05.2025, the last round data collection was conducted, heights, diameters and survival of saplings was recorded (Fig.6.2.6).

Figure 6.2.6 Experiment site (15.05.2025)

(CFM-plot 1)



(MFM-plot 2)

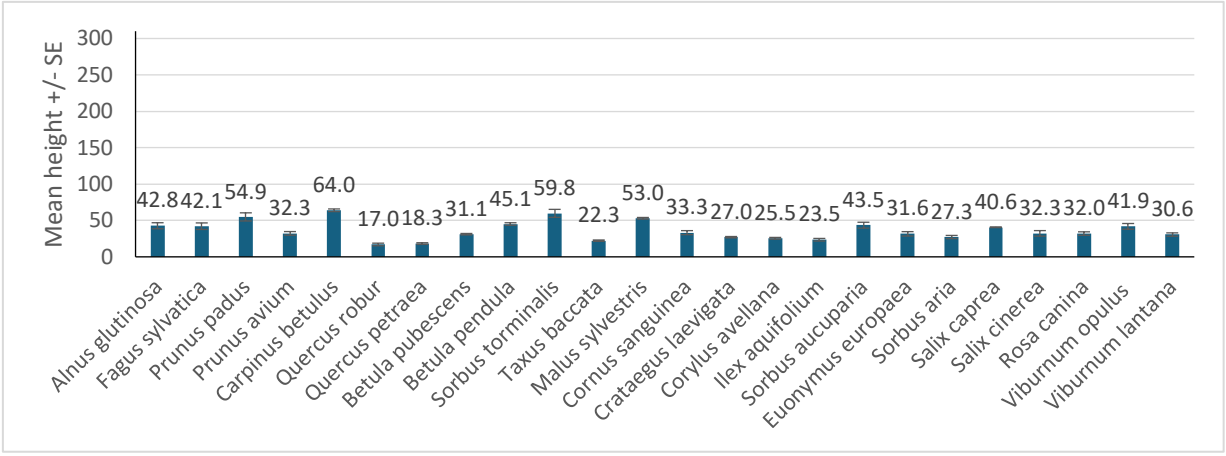


6.3 Do Miyawaki forest saplings have a higher growth rate and a thicker diameter compared to saplings planted in a Conventional forest?

6.3.1 Species growth rates

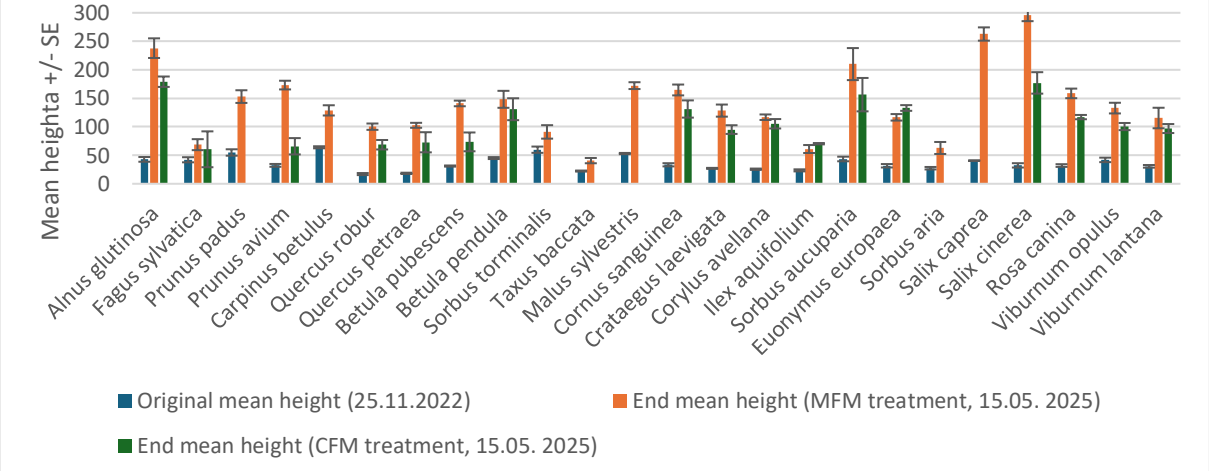
To assess saplings growth performance, eight individuals were randomly selected from each tree species, and their initial heights were recorded at the time of planting on 25.11.2022 (Fig. 6.3.1). At this stage, the mean height of all saplings across species was below 65 cm. Subsequent measurements of sapling height were conducted at the site during three subsequent site visits: 06.10.2023, 29.05.2024 and 15.05.2025, respectively. Full records of sapling heights are provided in Appendix 10.

Figure 6.3.1 Initial mean heights of planted saplings (cm)



A summary of mean height measurements at the initial and final time points is presented in Figure 6.3.2, which indicated an increase in sapling height from the original measurement (25.11.2022) to the most recent measurement (15.05.2025). Despite having only grown for two and half years, saplings in the MFM plot exhibited notably higher mean height increments compared to saplings in the CFM plots. Specifically, in the MFM plot, four species had reached mean heights exceeding 200 cm, 15 species were between 100 and 200 cm, and five species remained below 100 cm. In the CFM plots, nine species with mean heights between 100 and 200 cm, and eight species under 100 cm. There was no *Prunus padus* and *Taxus baccata* in the final data collection for CFM plots.

Figure 6.3.2 Original and end mean height data in both MFM and CFM treatments (cm)



Linear Mixed Models (LMMs) were conducted to assess whether the height growth of the same species within the same treatment showed statistically significant changes between 2022 and 2025 (Appendix 11).

One-way ANOVA was conducted to reveal whether the differences in height growth were statistically significant between treatments across 2022 – 2025 (Table 6.3.1). This analysis showed that height growth was significantly greater in the Miyawaki compared to the conventional control for *Alnus glutinosa* (P = 0.005), *Prunus avium* (P < 0.001), *Quercus robur* (P = 0.010), *Betula pubescens* (P = 0.002), *Euonymus europaea* (P = 0.043), *Salix cinerea* (P < 0.001), *Rosa canina* (P = 0.003), *Viburnum opulus* (P = 0.008), and *Viburnum lantana* (P = 0.005).

Table 6.3.1 Summary of species difference in height growth between treatments (2022 -- 2025) at a significant level (level of probability P) (cm)

Species name	**Growth rate P value**	**Species name**	**Growth rate P value**
	MFM vs CFM		**MFM vs CFM**
Alnus glutinosa	**P = 0.005**	*Corylus avellana*	P = 0.158
Fagus sylvatica	P = 0.869	*Ilex aquifolium*	P = 0.255
Prunus avium	**P < 0.001**	*Sorbus aucuparia*	P = 0.192
Quercus robur	**P = 0.010**	*Euonymus europaea*	**P = 0.043**
Quercus petraea	P = 0.154	*Salix cinerea*	**P < 0.001**
Betula pubescens	**P = 0.002**	*Rosa canina*	**P = 0.003**
Betula pendula	P = 0.499	*Viburnum opulus*	**P = 0.008**
Cornus sanguinea	P = 0.064	*Viburnum lantana*	P = 0.351
Crataegus laevigata	P = 0.086		

During the growth period (2022-2025), both treatments demonstrated strong performance in promoting sapling growth, with 17 out of 24 species (71%) demonstrating significant growth in MFM plot, and 14 out of 19 species (74%) in the CFM plots. The overall mean increase in the MF was still higher than CF for most of species (Fig. 6.3.3 and Fig. 6.3.4).

As shown in Appendix 11, the species with notable height growth performers in the MFM plot included: *Alnus glutinosa* (P < 0.001, mean increase: 125.2 cm), *Prunus avium* (P = 0.001, 93.5 cm), *Carpinus betulus* (P < 0.001, 62.5 cm), *Quercus robur* (P = 0.008, 36.0 cm), *Betula pubescens* (P < 0.001, 43.9 cm), *Taxus baccata* (P = 0.004, 17.8 cm), *Malus sylvestris* (P < 0.001, 69.5 cm), *Cornus sanguinea* (P < 0.001, 83.5 cm), *Crataegus laevigata* (P = 0.004, 57.3 cm), *Corylus avellana* (P = 0.001, 47.0 cm), *Ilex aquifolium* (P < 0.001, 23.0 cm), *Sorbus aucuparia* (P < 0.001, 134.6 cm), *Euonymus europaea* (P < 0.001, 49.6 cm), *Sorbus aria* (P = 0.043, 128.7 cm), *Salix cinerea* (P < 0.001, 142.5 cm), *Rosa canina* (P = 0.002, 33.5 cm), *Viburnum opulus* (P < 0.001, 52.6 cm) and *Viburnum lantana* (P = 0.025, 43.6 cm). These results indicate that the considerable vertical growth and a relatively positive responses to the MFM treatment during 2022 to 2025 growth period.

Conversely, as shown in Appendix 11, the CFM plots demonstrated a more moderate height growth trajectory. Certain species showed positive responses, including *Alnus glutinosa* (P < 0.001, mean increase: 77.4 cm), *Prunus avium* (P = 0.011, 43.6 cm), *Quercus robur* (P = 0.002, 43.5 cm),

Betula pendula (P = 0.046, 64.1 cm), *Cornus sanguinea* (P = 0.005, 61.1 cm), *Crataegus laevigata* (P = 0.009, 39.7 cm), *Corylus avellana* (P = 0.002, 58.0 cm), *Ilex aquifolium* (P = 0.002, 32.4 cm), *Sorbus aucuparia* (P = 0.003, 105.6 cm), *Euonymus europaea* (P < 0.001, 62.1 cm), *Salix cinerea* (P < 0.001, 33.3 cm), *Rosa canina* (P = 0.029, 52.5 cm), *Viburnum opulus* (P = 0.041, 32.2 cm) and *Viburnum lantana* (P = 0.024, 49.9 cm).

Figure 6.3.3 Mean height of saplings in the MFM treatment (2022 – 2025) (cm)

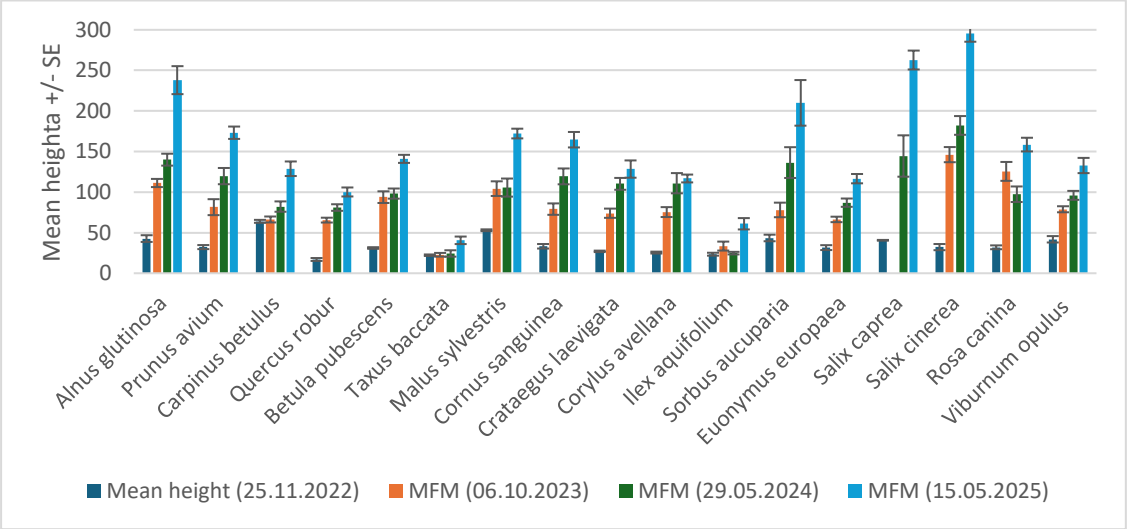
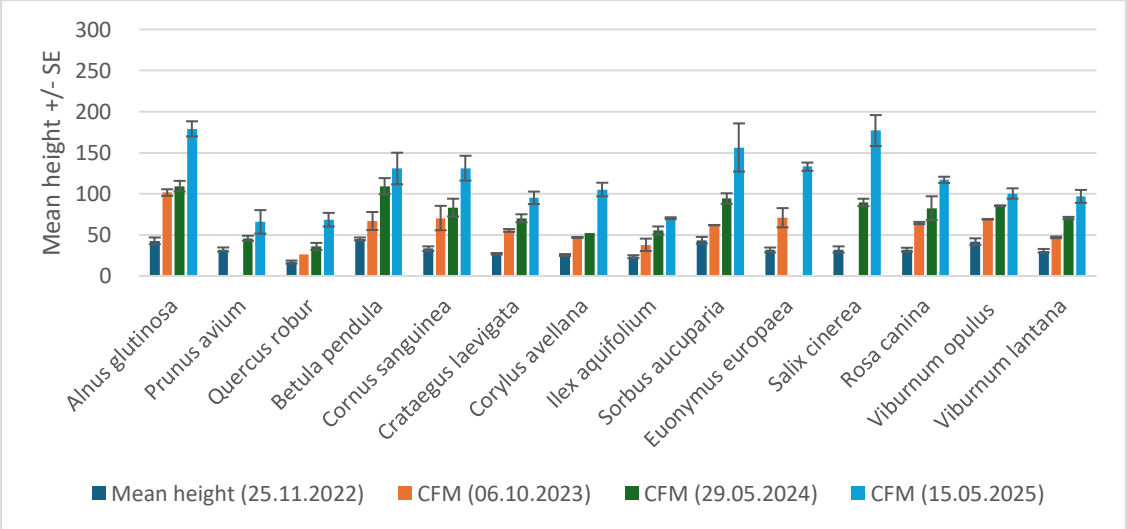


Figure 6.3.4 Mean height of saplings in the CFM treatment (2022 – 2025) (cm)



6.3.2 Species stem diameters

The saplings' stem diameters were measured three times at the site on 06.10.2023, 29.05.2024 and 15.05.2025. Full records of sapling diameters are provided in Appendix 12 Linear Mixed Models (LMMs) were conducted to analyse whether the sapling stem diameter growth of the same species within the same treatment showed statistically significant changes across 2023 – 2025 (Appendix 13). While one-way ANOVA was conducted to reveal whether the differences in sapling stem diameter growth were statistically significant between treatments across 2023 – 2025 (Table 6.3.2), with notable temporal variations in species responses. During the growth period (2023-

2025), the MFM treatment supported significant stem diameter growth in 18 out of 24 species (75%), compared to 10 out of 19 species (53%) in the CF treatment.

Table 6.3.2 Summary of species stem diameters at a significant level (2023 -- 2025) at a significant level (level of probability P) (mm)

Species name	**Diameter P value**	**Species name**	**Diameter P value**
	MFM vs CFM		**MFM vs CFM**
Alnus glutinosa	P= 0.383	*Euonymus europaea*	P = 0.349
Quercus petraea	P= 0.694	*Salix cinerea*	**P = 0.037**
Cornus sanguinea	P= 0.447	*Rosa canina*	**P = 0.004**
Crataegus laevigata	**P= 0.042**	*Viburnum opulus*	P = 0.353
Corylus avellana	P= 0.444	*Viburnum lantana*	P = 0.398
Sorbus aucuparia	P= 0.664		

As shown in Appendix 13, *Alnus glutinosa* exhibited the most substantial diameter growth response in the MFM plot (P < 0.001, mean increase: 22.5 mm), followed by *Salix cinerea* (P < 0.001, 16.4 mm), Sorbus aria (P = 0.050, 13.4 mm), *Sorbus aucuparia* (P < 0.001, 10.6 mm), *Carpinus betulus* (P < 0.001, 9.1 mm), *Malus sylvestris* (P < 0.001, 8.0 mm), *Vinurnum opulus* (P < 0.001, 7.9 mm), *Corylus avellana* (P = 0.002, 7.14 mm), *Rosa canina* (P < 0.001, 6.5 mm), *Bentula pubescens* (P < 0.001, 6.4 mm), *Bentula pendula* (P = 0.011, 6.3 mm) and *Cornus sanguinea* (P < 0.001, 6.0 mm). Other notable performers in the MF treatment included *Crataegus laevigata* (P < 0.001, 5.7 mm), *Quercus petraea* (P < 0.001, 4.0 mm), *Vinurnum lantana* (P = 0.003, 3.3 mm), *Quercus robur* (P < 0.001, 3.1 mm), *Fagus sylvatica* (P = 0.008, 2.9 mm) and *Ilex aquifolium* (P = 0.010, 2.5 mm).

Conversely, As shown in Appendix 13, the CFM plots demonstrated a more moderate diameter growth trajectory. While certain species showed positive responses, including *Alnus glutinosa* (P < 0.001, mean increase: 14.2 mm), *Quercus petraea* (P = 0.017, 3.4 mm), *Betula pendula* (P = 0.003, 8.5 mm), *Cornus sanguinea* (P < 0.001, 5.9 mm), *Crataegus laevigata* (P < 0.001, 5.6 mm), *Corylus avellana* (P = 0.039, 5.7 mm), *Ilex aquifolium* (P = 0.026, 2.1 mm), *Sorbus aucuparia* (P = 0.005, 7.9 mm), *Viburnum opulus* (P = 0.004, 5.0 mm) and *Viburnum lantana* (P = 0.003, 3.8 mm).

The effect of treatment i.e. MFM vs CFM, was only significant for *Crataegus laevigata* (P= 0.042) *Salix cinerea* (P = 0.037) and *Rosa canina* (P = 0.004), with the Miyawaki examples have significantly increased diameters compared to their conventional equivalents. Thus, there were not statistically significant differences for most of the species in terms of stem diameters in both treatments.

6.4 Do Miyawaki forest saplings have a higher survival rate compared to saplings planted in a Conventional forest?

The estimated sapling survival was monitored over a two and half year period to assess early-stage establishment across both planting treatments. Survival data were recorded during field visits on 08.06.2023, 29.05.2024, and 15.05.2025 (see Appendix 14 for full data records). Survival estimates are based on counts of visibly present, identifiable individuals within each plot. Species mortality over time and the presence of tall weeds that obscured smaller saplings resulted in some missing

data, requiring the use of estimated survival rates. This may have led to some under-representation, particularly of species at the smaller planting sizes. In addition, *Quercus spp.* has been pooled due to difficulty of identifying very small specimens within the tree guards at the species level, and *Salix spp.* were pooled due to variable leaf forms. Overall, nonparametric related sample Wilcoxon signed rank test was conducted to compare survival rates between MFM and CFM treatments at three monitoring points: 08.06.2023, 29.05.2024, and 15.05.2025. Each test was based on 19 matched species entries.

Generally speaking, differences in survival rates between MFM and CFM treatments were not statistically significant over the two and half years monitoring period (2023 – 2025), though CFM treatment consistently showed slightly higher survival rates. Specifically, the overall average survival rate in June 2023 was 96% for MFM treatment and 97 % for CFM treatment (P = 0.096). By May 2024, survival rates had declined in both treatments, with MFM treatment at 59% and CFM treatment at 63 % (P = 0.777). By May 2025, survival had further decreased to 36% in MFM plot and 48% in CFM plots, and this difference remained statiscally non-significant (P = 0.145). These findings suggest that despite there being short-term fluctuations, the long-term survival was broadly comparable in both treatments. Survival rates were often species dependent (Table 6.4.1).

Table 6.4.1 Summary of species survivals of MFM and CFM treatments (2025) (/: species exclusive included in MFM plot)

Forest layer	Scientific name	MFM (%)	Forest layer (%)	CFM (%)	Forest layer (%)
Canopy	*Alnus glutinosa*	97%	27%	70%	44%
	Fagus sylvatica	18%		20%	
	Prunus padus	22%		0%	
	Prunus avium	8%		60%	
	Carpinus betulus	32%		/	
	Quercus spp.	26%		50%	
Sub-canopy	*Betula pubescens*	39%	35%	20%	27%
	Betula pendula	65%		60%	
	Sorbus torminalis	17%		/	
	Taxus baccata	19%		0%	
Understory	*Malus sylvestris*	20%	34%	/	71%
	Cornus sanguinea	37%		50%	
	Crataegus laevigata	56%		100 %	
	Corylus avellana	12%		80%	
	Ilex aquifolium	13%		30%	
	Sorbus aucuparia	53%		50%	
	Euonymus europaea	26%		60%	
	Sorbus aria	13%		/	
	Salix spp.	140%		80%	
Shrub	*Rosa canina*	38%	33%	30%	47%
	Viburnum opulus	42%		50%	
	Viburnum lantana	17%		60%	

Overall, only the sub-canopy layer in the MF plot exhibited higher survival rates than in the CF plots. For all other layers, survival rate was generally higher in the CF plots. Among pioneer species commonly found in the UK, such as *Alnus glutinosa, Betula pendula,* and *Betula pubescens,* survival rate was higher in the in the MF plot compared with the CF plots. Beyond this, no clear relationship was identified between the number of individuals planted and their subsequent survival. Species planted in larger numbers did not consistently exhibit higher survival rates, nor did those planted in smaller numbers show consistently lower rates.

