The Importance of Multi-Scale Temporal and Spatial Management for Cemetery Trees in Malmö, Sweden

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Abstract: *Research Highlights*: A large body of research highlighted the important contributions that urban forests make to cities and their inhabitants. However, our urban forests face threats from issues such as rapid urbanization, climate change, and the spread of pests and diseases. As such, proactive and effective management is necessary to ensure their long-term sustainability. Given the multiple spatial and temporal scales on which threats can arise, effective management needs to account for these scales and adjust accordingly. The degree to which this currently happens is unclear. *Background and Objectives*: The aim of this study was to determine the role of multi-scale management in urban forestry, using cemeteries in Malmö, Sweden as a case study. Cemeteries can provide extensive tree canopy but are not readily considered in urban forest management. We sought to determine (1) the threats to the current cemetery tree populations, (2) the extent of multi-scale cemetery tree management, (3) whether tree management plans promote multi-scale management, and (4) how cemetery tree management can be improved. *Materials and Methods*: Malmö cemetery tree inventories were analyzed with respect to size class and species diversity. Existing cemetery tree management plans were examined to determine the spatial and temporal scales of their recommendations. Interviews were conducted with cemetery managers to determine management priorities and actions. *Results*: We found that cemetery tree populations in Malmö suffer from a lack of age class and species diversity. Management tends to occur on short time scales and efforts focus mainly on addressing individual trees, although some consideration is given to large-scale species diversification. The management plans previously created for these cemetery trees make recommendations for age class and species diversification but are yet to be used extensively by cemetery managers. *Conclusions*: The long-term stability of Malmö's cemetery tree populations is threatened by a lack of species and age diversity. Current management efforts emphasize addressing small-scale issues. Although there is a desire to improve species diversity, this can cause conflict with existing cultural values.

Keywords: cemeteries; urban forestry; management; Sweden; temporal; spatial; tree inventory

1. Introduction

The urban forest, defined here as all of the public and private trees within a city [1], provides a vast array of ecosystem services that benefit humans. These benefits include mitigation of the urban heat island effect [2,3], stormwater management [4], improved physical and mental wellbeing [5], support for biodiversity [6,7], and more. However, urban forests around the world are facing threats from increased urbanization [8], pest and disease outbreaks [9,10], and climate change [11,12]. Thus, it is imperative for urban forests to be managed proactively to ensure long-term stability of tree populations

in cities. The need to manage urban greenspace on multiple temporal (e.g., short and long term) and spatial (e.g., local, regional) scales has been highlighted [13] but is difficult to implement.

Research and management of the urban forest has focused on street trees [14–16] and park trees [17,18]. Little attention has been paid to tree management within cemeteries, despite these landscapes often having a relatively high canopy cover compared to the surrounding city [19]. Cemeteries are typically viewed as a sacred land use, which makes them less likely to be targeted for redevelopment [20], affording their trees a higher level of protection. Previous research on cemeteries indicated that their trees support biodiversity [21–23] and contribute to the overall peaceful and restorative atmosphere [24–26], indicating the valuable contributions that trees make to these landscapes. Thus, consideration needs to be given to how cemeteries can manage their tree populations to ensure the long-term maintenance of canopy cover and species diversity. Since cemeteries are not typically managed as part of the broader urban forest or by the same individuals who manage street and park trees, and since they may require additional considerations (such as cultural and spiritual values), it is important to determine how they can be suitably managed.

Cemeteries are described as financially unsustainable in the long term due to their reliance on the sale of burial plots to generate income and the perpetual ownership of burial space which prevents their re-use [25,27,28]. As space for burial plots run out, so does the money, limiting the funding available for reinvestment in cemeteries, including in tree management. Previous research on Canadian cemeteries indicated that tree management is not a high priority for cemetery managers, despite cemetery users highly valuing trees [25]. The low priority of tree management in these cemeteries is both directly and indirectly related to a lack of available funds [25]. Swedish cemeteries, unlike those in North America and the United Kingdom, are funded by a "burial fee" which is paid by Swedish citizens as part of their income tax [29]. Burial plots are owned for a period of 25 years, after which they can be renewed or re-used for additional burials [29]. Furthermore, the National Heritage Board [30], which is a government agency in Sweden, requires tree management plans to be created for all cemeteries. However, it is unclear whether the additional funding and tree management plans benefited the tree populations of cemeteries in Sweden.

Thus, this research had four main objectives surrounding cemetery tree management, using Malmö, Sweden, as a case study. The first was to determine what threats cemetery tree populations are currently facing based upon their biophysical characteristics. The second was to determine the extent to which multi-scale management strategies are employed in cemetery tree management. The third objective was to determine whether the existence of a tree management plan promotes multi-scale management. The final objective was to ascertain how cemetery tree management can be improved to promote more resilient tree populations in the future. These objectives are not only relevant for cemetery trees but also provide valuable insight into the role of scale in the management of urban forests in general. Other components of the urban forest, such as park trees for example, can also benefit from consideration of multi-scale management.

