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100K Trees

WP 3: Tree Attributes

Deliverable 3.3: Standardized tree types

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List of Acronyms

D3.3	Deliverable 3.3
LAI	Leaf Area Index
WP	Work package

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Executive summary

Deliverable 3.3 (D3.3) explains the process of categorizing different urban tree profiles into standardized tree types. It builds on the work already provided by WP3 (D3.1 and D3.2) and is intended to facilitate both the ecosystem services modelling work of WP4 and the decision-making of users of the 100k Trees toolbox.

Indeed, D3.2 made it possible to draw up a list of attributes capable of calculating the contribution of each tree to ecosystem services. Some of these attributes were selected to create relevant standardized tree types. To do this, 4 main criteria had to be respected in the categorization, namely:

- Having categories that are sufficiently differentiated from one another to best represent the diversity of urban trees,
- Having a limited number of tree categories to facilitate decision-making by users,
- Choosing attributes which enable modelling ecosystem services well enough,
- Having standardized tree types that can be applicable to the two climatic contexts studied as part of the 100k Trees project, i.e. Sofia and Copenhagen.

The general process of this categorization consisted in gathering the needs and expectations of users and of WP4 in charge of ecosystem services modelling, in order to find the best compromise of standardized tree types. This work finally led to the definition of 18 categories of standardized tree types, distinguished by 3 tree attributes: seasonality, Leaf Area Index (LAI) and tree size. An in-depth discussion of the choice of these categories and their respective advantages and disadvantages is given in Chapter 4. Finally, a proposal for visualizing standardized tree types is made in section 5, in order to assess the relevance of the number of categories chosen.

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1. Introduction

1.1 Purpose and audience of the document

The aim of this deliverable is to define standardized tree types corresponding to representative categories of trees present in the urban areas of Sofia and Copenhagen. Following on from previous work in WP3, these standardized tree types should be defined using the list of tree attributes developed in D3.2 (Vanwildemeersch et al., 2024). This tree categorization will serve as input data for WP4 to simplify ecosystem services modeling and facilitate user decision-making when using the 100kTREES' toolbox.

D3.3 is therefore the last deliverable produced by WP3, providing a link between the work of WP1, WP2 and WP4. It was drawn up in collaboration with partners in order to take their expectations into account and ensure the compatibility between the work packages. This deliverable is shared with project partners and EC auditors and will be made available publicly for transparency.

1.2 Structure of the document

After a brief introduction, section 2 recontextualizes the work of WP3 within the 100k Trees project and more specifically outlines the D3.3 objectives. Then, in the following section, the methodology used to define standardized tree types is explained in three stages, starting with the collection of WP4 needs, followed by user expectations, and finally the compromise to be found among all the criteria. The choice of categorization is then explained and discussed in section 4, followed by a visualization proposal in section 5. Section 6 concludes with the main contributions of this deliverable, as well as the difficulties encountered, and the importance of this work in ensuring the continuity of the project with the next work packages.

2. Interests of defining standardized tree types as part of the 100k Trees toolbox

A brief review of the context of the work is provided here to better understand the interest and objectives of defining standardized tree types and producing this deliverable.

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2.1 General context for using the 100k Trees toolbox

The 100k Trees project aims to create a toolbox to encourage European cities to plant trees in order to benefit from ecosystem services. In this way, the toolbox is intended to help users in their decision-making on planting strategies (which tree species to plant, where etc.).

The general context for using the 100k Trees toolbox would involve firstly identifying the most vulnerable urban areas, i.e. those where natural hazards are particularly high or locally produced ecosystem services are low. This is part of the work of WP4, whose mission is to create modelling tools for estimating ecosystem services. At the same time, the municipalities involved in the project will be in charge of drawing up an initial planting plan with very general information on the number of trees to be planted, as well as other urban planning projects to be integrated into the landscape.

In a second phase, local constraints will be added to the urban plan, restricting the areas and the type of trees to be planted. These constraints may relate, for example, to the space available, the resources required for tree development such as available under- and aboveground space, or other practical constraints.

The final step for decision-makers will then be to optimize the choice of trees to be planted, according to all the other flexible parameters. This is where WP3 comes in, and its role will be to help in the decision-making process by promoting the various advantages and disadvantages of each type of tree in terms of ecosystem services production.