Specifically, the MFM treatment demonstrated variable survival rates across species (Table 6.4.1). *Alnus glutinosa* exhibited the highest survival rate at 97% Other notable performers included *Betula pendula* (65%), *Crataegus laevigata* (56%), and *Sorbus aucuparia* (53%). Several species showed moderate survival rates including *Viburnum opulus* (42%), *Betula pubescens* (39%), *Rosa canina* (38%), and *Cornus sanguinea* (37%). However, several species exhibited poor survival in the MFM treatment, with *Sorbus aria* showing 13% survival, *Ilex aquifolium* (13%) and *Corylus avellana* (12%). *Prunus avium* performed particularly poorly with only 8% survival despite initially strong establishment.

The CFM treatment, while working with smaller initial planting numbers, showed some relatively remarkable results (Table 6.4.1). *Crataegus laevigata* achieved 100% survival, while *Corylus avellana* (80%), *Salix* spp. (80%) and *Alnus glutinosa* (70%) also performed well. Several species maintained moderate survival rates including *Betula pendula* (60%), *Prunus avium* (60%), *Euonymus europaea* (60%) and *Viburnum lantana* (60%).

Species that performed consistently across both treatments include *Alnus glutinosa*, which maintained high survival in both treatments (97% in MF, 70% in CF), demonstrating robust adaptability. *Betula pendula* showed consistent moderate performance (65% in MF, 60% in CF), as did *Sorbus aucuparia* (53% in MF, 50% in CF), *Viburnum opulus* (42% in MF, 50% in CF) and *Rosa canina (*38% in MF, 30% in CF). Conversely, some species such as *Fagus sylvatica* (18% in MF, 20% in CF), *Prunus padus* (22% in MF, 0% in CF) and *Taxus baccata* (19% in MF, 0% in CF) performed poorly across both treatments.

Interestingly, species performance in the MFM treatment was not always inferior to the CFM treatment. Eight species showed higher survival in the CFM treatment despite smaller planting numbers. *Crataegus laevigata* achieved perfect survival in CFM compared to 56% in MFM treatment, as well as *Prunus avium* (8% MF, 60% CF), *Quercus spp.* (26% MF, 50% CF), *Cornus sanguinea* (37% MF, 50% CF), *Crataegus laevigata* (56% MF, 100% CF), *Ilex aquifolium* (13% MF, 30% CF), *Euonymus europaea* (26% MF, 60% CF) and *Viburnum lantana* (17% MF, 60% CF), showed better performance in CFM than in MFM treatments.

In addition, the data reveals several anomalies, including *Salix spp.* showing 140% survival in MFM treatment, and *Crataegus laevigata* showing more survivors than planted in 2024 in CFM treatment, suggesting possible natural regeneration or recording error or other problems in the plots. The detailed estimated survival rates of saplings in MFM and CFM plots are presented below in Fig. 6.4.1, while the detailed estimated percentage survival rates are shown below in Fig. 6.4.2.

Figure 6.4.1 Number of trees alive in MFM and CFM treatments

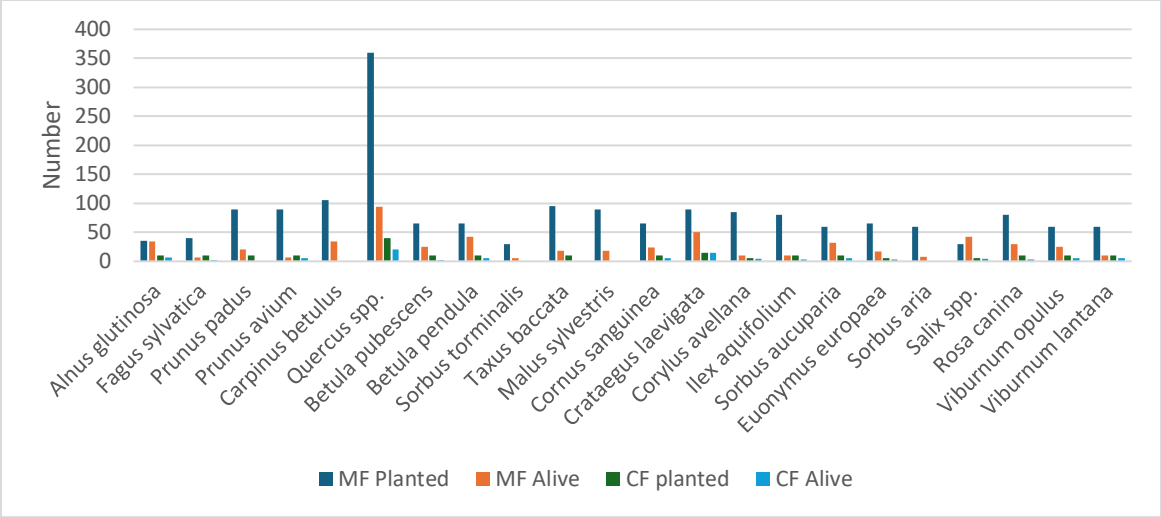
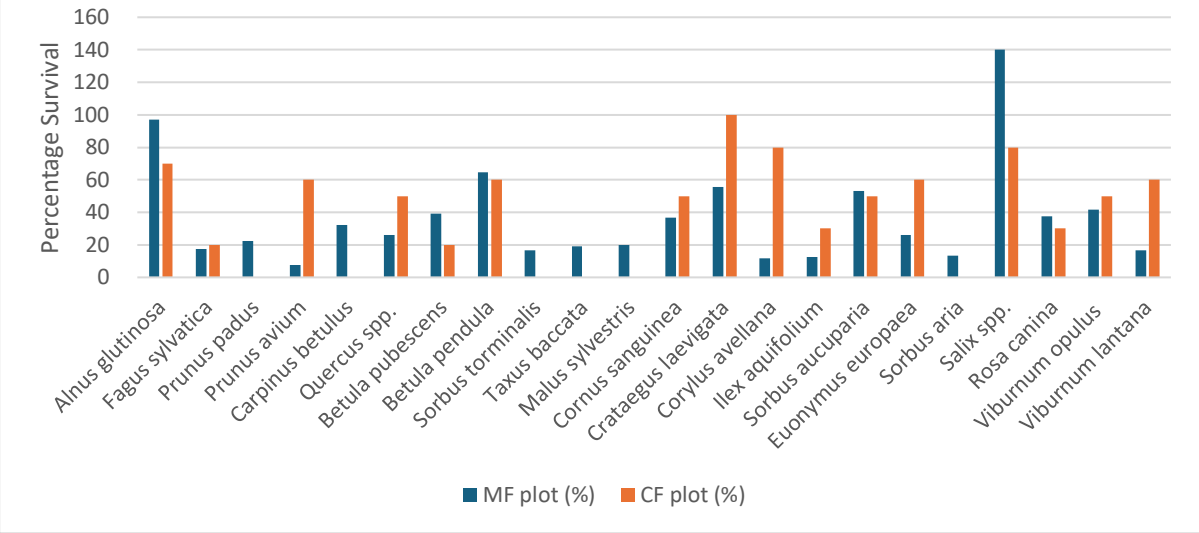


Figure 6.4.2 Percentage of trees alive in MFM and CFM treatments



Ch.7. Discussion

7.1 Introduction

This chapter synthesises the key findings from the questionnaires measuring expert and professional perceptions (Chapter 4), non-professionals perceptions (Chapter 5), and experimental outcomes (Chapter 6), integrating these empirical insights with the literature review (Chapter 2), to address the central research aim: to explore the suitability and potential application of the MFM in the UK context. The chapter critically evaluates the perceived suitability and practical implications of whether, and under what conditions, the MFM can be considered an appropriate and effective forestry strategy for use in the UK, with particular emphasis on urban applications.

Beyond interpreting and consolidating the findings of this research, this chapter positions the research within the broader landscape of environmental planning, ecological restoration, and public engagement with green spaces. It also provides evidence-based recommendations for the implementation of MFM in the UK. The discussion is organised into six sections. The findings are grouped together from the different questionnaires to reduce repetition across the chapter.

- Perceived perceptions of the awareness of the MFM (section7.2).
- Perceived support of the MFM (7.3).
- Perceived suitability of the MFM (7.4)
- Perceived environmental benefits and challenges (7.5).
- Tree species selection and climate change consideration (7.6).
- Costs and willingness to pay (experts and professional only) (7.7).
- Assessment of the empirical findings from the field experiment, comparing growth and survival patterns between the MFM and the CFM (7.8).

7.2 Respondents' awareness of the MFM in the UK

This section discusses the findings presented in section 4.3.1 and section 5.3 which explores the perceptions on the awareness of experts and professionals and the non-professionals on the MFM in the UK context. Experts and professionals demonstrated moderate awareness but limited engagement. In contrast, non-professionals awareness was low. These insights are analysed in relation to relevant literature and in response to Research Question 1.1, 2.1 and 2.4.

7.2.1 Experts and professionals' perceptions

The findings from Chapter 4 indicate that the MFM is more widely known in practice than in academic research in the UK. There was a notable difference between familiarity and involvement with the MFM amongst experts and professionals in the UK. While more than half of the experts and professionals (54.5%) surveyed reported familiarity with the MFM, only 28.6% had been involved in MFM-related projects. This demonstrates significant knowledge gaps exist across different groups regarding the varying levels of awareness of MFM, reflection the emerging nature of this method in the UK context, and further research would be needed to explore this.

Notably, factors such as occupation, age, and gender had a statistically significant influence on both familiarity and involvement. Indeed, a large minority of landscape professionals displayed notably limited familiarity and involvement with MFM, and this is particularly pronounced among academics. This result is somewhat counterintuitive, given that academics are typically expected

to be exposed to a broader range of emerging knowledges. However, the disparity reflects the practice-led trajectory of MFM's introduction into the UK. The method's spread from Japan through Asia and into Europe has largely been driven by governments, NGOs and 'grass-roots' actors promoting it as a pragmatic response to ecological degradation (Lewis, 2022c; Heuch and Thurman, 2024; Trees Outside Woodland, 2024).

The relatively limited academic familiarity and involvement with the MFM may also signify a typical academic's preponderance with theoretical research rather than practical applications (Williamson, 2002). However, in fields such as urban forestry, which involves multiple stakeholders and where interdisciplinary collaboration is essential, both theory and practical application are important (Lawrence et al., 2013). Respondents from the voluntary sector reported the highest level of familiarity and involvement, highlighting the importance of grass-roots initiatives and community-driven projects in the adoption and diffusion of MFM practices (Yalegama, Chileshe and Ma, 2016; Egerer *et al.*, 2024). As such, the Miyawaki method seems to currently be more embedded in practice than in academic discourse.

7.2.2 Non-professionals' perceptions

In contrast, non-professionals awareness of the MFM was generally low, with only a small minority having heard of (27.1%) or been involved within (8.9%) the MFM prior to participating in the survey. This limited awareness is perhaps unsurprising given the relatively recent introduction of MFM to the UK context and the low number of established projects during the survey period. By comparison, traditional afforestation strategies, with their longer history, remain far more visible and familiar in non-professionals discourse. This finding underscores the early developmental stage of MFM in the UK context, suggesting that the targeted outreach may have potential value and could be beneficial as the method scales up.

Nevertheless, greenspace visits frequency and personal interest in trees were significantly correlated with respondents' awareness of MFM. Those who indicated visiting greenspaces daily or weekly, and / or who rated themselves as highly interested in trees were more likely to be aware of the method. This suggests that regular exposure to natural environments and personal ecological interests can play important roles in shaping awareness (Jimenez *et al.*, 2021). While MFM has yet to reach broader non-professionals consciousness, individuals already engaged in outdoor or environmental activities, such as regular park users, or community volunteers, may form a potential entry point for building broader non-professionals understanding (Giseburt, 2023; Akram *et al.*, 2025).

Crucially, limited initial awareness did not equate to opposition. When respondents were given a brief explanation of the method and shown examples, non-professionals attitudes were generally positive to the use of MFM, especially among those with no previous knowledge of MF. This finding supports the notion that non-professionals unfamiliarity does not equate to disapproval, as non-professionals support for urban greening strategies often depends less on technical familiarity and more on perceived values and emotional connections to nature (Church, 2018; Buijs *et al.*, 2019). Moreover, non-professionals perceptions can be rapidly shaped by clear, engaging communication (Nisbet and Scheufele, 2009; Baderin, 2013). As such, interpretive strategies, particularly in places where people already connect with nature, such as informational signage, interactive media, or guided tours implemented in parks, schools, and community gardens, could therefore play a vital

role to increase awareness and supportive for Miyawaki-style planting in the UK (Wolf, Stricker and Hagenloh, 2013).

7.2.3 Summary

The findings reveal that current MFM awareness in the UK reflects its practice-led introduction and early developmental stage. Among experts and professionals, the method has gained moderate recognition but remains more embedded in practical applications than academic discourse. Non-professionals awareness remains limited but shows potential openness and positive attitudes when the method is explained. As MFM projects increase in number and visibility, awareness will likely grow, but proactive interpretive strategies could expand awareness for MFM within the UK context.

7.3 Support for the MFM

This section discusses the findings presented in section 4.3.2 and section 5.4 which explores the perceptions of support of experts and professionals and the non-professionals for the MFM in the UK context. When its application was explained, experts and professionals and the non-professionals all demonstrated a high support for the use of the MFM in the UK context, particularly in the urban settings. These insights are analysed in relation to relevant literature and in response to Research Question 1.1, 2.1 and 2.4.

7.3.1 Experts and professionals' perceptions

Respondents predominantly support the MFM over CFM (mean = 6.69, Fig. 4.3.8). However, the reasons for the significant correlation between age, and gender, for support for MFM are not clear. One possibility is that this may relate to respondents' frequency of engagement in practical conservation / re-greening activities, though this would require further investigations. Experts and professionals cited a range of motivations for supporting MFM: its perceived environmental benefits (e.g., biodiversity enhancement, microclimate regulation and climate mitigation), along with high species diversity, fast growing potential, and naturalistic design, drawing on ecological principles of succession, self-selection, and dense planting. These positive perceptions echo the benefits highlighted by proponents like Miyawaki (1999) and Schirone et al. (2011).

Nevertheless, the findings found that perspectives were far from unanimous. Approximately one-third of experts and professionals expressed reservations or outright scepticism toward the MFM. They have highlighted concerns around long-term ecological resilience, economic viability, and limitations for large-scale application of the method. For instance, dense planting was perceived by some respondents as inherently wasteful or potentially damaging to sapling health in stressed urban conditions. Other respondents questioned the credibility of rapid growth claims without robust UK-based evidence (Heuch and Thurman, 2024).

The skepticism expressed by participants aligns with broader debates in other research, regarding the empirical validation of MFM claims, which have noted that some claims made by MFM advocates lack empirical substantiation in temperate regions like the UK (Webber, 2022; Qi, Dempsey and Cameron, 2024; Rewilding academy, 2024; Give Me Trees Trust, no date). This professional critique requires more than just educational initiatives, it also reflects legitimate critical engagement with the scientific evidence supporting MFM claims, i.e. the potential wider

adoption of MFM requires both empirical validation and open professional dialogue (Kouarti, 2005).

7.3.2 Non-professionals perceptions

In addition, non-professionals support for MFM was generally strong (mean = 7.57) than CFM, and over 93 respondents (31.5%) rated the support at the maximum level (10). Many described the method as a timely and much-needed approach in response to climate change, biodiversity loss, and environmental degradation in small urban spaces, which closely mirror those expressed by experts and professionals in Chapter 4. Furthermore, respondents regarded the method as offering mental health, aesthetic value, and community engagement benefits, which aligns with Dr. Rajadurai (2024) and European Environment Agency, which states that small-scale natural spaces in urban areas contribute significantly to well-being, particularly when implemented near where people live (Baur and and Tynon, 2010; Bieling *et al.*, 2014; EEA, 2020).

60 (20.5%) respondents explicitly mentioned curiosity for, and personal interest in, the method as key motivations for their support. They stated they would like to see further results from trails in local contexts before making a definitive judgment, reflecting the ongoing need for evidence from current pilot projects across the UK. This is particularly about how MFM forests develop, how they are managed, and what ecological benefits they deliver. This position of cautious interest underscores the importance of demonstration projects and visible case studies in building confidence and acceptance, and the demand for more evidence also highlights the critical need for more research documenting and analysing the outcomes of existing MFM projects to inform broader adoption decisions. This also indicates that MFM could / being claimed to offer opportunities for citizen science, informal environmental education, and volunteer-based monitoring, all of which can strengthen community ties, enhance environmental literacy, and reconnect people to nature (UNESCO, 2023; Yan *et al.*, 2023; Domingues, 2025; Gross, 2025).

Of the 91.4% respondents who expressed a willingness to visit a MF if one were planted near their residence. This willingness to engage was significantly positively correlated with frequency in greenspace ($P = 0.039$), interest in trees ($P < 0.001$), and prior awareness of the MFM ($P \leq 0.05$). These findings underscore the role of nature connectedness and prior exposure in fostering non-professionals receptivity. As previous studies have shown, positive nature experiences tend to promote stronger pro-environmental attitudes and behaviours (Chawla, 1999; Rosa and Collado, 2019; DeVille *et al.*, 2021).

However, respondents also voiced concerns about the MFM, especially related to accessibility, distance, cost, initial maintenance, and uncertainty over long-term ecological success. In particular, MFM's dense planting configuration was viewed by some non-professionals as potentially hindering access or creating a 'closed' environment, which aligns with the views of experts and professionals who also note that such dense planting is likely to limits physical access. This aligns with broader public critiques of naturalistic or high-density planting style landscape in urban areas, which are sometimes perceived as less orderly or difficult to navigate (Nassauer, 1995; Özgüner and Kendle, 2006).

At the same time, some non-professionals perceived MFs as providing recreational and walking opportunities, which contrast with the perceptions above. Given that the original MFs varied in

terms of shapes and sizes (Urban Forests Company, 2020), the accessibility of sites might largely depend on the design and intended function of each site. For instance, many TFs established by Earthwatch include paths, benches, and signage, and some are designed to function as outdoor classrooms for schools. Therefore, while MFs are indeed densely planted and may be difficult to enter in certain configurations, implementing organisations are adapting designs to enhance accessibility, allowing the public to engage with these spaces.

To address accessibility, the incorporation of inclusive and accessible design principles is needed in the implementation of MFM in the UK. In addition, strategic site selection, for instance, prioritising locations within walking distance of residential areas, could mitigate issues related to distance and accessibility. While respect to costs concern, reducing mortality rates could lower the cost per surviving tree, while involving volunteers in planting and maintenance activities could help reduce labour costs, thereby narrowing the cost difference between the Miyawaki and control plots. Finally, ongoing monitoring and evaluation will be crucial to clarity the long-term ecological performance of MFM sites in the UK context.

7.3.3 Summary

The findings reveal the complexities underlying support for the MFM. While overall support levels were relatively high (experts and professionals: 6.69/10, non-professionals: 7.57/10), this enthusiasm was tempered by calls for empirical validation. Respondents acknowledge the method's potential environmental and social benefits, but also highlight concerns about the lack of robust, UK-specific evidence regarding its development, management, ecological resilience, and economic viability. This is the biggest gap but also the opportunity, which indicates that the need for further empirical research results, local demonstration projects, and inclusive design approaches.

7.4 Perceived suitability of the MFM

This section discusses the findings presented in section 4.4 and section 5.5 which explores the perceptions of experts and professionals and the non-professionals regarding the suitability of applying the MFM in the UK context (RQ 1.1, RQ 2.1 and RQ2.4). Overall, the non-professionals perceived the MFM as less suitable compared to experts and professionals.

7.4.1 Experts and professionals' perceptions

Experts and professionals generally rated the MFM as slightly more suitable for urban contexts than rural, although the mean difference was not statistically significant. Notably, respondents who were more familiar with or directly involved in MFM projects tended to be more likely to recognise its suitability and to emphasise its perceived environmental benefits, particularly its ability to deliver rapid ecological benefits in spatially constrained environment (Torkington, 2023; Rewilding academy, 2024).