Our study identified threats to the current cemetery tree populations in Malmö, such as a lack of species and age-class diversity. While cemetery tree management is adequately funded and well-equipped to deal with short-term problems, it is evident that there is a lack of long-term thinking needed to address the issues of inadequate species and age-class diversity. This is despite the existence of management plans that promote longer-term planning. Our results highlight the mismatch in both temporal and spatial scale between the issues present with the cemetery tree populations and management action, suggesting that multiple management scales need to be considered.

2. Materials and Methods

2.1. Study Sites

Malmö is the third largest city in Sweden and is located at the southwestern tip of the country (Figure 1). Approximately 341,000 people reside in the urban center, which has an area of 332.6 km^2 [31].

Average annual precipitation is 612 mm, and average daily temperatures range from 0.1 °C in January to 16.7 °C in July [32].
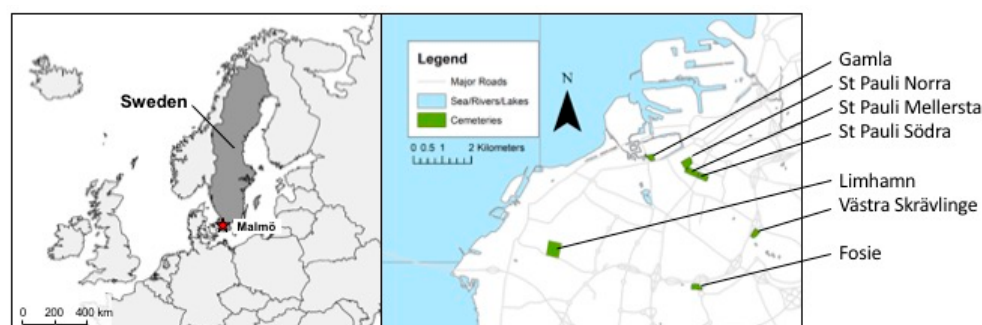

Figure 1. Map of Malmö and the studied cemeteries.

Cemeteries in Malmö were chosen as the objects of study for this research based on the availability of existing tree inventory data and tree management plans (Supplementary Table S1). Furthermore, the Swedish model of cemetery management (e.g., public funding, required tree management plans, etc.) provides an opportunity to study whether these resources, which are not readily available to cemetery managers in other countries, ultimately translate into better tree management. The cemeteries are all managed by the Malmö Cemetery Administration, but they differ in terms of when they were established and their size (Table 1).

Table 1. Cemeteries included in the study.

Cemetery	Year Established	Area (ha)	Tree Density (Trees/ha)	Year of Management Plan Creation
Gamla	1822	5.7	56.8	2015
St Pauli Norra	1870	8.0	52.4	2015
St Pauli Mellersta	1890	8.1	56.9	2015
St Pauli Södra	1904	6.0	53.8	2015
Limhamn	1880s	22.9	47.1	2017
Västra Skrävlinge	1885	5.6	42.3	2018
Fosie	1896	6.1	49.9	2018

2.2. Tree Inventory

Complete tree inventories were conducted for all cemeteries between 2015 and 2018. The inventories followed the Swedish Tree Inventory Standard [33] and were all conducted by the same individual. Trees were identified to the species level in most cases and the genus level when species-level identification was not possible. Diameter at breast height (DBH; cm) was measured following the i-Tree Eco guidelines [34]. Vitality, risk class, crown damage, stem damage, and root damage were evaluated on a scale of 1–4, with a score of one representing a low level of damage and risk and a high level of vitality and a score of four denoting severe damage, low vitality, and extreme risk.

2.3. Tree Management Plans

The tree management plans were created by consultants in close collaboration with the cemetery administration. Tree management plans were developed for the studied cemeteries between 2015 and 2018 and include data regarding the current cemetery tree populations, as well as guidance for their management in the future. The management plans included the following chapters: Introduction, Methods, Tree Policy, Legislation, Cultural and Historical Values, Biological Values, Social Values, Important Species (including condition and risk), Important Structures (e.g., avenue plantings), Possibilities and Restraints of the Growing Site, and Management and Development Recommendations. Some recommendations concerned replanting, species selection, and management of specific trees. All recommendations were linked to the biological, cultural, and social values of the cemeteries.

In accordance with the National Heritage Board requirements, the plans are valid for 10 years from their creation. The contents of these plans were examined to determine the spatial and temporal scales of their goals and recommended actions.

2.4. Canopy Cover Estimates

Canopy cover (%) for each cemetery was estimated using i-TreeCanopy v6.1. Shapefiles of each cemetery were overlaid on Google Maps aerial imagery, and randomly generated points were classified as "tree" or "non-tree" to estimate the proportion of canopy cover and associated standard error. Points were classified until the standard error reached 2%. The number of random points necessary to estimate canopy cover differed for each cemetery and was dependent on the cemetery's canopy cover, as increased numbers of points are required for classification when canopy cover is closer to 50% [35].