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2.2 Definition and objectives of defining standardized tree types

In this context, the work of WP3 is to simplify information about trees in order to facilitate decision-making by users and facilitate ecosystem services modelling. This work is thus closely linked with that of WP1, which focuses on user requirements, and WP4, which focuses on ecosystem services modelling. Within this framework, the definition of standardized tree types consists in creating theoretical categories of trees that can simply describe the diversity of urban trees and the different ecosystem services they produce. In concrete terms, this work contributes to two main objectives:

- Firstly, to visualize the best tree types to plant on the map of potential planting spots. The users will then be able to observe which types of trees are best suited to local urban planning constraints.
- Secondly, the standardized tree types will also be used to facilitate the simulation of “what if” scenarios, i.e. to compare the impact of these different tree types on ecosystem services. This will then ease the interpretation of the outcomes of the toolbox and help with the construction of “what if” scenarios. The standardized tree types will thus serve as input data for WP4.

As you can see, the idea is to limit the number of tree categories from several hundred tree species and varieties to a more usable number of tree types. To define these tree types, preliminary work has already been carried out under D3.1 and D3.2 to determine a list of pertinent tree attributes that can be used to model their associated ecosystem services. The idea is thus to select a small number from these attributes to define tree categories while meeting certain criteria.

3. Methodology for defining standardized tree types

Before addressing WP3's choice of categorization, this section aims to explain the methodology we followed, considering the expectations of toolbox users on the one hand, and the needs of WP4 on the other, for whom this deliverable serves as input data.

3.1 Gathering WP4 needs and opportunities

In the case of the 100k Trees toolbox, the aim is to help urban planners decide on the best combination of trees to plant to maximize ecosystem services. To this end, WP4 is in charge of creating tools for modelling the ecosystem services produced by trees in urban environments. However, the range and magnitude of ecosystem services that trees can provide can vary based on their type, spatial location and configuration. By identifying the risk hotspots

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for an urban area, different tree types can be proposed to be planted for different regions within a city. In such cases, it is useful to visualize the best planting scenario to adopt, given the various constraints. To quantify the ecosystem services provided by urban trees during the scenario planning process and compare them to the current situation, a simplified categorization of trees was therefore needed. Indeed, for the sake of simplicity and time, it is easier to test "what if” scenarios on a reduced number of tree profiles. The definition of standardized tree types is therefore a way of overcoming this problem, as the "what if" scenarios can then be tested on a few well-defined tree categories.

The definition of standardized tree types involves categorization based on well-chosen tree attributes. Indeed, since the aim is to compare tree categories with regard to the ecosystem services they produce, the attributes chosen must enable these ecosystem services to be correctly estimated. To this end, a pre-analysis of the attributes was carried out by WP4 in order to observe their respective links with 4 main factors, namely: tree growth, ecosystem services, social factors and costs (Figure 1).