The slight preference for implementing the MFM in urban settings over rural may be due to the fact that existing MFM projects in the UK are predominantly urban, which potentially have influenced respondents' perceptions of suitability locations. In addition, the fast growth, biodiversity uplift and spatial efficiency align with urban priorities, such as climate adaptation, well-being promotion, and the greening of small spaces (Webber, 2022; Torkington, 2023). Specifically, experts and professionals identified specific locations such as parks, blue

infrastructure, and school premises as considered particularly appropriate settings for MFM implementation. This suggests that MFM's perceived suitability may be context-dependent, with urban environments offering both practical advantages and established precedents for implementation (Fan et al., 2022) such as the MFs planted by SUGi and Earthwatch in the UK, some of which were visited during this PhD.

7.4.2 Non-professionals **perceptions**

Non-professionals respondents generally perceived the MFM as a relatively suitable (mean = 6.55) tree planting method for the UK, regardless of demographic background. This suggests a broad and cross-cutting receptive attitude towards the method, albeit a cautious one. Similar to the experts and professionals, respondents who had heard of MFM before, are more likely to recognise its suitability. Previous studies support this finding, which demonstrate that familiarity increases receptivity (Brock, Albert and Becker, 1970; Manika et al., 2021). This indicates that the exposure to MF projects, whether through media coverage, educational initiatives, or direct experience, may help expand non-professionals appreciation for the method's adaptability.

In addition, the non-professionals often referred to its compatibility with the UK's temperate climate, its potential applicability in space-constrained urban areas, and the importance of appropriate species selection. This indicates a conditional view of MFM suitability and reflects a growing public recognition of the value of compact, intensive greening strategies in dense city settings (Tian, Jim and Tao, 2012). That is, the non-professionals did not express blind enthusiasm, but rather demonstrated an increasing awareness that urban environments demand flexible, place-specific greening strategies, which need to be tailored to local climate, ecological context, and design limitations (Shwartz *et al.*, 2014). Specific sites such as parks, industrial areas, and blue infrastructure corridors were most frequently mentioned as suitable locations for MFM projects, further underscoring the importance of strategic site selection for non-professionals support (Fan *et al.*, 2022).

7.4.3 Summary

The findings reveal that both the experts and professionals and the non-professionals viewed the MFM as a conditionally suitable approach for the UK, with experts and professionals rating its suitability marginally higher than the non-professionals. A key finding across both groups was the strong association between familiarity or direct involvement with MFM projects and higher perceptions of suitability, highlighting the importance of outreach and engagement activities. Rather than expressing uncritical enthusiasm, respondents from both groups emphasised that the method's suitability depends on local climate, ecological context, and design constraints. This context-specific understanding suggests that the future adoption of the MFM in the UK will require tailored approaches that respond to site-specific conditions, rather than generic promotion. As to the experts and professionals' slight preference for urban applications, this may reflect the concentration of existing UK MFM projects in urban settings and the method's alignment with urban environmental challenges.

7.5 Perceived environmental benefits and challenges of the MFM

This section discusses the findings presented in section 4.5, 4.7, 5.6, and 5.7, which explores the perceptions of experts and professionals and the non-professionals, regarding the perceived environmental benefits and challenges of the MFM in the UK context (RQ 1.1, RQ 2.1 and RQ2.4).

While both experts and professionals and the non-professionals recognised the potential environmental benefits of the MFM, their perceptions remain divided. The experts and professionals perceived the MFM as offering greater environmental benefits than the CFM, whereas the non-professionals perceived the CFM as more beneficial. Despite these different perceptions, respondents from both groups identified several common challenges, including the risk of anti-social behaviour, ecological trade-offs such as limited ground flora diversity and carbon sequestration, high mortality and so on.

The perceived environmental benefits of MFM, such as increased biodiversity and urban microclimate regulation were acknowledged among experts and professionals (Miyawaki, 1998; Gamfeldt *et al.*, 2013; Lewis, 2022c; Torkington, 2023). In particular, survey data showed that professionals considered MFM more effective than CFM in providing city cooling ($P = 0.004$, Fig. 4.7.1). This perception may be attributed to MFM's high planting density, combined with rapid canopy formation, which together contribute to greater shading and evapotranspiration, contributing to localised temperature reductions. These mechanisms are especially valuable in urban settings where surface materials and reduced vegetation can exacerbate the urban heat island effect (Stache *et al.*, 2022; Topos, 2025).

In contrast, the non-professionals generally perceived the CFM to be marginally more effective than the MFM across all environmental benefit categories, though these differences were not always statistically significant. It is important to note that non-professionals' perceptions do not directly correspond to the actual environmental performance of these methods. While recent, limited literature suggests that MFM deliver superior environmental performance compared to CFM (Davies *et al.*, 2017; Kavana, 2023). Such non-professionals' ratings suggest that, from a lay perspective, the MFM is not yet perceived as providing superior ecological outcomes compared to CFM in the UK context. This difference between non-professionals perception and the emerging evidence base suggests that the environmental benefits of MFM may not be widely recognised or understood by the non-professionals in the UK.

Furthermore, the non-professionals demonstrated a significantly greater support for CFM across all six environmental benefit categories compared to the experts and professionals ($P < 0.001$). This further suggests that the non-professionals maintains greater trust in traditional approaches to afforestation (CFM), perhaps shaped by greater familiarity with CFM and its established presence in public narratives around traditional tree planting practices.

This preference highlights the need for more empirical research directly comparing the ecological performance of MFM and CFM under UK conditions, as the benefits of the MFM remains uncertain due to the lack of evidence. Without robust, context-specific evidence demonstrating MFM's claimed advantages, it is premature to conclude that MFM offer greater environmental benefits than CFM based on research from other countries. The current evidence base remains insufficient to support definitive claims about the method's comparative effectiveness in UK contexts.

While all respondents acknowledged many of the claimed ecological benefits attributed to the MFM, they also raised doubts about certain ecological claims, particularly regarding ground flora diversity and carbon sequestration. Specifically, while the dense planting of the method was noted to effectively control weed growth, it was also seen to restrict the development of ground layer

vegetation, which is crucial for supporting a diverse range of wildlife species (Kirby *et al.*, 2022). Respondents therefore raised concerns about the method's overall contribution to biodiversity enhancement.

Similarly, claims regarding accelerated carbon sequestration through MFM was met with skepticism. Dose the faster growth in the early stage result in a higher carbon sequestration in the long term? There is insufficient evidence to (dis)prove this at the moment. It was recognised that newly planted forests may take many years, if not decades, to sequester more carbon than is expended during their establishment period (Luck *et al.*, 2014; Petri *et al.*, 2016). The small scale of most UK-based MFM projects, and relatively short implementation history make it more difficult to assess their long-term carbon storage potential, further reinforcing respondents' skepticism about the method's immediate contribution to climate mitigation (Qi and Dempsey, 2024; Heuch and Thurman, 2024).

Beyond ecological concerns, both groups also identified potential social challenges associated with the MFM's dense planting. The high-density vegetation was perceived as potentially concealing anti-social behaviour or invite vandalism, though greenspace associated with less anti-social behaviour or crime (Venter *et al.*, 2022). This raises the need for careful consideration in urban implementation and site selection. In addition, experts and professionals were significantly more likely to identify potential challenges associated with MFM implementation than the non-professionals (73.2% vs. 55.8%; $P < 0.001$). These challenges included high mortality rates, intensive soil preparation and unclear long-term sustainability. These challenges indicate that the need for more further robust empirical validation and strategic site selection.

Overall, the findings reveal a divide between experts and professionals and the non-professionals in their perceptions of the environmental benefits of MFM and CFM. This indicates a complex and divergent landscape of views on the ecological value of the MFM in the UK context. This divergence reflects more than mere professional bias, it illuminates fundamental challenges when translating innovative methods from theory to practice. The non-professionals' preference for CFM underscores the need for locally relevant evidence and demonstrated outcomes rather than relying solely on theoretical claims.

Nevertheless, both groups shared concerns about the ecological and social challenges associated with MFM. These perceptions reinforce the urgent need for further UK specific empirical research to validate MFM's ecological claims and address practical implementation challenges. Without robust, empirical validation tailored to the UK context, assertions of the MFM's environmental superiority remain speculative, regardless of supporting evidence from other geographical contexts. Sustained research is therefore essential to build a credible evidence base that can support informed decision-making.

7.6 Tree species selection and climate change consideration

This section discusses the findings presented in section 4.8 and 5.8, which explores how both experts and the non-professionals perceive species selection for MFs, particularly in relation to climate change (RQ 1.2, RQ 1.3, RQ 2.2, RQ 2.3 and RQ2.4). While NT species remain the preferred choice across both groups, perspectives shift when future environmental uncertainties are introduced, revealing nuanced and adaptive attitudes toward the inclusion of NNT species.

Both experts and professionals and the non-professionals generally express a strong preference for using either exclusively native tree (NT) species or a mixture of NT and NNT species in both MFM and CFM settings. Experts and professionals perceived that the ecological principles of the MFM are transferable to the UK if NT species are appropriately selected. Non-professionals strong preferences for NT species, driven by concerns for ecological appropriateness, local biodiversity support, and cultural significance. Respondents indicated perceptions that NT species are best suited to the UK climate and more beneficial to local biodiversity which chimes with the literature (Berthon, Thomas and Bekessy, 2021). This reflects the literature that highlighting the role of NT species in supporting and enhancing local biodiversity, better adapting to local conditions, and minimising biosecurity risks (Boshier *et al.*, 2015; Sutcliffe *et al.*, 2018; Garland, 2020; Berthon, Thomas and Bekessy, 2021).

However, when explicitly prompted to consider future climate change, there was a noticeable shift towards a more open attitude to a mix of NT and non-native tree (NNT) species though NT was still dominant in both MFM and CFM settings. This may reflect a recognition among respondents that climate-induced stressors may exceed the adaptive capacity of some NT species, prompting consideration of incorporating NNT species, though it still has limited prevalence (Pötzelsberger *et al.*, 2020; Castro-Díez *et al.*, 2021; Dyderski *et al.*, 2025). Despite this shift, respondents who initially supported NT species maintained their reasoning after reading the climate information, suggesting that values-based preferences remain robust, even when confronted with complex environmental trade-offs (Findlater et al., 2020). In addition, their resistance to NNT species remained, particularly regarding their exclusive use. This may relate to the ecological risked of NNT species, including fears of invasive behaviour, disruption of native ecosystems or disease transmission that mentioned in literatures (Wohlgemuth *et al.*, 2022; Dyderski *et al.*, 2025).

Previous research regarded NT species to have more suitable nature conservation value than NNT species, which may be why respondents prefer NT species as well (Natural England, 2009). However, as a consequence of anticipated climate change, the geographical distribution of tree species is expected to shift in the future (US EPA, no date). The predictive models suggest that climate change will drive the geographical distribution of most species toward higher latitudes and elevations (northward trend migration) in the Northern Hemisphere, and the specific trajectories and outcomes of these changes remain uncertain (Ogawa-Onishi, Berry and Tanaka, 2010; Yousefzadeh *et al.*, 2024; Dyderski *et al.*, 2025). Respondents' perceptions about the species from southern England or southern Europe support the literature which considers the relevance of NNT species for future climate change.

The necessity of diversifying species composition in response to increasing climate stress has been acknowledged in the findings. Though a preference for NT species remained strong, there was a growing recognition of the need for flexibility and innovation in the face of ecological uncertainty. Respondents acknowledged that climate-resilient NNT species (not invasive) might need to be incorporated into future planting strategies. This reflects growing debate in urban forestry regarding ‘assisted migration’ or the use of NNT species to ensure ecosystem function under climate stress (Sjöman *et al.*, 2016). These findings suggest that while respondents’ views are rooted in traditional ecological values, they are responsive to new information.

In addition, when asked to consider future climate change, the experts and professionals' positive perceptions towards the proportion of NT species decreased in both MFM and CFM, while their perceptions of the percentage of NT in CF decreased more sharply ($P \leq 0.001$). This shows a gradual transition of respondents from the 'Native Species First' Stance towards a more pragmatic 'climate-adaptive' strategy, that maintain the principle of prioritising NT species, while conditionally incorporating NNT species with greater climate resilience, based on the urgency of climate change and the adaptive capacity of NT species. This also can be seen in the growing body of research, that in the context of global climate change, where the concerns about the capacity of native plant species to adapt and survive and the potential use of NNT species into European forestry are increasingly discussed (Thurm *et al.*, 2018; Watkins *et al.*, 2021; Wohlgemuth *et al.*, 2022; Cameron *et al.,* In Press). However, in the UK context, assessment of NNT has received little attention, making it challenging to generalise about NNT and highly uncertain for the ecological consequences of using NNT (Wohlgemuth *et al.*, 2022). Thus, this shift also reflects a need for more research, clear guidance and dialogue around species selection.

Furthermore, the experimental findings discussed in Chapter 6 may also inform the point toward NT and NNT species selection. Several native species (e.g. *Alnus glutinosa, Prunus avium, Carpinus betulus, Malus sylvestris, Cornus sanguinea and Sorbus spp.*) demonstrated rapid early growth under MFM, suggesting that native species could perform well (at least in establishment and early growth stages). This could strengthen the case for retaining native-only palettes within MFM applications in temperate UK contexts.

Ultimately, while both groups favoured NT species by default, the non-professionals showed greater willingness to use NT than experts and professionals in MFM ($P = 0.001$) and CFM ($P = 0.028$) before climate change information. However, the non-professionals indicated greater willingness to adopt NNT in both MFM ($P = 0.003$) and CFM ($P = 0.049$) than experts and professionals, after learning about climate change. Experts and professionals, by contrast, were more reserved, demonstrating a preference for maintaining native dominance unless ecological evidence supported alternatives. This finding indicates that climate change information had a stronger persuasive effect on non-professionals opinion than it did on expert opinion, which potentially reinforces the need for dialogue between experts and professionals and the non-professionals when implementing novel afforestation strategies, particularly those like MFM that challenge existing norms. Inclusive, evidence-informed decision-making that accounts for both non-professionals optimism and professional scrutiny will be essential to achieving socially and ecologically resilient forest establishment in the UK.

7.7 Costs and willingness to pay

The questionnaire responses reveal mixed perceptions among experts and professionals in terms of the perceived costs of MFM and CFM (RQ 1.1). Notably, 33.9% of respondents reported being unaware of MFM's potential costs, and a majority (56.3%) expressed uncertainty about investing in MF projects. This widespread uncertainty likely reflects the nascent state of MFM implementation in the UK and limited availability of comprehensive cost-benefit analyses in the literature.

Recent empirical findings from the Trees Outside Woodland's project showed that the overall initial cost of implementing the Miyawaki plots was consistently higher than that of their

corresponding controls, as the Miyawaki method requires more inputs (Trees Outside Woodland, 2024). This finding aligns with the literature (Vashisth, 2019; Crowd Foresting, 2022; Heuch and Thurman, 2024) and also with the respondents' perceptions to cost: most experts and professionals regard MFM as more expensive than CFM. Specifically, respondents perceived MFM would cost more than £20/m^2, while CF was viewed to cost less than £10/m^2.

However, the Trees Outside Woodland report also indicated that the mean costs per planted tree was £10.20 for Miyawaki plots, compared with £22.11 for control plots. More significantly, when considering cost per survived tree, Miyawaki plots achieved a mean cost of £16.97 compared with £79.38 for control plots. This demonstrates that while the initial investment for MFM is higher, it yields substantially greater cost-effectiveness when survival rates are factored in, indicating the true economic case for MFM may be stronger than current expert perceptions suggest.

This distinction between perceived and actual costs suggests that experts currently lack sufficient implementation data, or that costs vary significantly depending on site conditions, local labour rates, and materials sourcing etc.. It also highlights a critical evidence gap: experts appear to form perceptions around cost without sufficient exposure to comparative survival and establishment data that would allow them to assess cost-effectiveness. Addressing this evidence gap through targeted dissemination of case studies, cost-benefit analyses, and guidance documents tailored to different local authority contexts could meaningfully influence both practitioner confidence and policy support for MFM investment in the UK.

Soil preparation, high sapling density, and the labour required were key costs. Experts and professionals stated that the method's initial labour and financial costs could be prohibitive, especially in larger areas, or in the absence of NGO or government support. These concerns align with critiques found in the wider literature on MFM (Orchard of Flavours, 2023; Parikh, 2024; Qi, Dempsey and Cameron, 2024).

Moreover, there is a mixed willingness among experts and professionals to fund MFM projects in the UK. Respondents with greater familiarity with the MF demonstrating higher payment willingness than those who were less familiar. Similarly, those with master's-level and above qualifications exhibit greater willingness for their organisations to pay for MF compared to other educational cohorts. These suggest that more research about the actual costs should be prioritised, further education and debate around the MFM and its costs seems important and are needed (Alexander, Julia and Byun, 2018, p. 55). The observed correlation between familiarity and willingness to pay implies that the cost concerns may be partially rooted in unfamiliarity with real project data rather than genuine economic barriers. Transparent communication of actual cost, in particular the substantially lower cost per survived tree in MFM, might shift investment readiness among practitioners.

Not least, more than half of respondents (56.3%) reported uncertainty about their willingness to support such initiatives financially, reflecting broader concerns about the costs and economic viability of MFM (Wolff and Schweinle, 2022). The findings revealed stronger support for public sector funding of MFM rather than personal or organisational investment in the UK, suggesting that experts and professionals view MFM as primarily delivering public good rather than private

benefits. This funding preference creates the potential opportunity for public-private partnerships and green grants as viable financing mechanisms. This perspective shifts the perceived responsibility for implementation from individual practitioners to governmental bodies, driven by the recognition of the method's potential public benefits, including improved urban environments and enhanced community well-being (Rajadurai, 2024).

7.8 Early stage growth and survival rates of the MFM and CFM

The experimental findings presented in Chapter 6 provide empirical data into the early stage functional performance of the MFM in comparison to CFM treatments within a UK context. This section critically reflects on the experimental findings comparing the MFM and the CFM over a two and half years monitoring period, including an assessment of the measurable impacts of MFM through growth (RQ 3.1) and survival (RQ 3.2) rates. Overall, the comparative analysis findings of the experiment indicate statistically significant differences in height growth among eight species between MFM and CFM treatments, while overall differences in stem diameter were largely non-significant across most of the species, with only a few species showing statistically significant differences. Furthermore, early survival rates did not differ substantially between the two treatments, overall, but could vary strongly between species. Some species performed well in the Miyawaki treatment (e.g. *Alnus glutinosa* and *Betula pendula*), while others seemed to survive better in the conventional treatment (e.g. *Prunus avium, Crataegus laevigata, Corylus avellana* and *Viburnum lantana*). These findings provide evidence that can either support or challenge the MFM's suitability for the temperate UK climates, which will be discussed in the following sections.

7.8.1 Saplings growth: Evidence from the early stage

The dense planting regime of the Miyawaki system may stimulate competition induced growth spurts, as saplings compete for light, nutrients, and space, thereby accelerating early vertical growth (Dong *et al.*, 2016; Gruntman *et al.*, 2017; Qi, Dempsey and Cameron, 2024). Although limited to a two and a half years observation, the findings from this experiment indicate that saplings planted in the MFM plot promoted greater height increments and stem diameter gains than those in the CFM plots across most species, as demonstrated by significantly higher sapling height growth in 8 out of 17 species, though the stem diameter growth comparison was more moderate (Height growth was significantly higher in MF than CF for 47% of species, while only 27% showed significant differences in stem diameter growth at the species level). Thus, the current research findings support the short-term prospects of the MFM for rapid canopy formation. In addition, these findings support international findings that MFM can accelerate early-stage forest development through dense planting structure and intensive soil preparation (Miyawaki and Golley, 1993; Cárdenas *et al.*, 2022; Cambria *et al.*, 2024)

Between 2022 and 2025, 71% of the species in the MF plot showed significant height increases ($P < 0.05$), compared to 74% in CF plots. However, the overall height of growth was relatively higher in MFM. This difference was particularly pronounced in species such as *Alnus glutinosa, Prunus avium, Quercus robur, Betula pubescens, Salix cinerea, Rosa canina* and *Viburnum opulus* (Table 6.3.1 and Table 6.3.2), which showed strong, statistically significant growth under the MFM treatment. The variation in height growth among these species also underscores the importance of species selection and site–plant matching.