2.5. Manager Interviews

Semi-structured interviews were conducted with three cemetery managers from the Malmö Cemetery Administration in May and June of 2019. All three managers had work and/or education experience in landscape architecture, planning, and/or management. All participants gave their informed consent prior to the interviews. The study was conducted in adherence to the Declaration of Helsinki, and the research methods were approved by the Dalhousie University Ethics Committee (REB # 2019–4720). The interviews consisted of eight questions, with additional sub-questions, regarding cemetery management priorities, landscape maintenance, and concerns about trees. Two interviews were audio-recorded, while extensive notes were taken during the third. All interviews were conducted in English, but one manager had a second cemetery employee act as a translator. Interviews were coded using thematic analysis [36] to identify common themes across the interviews regarding the management of cemetery trees. Only three interviews were conducted given the low number of individuals working on cemetery tree management in Malmö and the general consensus seen across their answers.

3. Results

3.1. Species Richness, Diversity, and Composition

Across the seven cemeteries, 72 species and five unspecified genera were identified. *Tilia × europaea* was the most common species, making up 19.6% to 74.2% of the trees in any given cemetery and 40.8% of trees overall (Figure 2). As a genus, *Tilia* constituted 49% of all cemetery trees in Malmö.
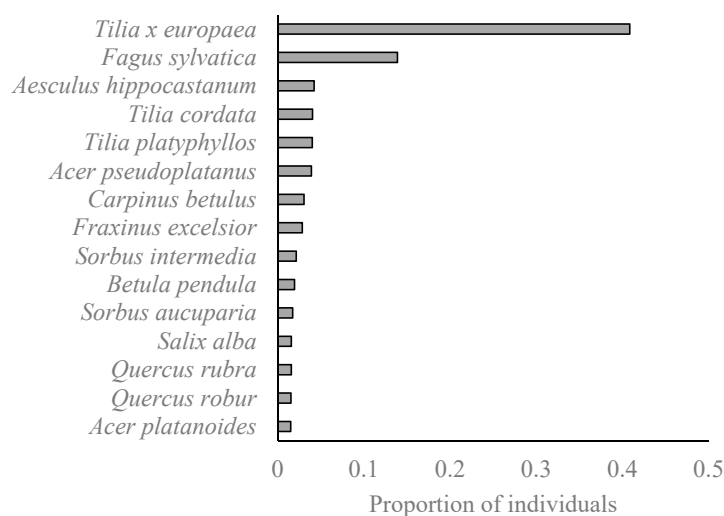

Figure 2. The proportion of total individuals belonging to the top 15 most common tree species in Malmö cemeteries.

3.2. Tree Damage and Risk Class

The majority of cemetery trees were given a rating of one for root, stem, and crown damage (Figure 3). The majority of cemetery trees were also assigned a risk class of one (Figure 3).
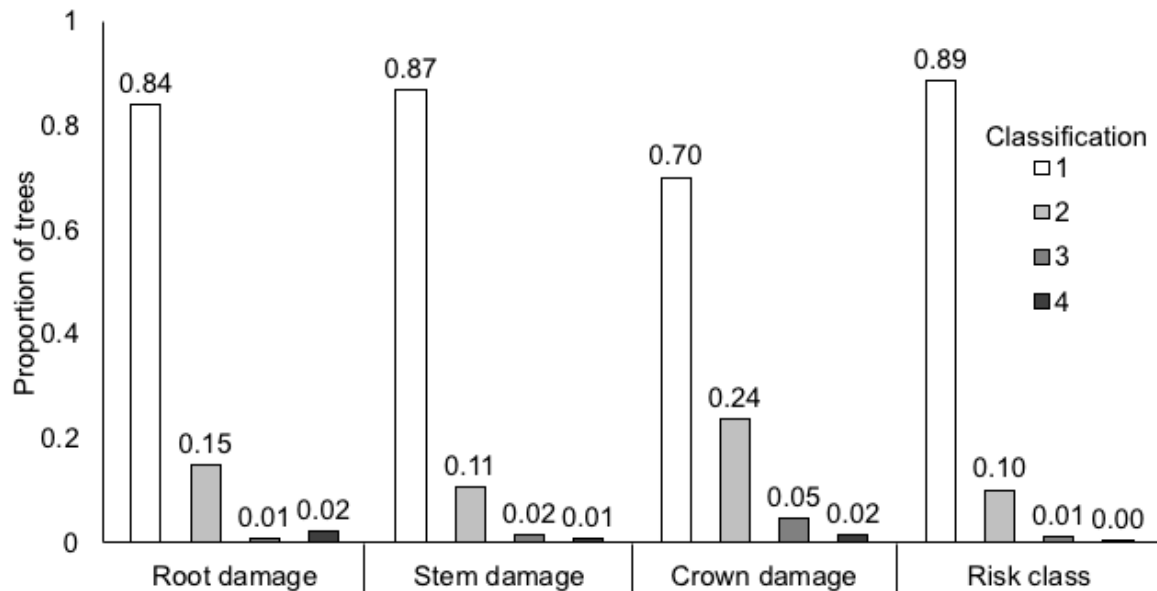

Figure 3. Root, stem, crown damage, and risk class of cemetery trees in Malmö, Sweden. Damage and risk increase on a scale of 1–4, with four being the highest level of risk or damage.