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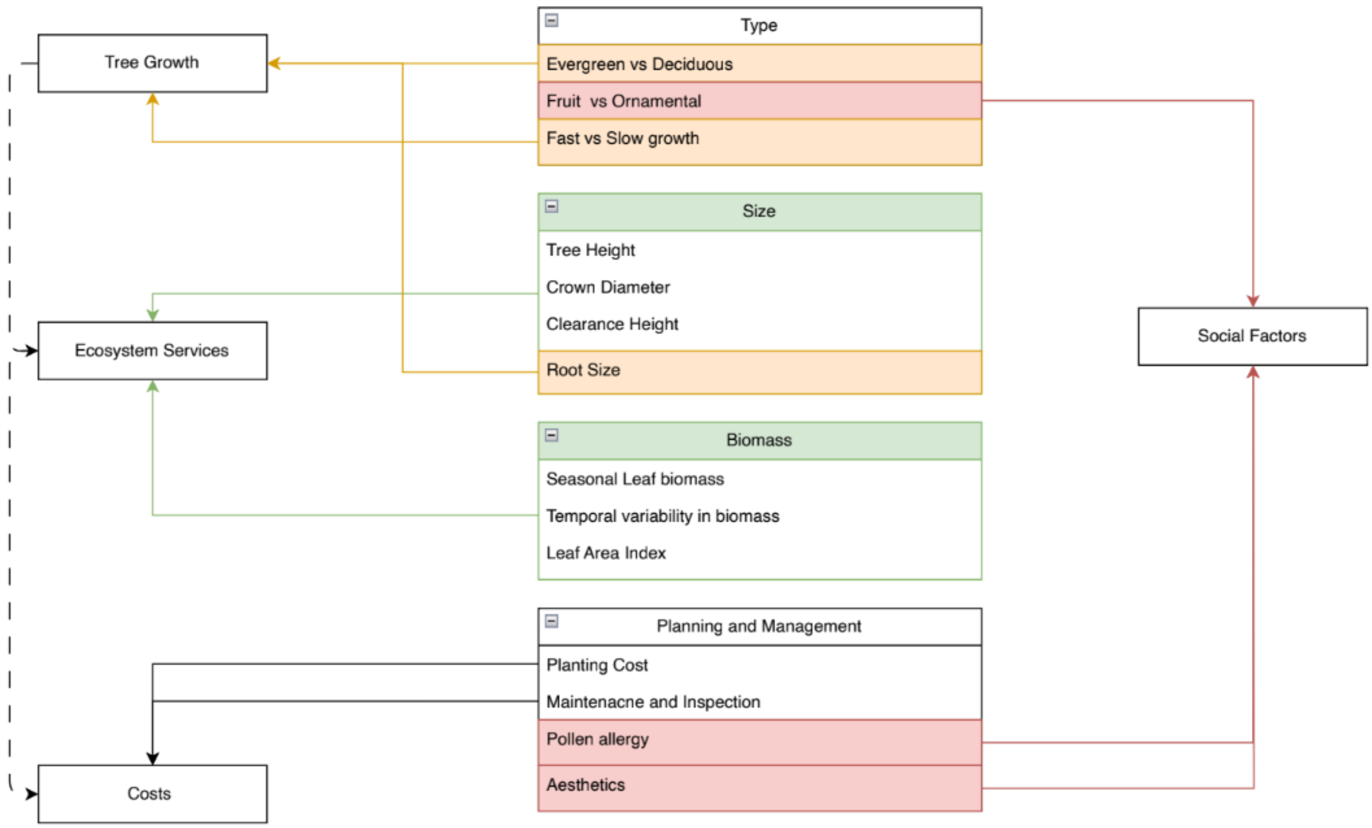

Figure 1. Link between attributes and their ability to estimate 4 different factors (A. Eslami, 2024).

This diagram shows that the attributes directly linked to ecosystem services are those relating to size and biomass. Root size, growth rate and seasonality are attributes linked to tree growth and are therefore also indirectly linked to ecosystem services. Thus, the choice of attributes should focus mainly on those directly linked to ecosystem services, since they are likely to be better able to estimate them. In addition, the combination of selected attributes should be designed to maximize their complementarity. In fact, choosing attributes that are too close to each other, such as crown size and diameter, will not enable optimum estimation of ecosystem services, as the only dimension used will be the "size" factor.

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Attribute	Ecosystem service
Allelochemicals	Biodiversity improvement
Clearance height	Cooling effect
Crown diameter (canopy projection area)	Air pollution reduction, Cooling effect, Noise abatement
Crown form	Cooling effect
Diameter / circumference of the trunk at breast height	Air pollution reduction, Biodiversity improvement, Cooling effect, Noise abatement, Potential carbon mitigation
Leaf Area Index (LAI)	Air pollution reduction, Cooling effect, Flood risk and estimated damages, Noise abatement
Presence of moss on trunk	Noise abatement
Pruning regime	Biodiversity improvement, Potential carbon mitigation
Radial roughness	Noise abatement
Species specific transpiration	Cooling effect
Tree height	Air pollution reduction, Cooling effect, Noise abatement, Potential carbon mitigation
Tree physiological status (health status of the tree)	Air pollution reduction, Cooling effect¸ Potential carbon mitigation
Tree planting date	Noise abatement, Potential carbon mitigation
Tree species	Air pollution reduction, Biodiversity improvement, Flood risk and estimated damages, Noise abatement, Potential carbon mitigation

Table 1. List of attributes for modelling individual tree contributions to the ecosystem services (Vanwildemeersch et al., 2023).