However, shade-tolerant and understory species, including *Taxus baccata* and *Ilex aquifolium*, consistently showed comparatively modest height growth across both treatment methods and time periods. This growth pattern aligns with expected ecological behaviour, as these species typically prioritise resource allocation toward structural development and root system establishment rather than rapid vertical expansion (Gommers *et al.*, 2013; Bai *et al.*, 2024).

Similarly, 75% of MFM species exhibited significant stem diameter increases, compared to 53% in CFM. The overall radial expansion was relatively higher in MFM, with species such as *Alnus glutinosa, Quercus petraea, Cornus sanguinea, Crataegus laevigata, Corylus avellana, Ilex aquifolium, Sorbus aucuparia* and *Viburnum opulus* (Table 6.3.3 and Table 6.3.4), which achieved statistically significant radial expansion under the MFM treatment.

These findings provide evidence to the claim that, at least in the early years of establishment, MFM accelerates early-stage growth compared to CFM. This is largely due to its emphasis on intensive soil preparation, incorporation of organic amendments, and high-density planting designed to replicate a natural ecosystem (Natural England, 2024; Qi, Dempsey and Cameron, 2024). Findings from the second monitoring period (2024–2025) highlighted even greater differences in growth performance, indicating that a cumulative effect of early soil enrichment, dense planting and microclimatic conditioning may become more pronounced over time, particularly for the species mentioned above that exhibited substantial gains in both height and diameter under the MFM treatment (von Arx *et al.*, 2013; Ho Vu *et al.*, 2024). This temporal pattern underscores the importance of long-term monitoring in forest restoration projects, as the full benefits of management interventions may not be immediately apparent. This is also the limitation of this study.

As noted by Cunningham *et al.* (2015a), Singh and Saini (2019) and Sjolander (2022), the use of native vegetation, combined with soil enrichment, i.e. the addition of organic matter in the soil, deep soil loosening, enhances root penetration and water retention. The use of native tree species helps promote local biodiversity and the soil management seems to facilitate rapid establishment and support the development of climax-stage forests. Moreover, the dense planting and mulching of the MFM create a humid microclimate and suppress weed competition, which may have contributed to reduced evapotranspiration and increased biomass accumulation (Cunningham *et al.*, 2015a; Fernando and Shrestha, 2023). Nonetheless, there were some challenges emerged. Not all species responded equally across plots, with some exhibiting stagnated growth or mortality regardless of method, such as *Prunus padus* and *Fagus sylvatica*.

In conclusion, the experimental findings of early stage growth provide empirical support for the short-term ecological viability of MFM in a temperate UK condition. The findings reinforce claims made by MFM advocates regarding rapid establishment and early growth, but also point to the need for long-term monitoring, to ensure sustainability under future climate and land-use conditions. Given the urgency of addressing climate and biodiversity crises, this temporal efficiency may prove valuable for policymakers and practitioners seeking to meet ambitious environmental targets quickly, particularly in constrained urban settings where rapid canopy development and biodiversity outcomes are desired

7.8.2 Saplings survival: Early stage variable survival outcomes and mortality drivers

The comparative survival analysis highlights complex temporal dynamics between MF and CF treatments. The survival rate of MFM is claimed to be higher than CFM. For instance, in one study in Kent, UK, reported a 79% survival rate in MF compared with 47% survival rate in the control plot (Trees Outside Woodland, 2024). In another study by SUGi, the average survival rate across all MFs was 83.5%, although SUGi had no control sites (SUGi, 2021). However, the results from this experiment demonstrated an inverse trend, despite the stronger early growth performance observed in MFM, overall survival rates were low (36% in MF and 48% in CF plots). The survival rates varied substantially across species, as the species that did not fare in the early stage MF plot, were more likely to be shade-intolerant or drought-sensitive species (Thiagarajan, 2020).

The survival rate of CF plots in this experiment was broadly comparable to that reported in Trees Outside Woodland's projects, whereas the MF plots showed a notably lower rate. The substantial difference in MF survival rates underscores the potential influence of site-specific factors, planting procedures, and management practices on overall survival outcomes, as the TOW report encompassed 14 different sites with highly variable conditions, compared to a single site in this study. However, without access to detailed site-level data from TOW, it remains difficult to determine precisely why the survival rates differed so markedly between the two studies.

The potential reasons for the relatively lower survival rate observed in this study might be as follows:

- Species sensitivity:
  In this experiment, *Alnus glutinosa* and *Betula pendula* showed consistent high survival in both treatments, which could be considered as species compatible (Leslie and Short, 2025). In contrast, 55% of the species in MFM survived less than 30% while this proportion was 33% in CFM. Species such as *Prunus avium* (8%), *Ilex aquifolium* (13%) and *Taxus baccata* (19%) exhibited low survival in MFM despite relatively strong growth among surviving individuals. These findings indicate that, for MFs, more shade-intolerant or drought-sensitive species may require targeted microsite interventions, or placement along plot peripheries rather than randomly planting, and then they might be able to have a better survival rate.

- Interspecific competition:
  These outcomes may reflect the effects of interspecific competition inherent in dense plantings (Suganuma and Durigan, 2015; Gruntman et al., 2017). While high density configurations can encourage vertical growth by intensifying competition for light, they may also negatively affect species that are slower growing or shade intolerant, potentially hindering their establishment during the early stages of development (Coomes and Grubb, 2000; Valladares and Niinemets, 2008). Conversely, mixed-species plantings may offer potential benefits through facilitative processes, such as shared mycorrhizal fungal networks that can enhance nutrient exchange among neighbouring trees, or the presence of nitrogen-fixing species that improve soil fertility for companion plants (Simard *et al.*, 2012, Reid *et al.,* 2024). However, the balance between competitive and facilitative effects likely varies by species combination, planting density, and site conditions. Consequently, careful species selection is essential. For MFs in temperate climates, species selection should not rely solely on local status but need also consider key ecological traits, including shade tolerance and competitive dynamics. In this context, local

ecological knowledge and site-specific trials remain critical for evaluating the suitability and benefits of the MFM in the UK context.

- Trade-offs between biodiversity and survival:
  Some of these points may need to be considered in an economic scenario. Despite the strong visual appeal of biodiversity in the Miyawaki plot, the results suggest losses greater than 70% for species such as *Fagus sylvatica, Prunus padus, Prunus avium, Carpinus betulus, Quercus* spp*., Sorbus torminalis, Taxus baccata, Malus sylvestris, Corylus avelllana, Ilex aquifolium, Euonymus europaea, Sorbus aria* and *Viburnum lanata*. If the average sapling costs £1.50, then that equates to an approximate cost of £1,890. Therefore, some visually dominant species contributed to greater biodiversity but also suffered higher mortality, suggesting a potential trade-off between ecological and cost-efficiency considerations.

  When these findings are considered alongside experts and professionals' perceptions of species selection, it reveals that species such as *Prunus spp.*, *Quercus spp., Fagus sylvatica,* and *Taxus baccata*, which were commonly recommended by the experts and professionals, actually performed poorly in the experiment. In contrast, species like *Alnus glutinosa*, *Betula pendula* and *Sorbus aucuparia* (all species with reputations for being pioneering – i.e. being part of early land colonisation) maintained high survival rates across both treatments, despite not being mentioned in the responses by the experts and professionals.

Furthermore, these findings challenge the assumption that denser planting and enhanced soil conditions could lead to better survival rates of trees. In fact, some evidence suggests that excessive competition may increase early-stage mortality in species with poor early vigour or high sensitivity to shade and root competition (Coomes and Grubb, 2000; Vandermeer *et al.*, 2002; Lyu and Alexander, 2022). In addition, the anomalous results require further consideration, i.e., the survival rates for *Salix spp.* in MF plots exceeded 100%. The reason is still unclear, but it could raise questions about natural regeneration, volunteer seedlings, or recording inconsistencies.

These findings offer important information for UK-based applications of the Miyawaki method. While the method appears promising in delivering rapid early-stage forest structural development, it is not universally advantageous across all native species, and the long-term ecological trajectories remain unknown. The method's inherent intensification (high planting density, deep soil mixing, mulch cover) may need to be tailored for certain ecological contexts and species compositions. Additionally, long-term monitoring is essential to evaluate whether early growth advantages persist into canopy closure and maturity.

Moreover, while the MFM traditionally emphasises the use of PNV as a baseline, climate change necessitates a more dynamic and future-facing approach (Miyawaki and Golley, 1993). This is also reflected in respondents' perceptions, as many recognised the need to incorporate some NNT species which are not invasive. Some traditional native species may no longer be well-suited to urban conditions such as heat island effects, compacted soils, and altered precipitation patterns (Broadmeadow, Ray and Samuel, 2005; Müller *et al.*, 2013). Therefore, adapting the MFM to the UK context may benefit from a 'climate-smart' adaptation strategy that balances ecological integrity with enhanced resilience to environmental stressors.

7.9 Bridging perception and practice: Priority research for the MFM

The findings of this research reveal that both experts and professionals, and the non-professionals, share enthusiasm for the application of the MFM in the UK context. However, they also express a number of consistent uncertainties and critiques regarding its performance and long-term viability within the UK context. Many of these concerns relate to the lack of empirical, UK-specific evidence, as well as to perceptual differences between experts and professionals who involved in practice and the non-professionals. The table below summarises a series of critiques (research wins) of this study, and achievable research opportunities to address professionals and non-professionals critiques and support wider adoption.

Table 7.9.1 Proposed research focus for strengthening the application of the MFM in the UK

Critiques	**Source of concerns**	**Proposed research focus**
Lack of UK-specific ecological evidence	Professionals highlighted uncertainty over MFM survival, biodiversity, and carbon outcomes.	Establish multi-site comparative monitoring (MFM vs CFM) to track growth, survival, and biodiversity etc..
Perceived high costs and labour intensity	Professionals viewed MFM as resource-heavy, non-professionals questioned value for money.	Conduct detailed cost–benefit analyses overtime.
Accessibility and dense planting concerns	Non-professionals raised fears of “closed” or inaccessible forests.	Test alternative spatial designs of MF (e.g. paths, edge planting, visual permeability).
Low awareness and familiarity	Non-professionals awareness was low but support increased after explanation.	Implement and evaluate interpretive communication strategies (signage, guided tours, school engagement) at pilot sites.
Uncertainty over long-term ecological resilience	Professionals sceptical about durability under UK conditions.	Launch 5–10 year longitudinal studies of existing UK MFs assessing canopy closure, soil recovery, and successional change.
Native vs non-native species selection under climate change	Both professionals and non-professionals favoured native species but recognised the need for adaptation.	Run controlled trials comparing native-only and mixed (native and non-native) species within MFM.
Divergent perceptions of environmental benefits	Professionals saw greater benefits of MFM, non-professionals preferred conventional planting.	Develop citizen science biodiversity and microclimate monitoring programmes near existing MFs and CFs.

Collectively, these proposed research focus will respond directly to the critiques identified through this study. Implementing these research focus would not only clarify ecological and economic uncertainties but also foster mutual understanding between experts and professionals, policymakers, and non-professionals. This, in turn, would support the development of more inclusive, evidence-informed, and resilient urban forest strategies suited to the challenges of the 21st century.

Ch.8. Conclusions and further research

8.1 Introduction

This thesis has investigated the suitability of the Miyawaki Forest Method (MFM) for application in 21st-century England, drawing on professional and non-professionals perceptions as well as empirical data from an experimental planting site.

This chapter reviews the primary findings of this research to address the research questions. In addition, the contributions to existing knowledge of the research, limitations and propose recommendations for future research in the field are outlined.

- Research overview and conclusions (section 8.2).
- Contribution to knowledge (8.3).
- Limitations (8.4)
- Scope for further research (8.5).

8.2 Research overview and conclusions

Amidst accelerating climate change and ongoing deforestation, a range of urban environmental challenges has emerged, underscoring the urgent need for nature-based solutions such as urban forests. The Miyawaki Forest Method has been recognised as a tree-planting method which has claims to be an extension of existing efforts to green cities, with rapid forest establishment, ecological benefits, by creating diverse and healthy forests (Webber, 2022; Zeybek, 2025). This method of planting has been implemented in the UK since 2020, by practitioners including the charity Earthwatch Europe. However, there remains a lack of clear understanding of the perceptions of its suitability and a need for further empirical evidence regarding its long-term performance in the UK.

This study provides one of the first integrated evaluations of the MFM in the UK, exploring the perceptions of experts, professionals and non-professionals perceptions, alongside empirical data from a comparative field experiment. The findings offer a multi-dimensional understanding of how different actors perceive the method's suitability, environmental benefits, costs, tree species selection debates. The findings also provide data about the promise and challenges associated with implementing specific urban tree-planting initiatives in the UK.

Research question 1: What are the dominant discourses on the MFM both in the UK and around the world from the perspective of experts and professionals?

Among UK experts and professionals, the MFM is recognised as a conceptually promising but practically complex strategy, marked by broad conceptual support but substantial practical barriers. While conceptual alignment with urban greening priorities was strong, substantial concerns remain around high initial costs, long-term maintenance requirements, and the method's limited empirical validation within the UK context.

There is a significant disparity between awareness and active involvement with MFM among UK experts and professionals. Awareness of the method was moderate (54.5%), yet active involvement remained low (28.6%), particularly pronounced among academics respondents. This suggests a practice-led diffusion of MFM knowledge, with minimal penetration into academic

discourse, highlighting a pressing need for greater cross-sectoral knowledge exchange to fully evaluate the method's potential and application.

The findings also indicate that the support among experts and professionals is particularly strong for urban application of MFM, especially in parks, blue infrastructure, and educational sites, where space is constrained and public benefits are considered to be clear. This perspective on strategic site selection offers critical guidance for policymakers, environmental advocates, and urban planners.

Addressing the perceived challenges, particularly regarding high initial costs and uncertainties about long-term outcomes, such as how many tree species / individuals survive and how do ground flora / invertebrate biodiversity indices change with time, is crucial for the wider experts and professional buy-in of MFM. In addition, there is strong support from experts and professionals for MFM projects to be funded via the public sector to gain public benefits, particularly in dense urban areas where green space is limited, reflecting the method's alignment with public goods rather than private returns.

In addition, the findings illustrate that while experts and professionals would prefer the use of native tree (NT) species in MFM (aligning with the core principles of the original Miyawaki method) by, this position slightly changes to a growing openness to incorporating non-native trees (NNT) which are non-invasive when they are asked to consider the impacts of climate change. Thus, there is growing recognition among experts and professionals of the potential need to incorporate NNT species to enhance resilience and ensure long-term forest viability, which could provide an adaptive afforestation strategy to help mitigate climate change.

In summary, experts and professionals share perspectives which highlight both the conceptual appeal and the practical complexity of implementing the MFM in the UK. While support is strong in principle, particularly for its perceived relevance to urban greening and biodiversity goals, key concerns remain around cost, long-term outcomes, and species resilience, pointing to the need for further research projects. The shift towards NNT in species selection reflects an evolving, adaptive stance among experts and professionals that balances ecological ideals with practical realities. These insights offer critical foundations for future research, policy refinement, and cross-sector collaboration in testing MFM as part of the UK’s urban forest strategy.

Research question 2: How much does the non-professionals know about the Miyawaki Forest method?

The non-professionals perspective on the MFM in the UK reflects a cautiously optimistic but informed attitude towards this novel afforestation strategy. In contrast to experts and professionals, the non-professionals exhibited a much lower initial awareness, with only a minority having heard of (27.1%) or been involved with (8.9%) the Miyawaki method prior to participating in the survey. However, the responses shifted markedly to widespread enthusiasm and high receptiveness once the method was explained, highlighting the potential for building non-professionals support through interpretive outreach. Moreover, frequent greenspace users and members of the public with a strong interest in trees were more aware of the method and especially receptive, suggesting that nature-connected individuals may be a means of fostering broader public understanding and acceptance of afforestation efforts.

Non-professionals perceptions were similar to those of experts and professionals when considering MFM's suitability. They assessed MF as a relatively suitable tree-planting approach for the UK (mean = 6.55), with a wide level of acceptance across different demographic groups. This indicates a general openness to the method, but it is conditional. Respondents often emphasised the method's suitability with the UK's temperate climate, its potential applicability in space-constrained urban settings, and the importance of appropriate species selection. This reflects growing public awareness of the need for site-specific urban greening strategies that account for local soil conditions, microclimates, existing ecosystems, and community preferences.

In addition, the perceived value of the method's promise of rapid establishment, native species focus, and urban-scale adaptability, particularly in compact and degraded environments, could be the key factors for developing the MFM method more widely in urban environments in the UK. However, the limited empirical data available on MFM in the UK context meant the non-professionals expressed reservations about its long-term effectiveness and resilience. Although the non-professionals can be open to innovative methods and acknowledged MFM's relevance to climate and biodiversity challenges, they did not view it as inherently superior to conventional forestry methods, as the support is contingent on robust local evaluation. In fact, non-professionals perceived the CFM to be slightly more beneficial across all ecological dimensions: carbon capture and storage, flood risk reduction, urban cooling, and biodiversity enhancement (tree, ground flora, and insect population diversity). The non-professionals didn't perceive MFM as delivering greater ecological benefits which reflects legitimate concerns around that theoretical principles when visible, measurable benefits are essential for non-professionals acceptance.

While general attitudes were positive among the non-professionals, MFM's spatial applicability was more readily accepted by those already familiar with the method, reinforcing the role of familiarity in shaping receptiveness. The exposure to MFM projects through multiple ways may be key to strengthening non-professionals support. There was emphasis on parks, industry, and blue infrastructure, which aligned closely with professional views (parks and blue infrastructure,) and underscored the importance of targeted, context-sensitive implementation.

On the issue of species selection, the non-professionals shared the same opinion as experts and professionals, supporting the use of NT species in MFM and some support for the inclusion of NNT species, in light of increasing awareness of climate change impacts. However, the support for NNT species remained conditional, with concerns about invasiveness and ecological mismatch. However, this also reflects the non-professionals' growing recognition that traditional conservation methods, which typically prioritise strictly native species, may be insufficient given the rapidly changing environmental conditions.

In summary, non-professionals perceptions for the support the use of MFM appears to fall into multiple categories. Firstly, they are interest driven, particularly by those who regularly use green spaces, participate in gardening, or engage in conservation show greater receptiveness. Secondly, they are contextual and conditional when respondents considered the potential applicability of NNT species. Thirdly they are more positive as respondents were informed about the MFM approach. Finally, they are shaped by their perceptions of the ecological benefits, that are

somewhat distinct from the more conceptual and practical driven concerns of experts and professionals.

While non-professionals respondents lack the professional familiarity or direct involvement seen among practitioners, they are still supportive to the method overall. This support is closely correlated to the green space interest and exposure to the method, underscoring the importance of inclusive education, participatory implementation, community engagement and further research and transparency in fostering non-professionals supportive for MFM initiatives across the UK.

Research question 3: How do growth rates and survival rates of trees planted using the MFM compared to CFM in the UK?

This section presents one of the first empirical assessments of MFM performance in the UK, using comparative experimental data from MF and CF plots. The findings of early-stage sapling performance in MFM and CFM treatments offer a further insight. After two and half years of monitoring, MF plot demonstrated significantly higher height growth rates, with similar diameter growth rates but lower sapling survival rates than CF plots, under UK climatic and soil conditions. These results validate some of the key claims of the method. High-density planting and intensive soil preparation appear to offer advantages in accelerating height growth of saplings, potentially aiding in the rapid canopy closure and competitive vertical growth.

However, these growth benefits did not consistently translate into improved survival, particularly for shade-intolerant or drought-sensitive species, which experienced considerable early-stage mortality under MFM treatment. The findings diverge from the consistently high survival rate claimed in existing literature, where differences between plots were less pronounced (Miyawaki, 1999; Suzuki, 2022). This suggests that such claims may not be directly transferable to the temperate UK context without adaptation.

These findings highlight both the potential and the limitations of MFM when applied in a temperate UK context, emphasising that MFM is not a one-size-fits-all solution. Careful species selection, site-specific design, and adaptive strategies, such as microsite management and, where appropriate, the inclusion of climate-resilient NNT species, could play a critical role in improving long-term outcomes.

Given that the method is relatively new in its application to the UK context, the long-term monitoring of both growth and survive is critical to assess whether early-stage growth benefits persist into later successional stages. In the broader context of responding to climate and biodiversity crises, the temporal efficiency of MFM offers practical value for urban greening and rapid afforestation initiatives. However, its long-term growth, survival and ecological sustainability and resilience under UK conditions remain uncertain. Before widespread adoption, the method's performance must be critically and locally evaluated through continued research and adaptive implementation.