3.3. DBH Distribution, Decade Planted, and Vitality

The diameter distribution of cemetery trees was largely skewed toward trees between 40 and 59.9 cm with relatively low numbers of trees < 30 cm (Figure 4).
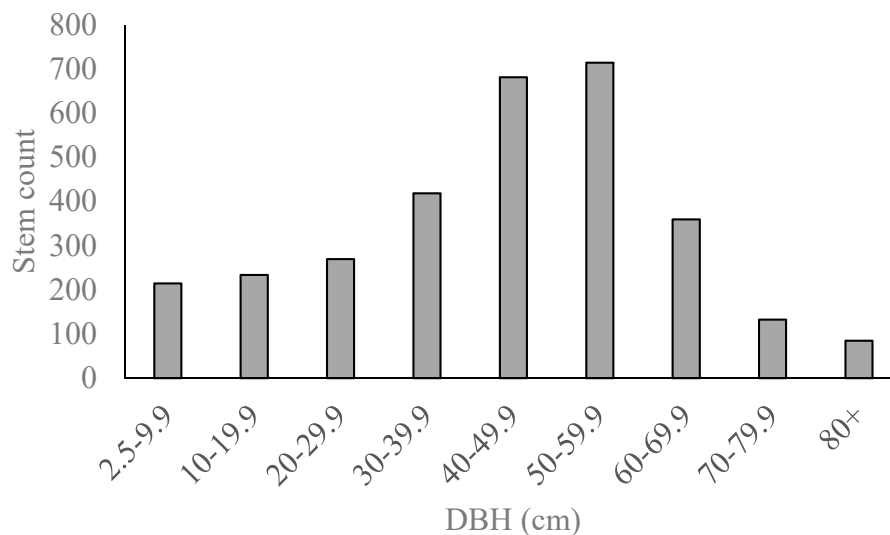

Figure 4. Diameter at breast height (DBH) distribution of trees in seven cemeteries in Malmö.

The majority of cemetery trees were planted in Malmö in 1930 and 1960 (Figure 5). Over 75% of cemetery trees in Malmö were rated as having a vitality class of one or two while less than 5% were rated as a four. Higher proportions of recently planted trees were ranked as class one compared to older trees.
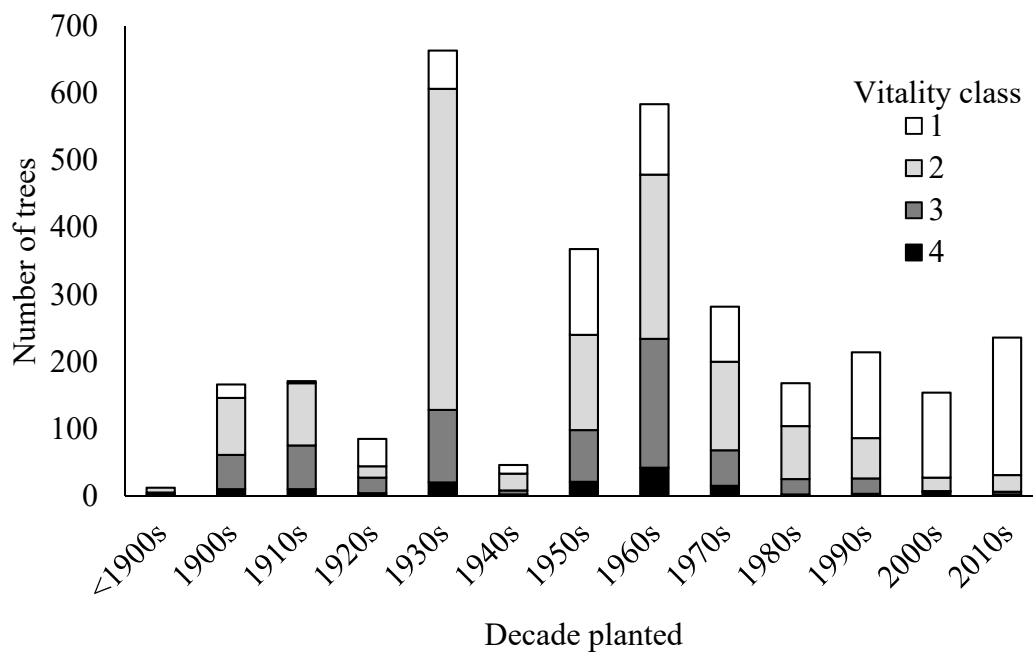
Figure 5. Vitality and estimated decade planted of cemetery trees in Malmö. Vitality decreases from 1–4.