Table 1 shows the link between each attribute and the ecosystem services it enables to estimate. The idea, then, is to obtain a combination of attributes that allows us to model the greatest possible diversity of ecosystem services.

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3.2 Gathering user needs and expectations from WP1

To properly address user expectations in the definition of standardized tree types, WP3 sought to understand exactly which different types of users were involved, and what their needs were. After discussions with WP1 partners, we were able to identify 3 potential categories of users:

- **Operational users:** they are in charge of the operational implementation of planting projects. They have a good knowledge of trees and the field. They are supervised by urban planners.
- **Urban planners:** they are mostly landscape architects who are focusing on building urban spaces and making livable neighborhoods. Their main expertise lies in the aesthetic and social aspects of urban greening, but less in the trees themselves. This level of users informs the politicians who are the decision makers.
- **Policy – decision makers:** Politicians are decision-makers, but they don't really have any expertise in urban planning. They must therefore rely primarily on the advice of urban planners to make their decisions. However, they make the final decisions so they can also go against the urban planners' recommendations.

This organizational structure can be found in the majority of European cities with a regional planning department, which is why we decided to build on it. The main feature of this organization is that the urban planners have a particularly important role to play in the planting strategy. Indeed, they are the ones who carry out the planning (they determine what types of trees to plant where and supervise the operations) and therefore have the power to influence decision-makers. This category of stakeholder is therefore the most likely to use the 100kTrees toolbox, which is why we have based our work on their perspective.

Usually, the main criteria used by urban planners when making planting choices are aesthetics and social aspects such as the different landscape environments, recreational areas etc. However, the benefits linked to the ecosystem services produced by trees are relatively little known and put forward in decision-making. In addition, adaptation to climate change is becoming a growing topic in urban planning projects, particularly due to the increased risks of flooding and extreme heat. It was therefore decided that the 100kTrees toolbox would have real added value if it enabled the various ecosystem services to be brought into the decision-making process, rather than just the standard criteria used by urban planners. The tool would then have an awareness-raising and a planning support function for climate change adaptation. To do so, the chosen attributes need to be easily understood by urban planners, who don't always have tree expertise.

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3.3 Standardized tree types: a compromise between user expectations and ecosystem services modelling possibilities

The challenge for WP3 is therefore to propose a categorization of standardized tree types that meets the expectations of both WP1 and WP4. In other words, the aim was to identify limited, yet optimized set of attributes that effectively represent the processes involved in a tree's role in different ecosystem services. Finally, the standardized tree types should play a role in raising users' awareness of climate issues, and thus influence their decision-making in favor of adaptation to climate change.

4. Proposal for standardized tree types

This section sets out the categorization into standardized tree types proposed by WP3, followed by a discussion of the choices and key assumptions that led to this result.

4.1 Choice of the standardized tree types

In view of the constraints and expectations set out above, WP3 chose the following categorization system for standardized tree types:

- **Seasonality**, divided into 2 categories: **deciduous/evergreen**
- **Leaf Area Index (LAI)**, divided in 3 categories: **low/medium/high**
- **Tree height**, divided in 3 categories: **small/medium/tall**

This represents a total of 18 tree categories (Figure 2).