Ultimately, comprehensive long-term empirical research is needed to fully verify or refine the claims around the MFM. The findings from experts and professionals, the non-professionals, and experimental trial data suggest that the MFM holds significant potential within the UK as an

intensive, community-responsive, and ecologically driven urban greening strategy. It also confirms that MFM is raising interest levels in a wide range of people in the UK (Pavlis, 2023; Rauf *et al.*, 2024). It is at least acting as a catalyst for debates around the environment, urban planning and access to nature. There is no doubt that questions and concerns remain around the costs and actual environmental benefits of Miyawaki method. In addition, the early-stage experimental evidence underscores MFM's claims for rapid growth, though survival outcomes did not. As such, the MFM should be seen not as a one-size-fits-all solution, but as an adaptive framework whose potential lies in its adaptation to specific ecological, climatic, and social contexts.

Is the Miyawaki Method 'doing its job' in the UK? This remains an open question. While respondents across all groups generally expressed support for the method and recognised its suitability in the UK context, they also voiced significant reservations. Doubts persist regarding the method's core claims of rapid growth, low mortality, low costs and superior environmental benefits, especially given the limited UK-specific empirical evidence available. In addition, there is a need to raise the profile of urban forests and advancing the case for greater tree cover in our cities with the public. In its current state, the MFM approach within the UK's afforestation and urban greening strategies needs to continue to be critically evaluated and locally adapted.

To achieve this, continued and coordinated action across research, policy, and practice is needed, in order to assess the ecological effects, as well as cost-benefits more precisely (Schorine *et al.,* 2011). Understanding these perceptions and knowledge needs is essential for determining whether the MFM can gain wider adoption in the UK, or whether evidence may reveal fundamental limitations in this context. By identifying how the MFM is perceived by professionals and the non-professionals, this study offers important insights for policymakers and planners seeking to develop greener, healthier, and more resilient cities across the UK. The findings emphasise that effective implementation depends not only on ecological evidence but also on building informed understanding and support among professionals and communities who will manage and benefit from these living environments.

8.3 Contribution to knowledge

This study makes several original contributions to the growing body of research on the perceptions to urban forestry, ecological restoration, climate change and NT and NNT species debate. While MFM has gained global attention for its claim to deliver rapid, more biodiverse forests, its empirical evaluation in temperate UK contexts has remained extremely limited. This study fills a significant gap in the current literature in the UK temperate context, as well as providing empirical research into perceptions of different aspects of MFM.

This research offers the first exploration of UK-wide examination of how experts and professionals, and the non-professionals, perceive the MFM thereby opening new dialogue on the method's practical, perceptual, and ecological relevance in the UK context. By assessing expert and non-expert perceptions, this study reveals significant differences in awareness levels and involvement experiences with the method. The research further explores how different groups perceive the suitability and environmental benefits of Miyawaki forests, while also identifying perceived costs and challenges. In addition, the study examines perspectives on adaptive species selection strategies in light of climate change considerations. These findings build on existing literature by

situating the debate within a UK-specific cultural and environmental context, thereby expanding understandings of how this novel afforestation strategy is interpreted by different societal groups.

Specifically, the findings offer advice for urban planners, environmental organisations, and policymakers seeking to implement afforestation in densely populated and degraded urban spaces. As urban areas across the UK face intensifying challenges from climate change, biodiversity loss, and health inequalities, forests present an intervention that aligns with several UK policy responses, such as the Trees Outside Woodland project, Nature Recovery Green Paper and England's Trees Action Plan 2021 to 2024 (Defra, 2021, 2022; Goldhill and Fitzgibbon, 2021; Kapucu et al., 2024; Dale, 2025; Taylor, 2025). This study finds that strategic site selection, outreach, public communication and robust evidence on the establishment, environment and social benefits are identified as critical for building cross-sectoral support. This research thus can inform emerging practice and policy agendas around equitable access to urban nature and climate-adaptive planting strategies, and also supports the consideration to incorporate Miyawaki-style planting into broader urban green infrastructure strategies.

The study brings forward the debate on NT and NNT species selection in afforestation strategies. It challenges the idea that only NT species should be planted in the Miyawaki method. It reveals a shift among both experts and professionals and the non-professionals towards conditional support for incorporating selected NNT species to enhance resilience to climate change, while still maintaining an ecological preference for NT species. This contribution adds critical depth to ongoing debates about nativeness, ecological integrity, and urban forest adaptation in response to environmental uncertainty.

Finally, though Miyawaki-style forests have been planted in the UK since 2020, there had been no comparison of MFM with CFM treatments, to test the performance of both methods. This study contributes to knowledge through its empirical evaluation of MFM and CFM treatments over two and half years, to provide one of the first such experimental comparisons in a UK setting. Through a longitudinal comparative experiment, this study provides empirical data on the growth and survival performance of MFM versus CFM treatments in a temperate area in the UK. Though data is limited, the findings offer early-stage evidence around the implications of MFM in the UK. The results confirm that MFM can offer higher growth rates in certain native species compared to CFM treatment, but also highlight lower survival rates in MFM. This contributes to the empirical understanding of MFM's ecological functionality beyond its original subtropical applications and introduces new evidence into discussions around urban forest planning in temperate climates.

8.4 Limitations

There are some limitations of this study to be acknowledged. These constraints include the sampling bias, survey design and distribution, limited timeline for experiment, site conditions and weather dynamics of experiment, and variable definitions. Although each limitation holds relevance, they collectively form the boundaries of this study, influencing its scales and findings. This section explains these limitations to fully understand their impact on the research findings and conclusions.

8.4.1 Sampling bias

Although this study aimed to encompass a wide range of the experts and professionals and the non-professionals, the sampling approach resulted in samples that are likely not representative of broader populations, especially pronounced for the non-professionals group.

The majority (53.6%) of expert and professional respondents (Questionnaire 1) were from academia, a higher proportion than might otherwise be the case. It was because the research was initiated in an academic institution, resulting in greater responses rates from academics through institutional networks. Thus, this representation of the sample does not necessarily reflect the full range of green space professionals (nor their attitudes).

In addition, the sample of respondents to the non-professionals questionnaire (Questionnaire 2) were primary individuals with existing interests in the tree planting, forests or greenspace environment. This recruitment strategy, which relied on networks and platforms frequented by those already engaged with environmental topics. Questionnaire 2 sample therefore had a heavily bias toward tree likers. Future work on general public acceptance and perceptions would be of value.

The questionnaire was circulated through established networks, some of which were already involved with the MFM in the UK. The data may therefore reflect those individuals / groups disproportionately, although in reality many of these also are involved with conventional forest initiatives and thus useful to harness their views in the comparisons. Although this sampling approach proved effective in accessing a wide response, it introduced selection bias towards individuals already engaged with environmental organisations or professional networks (Millard *et al.*, 2023). This may have potentially overrepresented their perspectives and excluded those with limited or no affiliation to such networks. Also, the survey was conducted within one country, with three quarters of respondents from UK and the findings are not international in scope.

8.4.2 Survey design and distribution

The survey design posed challenges. The questionnaire was long and may have reduced response rates. However, this length was necessary due to the lack of empirical data about MFM research in the UK. Some respondents expressed that they felt ‘over-loaded’, some might be busy and don’t have enough time to provide all details, and this may have led to survey abandonment, influencing the sample size.

In addition, the Likert scale was used in some questions because it is easy to construct and has the potential to produce highly reliable scales. In addition, from the perspective of participants, it is designed to be easy to read and complete in terms of the participant's perspective. However, in Likert scales, some respondents may avoid extreme response categories, which will cause central tendency bias. Also, respondents may respond to the statements in order to please the experimenter (acquiescence bias). These surveys were not conducted face-to-face in an effort to avoid this.

Furthermore, the survey was conducted through online questionnaires. While email distribution facilitated broad distribution, it did not inherently guarantee a large or diverse representative

sample. This approach may have excluded individuals with limited digital access or lower levels of digital literacy (Dillman, 2014).

8.4.3 Timescale of the experiment

There is limited longitudinal data from the field experiments. Though the study provides a snapshot of current perceptions into the early-stage development of very young Miyawaki-style forests planted in the UK, the two and half year monitoring period generated only the early establishment phase data of Miyawaki-style forest development, in terms of early growth patterns, and survival rates. While this timeframe generated important baseline data on initial tree establishment, short-term assessments are inherently limiting for forest systems, as the absence of long-term data makes it difficult to evaluate the ecological outcomes and sustained impacts and viability of MFM projects over time. For a truly comprehensive understanding, long-term monitoring beyond this study would be necessary, in terms of growth trajectories, survival, carbon sequestration, and biodiversity outcomes (Stanturf *et al.*, 2014). A model to speculate future trends in forest structure and ecological outcomes could be developed when the data collected is sufficiently large and comprehensive.

8.4.4 Experiment site condition and weather dynamics

As the site has a slope, there were site-specific constraints, including waterlogging in plot 3 (CFM). This subsequently created drainage challenges for planting and growing challenges for saplings. These localised limitations underscore the importance of considering topography, drainage, and soil type when selecting planting methods (Siyag, 2014). In addition, variable weather conditions, pest and disease pressure, and wildlife browsing, also posed potential influences beyond the control. The findings of the experiment should therefore be interpreted as exploratory.

8.4.5 Experiment spatial configuration constraints

The site could be further split into more plots, to investigate which factors (e.g. soil condition, planting density or mulching) most strongly influence growth rate, stem diameter and survival rate. However, the sampling strategy was limited by the nature of the study site. The experiment plots were long and narrow, situated on privately owned land with limited available space, bordered by existing woodland along the back long edge and open field on the other side. To maintain adequate plot sizes for the MFM treatment (each plot requiring an area approximately equivalent to a tennis court to accommodate high-density, multi-species planting), it was not feasible to increase the number of replicate plots or implement a more extensive sampling design. As a result, the observed differences in growth and survival between treatments cannot be conclusively attributed to the planting method alone, as underlying soil differences between the MF and CF plots may also have influenced outcomes. Future studies should therefore incorporate multiple replicate plots across varied sites to better isolate method effects from soil factors.

8.4.6 Incomplete data across species and time

A key limitation of the experimental study relates to the incomplete data collection of certain species across all monitoring years. Due to natural mortality, limited sample sizes, and occasional fieldwork constraints, it was not always possible to obtain sufficient measurements for every species within each plot at each time point. In some cases, height or stem diameter data were

missing for certain species either because seedlings had not survived or because the number of remaining individuals was too low to ensure meaningful representation.

As a result, the statistical robustness of comparisons of single species was limited, reducing the strength of inferences that could be drawn about species-specific growth trajectories under the MFM and CFM. While the patterns at the plot scale remain valid and informative, these gaps in the dataset constrain the generalisability and statistical power of certain findings, especially those related to individual species performance. More comprehensive and consistently collected species-level data would be required to strengthen the reliability of conclusions about specific taxa and their responses to different planting approaches.

8.5 Scope for future research

Though there is good evidence that the MFM is gaining momentum in the UK, the debate across its practical, ecological, and social implications is also expanding. Building upon the insights and limitations demonstrated in this study, several promising avenues for future research emerge. While this study focuses exclusively on the UK, particularly England, subsequent investigations could delve into the application and adaptation of the MFM across other European countries. As there is increasing popularity of, and interest in, MFM in Europe, there is an opportunity to build a more comprehensive and comparative dataset that examines how sociocultural, climatic, and governance factors influence the perceived and actual outcomes of MFM initiatives.

First, this study highlights the pressing need for more longitudinal research in the UK. Long-term monitoring of Miyawaki projects is essential to understand their development trajectories, species dynamics, and the stability of ecological functions as they mature. In particular, studies that extend beyond the establishment phase could reveal whether initial rapid growth rates translate into sustained ecosystem service delivery and biodiversity benefits. While some evidence exists regarding short-term growth and survival parameters of Miyawaki-style forests in the UK, the current findings are based on very young forests planted within the last four or five years, offering only a snapshot of early-stage development. There is still a lack of empirical data capturing the longer-term growth and survival.

Although research on carbon storage, thermal comfort and biodiversity outcomes has started to emerge, again, there remains limited empirical data capturing the longer-term ecological dynamics of these planting schemes beyond the initial establishment phase. This scarcity of longer-term data makes it difficult to evaluate the sustained impacts and long-term viability of MFM projects over time at present. Tracking outcomes over long term would fill key evidence gaps currently limiting the scalability of the method. Future research should prioritise continuous monitoring growth and survival patterns, and also species composition changes, ground flora regeneration, invertebrate community establishment, thermal condition, carbon sequestration trajectories and the forests' long-term management. Such comprehensive and robust long-term datasets are critical for integrating MFM into national climate adaptation strategies and urban resilience planning.

In addition, this study calls for modelling-based approaches to complement field studies, particularly if measuring ecosystem services such as air pollution reduction, microclimate regulation, and soil carbon storage. Modelling approach could help to simulate the long-term structural and functional outcomes of Miyawaki-style forests over 10 -- 20 year timescales quickly,

especially where physical monitoring is constrained by time, space, or resources. Such modelling approaches could help address critical questions regarding the mature characteristics and ecological functioning of Miyawaki-style forests, thereby supplement the current paucity of long-term empirical data in the UK context. This would provide a valuable basis for anticipating future outcomes and informing the design and management of Miyawaki projects under diverse environmental and urban conditions.

Furthermore, further research should explore general public perceptions over time, particularly as Miyawaki-style forests mature and their visibility increases in the UK. This would help assess whether initial perceptions align with longer-term experiences and attitudes, thereby informing public engagement and policy strategies.

Using NT species that would naturally occur in a specific region is one of the core principles of the MFM. However, in the current contexts, strict adherence to a 100% native composition may not always be feasible, given the pressures of climate change, urban soil degradation, and the potential need for species with broader ecological tolerances. Furthermore, both professionals and non-professionals increasingly perceive the inclusion of NNT as acceptable, representing a departure from the typical MFM principle.

At the same time, the notion of “native” becomes increasingly complex, particularly in highly urbanised environments where historical vegetation has been lost and future climates may no longer support past assemblages. This raises a critical question: at what point does a MF cease to be a MF? Or is it already on that trajectory? Specifically, when NNT species are introduced, where is the threshold? Is the MFM defined only when 100% of the species are locally native, or is there scope for limited flexibility to accommodate future climate shifts and site-specific constraints? Exploring these questions will be an important direction for future research.

Last but not the least, there is also a strong rationale for more applied and interdisciplinary research at the intersection of education, health, social, and economic dimensions to ensure that urban forest interventions are contextually appropriate and widely supported. As there are already Miyawaki-style forests within/ near school grounds, future studies could investigate how regular engagement with Miyawaki-style forest affects environmental learning, wellbeing, and behaviour in children and youth across different school settings. In addition, there are also Miyawaki-style forests within hospital premises and further investigations could also assess how these spaces are used by medical practices and social prescribing schemes, in order to understand their role in preventative health. Moreover, the further study to the community Miyawaki-style forests could contribute to citizen science, community education and serve community amenity. It might also contribute to increasing property values and generating other indirect economic benefits for local communities. Finally, the cross-sector partnerships, especially with non-governmental organisations which are implementing the MFM, can play a critical role and platform for delivering applied research.

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Appendices

Appendix 1 Research Ethics Review Application

The University Of Sheffield.

Downloaded: 18/05/2022
Approved: 25/04/2022

Hanyu Qi
Registration number: 210193499
Landscape
Programme: not applicable

Dear Hanyu

PROJECT TITLE: Exploring the feasibility of the Miyawaki Forest method in the UK context
APPLICATION: Reference Number 045672

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 25/04/2022 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 045672 (form submission date: 22/04/2022); (expected project end date: 01/10/2025).
- Participant information sheet 1104917 version 1 (22/04/2022).
- Participant information sheet 1104858 version 1 (20/04/2022).
- Participant information sheet 1103588 version 2 (18/03/2022).
- Participant information sheet 1103556 version 2 (17/03/2022).
- Participant consent form 1104857 version 1 (20/04/2022).
- Participant consent form 1103557 version 1 (16/03/2022).

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

James Simpson
Ethics Administrator
Landscape

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy: https://www.sheffield.ac.uk/rs/ethicsandintegrity/ethicspolicy/approval-procedure
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.

Appendix 2 Experts and Professionals Questionnaire Survey

Tree planting research in the UK

Hi, I'm Hanyu Qi, a PhD student at The University of Sheffield. I am currently doing research about tree planting in the UK. This questionnaire is exploring professional's perceptions towards different tree planting methods and attitudes around choice of tree species.

Please read the following information before continuing to the survey.

Project information

The questionnaire is part of PhD research conducted in the Department of Landscape Architecture at the University of Sheffield, under the supervision of Dr Nicola Dempsey and Dr Ross Cameron.

If you are 18 or over, currently living in the United Kingdom, have experience and knowledge or doing relevant research or project on tree planting, or with an interest in trees, please consider participating in this study about trees.

What do I need to do?
You will be asked a sequence of questions about the tree planting. This questionnaire should take **about 20-25 minutes** to complete. You are free to stop participating in this survey at any time.

Anonymity
Your participation is voluntary, and all your answers remain entirely confidential. You will not be asked to provide any personal information that could identify you as an individual.

Ethics and Data Protection
This research has been approved by the Department of Landscape Architecture Research Ethics Committee at The University of Sheffield.

The Data Controller institution is the University of Sheffield, and the legal basis for processing the data is research in the public interest (Article 6(1)(e)). Further information can be found in the University's Privacy Notice

Thank you very much.

Contacts
If you have any questions, concerns or complaints, please contact the PhD candidate Hanyu Qi (hqi8@sheffield.ac.uk), or their supervisor Dr Nicola Dempsey (n.dempsey@sheffield.ac.uk). If the complaint relates to how the data you provide has been handled, you can find information about how to raise a complaint in the University's Privacy Notice here

Before I go on:
- I have read and understood the project information (provided on the previous page).

- I understand that taking part is voluntary and that I can withdraw from the study at any time. I do not have to give any reasons if I no longer want to take part and there will be no adverse consequences if I choose to withdraw.

- I understand that NO personal details (e.g. my name or phone number) will be collected as part of the survey.

- I consent to the answers I contribute will be used to generate insights in this research project.

- I consent to allow the fully anonymised information to be used for future publications, research and learning.

- I understand that the information acquired will be stored by the researchers securely (all data will be stored and analysed on encrypted password-protected computers); The University of Sheffield will act as the Data Controller for the project.

- I understand that the anonymised pooled data may in future be made available to other for research purpose only.
- I am aged 18 or over.

1. By submitting the questionnaire, I are giving my informed consent to use the data and comments I provide (anonymously) in this PhD thesis and possible publications.*

○ I agree to take part in the project. I understand that taking part in the project will include filling a questionnaire about my perceptions towards tree planting and agree with the way my data will be managed.

Welcome to the survey!