3.4. Canopy Cover

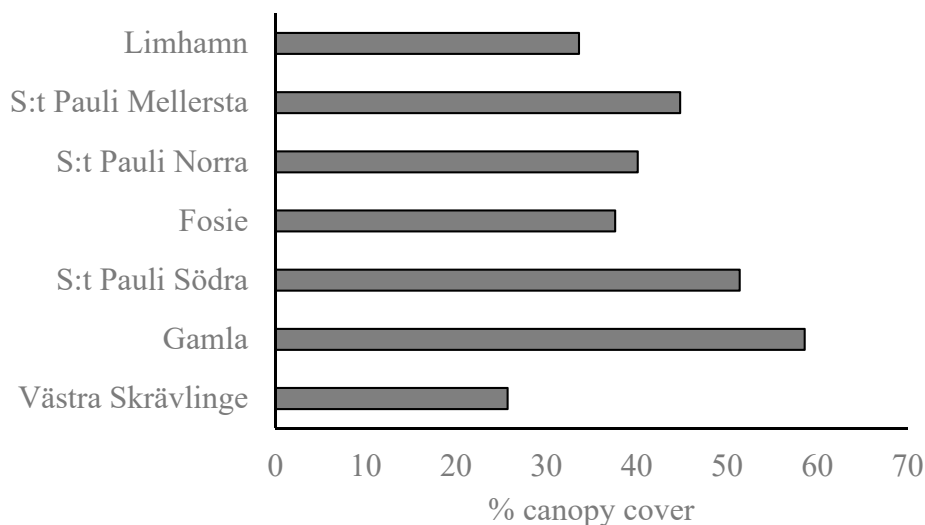Cemetery canopy cover ranged from 25.7% to 58.6% with an average of 41.7% (Figure 6).

Figure 6. Canopy cover of the seven Malmö cemeteries.

3.5. Management Plans

The management plans had a broad perspective and described the different values that the cemeteries provide (e.g., cultural, biological, and social values). The plans also described desired outcomes and clear actions needed to maintain these values. An example of a recommendation included is that a large tree stand affected by severe soil compaction and root damage should be re-planted to maintain the delineation of the cemetery border. The plans also describe how alley trees should be re-planted with a previously used species, thereby maintaining historical and cultural values. Maintenance and planting guides were included as appendices to provide practical guidance on actions to be taken. In each plan's foreword, it was recommended that these guides be used as a

standard for the Malmö cemeteries. Despite the National Heritage Board requirement stating that the plans should be updated every 10 years, the plans lacked information on these time frames.

3.6. Manager Interviews

Malmö cemetery managers indicated a strong appreciation for their trees and the many benefits they provide, such as contributing to the cozy and peaceful atmosphere and supporting biodiversity. They recognized the important contribution that their trees currently make to the city and their potential contribution in the future: "I think we have a huge responsibility to do that [plant and maintain trees] because we own so much land". While the cemetery managers in Malmö showed a high degree of arboriculture and landscape knowledge, there was some confusion regarding whether they had tree management plans. The managers believed the plans were still being created or were just completed a few months earlier, when some were around for almost three years. It was evident that most planning is done on a short-term basis (e.g., 1–3 years), with one manager stating "I'm mostly like one year in . . . but there was no planning before, so I'm starting it all up from the beginning right now. So maximum one year I would say". However, there was indication from the managers of a desire to move to planning on a longer time scale: "[I] prefer to have long plans . . . so you don't have to put out fires".

The biggest concern the managers had about their trees was the lack of diversity and the overemphasis on *Tilia* species. One manager talked about needing "time to plant new species so we don't lose the structure when the trees are actually dying because they're in so bad condition". Although they are trying to plant a variety of species, they also noted the conflict this created with the National Heritage Board: "They are very fond of planting the same type of species that we have been taking down. That's not possible all the time. We are a bit in a conflict with them". The National Heritage Board is also very resistant to removing any of the trees from the alley plantings. The managers also indicated that the general public showed a similar resistance to changes to the cemetery landscape and the trees: "Often it's so traditional . . . so like they want it to be in one way". Although the lack of age diversity was mentioned briefly by some managers, there was no discussion of how this issue was being addressed.

Tree maintenance in the cemeteries mainly involves pruning and trimming branches. Hazardous trees are also removed and typically replanted. Young trees are watered for the first three years after planting. One manager outlined the importance of tree planting and maintenance, saying "we need to think about how to establish the trees and take care of them, also of course, and we need our people to be able to take care of all the planted trees. I think we have a lot of potential to do that actually".

4. Discussion

Cemeteries in Malmö have a relatively high canopy cover (Figure 6), which exceeds the average canopy cover of the surrounding city by 20.2% [37]. Previous research in Canada found cemeteries to have a higher canopy cover than the surrounding city [25], and this trend is often true of urban parks as well (e.g., [38,39]). Increased canopy cover is associated with reduced air temperatures [3], greater stormwater interception [4], and increased removal of air pollutants [40], indicating the value of maintaining tree canopy. Canopy cover is also integral to the values that were previously ascribed to cemetery trees by the public, such as shade provision, aesthetics, and their contribution to improved personal wellbeing and the overall restorative atmosphere of cemeteries [24–26]. Previous research in Finland has indicated the restorative value of patches of urban forest [41,42], and Swedish research has also highlighted the importance of urban forests for their beauty, recreation opportunities, improved health and wellbeing, and biodiversity support [43]. As such, it can be inferred that the canopy cover provided by cemetery trees is a valuable contribution to the city of Malmö, particularly as previous studies in Nordic cemeteries have indicated that trees are a valued component of the cemetery landscape for multiple reasons [44,45].

The specific contribution of canopy cover to cemetery-user values of trees in this city may differ from other cities. For example, shade provision may not be as valued in Sweden as in warmer

climates (although previous research has emphasized the importance of cooling from urban trees in Sweden [46]). It has been suggested that recreation and aesthetics are often the most highly valued ecosystem services in Nordic countries [5].