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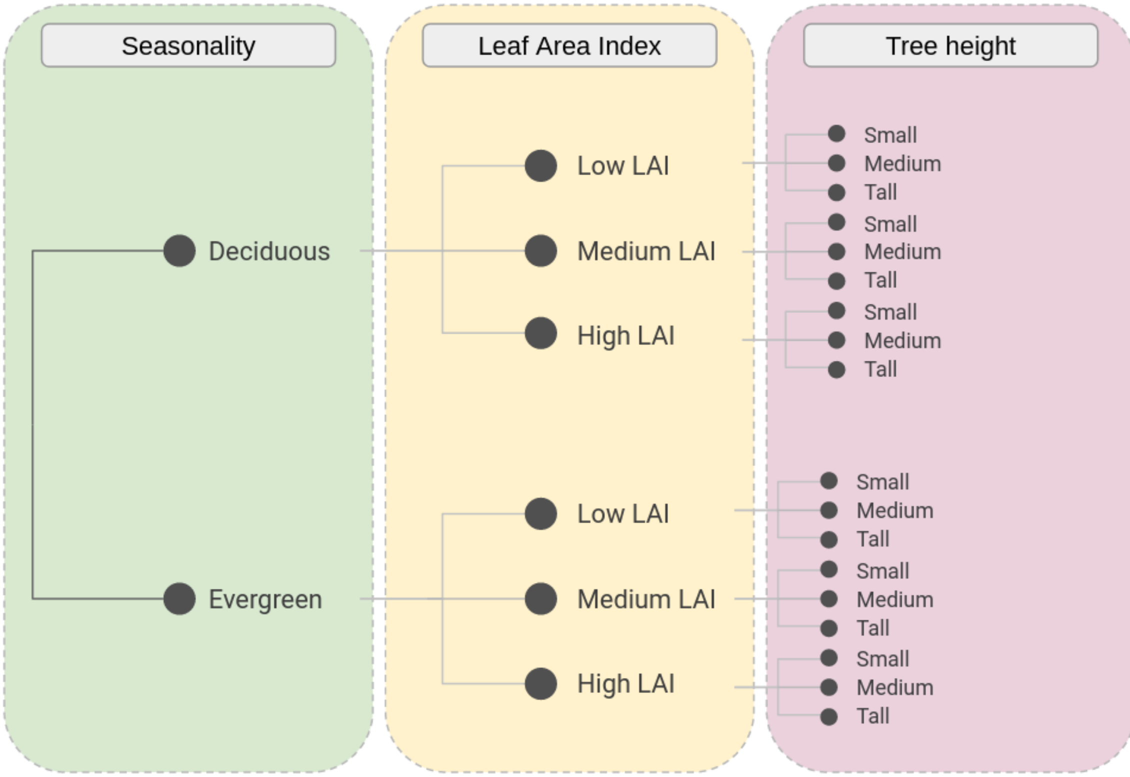

Figure 2. Categorization for standardized tree types according to selected attributes

The first attribute chosen was LAI, as it is the most important for ecosystem services modelling. In fact, since LAI is an indicator of leaf area, it represents the processes that occur within a tree canopy that can influence every ecosystem service. For example, it is directly linked to the capacity of trees to carry out photosynthesis and evapotranspiration, which influences the reduction of heat islands. However this attribute must be associated with each tree's seasonality, i.e. whether it is evergreen or deciduous. Indeed, as previously said in D3.1: "The temporality of most of these attributes is also to be considered [...] All dendrometric attributes (diameter, height, clearance height, diameter at breast height) and season, size or age-dependent attributes (e.g. LAI, crown form, radial roughness) evolve greatly over the lifespan of a tree, as do their impact on the ecosystem services the tree provides." (Vanwildemeersch et al., 2023). This means that a high LAI will not have the same value for an evergreen or deciduous tree as it will drastically change during the time of the year. This is why this second attribute has also been added.

Furthermore, as mentioned in D3.1, tree size is also an important consideration for estimating cooling effect and noise reduction and is fundamental for calculating carbon storage.

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As tree size is influenced by physical factors such as plantation layout and density, climate, soil type and nutrient availability, it enables urban planners to fine-tune their choice according to local constraints. This attribute has therefore been chosen to represent part of the tree's canopy structure.

Finally, the categories chosen also have the advantage of being fairly general, so they can be transposed to any other European city wishing to use the toolbox. This is an interesting element for the continuity of the 100k Trees project and its long-term success.

To further clarify these categories, reference value ranges must be defined for the LAI attribute (high, medium and low) and for the tree height attribute (tall, medium and small). It was not possible to define these intervals in D3.3 due to missing data. However, a methodology has been worked out collectively between WP3 and WP4 so that the intervals can be calculated once the databases have been corrected. This methodology consists of several steps:

- **Merging the Sofia and Copenhagen tree databases** into a single database. This will provide average value intervals for Sofia and Copenhagen trees.
- Divide the trees in the database into **two categories according to their seasonality**: deciduous or evergreen. Indeed, as mentioned above, LAI is dependent on seasonality, so this attribute must be considered when defining reference values.
- For LAI intervals, **the LAI values should be divided into 3 equal categories**, taking the minimum and maximum values as the boundaries. The high, medium and low thresholds will then correspond to the first third of the highest LAI values, then to the median interval, and finally to the third of the lowest values. This method is considered statistically correct, given that the data sample we have worked on is randomized and corresponds to a representative sample of the overall population of urban trees. Furthermore, LAI was considered constant over time (without considering annual seasonal variations), i.e. the tree's leaf area was assumed to remain proportional to its size, whether it is young or mature.
- For the **tree height intervals**, we decided not to divide the trees into 3 equal categories as for the LAI, but rather to use the standard size categories usually used. These standard categories are normally 5 in number, namely: under 5m, 5 to 10m, 10 to 20m, 20 to 30m, and above 30m. However, we have reduced them to 3 so that they correspond to the tall/medium/small categorization. We therefore chose to merge the first 2 categories with the last 2 to obtain: **under 10m for small, 10 to 20m for medium and over 20m for tall**. The size used for categorization corresponds to the maximum

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potential size attainable by each tree category. However, when a tree has not yet reached maturity, it will be considered smaller and will therefore not have the same impact on ecosystem services. The temporality of this attribute will be considered thanks to the growth model developed by WP4, which means the user can visualize the evolution of ecosystem services produced by the tree over time.

The categorization method can be adjusted according to the results obtained in the samples. Particularly regarding tree size, the arbitrarily defined categories may need to be modified if they are not sufficiently representative. This is therefore a suggestion for a method that may evolve if necessary.

4.2 Discussion

This choice of categorization represents a satisfactory compromise between the expectations of potential users and the technical requirements for modelling, as documented in chapter 3. However, certain elements remain debatable in relation to the initial proposal.

The first concerns the number of categories defined, i.e. 18 in this case, which far exceeds the 4 to 6 initially envisaged. However, this was deemed necessary by WP3, as the attributes chosen for categorization turned out to be the most interesting for ecosystem services modelling. Furthermore, the number of sub-categories defined for each attribute (e.g. small/medium/tall for tree size) could not have been reduced any further, as the distinction between categories would not have been sufficiently highlighted. The working group therefore admitted that 18 remained an acceptable number of categories for user decision support. This was supported by an attempt at visualization using symbols, which will be detailed in a later section.

The second element concerns the use of LAI in categorization, which is not an attribute commonly used by urban planners. Indeed, as mentioned above, this type of user has more expertise in urban planning and landscape design, but not specifically in trees. As LAI is an attribute derived from leaf area and soil surface, it is more complex to imagine than a one-dimensional attribute such as tree size. To accompany the use of this attribute in the final toolbox, detailed explanation of what it consists of, how it is constructed, and how it influences ecosystem services are given in D3.1.

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A third element concerns the complementarity of the attributes chosen to model ecosystem services. In our view, this choice reflects the best possible optimization in the sense that the chosen attributes enable modelling as many ecosystem services as possible, namely: air pollution reduction, cooling effect, flood risk and estimated damages, noise abatement and potential carbon mitigation. Among the 6 ecosystem services studied as part of the project, only biodiversity improvement cannot directly be estimated using these attributes. Indeed, for detailed modelling of biodiversity improvement, the most significant issue lies in the availability of detailed attributes (i.e. complete species inventory for a city, detailed information about health etc.) which are difficult to complete. External data that aren't specifically related to trees are also needed (e.g. bird species or fauna in general). However, some aspects of biodiversity improvement can still be assessed indirectly with some of the attributes by estimating other parameters such as connectivity between trees. The decision was therefore taken to keep the previously described categories and propose, if necessary, additional information on biodiversity to help user decision-making on this specific service. If the tool works well, an "expert mode" could also be envisaged, with more categories and a better estimate of ecosystem services.

Finally, the last element for discussion is the temporality of attributes. Indeed, a tree will not have the same impact on ecosystem services throughout its lifetime, regardless of the category to which it belongs. We therefore decided that at least one of the three attributes should carry this temporality dimension to best model ecosystem services. As far as seasonality is concerned, there is an annual variation, but this is repeated every year, so there is no long-term evolution. However, regarding LAI and tree height, the question is less clear-cut. We have assumed that LAI remains constant over the years (without taking seasonal variations into account), which means that the leaf area of a tree type remains proportional to its size throughout its life. Tree size, on the other hand, necessarily varies over time, which is why we have chosen this attribute to take temporality into account. It will therefore be crucial in representing the planting proposals as well as the modeling “what if” scenarios to visualize and compare the benefits of different tree categories over a given time horizon.