2. What is your occupation/job title? (e.g. academic, practitioner, woodland management etc.) (write in your answer below) *

_____

3. Which sector do you work in? *

○Academic (e.g. university, college)

○Public (e.g. local authority)

○Voluntary community (e.g. charity)

○Private (e.g. landowner, consultant)

○Other (please specify) _____

4. How frequently did/do you spend time in green space ...? *

	Daily	Weekly	Monthly	Less than monthly	Never
as a child	○	○	○	○	○
now	○	○	○	○	○

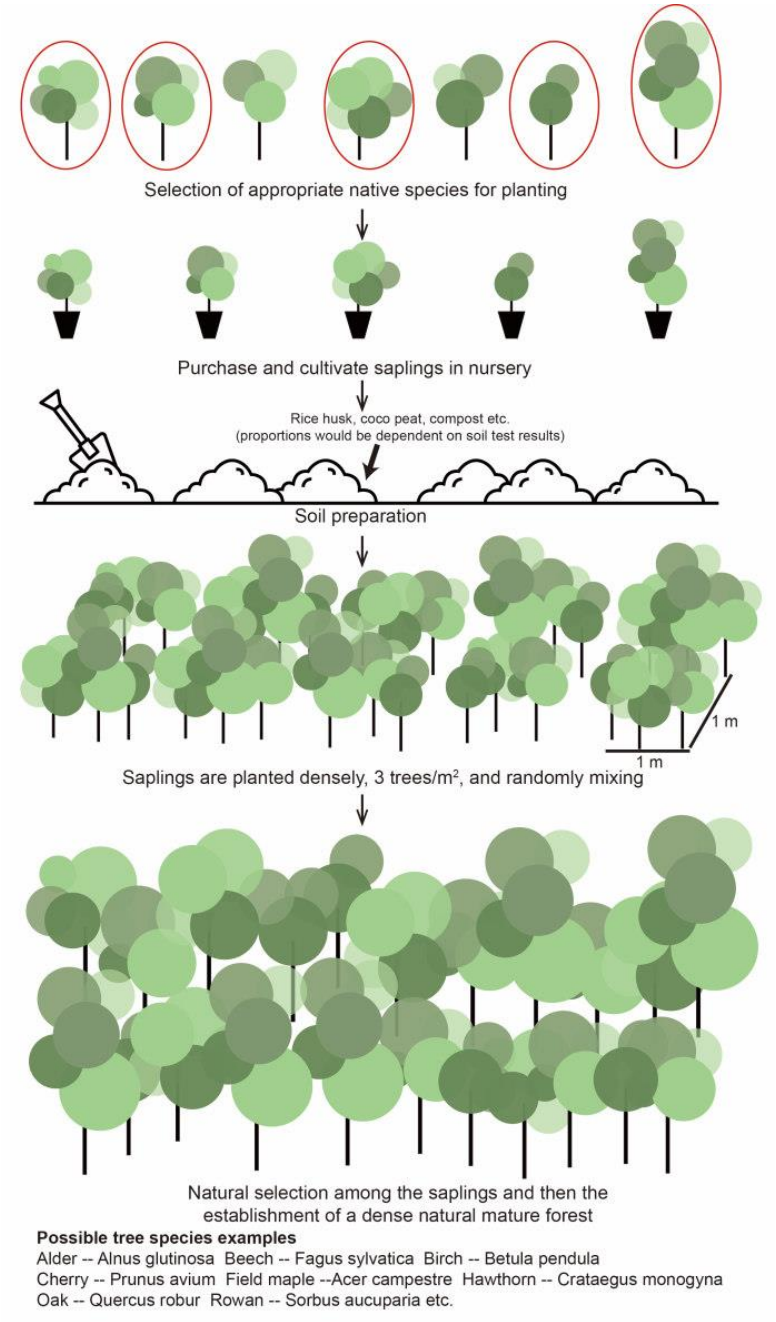
5. Are you familiar with the Miyawaki Forest method? *

○Yes

○No

A quick introduction to the Miyawaki Forest method

The Miyawaki Forest method was developed in Japan. It is based on the planting of native tree species and well-prepared soil. Miyawaki forests grow relatively quickly. In Japan, the Miyawaki Forest method has resulted in mature forest in 15-20 years, with no maintenance required after 3-5 years.



After reading this information, please answer the questions below.

6. Have you been involved in any Miyawaki Forest (also called Tiny Forest) projects?

○Yes

○No

7. Have you ever visited a Miyawaki forest before? *

○Yes

○No

9. To what extent do you agree that the Miyawaki Forest method is a suitable tree planting method in urban/rural areas? (1=do not agree, 10=strongly agree)

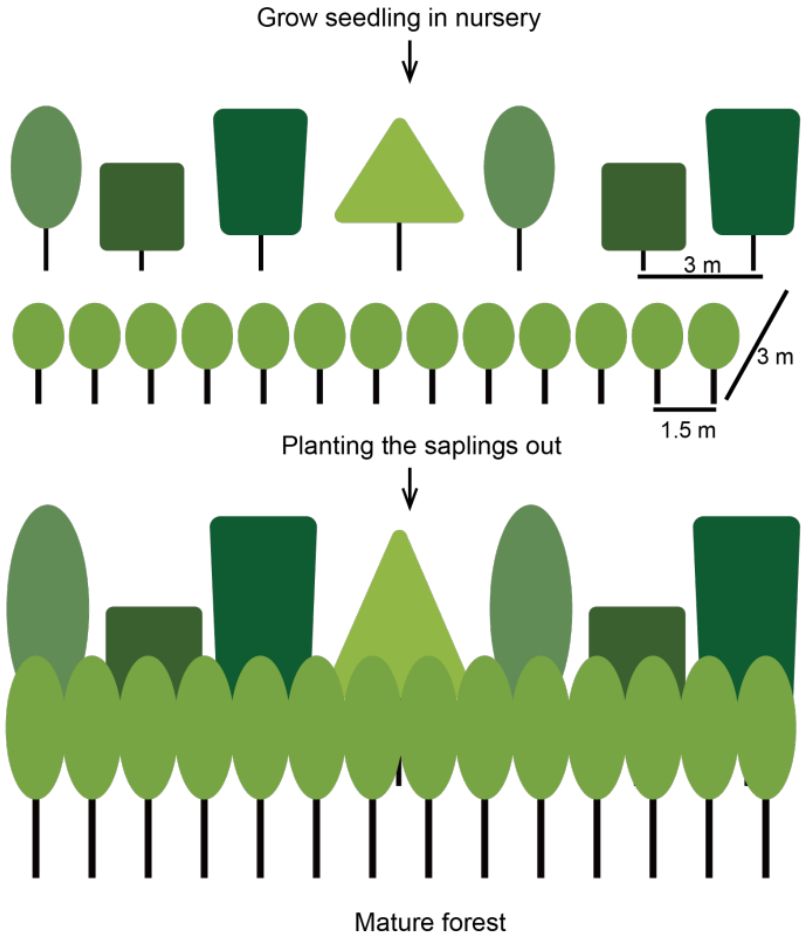
	1	2	3	4	5	6	7	8	9	10
in urban areas	○	○	○	○	○	○	○	○	○	○
in rural areas	○	○	○	○	○	○	○	○	○	○

10. Please explain your rating in Q9.

_____

A quick introduction of the Conventional mixed forest planting

Conventional mixed forest planting is the planting of two or more tree species together in the same area. The trees can be mixed in rows, in intervals, or set in blocks. This method is used widely in UK forests/woodlands, and traditionally involves some maintenance (weeding, thinning, lower branch removal etc.). Conventional mixed forest planting results in mature trees being present in 100+ years.



Possible tree species examples
Cherry – Prunus avium Hazel – Corylus avellana Oak – Quercus robur
Beech – Fagus sylvatica Lime – Tilia cordata etc.

After reading this information, could you please answer a series of questions below.

11. To what extent would you support using the Miyawaki Forest method to plant a forest rather than using the Conventional Forest method? (1=not at all supportive, 10=very supportive)*

_____

12. Please explain your reason in Q11.

_____

The Miyawaki Forest method has been tested in Japan (mostly a temperate climate with 4 distinct seasons) and Southeast Asia (tropical climate). There is very little current data about applying the Miyawaki Forest method in the UK at the moment (temperate climate). In light of this information, please answer the following questions:

13. Do you agree that the Miyawaki Forest method is a suitable tree planting method in the UK? (1=do not agree, 10=strongly agree)*

_____

14. Please explain your reason in Q13.

_____

15. In the following areas where do you think the Miyawaki forest planting would be suitable in the UK? *

□Urban

□Suburban

□Rural

□Don't know

□Non of these areas (please specify) _____

16. Please explain your reason in Q15.

_____

17. Do you think there are any potential problems with planting in these areas? *

○Yes and please outline the problems _____

○No and please indicate why not _____

○Don't know _____

18. Which of the following specific locations do you think Miyawaki forest planting would be suitable? *

	Not suitable at all	Not very suitable	Suitable to some extent	Very suitable	Not sure
Housing developments/estates	○	○	○	○	○
School premises	○	○	○	○	○
Hospital premises	○	○	○	○	○
River corridors	○	○	○	○	○
Parks/Public gardens	○	○	○	○	○

On road verges/footpaths	o	o	o	o	o
Industrial estates	o	o	o	o	o
Agricultural/Farmland	o	o	o	o	o

19. Are there any other specific locations that you think would be suitable for Miyawaki forests planting that are not mentioned in Q18?
(write in your answer below)

_____

20. On average how much do you think the Miyawaki forest planting/'Conventional' mixed forest planting costs in the UK? (per square metre) *

	£0 - £5	£6 - £10	£11 - £20	£20+	Other amount (please specify)	Not sure/Don't know
the Miyawaki forest planting	o	o	o	o	o	o
Conventional mixed forest planting	o	o	o	o	o	o

21. Would you be willing to pay for Miyawaki forest planting in the UK? *

oYes

oNo

oNot sure/Don't know

22. How much could you (or your organisation) afford to pay for Miyawaki forest planting in the UK? (per square metre)
(write in your answer below)

_____

23. Do you think Miyawaki forest planting should be funded by the public sector? (please specify the reason after your choice) *

oYes _____

○No _____

○Don't know _____

24. What is the relative cost percentage you would expect to pay for soil preparation/ tree purchases/ ongoing maintenance for the Miyawaki forest planting in per square metre? *
soil preparation_____
tree purchases_____
ongoing maintenance_____

25. Apart from those listed above in Q24, are there any other costs involved? (please specify)
_____

26. Which method do you think is more expensive in urban/rural areas? (please specify the reason after your choice)

	Miyawaki Forest	Conventional Forest	Don't know
in urban areas	○	○	○
in rural areas	○	○	○

27. To what extent do you think Miyawaki forest planting could help mitigate the following aspects. (1=completely unhelpful, 10=very helpful) *

Help carbon capture?	_____
Help reduce flooding risks?	_____
Provide city cooling?	_____
Promote more tree biodiversity?	_____
Promote more ground flora diversity?	_____
Promote more invertebrate diversity?	_____

28. Please explain your rating in Q27.
_____

29. To what extent do you think Conventional mixed forest planting could help mitigate the following aspects. (1=completely unhelpful, 10=very helpful) *

Help carbon capture?	_____
Help reduce flooding risks?	_____
Provide city cooling?	_____
Promote more tree biodiversity?	_____
Promote more ground flora diversity?	_____
Promote more invertebrate diversity?	_____

30. Please explain your rating in Q29.

_____

31. Do you agree with the following statements: *

	I strongly disagree	I disagree	I partly disagree	I partly agree	I agree	I strongly agree	Not sure
Native tree species only should be used in the Miyawaki Forest method	o	o	o	o	o	o	o
A split of native and non-native tree species should be used in the Miyawaki Forest method	o	o	o	o	o	o	o
Non-native tree species only should be used in the Miyawaki Forest method	o	o	o	o	o	o	o
Native tree species only should be used in the Conventional Forest method	o	o	o	o	o	o	o
A split of native and non-native tree species should be used in the	o	o	o	o	o	o	o

Conventional Forest method							
Non-native tree species only should be used in the Conventional Forest method	○	○	○	○	○	○	○

32. Please explain your reason in Q31.

_____

33. Please select the percentage of native and non-native tree species in the Miyawaki forests, if planted in the UK.*

Native tree species_____

Non-native tree species_____

34. Please select the percentage of native and non-native tree species in the Conventional mixed forest planting, if planted in the UK.*

Native tree species_____

Non-native tree species_____

35. What non-native tree species might you consider in the UK and why?

In urban areas	_____
In rural areas	_____

Some climate models for the UK predict that temperatures could rise rapidly over the next 50-100 years, e.g. London having a climate similar to that of Barcelona within the next 50 years.

And there is a debate around native and non-native tree species with some people believing that native tree species will not be able to survive in the changing climate.

Do these points alter your opinion about the species mix in Miyawaki forests and 'Conventional' mixed forest planting in the UK? Please answer the following questions.

36. In light of rising temperatures, do you agree with the following statements: *

	I strongly disagree	I disagree	I partly disagree	I partly agree	I agree	I strongly agree	Not sure

I still believe that native tree species are most appropriate for Miyawaki forests	o	o	o	o	o	o	o
I believe a mix combination of native and non-native tree species are most appropriate for Miyawaki forests	o	o	o	o	o	o	o
I believe that non-native tree species are most appropriate for Miyawaki forests	o	o	o	o	o	o	o
I still believe that native tree species are most appropriate for Conventional forests	o	o	o	o	o	o	o
I believe a mix combination of native and non-native tree species are most appropriate for Conventional forests	o	o	o	o	o	o	o
I believe that non-native tree species are most appropriate for Conventional forests	o	o	o	o	o	o	o

37. Please explain your reason in Q36.

_____

38. In light of rising temperatures, please select the percentage of native and non-native tree species in the Miyawaki forests, if planted in the UK. *

Native tree species_____

Non-native tree species_____

39. In light of rising temperatures, please select the percentage of native and non-native tree species in the Conventional mixed forest planting, if planted in the UK. *

Native tree species_____

Non-native tree species_____

40. Overall view

Please provide any additional comments you have on either the Miyawaki or conventional forest methods, and their relative benefits and drawbacks.

_____

41. How old are you? *

○18-24

○25-34

○35-44

○45-54

○55-64

○65+

42. What is your gender? *

○Male

○Female

○Non-binary/third gender

○Prefer not to say

43. What is your ethnic group? *

○White

○Asian/Asian British

○Black/African/Caribbean/Black British

○Mixed/Multiple ethnic groups

○Other ethnic groups (please specify) _____

44. Education level (all equivalent) *

○GCSE, A levels, vocational training

○Bachelor, University degree

○Masters, Higher education certificate

○PhD

○None of the above

45. As a follow-up research, I would like to conduct some interviews with professionals to explore these issues in more detail. If you would like to take part in a follow-up interview please provide your email details below.

_____

Thank you so much for your time and participating in this study!

46. If you are interested in receiving a summary of the research once it is done, please leave your email details below.

_____

Appendix 3 Non-professionals Questionnaire Survey

Tree planting research in the UK

Hi, I'm Hanyu Qi, a PhD student at The University of Sheffield. I am currently doing research about tree planting in the UK. This questionnaire is exploring peoples' perceptions towards different tree planting methods and attitudes around choice of tree species.

Please read the following information before continuing to the survey.

Project information

The questionnaire is part of PhD research conducted in the Department of Landscape Architecture at the University of Sheffield, under the supervision of Dr Nicola Dempsey and Dr Ross Cameron.

If you are 18 or over, currently living in the United Kingdom, have experience and knowledge or doing relevant research or project on tree planting, or with an interest in trees, please consider participating in this study about trees.

What do I need to do?

You will be asked a sequence of questions about the tree planting. This questionnaire should take about 15-20 minutes to complete. You are free to stop participating in this survey at any time.

Anonymity

Your participation is voluntary and all your answers remain entirely confidential. You will not be asked to provide any personal information that could identify you as an individual.

Ethics and Data Protection

This research has been approved by the Department of Landscape Architecture Research Ethics Committee at The University of Sheffield.

The Data Controller institution is the University of Sheffield, and the legal basis for processing the data is research in the public interest (Article 6(1)(e)). Further information can be found in the University's Privacy Notice

Thank you very much.

Contacts
If you have any questions, concerns or complaints, please contact the PhD candidate Hanyu Qi (hqi8@sheffield.ac.uk), or their supervisor Dr Nicola Dempsey (n.dempsey@sheffield.ac.uk). If the complaint relates to how the data you provide has been handled, you can find information about how to raise a complaint in the University's Privacy Notice here

Before I go on:
- I have read and understood the project information (provided on the previous page)

- I understand that taking part is voluntary and that I can withdraw from the study at any time. I do not have to give any reasons if I no longer want to take part and there will be no adverse consequences if I choose to withdraw.

- I understand that NO personal details (e.g. my name or phone number) will be collected as part of the survey.

- I consent to the answers I contribute will be used to generate insights in this research project.

- I consent to allow the fully anonymised information to be used for future publications, research and learning.

- I understand that the information acquired will be stored by the researchers securely (all data will be stored and analysed on encrypted password-protected computers); The University of Sheffield will act as the Data Controller for the project.

- I understand that the anonymised pooled data may in future be made available to other for research purpose only.

- I am aged 18 or over.

1. By submitting the questionnaire, I are giving my informed consent to use the data and comments I provide (anonymously) in this PhD thesis and possible publications. *
○ I agree to take part in the project. I understand that taking part in the project will include filling a questionnaire about my perceptions towards tree planting and agree with the way my data will be managed.

Welcome to the survey!

2. How frequently did/do you spend time in green space ...? *

	Daily	Weekly	Monthly	Less than monthly	Never
as a child	o	o	o	o	o
now	o	o	o	o	o

3. How would you describe where you ...? *

	Urban	Suburban	Rural
grew up as a child	o	o	o
live now	o	o	o

4. Have you ever heard of the Miyawaki Forest method before? *

oYes

oNo

A quick introduction to the Miyawaki Forest method

The Miyawaki Forest method was developed in Japan. It is based on the planting of native tree species and well-prepared soil. Miyawaki forests grow relatively quickly. In Japan, the Miyawaki Forest method has resulted in mature forest in 15-20 years, with no maintenance required after 3-5 years.



Saplings are planted densely, 3 trees/m^2, and randomly mixing

Possible tree species examples

Alder -- Alnus glutinosa Beech -- Fagus sylvatica Birch -- Betula pendula
Cherry -- Prunus avium Field maple --Acer campestre Hawthorn -- Crataegus monogyna
Oak -- Quercus robur Rowan -- Sorbus aucuparia etc.

After reading this information, please answer the questions below.

5. Have you ever visited a Miyawaki forest before? *

○Yes

○No

6. If yes, on average how often do you visit it? *

○On a daily basis

○On a weekly basis

○On a monthly basis

○On a yearly basis

7. How does it make you feel or think when you are in a Miyawaki forest/woodland? *

	Strongly disagree	Disagree	Neither agree not disagree	Agree	Strongly agree
…I enjoy it	○	○	○	○	○
…It makes me feel calm and relaxed	○	○	○	○	○
…It makes me feel refreshed and revitalised	○	○	○	○	○
…I take time to appreciate my surroundings	○	○	○	○	○
…I learn something new about the natural world	○	○	○	○	○
…I feel close to nature	○	○	○	○	○

8. What is it about the Miyawaki forest/woodland that makes you feel like that

_____

9. To what extent would you support using the Miyawaki Forest method to plant a forest in your area? (1=not at all supportive, 10=very supportive)
*

_____

10. Please explain your rating in Q9.

_____

11. Would you visit a Miyawaki forest if there was one in your local area? (please indicate why) *

○Definitely _____

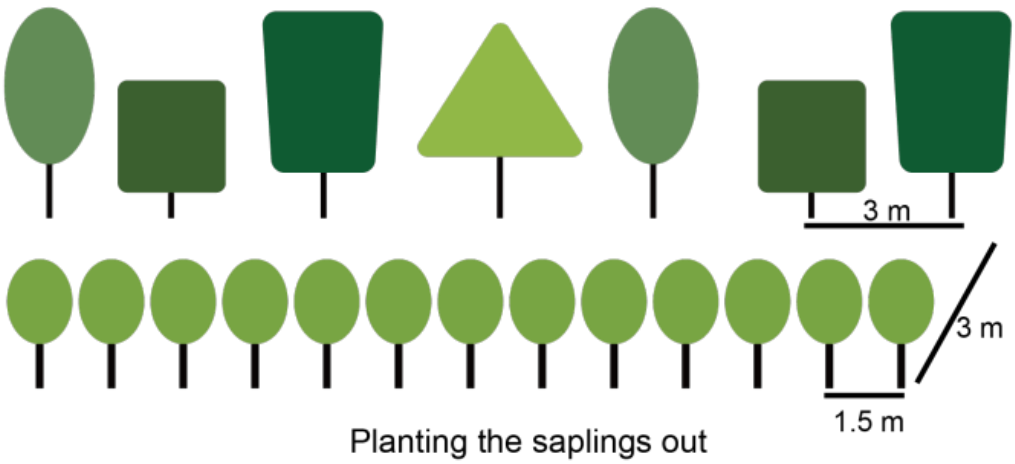
○Probably _____

○Probably not _____

○Definitely not _____

A quick introduction of the Conventional mixed forest planting

Conventional mixed forest planting is the planting of two or more tree species together in the same area. The trees can be mixed in rows, in intervals, or set in blocks. This method is used widely in UK forests/woodlands, and traditionally involves some maintenance (weeding, thinning, lower branch removal etc.). Conventional mixed forest planting results in mature trees being present in 100+ years.



Planting the saplings out

Possible tree species examples
Cherry – Prunus avium Hazel – Corylus avellana Oak – Quercus robur
Beech – Fagus sylvatica Lime – Tilia cordata etc.

After reading this information, could you please answer a series of questions below.