Currently, very few cemetery trees in Malmö show signs of damage or present a high level of risk (Figure 3). The root damages were often related to lawn mowers, stem damages to pruning, and crown damages to topping in the 1970s and risk due to dead branches. Additionally, a large proportion of the trees had a high vitality (levels one or two; Figure 5). Recently planted trees were more frequently rated as vitality class one, but older trees were frequently rated as vitality class two, indicating that they are still in relatively good condition [33]. According to the inventory data, it appears that the cemetery trees in Malmö are currently facing few immediate problems or threats on an individual level. Current cemetery tree management is focused on actions such as pruning and removing hazardous trees, which makes it ideally suited to dealing with short-term issues such as risk and damage. This may be why so few of these issues are seen in the inventory data—not because they are not occurring but because they are being effectively dealt with. In fact, these issues may be very prevalent, which leads to management actions focusing on pruning and removing hazardous trees. While these actions are beneficial (and necessary), the emphasis on addressing short-term issues may lead to long-term issues being overlooked.

4.1. Species Diversity

Problems with Malmö cemetery trees become more evident when examining the species composition of the tree populations (Figure 2). *Tilia* species make up nearly half of the trees, with *Tilia × europaea* being especially dominant. *Tilia* trees are less dominant in the surrounding city of Malmö, making up only 13.3% of the total number of trees, but they are still one of the most abundant genera [47]. *Tilia* was also the most dominant genus (63% of trees) when comparing the Malmö cemeteries with those in Lund, a smaller city 20 km north of Malmö [48,49]. The prominence of *Tilia* in urban areas is seen across other Nordic cities [50,51], and the genus is quite common in temperate cities around the world [52]. Interestingly, de Lacy and Shackleton [53] found a high level of woody plant species diversity across sacred urban sites in South Africa. They suggested it was due to different management regimes, which could explain the lack of species diversity across cemeteries in Malmö, as they are managed by the same authority.

The lack of species diversity makes these cemetery tree populations particularly vulnerable to invasive pests or diseases [9,54,55] which could spread and cause extensive canopy loss in a short period of time. According to the manager interviews, this occurred previously in Malmö cemeteries when Dutch Elm Disease (DED) resulted in the loss of many *Ulmus* trees. Although *Tilia* species are yet to face a threat on the scale of DED or Emerald Ash Borer (EAB), there is some indication that they may be susceptible to the Asian longhorn beetle [50]. Additionally, there is always the potential that new invasive pests and diseases will be introduced in the future, which may have a negative impact on *Tilia* species.

Tree species diversity is also being recognized for its importance in the face of global climate change [12], which may result in existing species becoming less suited for their changing environment based on their hardiness and drought tolerance [11,56]. However, climate change may also increase the number of tree species that can survive in certain urban environments [11], increasing the potential for species diversification. It was also suggested that species diversity can improve the provision of certain ecosystem services [57]. The importance of species diversity of urban forests has been noted for many cities in Scandinavia for its contribution to habitat provision [58].

There were many estimates of what constitutes an ideal (or, at least, acceptable) level of urban tree species diversity. Estimates are typically made at the level of the individual urban forest and include no species constituting more than between 5% and 15% of the total population and no genus making up more than 10–20% [59–63]. Such ideal distributions were criticized for not being supported by empirical evidence [64]; however, it can be assumed that having nearly 50% of cemetery trees belonging

to the *Tilia* genus makes these tree populations particularly vulnerable. This is especially true when considering that *Tilia* is one of the most dominant genera in the surrounding city. Thus, *Tilia* should be avoided during planting efforts in cemeteries in Malmö. *Fagus sylvatica* should also be avoided, given that it already makes up nearly 14% of the total number of trees.

The cemetery managers indicated the difficulty with replacing *Tilia* with other species, as the National Heritage Board desires having the same species replanted when a tree is removed. They also desire maintaining the alley plantings lining many of the pathways, which are primarily composed of *Tilia*. Given that cemeteries are often viewed as cultural and historical landscapes [27,65], the desire to maintain tree species reflective of these values is not surprising. However, compromises will need to be made for the creation of more resilient cemetery tree populations. Communication between cemetery managers and the National Heritage Board should be used to facilitate discussions surrounding how to best promote species diversification while maintaining cultural values. Given the strong emphasis placed on maintaining the alley trees, a compromise may involve maintaining selected *Tilia* alley plantings while diversifying other alley planting species and the species in other cemetery areas. Furthermore, since *Tilia × europaea* is largely responsible for dominance of this genus, efforts should be made to plant a wider variety of *Tilia* species in areas selected to be maintained with this genus. However, it should be noted that many forest pests and diseases affect entire genera, such as EAB [66] or DED [67], suggesting that simply planting different species of *Tilia* is not an ideal solution. Many tree species are associated with cemeteries historically [68,69] suggesting that there may be a wide variety of species that have some cultural value which could be planted instead of *Tilia*.

The cemetery managers indicated that it is not only the National Heritage Board that desires maintaining the current cemetery landscape but also the general public: "You have a traditional way of seeing the cemetery, so people don't agree with that, to change. They want a specific look". It is unclear whether species selection in particular is important to the public or whether it is the characteristics of the trees or their layout that they wish to maintain. Increased communication, education, and involvement in decision-making [70] would be beneficial for gaining public support for any changes, including species diversification, in the Malmö cemeteries.