5. Thoughts on the visual representation of the standardized tree types

For the reasons listed above, the number of categories chosen for the standardized tree types is higher than initially planned (18 vs. 4 to 6). The main risk is therefore to complicate

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users' decision-making, due to the lack of differentiation between categories. To go further and assess the relevance of this solution, we tried to represent these categories visually in the form of symbols, as they might appear on a map with the toolbox. The aim is to determine if differentiation is still feasible with such many categories.

To represent the categories, we proposed the use of 3 different dimensions to illustrate the 3 chosen attributes (Figure 3):

- The shape of the symbol for seasonality: deciduous/evergreen
- Color for LAI value: 3 shades for high, medium and low
- Symbol size for tree height: 3 sizes for tall, medium and small.

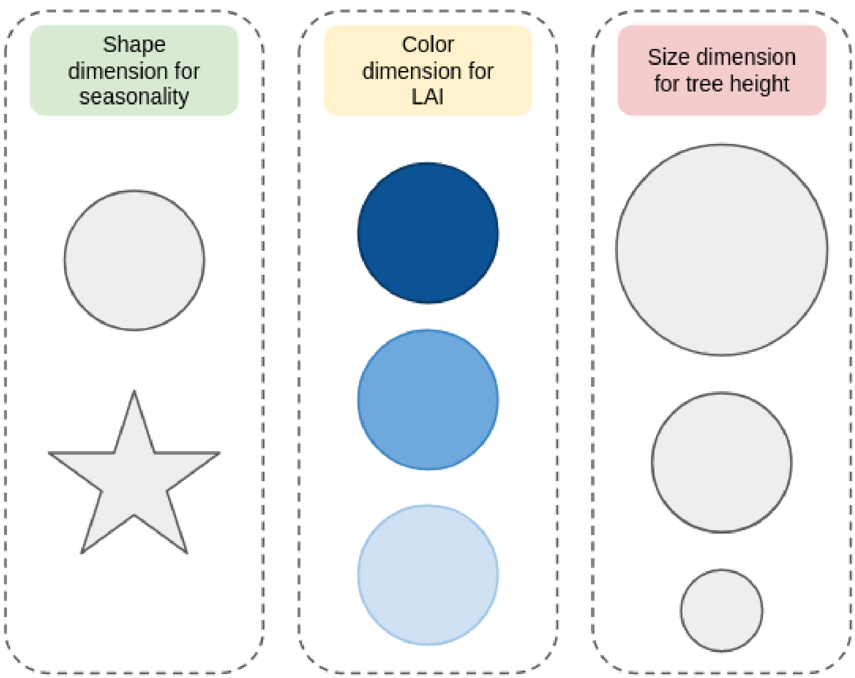

Figure 3. Construction of category symbols

All these elements are given as examples but may be modified later to match the toolbox design. This gives 18 different symbols for each category (Figure 4).