12. Have you ever visited a Conventional forest/woodland before? *

○Yes

○No

13. If yes, on average how often do you visit it? *

○On a daily basis

○On a weekly basis

○On a monthly basis

○On a yearly basis

14. How does it make you feel or think when you are in a Conventional forest/woodland? *

	Strongly disagree	Disagree	Neither agree not disagree	Agree	Strongly agree
…I enjoy it	○	○	○	○	○
…It makes me feel calm and relaxed	○	○	○	○	○
…It makes me feel refreshed and revitalised	○	○	○	○	○
…I take time to appreciate my surroundings	○	○	○	○	○
…I learn something new about the natural world	○	○	○	○	○
…I feel close to nature	○	○	○	○	○

15. What is it about the Conventional forest/woodland that makes you feel like that

_____

16. Would you be in favour of using the Miyawaki Forest method to plant a forest rather than using the Conventional Forest method in your area? (1=not at all in favour, 10=greatly in favour)*

_____

17. Please explain your answer in Q16.

_____

The Miyawaki forest method has been tested in Japan (mostly a temperate climate with 4 distinct seasons) and Southeast Asia (tropical climate). There is very little current data about applying the Miyawaki Forest method in the UK at the moment (temperate climate). In light of this information, please answer the following questions:

18. Do you agree that the Miyawaki Forest could be a suitable tree planting method in the UK? (1=do not agree, 10=strongly agree)*

_____

19. Please use this space to provide the reason about your answers in Q18.

_____

20. In the following areas where do you think the Miyawaki forest planting would be suitable in the UK? (tick all that apply) *

□Urban

□Suburban

□Rural

□Don't know

□None of these areas (please specify) _____

21. Do you think there are any potential problems with planting in these areas?

○Yes and please outline the problems _____

○No and please indicate why not _____

○Don't know _____

22. Which of the following specific locations do you think Miyawaki forest planting would be suitable? *

	Not suitable at all	Not very suitable	Suitable to some extent	Very suitable	Not sure

Housing developments/estates	o	o	o	o	o
School premises	o	o	o	o	o
Hospital premises	o	o	o	o	o
River corridors	o	o	o	o	o
Parks/Public gardens	o	o	o	o	o
On road verges/footpaths	o	o	o	o	o
Industrial estates	o	o	o	o	o
Agricultural/Farmland	o	o	o	o	o

23. Are there any other specific locations that you think would be suitable for Miyawaki forests that are not mentioned in Q22?
(write in your answer below)

_____

24. To what extent do you think the Miyawaki forest planting could help mitigate the following aspects. (1=very unhelpful, 10=very helpful) *

Help capture and store carbon dioxide?	_____
Help reduce flooding risks?	_____
Provide city cooling?	_____
Provide food/habitats in the trees (e.g. for bees, birds etc.)?	_____
Provide more ground level plants/flora?	_____
Help support insect populations?	_____

25. Please use this space to provide the reason about your answers in Q24.

_____

26. To what extent do you think the Conventional mixed forest planting could help mitigate the following aspects. (0=completely unhelpful; 10=very helpful) *

Help capture and store carbon dioxide?	_____
Help reduce flooding risks?	_____
Provide city cooling?	_____
Provide food/habitats in the trees (e.g. for bees, birds etc.)?	_____
Provide more ground level plants/flora?	_____
Help support insect populations?	_____

27. Please use this space to provide the reason about your answers in Q26.

_____

Native Trees are those trees that have colonised the UK through natural means since the last ice age. E.g. silver birch and oak.

Non-native Trees (also sometimes referred to as “aliens”, “introduced” or “exotic”) are those brought in by humans and are growing outside of their natural range. E.g. Sweetgum and horse chestnut.

28. Do you agree with the following statements: *

	I strongly disagree	I disagree	I partly disagree	I partly agree	I agree	I strongly agree	Not sure
Native tree species only should be used in the Miyawaki Forest method	o	o	o	o	o	o	o
A split of native and non-native tree species should be used in the Miyawaki Forest method	o	o	o	o	o	o	o
Non-native tree species only should be used in the Miyawaki Forest method	o	o	o	o	o	o	o

Native tree species only should be used in the Conventional Forest method	o	o	o	o	o	o	o
A split of native and non-native tree species should be used in the Conventional Forest method	o	o	o	o	o	o	o
Non-native tree species only should be used in the Conventional Forest method	o	o	o	o	o	o	o

29. Please use this space to provide more information about your answers in Q28.

_____

Some climate models for the UK predict that temperatures could rise rapidly over the next 50-100 years, e.g. London having a climate similar to that of Barcelona within the next 50 years.

And there is a debate around native and non-native tree species with some people believing that native tree species will not be able to survive in the changing climate.

Do these points alter your opinion about the species mix in Miyawaki Forests and Conventional Forests in the UK? Please answer the following questions.

30. In light of rising temperatures, do you agree with the following statements: *

	I strongly disagree	I disagree	I partly disagree	I partly agree	I agree	I strongly agree	Not sure
I still believe that native tree species are most appropriate for Miyawaki forests	o	o	o	o	o	o	o
I believe a mix combination of native and non-native tree species are most appropriate for Miyawaki forests	o	o	o	o	o	o	o

I believe that non-native tree species are most appropriate for Miyawaki forests	○	○	○	○	○	○	○
I still believe that native tree species are most appropriate for Conventional forests	○	○	○	○	○	○	○
I believe a mix combination of native and non-native tree species are most appropriate for Conventional forests	○	○	○	○	○	○	○
I believe that non-native tree species are most appropriate for Conventional forests	○	○	○	○	○	○	○

31. Please use this space to provide more information about your answers in Q30.

_____

32. Overall view

Please provide any additional comments you have on either the Miyawaki or conventional forest methods, and their relative benefits and drawbacks.

_____

33. How old are you? *

○18-24

○25-34

○35-44

○45-54

○55-64

○65+

34. What is your gender? *

○Male

○Female

○Non-binary/third gender

○Prefer not to say

35. What is your ethnic group? *

○White

○Asian/Asian British

○Black/African/Caribbean/Black British

○Mixed/Multiple ethnic groups

○Other ethnic groups (please specify) _____

36. Education level (all equivalent) *

○GCSE, A levels, vocational training

○Bachelor, University degree

○Masters, Higher education certificate

○PhD

○None of the above

37. How would you describe yourself and your interest in trees? (1=not at all interested, 10=very interested)*

_____

38. How long would it take you to walk to your neatest forest/woodland (in minutes)? *

_____

39. Which of these describes your household best? *

○One adult

○Two adults

○Three or more adults

○One-parent family with child(ren) under 18

○Two-parent family with child(ren) under 18

○Other (please specify) _____

Thank you so much for your time and participating in this study

40. If you are interested in receiving a summary of the research once it is done, please leave your email details below.

Appendix 4 Summarised Statistical Methods (Questions are outlined in full in Appendix 2 and 3)

Quantitative statistical analysis	Questionnaire 1	Questionnaire 2
Independent sample t-test	Q21 Q24	Q4 by Q37
		Q5
		Q9
		Q11
		Q12
		Q16
Paired-sample t-test	Q9	Q4
	Q33 by Q34, Q38	Q5 by Q12
	Q39 by Q34, Q38	Q28 by Q30
One-way Analysis of Variance (ANOVA)	Q9 by Q3	Q9 by Q34
		Q11
		Q16 by Q34
		Q18 by Q33, Q34, Q36
		Q20 by Q2, Q3, Q37
Two-way repeated measures Analysis of Variance (ANOVA)	Q9 by Q5	Q24 Q24 by Q26
	Q27 by Q29	
	Q31	
	Q36	Q28 Q28 by Q30
	Q31 by Q36	
	Q33 by Q34, Q38	
	Q39 by Q34, Q38	
Nonparametric test related samples Friedman's two-way analysis of variance	Q18	Q22
	Q22	
	Q24	
Nonparametric test Related-Samples Cochran's Q Test	Q15	Q20, Q22
Cross-Tabulation with Pearson's Chi-squared test analysis	Q5 by Q3, Q4, Q41, Q42, Q44	Q5 by Q2, Q3, Q4, Q12, Q33, Q34, Q36
	Q6 by Q3, Q4, Q41, Q42, Q44	Q9 by Q2, Q3, Q4, Q5, Q33, Q34, Q36, Q39
	Q7 by Q3, Q4, Q41, Q42, Q44	
	Q9 by Q4, Q6, Q41, Q42, Q44	Q11 by Q2, Q3, Q4, Q5, Q33, Q34, Q36, Q39
	Q11 by Q3, Q4, Q5, Q6, Q41, Q42, Q44	Q16 by Q2, Q3, Q4, Q5, Q33, Q34, Q36, Q39
	Q13 by Q3, Q4, Q5, Q6, Q41, Q42, Q44	
	Q20 by Q3, Q5, Q6, Q41, Q42, Q44	Q18 by Q2, Q3, Q4, Q5, Q33, Q34, Q36, Q39

Quantitative statistical analysis	Questionnaire 1	Questionnaire 2
	Q21 by Q3, Q5, Q6, Q41, Q42, Q44	
	Q23 by Q3, Q5, Q6, Q41, Q42, Q44	Q20 by Q4, Q5, Q33, Q34, Q36
	Q26 by Q3, Q5, Q6, Q41, Q42, Q44	
Cohen's kappa in crosstabulation		Q4, Q5, Q12
Spearman's bivariate correlation		Q5 by Q37
		Q9 by Q37
		Q11 by Q2, Q37
		Q16 by Q37
		Q18 by Q2, Q3, Q4, Q37

Appendix 5 Coding of the respondents (experts and professionals)

Factor	Option	Code
Education level	GCSE, A levels, vocational training	GAV
	Bachelor	BA
	Masters	MA
	PhD	PhD
Age	18-34	18-34
	35-44	35-44
	45-54	45-54
	55+	55+
Gender	Male	M
	Female	F
	Prefer not to say	N
Occupation	Academic	AC
	Public (e.g. Local authority)	LA
	Voluntary community	VOL
	Private	PR
Have been involved in Miyawaki method planting or not	Yes	MY
	No	MN

Appendix 6 Coding of the respondents (non-professionals)

Factor	Option	Code
Education level	GCSE, A levels, vocational training	GAV
	Bachelor	BA
	Masters or above	MA
Age	18-34	18-34

	35-44	35-44
	45-54	45-54
	55-64	55-64
	65+	65+
Gender	Male	M
	Female	F
	Prefer not to say	N
Frequency in greenspace	Daily	D
	Weekly	W
	Monthly	M
	Less than monthly	LM
Living environment	Urban	URB
	Suburban	SUB
	Rural	RUR
Interest in trees	1	1
	2	2
	3	3
	4	4
	5	5
	6	6
	7	7
	8	8
	9	9
	10	10
Have heard of Miyawaki method planting or not	Yes	MY
	No	MN

Appendix 7 The Full Set of Factors that Affected Attitudes to MF and CF (experts and professionals)

Question	**Factor**	**P value**
Are you familiar with the Miyawaki Forest method?	Age	P=0.945
	Gender	P=0.759
	Education level	P=0.069
	Occupation	p<0.001
	Frequency of visiting greenspace	P=0.380
Have you been involved in any Miyawaki Forest (also called Tiny Forest) projects?	Age	P=0.984
	Gender	P=0.538
	Education level	P=0.060
	Occupation	P=0.001
Have you ever visited a Miyawaki forest before?	Age	P=0.477
	Gender	P=0.050
	Education level	P=0.077
	Occupation	p<0.001

To what extent do you agree that the Miyawaki Forest method is a suitable tree planting method in urban areas?	Age	P=0.944
	Gender	P=0.113
	Education level	P=0.020
	Occupation	P=0.228
	Familiarity with MF	P=0.211
	Involvement of MF	p<0.001
To what extent do you agree that the Miyawaki Forest method is a suitable tree planting method in rural areas?	Age	P=0.758
	Gender	P=0.137
	Education level	P=0.050
	Occupation	P=0.513
	Familiarity with MF	P=0.062
	Involvement of MF	P=0.065
To what extent would you support using the Miyawaki Forest method to plant a forest rather than using the Conventional Forest method?	Age	P=0.046
	Gender	P=0.047
	Education level	P=0.426
	Occupation	P=0.911
	Familiarity with MF	P=0.540
	Involvement of MF	P=0.235
Do you agree that the Miyawaki Forest method is a suitable tree planting method in the UK?	Age	P=0.354
	Gender	P=0.139
	Education level	P=0.232
	Occupation	P=0.100
	Familiarity with MF	P=0.396
	Involvement of MF	P=0.060
In the following areas where do you think the Miyawaki forest planting would be suitable in the UK?		P=0.000
Which of the following specific locations do you think Miyawaki forest planting would be suitable?		p<0.001
On average how much do you think the Miyawaki forest planting costs in the UK?	Age	P=0.280
	Gender	P=0.262
	Education level	P=0.082
	Occupation	P=0.050
	Familiarity with MF	p<0.001
	Involvement of MF	P=0.068
On average how much do you think the 'Conventional' mixed forest planting costs in the UK?	Age	P=0.095
	Gender	P=0.006
	Education level	P=0.097
	Occupation	P=0.577
	Familiarity with MF	P=0.006
	Involvement of MF	P=0.046

Would you be willing to pay for Miyawaki forest planting in the UK?	Age	P=0.817
	Gender	p<0.001
	Education level	P=0.027
	Occupation	P=0.035
	Familiarity with MF	P=0.002
	Involvement of MF	P=0.009
Do you think Miyawaki forest planting should be funded by the public sector?	Age	P=0.132
	Gender	P=0.107
	Education level	P=0.233
	Occupation	P=0.035
	Familiarity with MF	P=0.271
	Involvement of MF	P=0.466
Which method do you think is more expensive in urban areas?	Age	P=0.004
	Gender	P=0.517
	Education level	P=0.050
	Occupation	P=0.782
	Familiarity with MF	P=0.022
	Involvement of MF	P=0.278
Which method do you think is more expensive in rural areas?	Age	P=0.007
	Gender	P=0.626
	Education level	P=0.103
	Occupation	P=0.491
	Familiarity with MF	P=0.027
	Involvement of MF	P=0.015
To what extent do you think Miyawaki forest planting/ Conventional mixed forest planting could help mitigate the following aspects.		p<0.001
To what extent do you think Miyawaki forest planting or Conventional mixed forest planting could help mitigate the following aspects.	Provide city cooling	P=0.004
	Promote more tree biodiversity	p<0.001
	Promote more invertebrate diversity	p<0.001
The statements about NT and NNT tree species selection in the MF before and after climate change information.	A split of NT and NNT species	p<0.001
	NNT species only	P=0.007
The statements about NT and NNT tree species selection in the CF before and after climate change information.	A split of NT and NNT species	p<0.001
	NNT species only	p<0.001

Appendix 8 The Full Set of Factors that Affected Attitudes to MF and CF (non-professionals)

Question	**Factor**	**P value**
	Age	**P=0.010**

Have you ever heard of the Miyawaki Forest method before?	Gender	P=0.832
	Education level	P=1.00
	Frequency in greenspace	**p=0.044**
	Living environment	**P=0.010**
	Interest in trees	**p<0.001**
Have you ever visited a Miyawaki forest before?	Age	P=0.196
	Gender	P=0.877
	Education level	P=0.410
	Frequency in greenspace	P=0.788
	Living environment	P=0.199
	Interest in trees	**P=0.008**
	Have heard of it or not	p<0.001
To what extent would you support using the Miyawaki Forest method to plant a forest in your area? (1=not at all supportive, 10=very supportive)	Age	P=0.439
	Gender	**P=0.037**
	Education level	P=0.833
	Frequency in greenspace	p=0.631
	Living environment	p=0.317
	Interest in trees	P=0.925
	Have heard of it or not	**P=0.007**
	Have visited or not	P=0.501
Would you visit a Miyawaki forest if there was one in your local area?	Age	P=0.355
	Gender	P=0.302
	Education level	P=0.275
	Frequency in greenspace	**P=0.003**
	Living environment	P=0.340
	Interest in trees	**p<0.001**
	Have heard of it or not	**P=0.036**
	Visited or not	**P=0.050**
Would you be in favour of using the Miyawaki Forest method to plant a forest rather than using the Conventional Forest method in your area? (1=not at all in favour, 10=greatly in favour)	Age	P=0.356
	Gender	**P=0.049**
	Education level	P=0.483
	Frequency in greenspace	P=0.251
	Living environment	P=0.368
	Interest in trees	p=0.961
	Have heard of it or not	**P=0.005**
	Visited or not	P=0.627
Do you agree that the Miyawaki Forest could be a suitable tree planting method in the UK? (1=do not	Age	P=0.68 P=0.202
	Gender	P=0.304 P=0.304
	Education level	P=0.092 P=0.092
	Frequency in greenspace	P=0.447 P=0.122
	Living environment	P=0.307 P=0.928

agree, 10=strongly agree)	Interest in trees	p=0.416 P=0.416
	Have heard of it or not	P=0.090 P=0.627
	Visited or not	P=0.345 P=0.171
In the following areas where do you think the Miyawaki forest planting would be suitable in the UK? (tick all that apply)		p<0.001
Do you think there are any potential problems with planting in these areas?	**Age**	**P=0.011**
	Gender	P=0.7
	Education level	P=0.375
	Frequency in greenspace	**P<0.001**
	Living environment	**P=0.043**
	Interest in trees	**P<0.001**
	Have heard of it or not	**P<0.001**
	Have visited or not	**P=0.009**
Which of the following specific locations do you think Miyawaki forest planting would be suitable?[single choice]		
To what extent do you think Miyawaki forest planting or Conventional mixed forest planting could help mitigate the following aspects.	Help capture and store carbon dioxide?	
	Help reduce flooding risks?	
	Provide city cooling?	
	Provide food/habitats in the trees (e.g. for bees, birds etc.)?	
	Provide more ground level plants/flora?	
	Help support insect populations?	