4.2. Age and Size Class Diversity

The lack of species diversity is not the only problem that exists for cemetery tree populations in Malmö. Figure 4 shows that the majority of trees have a diameter between 40 and 59.9 cm, while Figure 5 shows that over half of the trees were planted between 1930 and 1960. The lack of age and size class diversity could result in large canopy loss in a relatively short period of time in the future as the trees reach the end of their lifespans. This in turn would reduce the ecosystem services provided [71]. Additionally, Ordòñez et al. [12] highlighted the importance of age class diversity due to the differences in climate change adaptability between seedlings and middle-aged and old trees. Millward and Sabir [55] also pointed out that age and size class diversity allow for maintenance costs to be spread out over time, allowing financial resources to distributed more evenly over time. Even though Malmö cemeteries have the money and knowledge necessary to promote better tree management, it is unclear whether these resources will be sufficient during future periods in which increased money and time are required for tree management and maintenance. One manager even voiced concern about currently not having enough time to properly manage the cemetery trees: "There are a lot of old trees, and they're not always as healthy as we would like. The worry is that we're not having time to look after them the way we should to make them live longer".

Cemetery managers indicated that most of the tree planting that was occurring was done to replace trees that were removed. Only planting enough trees to replace those that were removed that year or the previous year will not be enough to compensate for the large-scale canopy loss that will occur as the trees in the 40–59.9 cm size class and those planted between 1930 and 1960 approach the end of their lifespan. Even if planting efforts can be sustained during these periods of massive loss, the small canopy size of the younger trees will not provide the same overall benefits as the older trees that

were removed [7,72]. Furthermore, not every planted tree will survive. Thus, only planting the same number of trees as the number removed will lead to a net loss of trees and canopy cover over time. Trees need to be planted at a higher rate than they are being removed to allow them time to survive and grow to a larger size before the older trees reach the end of their lifespans.

Age and size class diversification needs to be given consideration not only for the cemetery tree populations as a whole but also for important cultural elements such as the alley plantings. Currently, trees planted in long rows adjacent to paths in the cemeteries primarily comprise one species (typically *Tilia*) and the trees are the same size and age. This indicates the threat to these culturally valuable plantings in the future. Where space permits, consideration should be given to planting new trees between the current alley trees, to allow them to grow to a larger size before the older alley trees die. This will ensure that the aesthetic of the alley plantings will not be completely lost in the future.

4.3. The Importance of Multi-Scale Cemetery Tree Management in Malmö

4.3.1. Temporal Scales

Interviews with Malmö cemetery managers indicated that, although there was some desire for long-term management, trees are currently managed on a relatively short timescale (e.g., 1–3 years). While tree management plans were created for all cemeteries in this study, some as much as three years ago, it was evident that they were not being extensively used. Short-term management is adequate for addressing issues such as watering young trees, pruning branches, and removing and replanting trees that are high risk. This is beneficial for addressing issues such as damage and risk. However, it is evident from the tree inventory data that the issues facing the trees in Malmö cemeteries are not issues that can be addressed solely with short-term management. This sort of temporal mismatch in urban greenspace management was noted previously, whereby management time horizons do not align with those of ecological processes [7,13,73].

The main issues facing the trees in Malmö cemeteries, such as the lack of species, size, and age class diversity, will require planning further into the future than 1–3 years. The current management plans include goals and recommendations to improve species, age, and size diversity through a combination of direct recommendations (e.g., where to plant new trees) but also long-term goals such as increasing species diversity. It may be that the current management plans were not effectively communicated to the cemetery managers. By promoting greater inclusion of the cemetery managers in the development of the management plans and communicating the results in the future, the plans may be more likely to be translated into actions. Cemetery managers need to set long-term targets for improving their species and age/size-class diversity which will inform short-term actions such as species selection and the number of trees that are planted each year. The necessity of creating long-term targets and goals for urban greenspace management was indicated previously [13,74]. Long-term planning and management are necessary for dealing with invasive pests and diseases [9], ensuring the maintenance of ecological and cultural values [75], and promoting age and size class diversity [76]. However, it was noted, both in cemetery tree management and in the management of urban forests in general, that management is often short-term and reactive (e.g., [25,77,78]).

When it comes to consideration of temporal scales of management, it is also necessary to incorporate the element of change. While cemeteries themselves may be viewed as static elements resistant to development pressures [20,65], their meaning is temporally dynamic [27]. This is evident when examining how cemetery landscapes and their uses evolved over time, for example, changing from places viewed as a public health threat to places ideally suited for recreation [79]. This evolution may affect the cultural values associated with cemeteries and what is deemed acceptable in terms of the landscape. Time was found to influence cultural values on not just cemeteries but greenspace in general [80]. Additionally, climate change, future pest/disease outbreaks, and other unforeseen circumstances will necessitate revisions to cemetery tree management plans as new information becomes available and new issues arise. This indicates that multi-temporal cemetery tree management

cannot be facilitated solely by the creation of long-term management plans. It will require an iterative process that re-examines management and the context surrounding it to make necessary adjustments in the future to accommodate changing perceptions of cemeteries, evolving cultural and societal values, and changes to the surrounding environment.