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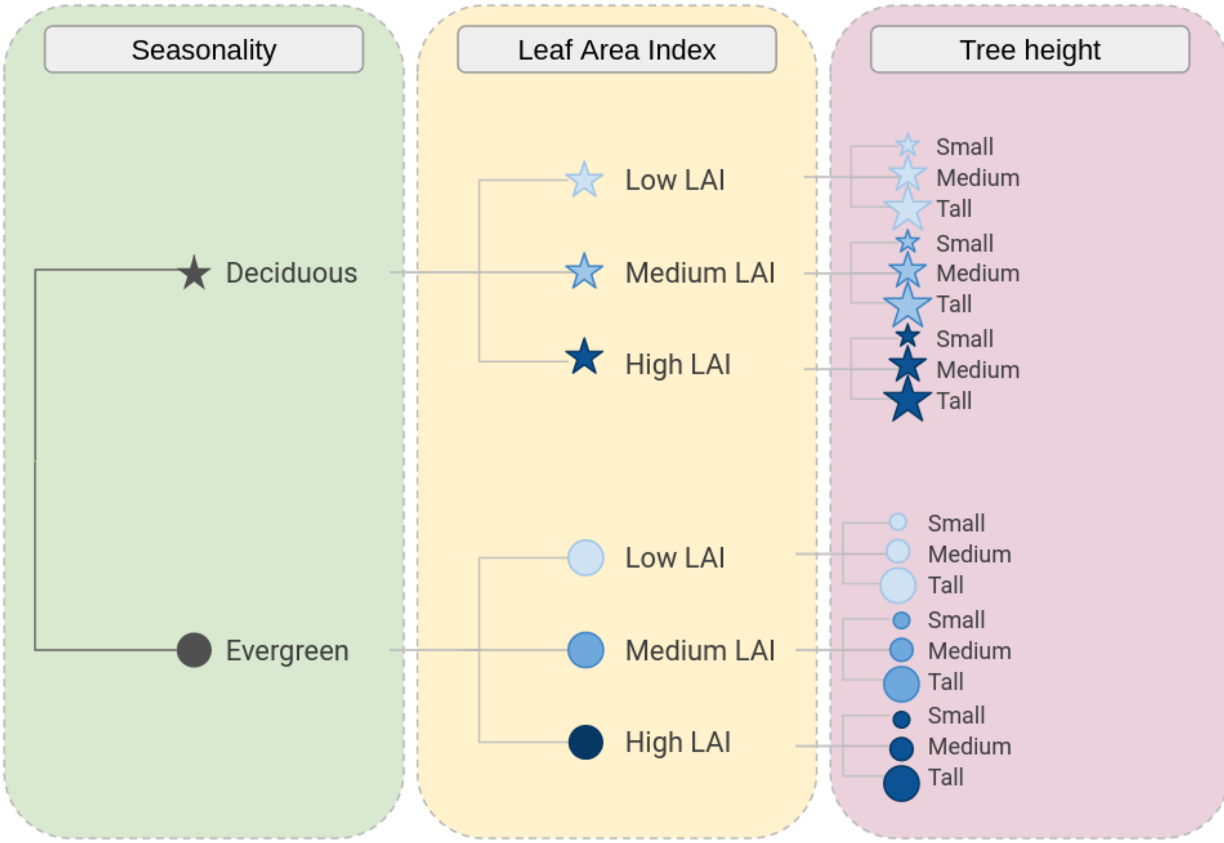

Figure 4. Suggested symbols for standardized tree types

This visual representation shows that it's relatively easy to differentiate one symbol from another, despite the number of categories. Without providing any proof that this is an optimal number of categories, it does show that the chosen solution remains consistent with the prerequisites of standardized tree types, i.e. to facilitate user decision-making.

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6. Conclusion

The content of this deliverable serves two main purposes: identification of potential planting spots on the future toolbox map, and production of input data for WP4 in the modeling of "what if" scenarios. It thus closes the WP3 mission on tree attributes and ensures the continuity of the 100k Trees project.

The choice of attributes for standardized tree types has been strongly influenced firstly by the needs of WP4, thus meeting the initial demand for decision support in terms of ecosystem services. Secondly, the outcomes of WP4 also allowed to identify LAI as the most important attribute for comprehensive ecosystem service modeling. However, given that the meaning of this attribute is not obvious to users (urban planners particularly), it was agreed that it would be accompanied by explanations to make it easier to understand and use. Two other complementary attributes were added, enabling us to draw up 18 distinct tree categories, representative of the diversity of urban trees.

The main difficulty of defining standardized tree types was that no single attribute combination was able to estimate all ecosystem services, while offering a limited number of categories to simplify users' choice. Indeed, the combination of attributes we have chosen doesn't enable estimating directly biodiversity improvement. However, it is the one that maximizes the number of estimable ecosystem services (5 out of the 6 studied), that's why we've decided to go ahead with this compromise. To remain exhaustive in the estimation of ecosystem services, additional information could be added about biodiversity regarding each standardized tree type. Finally, to go further, even a more advanced level of the tool could be built with more categories if users manage to get the hang of it.

All the information on standardized tree types have been discussed and shared with the modelling specialists of WP4.

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7. References

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