The statements about NT and NNT tree species selection in the MF before and after climate change information.	A split of NT and NNT species	p<0.001
	NNT species only	P=0.007
The statements about NT and NNT tree species selection in the CF before and after climate change information.	A split of NT and NNT species	p<0.001
	NNT species only	p<0.001

Appendix 9 General weather condition in Sheffield (2022 -- 2025)

Year	Month	temperature max	temperature min	air frost	rainfall	sunshine	**temperature max**	**temperature min**	**air frost**	**rainfall**	**sunshine**
		degC	degC	days	mm	hours	**diff from exp**	**diff from exp**	**diff from exp**	**diff from exp**	**hours**
2022	1	8	2.6	3	25.8	85.7	**1.0**	**0.4**	**-4.2**	**-49.9**	**35.6**
2022	2	9.6	3.5	1	182.6	80.4	**1.9**	**1.3**	**-5.9**	**115.6**	**3.6**
2022	3	11.9	3.7	3	46.4	150	**1.9**	**0.3**	**-0.6**	**-13.1**	**29.0**
2022	4	13.7	5.1	2	27.6	165.3	**0.6**	**-0.1**	**0.9**	**-31.2**	**12.1**
2022	5	17.8	9.6	0	28.4	138.3	**1.4**	**1.8**	**-0.1**	**-26.1**	**-59.9**
2022	6	20.4	10.8	0	55	203.3	**1.2**	**0.0**	**0.0**	**-20.1**	**22.3**
2022	7	23.2	14.5	0	23.8	187.8	**1.9**	**1.7**	**0.0**	**-38.4**	**7.1**
2022	8	23.9	13.6	0	56.4	234.5	**3.1**	**1.0**	**0.0**	**-8.7**	**53.2**
2022	9	18.4	11.1	0	50	124.8	**0.5**	**0.6**	**0.0**	**-13.5**	**-13.4**
2022	10	15.6	9.6	0	124	113.4	**2.0**	**1.9**	**-0.4**	**45.3**	**16.4**
2022	11	10.9	6.6	0	122.8	37.7	**1.1**	**1.8**	**-2.4**	**38.2**	**-21.7**
2022	12	6.2	1.2	11	79.6	54.6	**-1.1**	**-1.4**	**4.5**	**-7.3**	**6.3**
2023	1	7.9	2.9	7	82.8	78.4	**0.9**	**0.7**	**-0.2**	**7.1**	**28.3**
2023	2	9.9	4.5	2	9.4	77.3	**2.2**	**2.3**	**-4.9**	**-57.6**	**0.5**
2023	3	10.1	3.9	6	110.2	79.1	**0.1**	**0.5**	**2.4**	**50.7**	**-41.9**
2023	4	12.8	5	2	63.8	127	**-0.3**	**-0.2**	**0.9**	**5.0**	**-26.2**
2023	5	17.9	8.9	0	18.6	186.4	**1.5**	**1.1**	**-0.1**	**-35.9**	**-11.8**
2023	6	22.2	12.1	0	35.6	206.6	**3.0**	**1.3**	**0.0**	**-39.5**	**25.6**
2023	7	20.1	12.6	0	162	112.2	**-1.3**	**-0.2**	**0.0**	**99.8**	**-68.5**
2023	8	20.6	13.1	0	54.8	151.4	**-0.2**	**0.5**	**0.0**	**-10.3**	**-29.9**

2023	9	20.9	12.8	0	76.6	127.8	3.1	2.3	0.0	13.1	-10.4
2023	10	14.9	8.9	0	203.2	77.5	1.3	1.2	-0.4	124.5	-19.5
2023	11	9.4	5	2	108.2	68.1	-0.4	0.2	-0.4	23.6	8.7
2023	12	8.8	4.6	5	163.4	31.5	1.5	2.0	-1.5	76.5	-16.8
2024	1	7	2.6	6	72	54.9	0.0	0.4	-1.2	-3.7	4.8
2024	2	10.2	4.8	2	91.8	42	2.5	2.6	-4.9	24.8	-34.8
2024	3	11.1	4.4	1	94.4	75.6	1.1	1.0	-2.6	34.9	-45.4
2024	4	13	5.8	0	86.2	100.7	-0.1	0.6	-1.1	27.4	-52.5
2024	5	18.5	10.5	0	58.4	117.5	2.1	2.7	-0.1	3.9	-80.7
2024	6	19.1	10.7	0	28.4	149.3	-0.1	-0.1	0.0	-46.7	-31.7
2024	7	21.1	12.4	0	86.4	159.4	-0.3	-0.4	0.0	24.2	-21.3
2024	8	21.3	12.7	0	19	139.2	0.5	0.1	0.0	-46.1	-42.1
2024	9	16.7	10.4	0	143.2	92	-1.2	-0.1	0.0	79.7	-46.2
2024	10	14.2	8.1	0	75.8	83.6	0.5	0.4	-0.4	-2.9	-13.4
2024	11	9.6	4.5	7	62.8	58.8	-0.2	-0.3	4.6	-21.9	-0.6
2024	12	9.3	4.6	0	118	42.4	2.0	2.0	-6.5	31.1	-5.9
2025	1	5.7	1	9	100.6	81.6	-1.3	-1.2	1.8	24.9	31.5
2025	2	7.5	2.6	4	35.4	59.7	-0.2	0.4	-2.9	-31.6	-17.1
2025	3	12.6	3.6	3	28.8	173	2.6	0.2	-0.6	-30.7	52.0
2025	4	16.4	5.7	0	10.2	220.5	3.3	0.5	-1.1	-48.6	67.3
2025	5	18.6	8.2	0	31.8	210.7	2.2	0.4	-0.1	-22.7	12.6
2025	6	22.6	12.8	0	22.8	193.2	3.4	2.0	0.0	-52.3	12.2
2025	7	22.9	14.2	0	46.8	165.3	1.6	1.4	0.0	-15.4	-15.4
2025	8	22.5	13.6	0	27.4	159.2	1.7	1.0	0.0	-37.7	-22.1

Appendix 10 Sapling heights data over years (MFM and CFM treatments)

Scientific name	Height (original) (cm) (25.11.2022)								MFM Tree height (cm) (06.10.2023)						MFM Tree height (cm) (29.05.2024)					MFM Tree height (cm) (15.05.2025)				
Alnus glutinosa	25	49	55	53	43	25	48	44	123	127	101	97.8	116	103	114	142	137	150	157	229	234	192	236	299
Fagus sylvatica	34	48	56	28	58	44	23	46	49.2	44.5	51.7				63	46	47			70	70	33	90	80
Prunus padus	51	36	74	77	67	38	47	49							158	164	97	167		190	162	145	123	145
Prunus avium	40	42	27	24	26	35	27	37	96.4	62.8	100	66.3			138	105	136	100		171	163	203	167	162
Carpinus betulus	68	62	58	70	56	68	63	67	74.5	76.2	67	55.8	69	55.3	60	80	97	82	92	108	128	110	151	147
Quercus robur	24	18	13	13	23	20	10	15	62	55.2	65	75.7	63.4	71.7	76	88	68	90	83	115	92	108	102	84
Quercus petraea	14	22	17	17	20	23	18	15	88	59.8	57	85.4	72.7	79	70	76	80	85	80	104	97	96	97	119
Betula pubescens	35	31	33	31	28	27	34	30	98	109	102	109	67	77.4	100	95	115	104	77	152	151	137	140	125
Betula pendula	47	50	52	45	42	37	42	46	107	70	102	88	105	98.5	110	108	114	104	126	186	169	141	147	98
Sorbus torminalis	76	80	53	45	74	63	46	41							84	102	95	87		130	72	62	93	98
Taxus baccata	24	22	23	20	25	17	24	23	18	18.5	31.1	17.8	27.5	23.8	20	37	14	22	29	52	41	27	49	34
Malus sylvestris	54	56	53	53	57	54	48	49	115	127	85.6	117	69	112	126	103	133	71	95	193	161	177	169	161
Cornus sanguinea	46	36	37	34	32	27	35	19	71.4	57.2	86.8	107	83.4	68.8	135	140	127	108	87	151	162	202	154	154
Crataegus laevigata	32	28	27	24	26	28	24	27	60.4	72.7	55	87.4	80	88.5	96	109	138	106	102	142	142	98	152	108
Corylus avellana	25	28	31	25	24	28	22	21	71.9	58.4	75.4	73.2	70.1	103	114	74	93	132	142	115	105	121	133	110
Ilex aquifolium	21	30	28	14	26	26	22	21	45	48.5	33.5	36	27	11	22	22	23	30	27	34	73	69	62	67
Sorbus aucuparia	53	43	50	55	32	33	55	27	54.2	55.8	86.5	70.3	110	91.1	200	106	156	125	95	113	243	184	272	238
Euonymus europaea	32	37	25	22	44	42	27	24	72	80	65	57.8	60.4	63	74	82	83	92	104	110	113	126	101	133
Sorbus aria	39	30	24	26	25	22	20	32												44	91	60	65	54
Salix caprea	41	40	40	42	38	41	42	41							119	170				232	320	252	221	289
Salix cinerea	53	35	42	26	25	30	20	27	127	153	172	154	161	111	153	182	218	195	163	273	298	331	276	301
Rosa canina	27	32	26	40	37	32	40	22	152	163	121	100	90	128	98	84	119	117	69	154	180	152	174	133
Viburnum opulus	46	30	26	31	47	54	48	53	77.8	95.3	80.6	78.2	69.1	72.2	80	107	108	98	87	145	163	126	112	118
Viburnum lantana	38	36	32	30	25	38	21	25	66.8	57.8	82.5	86.6	65.2	71.1	100	108	72	86	76	142	118	71	166	80

Scientific name	Height (original) (cm) (25.11.2022)								CFM Tree height (cm) (06.10.2023)				CFM Tree height (cm) (29.05.2024)					CFM Tree height (cm) (15.05.2025)										
Alnus glutinosa	25	49	55	53	43	25	48	44	106	93.5	105		128	108	91	102	118	197	173	200	151	146	179	208				
Fagus sylvatica	34	48	56	28	58	44	23	46					33					92	29									
Prunus padus	51	36	74	77	67	38	47	49																				
Prunus avium	40	42	27	24	26	35	27	37					49	43				122	31	25	73	73	71					
Carpinus betulus	68	62	58	70	56	68	63	67																				
Quercus robur	24	18	13	13	23	20	10	15	26				28	36	47	44	25	60	87	75	22	49	90	81	84			
Quercus petraea	14	22	17	17	20	23	18	15	39	37.4	57		41	61	29	60	37	39	153	32	62	78	73					
Betula pubescens	35	31	33	31	28	27	34	30					59					90	57									
Betula pendula	47	50	52	45	42	37	42	46	51.2	61.5	88		128	105	95			196	112	131	158	133	55					
Sorbus torminalis	76	80	53	45	74	63	46	41																				
Taxus baccata	24	22	23	20	25	17	24	23	18.5	27.5	21.8		23	25	24													
Malus sylvestris	54	56	53	53	57	54	48	49																				
Cornus sanguinea	46	36	37	34	32	27	35	19	52.7	58.7	100		55	89	82	107		138	100	162	164	92						
Crataegus laevigata	32	28	27	24	26	28	24	27	52	56.7	57.5		67	78	60	85	61	139	124	66	59	77	93	95	89	81	98	125
Corylus avellana	25	28	31	25	24	28	22	21	47.4	46.4			52					98	96	97	130							
Ilex aquifolium	21	30	28	14	26	26	22	21	48.5	31.3	19.7	52	66	40	66	53	52	72	70	72	67							
Sorbus aucuparia	53	43	50	55	32	33	55	27	61.5	62.3	61.8		87	111	82	97		222	170	212	105	73						
Euonymus europaea	32	37	25	22	44	42	27	24	59.2	82.6								128	143	128								
Sorbus aria	39	30	24	26	25	22	20	32																				
Salix caprea	41	40	40	42	38	41	42	41	137																			
Salix cinerea	53	35	42	26	25	30	20	27					94	85				172	145	160	231							
Rosa canina	27	32	26	40	37	32	40	22	67	62.4	64		97	68				118	123	110								
Viburnum opulus	46	30	26	31	47	54	48	53	69	69			85	86				98	123	88	90	103						
Viburnum lantana	38	36	32	30	25	38	21	25	46	48			74	71	67	70		115	51	98	91	97	124	111	88			

Appendix 11 Summary of species height growth of each treatment (2022 -- 2025) at a significant level (level of probability P) (cm) (N/A: no data recorded)

Species name	Growth rate P value		Species name	Growth rate P value	
	MFM	CFM		MFM	CFM
Alnus glutinosa	**P < 0.001**	**P < 0.001**	*Cornus sanguinea*	**P = 0.005**	**P < 0.001**
Fagus sylvatica	P = 0.064	N/A	*Crataegus laevigata*	**P = 0.009**	**P = 0.004**
Prunus padus	P = 0.731	N/A	*Corylus avellana*	**P = 0.002**	**P = 0.001**
Prunus avium	**P = 0.001**	**P = 0.011**	*Ilex aquifolium*	**P = 0.002**	**P < 0.001**
Carpinus betulus	**P < 0.001**	N/A	*Sorbus aucuparia*	**P = 0.003**	**P < 0.001**
Quercus robur	**P = 0.008**	**P = 0.002**	*Euonymus europaea*	**P < 0.001**	**P < 0.001**
Quercus petraea	P = 0.098	P = 0.081	*Sorbus aria*	N/A	N/A
Betula pubescens	**P < 0.001**	P = 0.068	*Salix caprea*	N/A	N/A
Betula pendula	P = 0.120	**P = 0.046**	*Salix cinerea*	**P < 0.001**	**P < 0.001**
Sorbus torminalis	P = 0.983	N/A	*Rosa canina*	**P = 0.029**	**P = 0.002**
Taxus baccata	**P = 0.004**	P = 0.826	*Viburnum opulus*	**P = 0.041**	**P < 0.001**
Malus sylvestris	**P < 0.001**	N/A	*Viburnum lantana*	**P = 0.024**	**P = 0.025**

Appendix 12 Sapling diameters data over years (MFM and CFM treatments)

Scientific name	MFTree diametre (mm) (06.10.2023)					MF Tree diametre (mm) (29.05.2024)					MF Tree diametre (mm) (15.05.2025)				
Alnus glutinosa	13	14	7.5	11	9.9	9.8	15	14	16	15.7	27.1	31.1	21.3	41.5	47.3
Fagus sylvatica	1.8	1.3				2	1.1	3.5			5.07	4.71	3.85	3.78	4.41
Prunus padus						10	9.6	5.3	11.9		16.3	11.5	12.2	7.23	8.78
Prunus avium	6.5	4.2	5.2			9.1	6.5	9.6	5		15.7	13.6	18.2	13.5	14.1
Carpinus betulus	2.4	2.5	1.3	4	1.6	3.6	4.2	4.4	3.4	4.8	13.1	12.2	10.4	11.2	10.5
Quercus robur	2.5	4	4	3.1	4.1	4.1	4.9	3.4	4.9	4.3	4.7	5.9	9.35	7.03	6.2
Quercus petraea	6	3.5	3.8	4.5	2.8	3	5.3	4.4	4.5	4.1	5.79	7.93	9.87	7.72	9.17
Betula pubescens	3.5	4.3	4	2.3	3	4	3.5	4.5	4.8	4.5	9.22	13.8	9.98	9.47	6.63
Betula pendula	5.5	2.7	4.1	4.8	5.2	6.9	5.7	7.8	5.3	7.4	13.9	13.7	10.7	7.74	7.93
Sorbus torminalis						3.1	4.6	5.3	3.7		7.71	4.53	4.37	6.1	4.27
Taxus baccata						3.6	4.8	6	2.9	8	3.58	4.69	3.79	4.78	3.48
Malus sylvestris	5.2	6.6	4.4	4	5.4	7.7	4.5	6.9	3.2	6.8	17.2	11.8	9.08	15.7	11.6
Cornus sanguinea	3.3	2.2	3.5	3.2	3.2	9.3	6.1	7.7	5.3	5.1	7.38	10.8	10.7	8.64	7.77
Crataegus laevigata	2	4.9	6.1	4.7	5.1	5	7.1	9.3	5.7	5.2	8.55	11	8.6	13.5	9.46
Corylus avellana	3.9	3	3.7	4.8	5.7	7.7	3	4.6	13.1	13.2	10.6	12	12.5	10.5	11.2
Ilex aquifolium						4.1	3.1	5.6	4.8	4.4	6	6.76	6.74	6.74	7.99
Sorbus aucuparia	4.4	3.5	4.8	9.1	8.4	14	5.7	9.4	8.7	5.3	8.58	19.5	14.5	23.3	17.5
Euonymus europaea	4.2	4.5	2.1	2.9	2.5	6.3	2.3	4	5	5.4	1.68	5.53	8.46	7.99	7.81
Sorbus aria											4.94	6.14	3.65	4.89	4.73
Salix caprea						9.5	10				20.5	33.7	22.1	19.5	19.1
Salix cinerea	5.9	6.3	7.4	8.7	5.2	6.7	9.7	11	16.7	11.3	28	24.7	24.5	21.7	16.7
Rosa canina	4.4	5.2	3.9	2.9	3.7	7	5	4.5	4.9	5.2	11.2	10.8	8.49	13.9	8.29
Viburnum opulus	3.3	6.1	4.3	4.8	5.2	4.6	10	4.1	5	4.5	13.1	17.5	11.5	10.1	10.8
Viburnum lantana	4.4	4.3	6	3.4	3.6	6	6	3.7	5.4	3.6	10.9	8	4.63	9.55	5.12

Scientific name	CF Tree diametre (mm) (06.10.2023)			CF Tree diametre (mm) (29.05.2024)					CF Tree diametre (mm) (15.05.2025)										
Alnus glutinosa	5.3	4.6	12	6.8	7.7	5.2	5.7	10	20.6	27.9	25.6	20.7	16.3	17.4	21.8				
Fagus sylvatica				2.5					7.95	6.16									
Prunus padus																			
Prunus avium				5.1	3.7				6.68	5.1	3.51	6.2	5.74	4.39					
Carpinus betulus																			
Quercus robur				2.5	2.6	3.5	5.4	3.3	3.98	5	4.39	2.21	3.34	7.03	4.86	3.76			
Quercus petraea	1.3	1.4	1.7	3.1	2.4	2.5	5	4	2.99	9.2	2.91	3.6	5.21	4.43					
Betula pubescens				3.2					3.77	2.13									
Betula pendula	1.5	1	2.4	6.9	5.4	3.8			16.9	8.93	9.39	11.9	6.26	4.21					
Sorbus torminalis																			
Taxus baccata				4	4.8	3.9													
Malus sylvestris																			
Cornus sanguinea	1.9	1	3.6	3	3.8	3.5	4.8		9.31	5.91	8.84	10.3	5.93						
Crataegus laevigata	0.8	1.5	1.5	3.7	2.8	3.2	4.7	4.5	8.99	9.5	7.21	4.95	5.28	8.95	6.24	6.45	6	5.77	6.79
Corylus avellana	1.7	1.6		2.2					6.55	7.35	9.32	6.19							
Ilex aquifolium				3.2	4.8	5.6	5	4.9	7.73	8.25	6.31	4.76							
Sorbus aucuparia	2.5	3.2	2.5	4.5	6.4	3.7	5.7		13.3	11.4	12.6	7.08	7.51						
Euonymus europaea	2.6	3.8							7.87	7.81	4.37								
Sorbus aria																			
Salix caprea																			
Salix cinerea	5.5			3.8	3.5				7.31	10.1	8.36	11.7							
Rosa canina	3.2	1.6	2.4	5.2	1.9				6.03	4.77	2.4								
Viburnum opulus	2.5	2.5		3.3	4.1				6.55	8.85	7.05	4.84	8.78						
Viburnum lantana	2.9	1.9		3.6	4.7	3.4	2.7		6.78	5.72	6.74	4.86	5.14	6.04	7.21	5.29			

Appendix 13 Summary of species stem diameters of each treatment (2022 -- 2025) at a significant level (level of probability P) (mm) (N/A: no data recorded)

Species name	Diameter P value		Species name	Diameter P value	
	MFM	**CFM**		**MFM**	**CFM**
Alnus glutinosa	**P < 0.001**	**P < 0.001**	*Cornus sanguinea*	**P < 0.001**	**P < 0.001**
Fagus sylvatica	**P = 0.008**	N/A	*Crataegus laevigata*	**P < 0.001**	**P < 0.001**
Prunus padus	P = 0.502	N/A	*Corylus avellana*	**P = 0.002**	**P = 0.039**
Prunus avium	N/A	N/A	*Ilex aquifolium*	**P = 0.010**	**P = 0.026**
Carpinus betulus	**P < 0.001**	N/A	*Sorbus aucuparia*	**P < 0.001**	**P = 0.005**
Quercus robur	**P < 0.001**	P = 0.196	*Euonymus europaea*	P = 0.068	P = 0.053
Quercus petraea	**P < 0.001**	**P = 0.017**	*Sorbus aria*	**P = 0.050**	N/A
Betula pubescens	**P < 0.001**	P = 0.792	*Salix caprea*	N/A	N/A
Betula pendula	**P = 0.011**	**P = 0.003**	*Salix cinerea*	**P < 0.001**	P = 0.109
Sorbus torminalis	P = 0.432	N/A	*Rosa canina*	**P < 0.001**	P = 0.287
Taxus baccata	P = 0.345	N/A	*Viburnum opulus*	**P < 0.001**	**P = 0.004**
Malus sylvestris	**P < 0.001**	N/A	*Viburnum lantana*	**P = 0.003**	**P = 0.003**

Appendix 14 Sapling survival data over years (MFM and CFM treatments)

Scientific name	MFM Planted	MFM Alive (08.06.2023)	MFM Alive (29.05.2024)	MFM Alive (15.05.2025)	Control planted	CFM Alive (08.06.2023)	CFM Alive (29.05.2024)	CFM Alive (15.05.2025)
Alnus glutinosa	35	34	36	34	10	10	8	7
Fagus sylvatica	40	38	11	7	10	10	2	2
Prunus padus	90	90	14	20	10	6	0	0
Prunus avium	90	83	15	7	10	9	2	6
Carpinus betulus	105	103	53	34				
Quercus robur	180	178	86	42	20	19	16	13
Quercus petraea	180	177	61	52	20	20	17	7
Betula pubescens	65	56	31	25	10	10	1	2
Betula pendula	65	60	51	42	10	10	6	6
Sorbus torminalis	30	27	9	5				
Taxus baccata	95	94	45	18	10	10	4	0
Malus sylvestris	90	90	51	18				
Cornus sanguinea	65	65	48	24	10	10	6	5
Crataegus laeviga	90	89	54	50	15	15	24	15
Corylus avellana	85	85	22	10	5	5	5	4
Ilex aquifolium	80	61	75	10	10	10	8	3
Sorbus aucuparia	60	56	51	32	10	10	7	5
Euonymus europa	65	65	38	17	5	5	1	3
Sorbus aria	60	60	2	8				
Salix caprea	10	10	68	26				
Salix cinerea	20	20	16	16	5	5	4	4
Rosa canina	80	80	53	30	10	10	9	3
Viburnum opulus	60	59	51	25	10	10	9	5
Viburnum lantana	60	55	45	10	10	10	6	6