4.3.2. Spatial Scales

In addition to management on multiple timescales, managing urban forests on multiple spatial scales is also important [74]. Management needs to be considered not just on the level of the individual tree but in terms of the cemetery tree populations as a whole and also within the broader context of the urban forest of the city. Management on an individual level helps identify hazardous trees and damage, while cemetery-level management indicates issues such as a lack of species and age/size class diversity. Management across multiple land uses (e.g., on the level of the city) will promote consideration of cemeteries as part of a wider network of greenspaces, which could be beneficial to various ecological processes. Nordh and Evensen [48] and Kjøller [81] pointed out that, even when cemeteries are considered by municipalities to be greenspaces, they are often kept separate and managed differently than other green infrastructure. However, inclusion of cemeteries in discussions of urban greenspace can promote improved resilience and stability for the urban forest of Malmö as it could, for example, inform better species selection for future planting, such that it diversifies the species not only in the cemetery but also within the surrounding city.

To highlight the necessity of managing on multiple spatial scales, it is useful to examine the presence of *Tilia* in the city of Malmö. For example, *Tilia × europaea* constitutes only 7.97% of trees in the city's urban forest [50], suggesting that it is not particularly overabundant on this scale. However, the problematic overabundance of *Tilia* becomes clear when examining species diversity on the cemetery level and indicates the risk they pose in terms of future canopy loss in these landscapes. Furthermore, cemeteries represent a unique land use with values ascribed to trees that differ from those attributed to other areas of the urban forest [25]. The manager interviews also highlighted the important cultural values ascribed to trees in their cemeteries, which are reinforced by the insistence of the National Heritage Board that certain cemetery tree plantings be maintained. Thus, the consideration of tree management on the cemetery scale is necessary for the identification and maintenance of unique values which would be overlooked if management focused solely on a broader scale. Previous urban forestry research highlighted the need to consider management on spatial scales that are not just politically or economically relevant (e.g., based on municipal boundaries) but that are socially relevant, such as those based on population density, socio-demographics, and lifestyle [82,83]. Based on our study, it is evident that management on scales relevant to cultural values should also be considered.

Previous research also highlighted the mismatch between management spatial scales and the scale of ecological processes in urban areas in general [7,13], indicating that this is not just a problem faced by cemeteries. Studies showed that relying on a single spatial scale can lead to a misunderstanding of ecosystem services and disservices [4,80,84] and species richness [85], and it can overlook issues such as topography, land use, history, and so on [74]. As these factors motivate and/or inform management, it is evident that considering multiple spatial scales is critical for successful tree management.

5. Conclusions

It is evident from this study that the long-term stability of cemetery tree populations in Malmö is threatened by their lack of species and age/size class diversity. Current cemetery tree management emphasizes a short time scale, and much of the maintenance work focuses on addressing issues pertaining to individual trees. While cemetery managers identified the lack of tree species diversity as an issue, they have difficulty reconciling the need to diversify the tree species while also maintaining cultural values associated with *Tilia* plantings. It is evident that tree management plans are not extensively used by the managers, even though they include recommendations for creating better species and size diversity. Future tree management plans should incorporate more stakeholders during

their creation, including cemetery users and the National Heritage Board. Promoting more resilient and stable tree populations in the future will require cemetery managers to consider longer-term management and planning actions and focus their actions not only on maintaining individual trees but the entire cemetery tree populations, giving consideration to how cemetery trees should be managed in the broader context of the surrounding urban forest of Malmö. Long-term planning is required, and cemetery managers will need to diversity the species they are planting and identify new spots to plant trees within their cemeteries to avoid large losses in canopy cover in the future. Multi-scale management will be necessary to address the issues of species and age/size class diversity. This concept of multi-scale management and recommendations regarding the improvement of species and age class diversity could likely be usefully applied to other urban cemeteries with trees, as well as to other parts of the urban forest.

One of the prominent issues identified by this study is the need to reconcile the maintenance of cultural values and the need for species diversification. There is increasing discussion regarding the need to better incorporate spiritual and cultural values into the ecosystem benefits and services framework, landscape and urban planning, and resource management. Future research on incorporating cultural and spiritual values into cemetery landscape management could provide insight into how species diversification can be achieved within culturally and spiritually important landscapes. Malmö could be a good location for such a case study, and emphasis could be placed on understanding public values of these cemetery trees. Further studies could also attempt to quantify certain ecosystem services and compare these values to those obtained in previous studies to determine the extent to which cemeteries provide services such as stormwater management and mitigation of air pollution.

Given the relatively high canopy cover of many urban cemeteries, the ecosystem services they can provide, and the values ascribed to cemetery trees, there is a clear need for appropriate cemetery tree management to ensure their maintenance in these landscapes. While resources such as funding and arboriculture knowledge can be beneficial for management, it is evident from this study that they do not ensure a resilient tree population and that issues such as a lack of age/size and species diversity can still exist. Management needs to better consider multiple temporal and spatial scales to identify issues undermining the long-term stability of tree populations and inform management actions to address these problems.

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