Ecosystem services from urban trees in Berlin: a feasibility study based on open data

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Abstract:

Using the i-Tree software, this paper provides an overview of the ecosystem services of urban trees in Berlin. The purpose of this study is to determine the feasibility of research studies concerning the ecosystem services of Berlin's urban trees based on the Berlin Geoportal. The purpose of this paper is to show how public cadastral data can be used to assess ecosystem services provided by trees. The modeling of the data is done by the software i-Tree. The paper focuses on defining the requirements for data provision and illustrates the process of data preparation using the Berlin tree cadastre as an example. In addition, an approach to fill in incomplete data sets using linear regression was made. The results of the analysis should highlight which further information on urban trees would be necessary to improve the informative value of future studies and, based on this, to improve the structure of the tree population and to enable the continuous provision of benefits by urban trees.

Keywords: i-Tree, urban trees, regression analysis, GIS, ecosystem services, feasibility study

1. INTRODUCTION

Ecosystem services refer to the benefits provided by urban trees, meadows and parks, among others. Several studies also indicate that urban trees improve air quality (Manes, et al., 2012; Soares, et al., 2011; Wang, et al., 2018).

The objective of this work shall be to identify and assess the ecosystem services provided by Berlin's urban trees and urban tree species. This study aims to determine the feasibility of research studies concerning the ecosystem services of Berlin's urban trees based exclusively on open data from the Berlin Geoportal. The study does not draw on additional forestry knowledge and is carried out without the assistance of public authorities. Only freely accessible urban tree data is used. This paper aims to highlight what further information on urban trees would be necessary to improve the results of future studies.

2. DATA AND METHODOLOGY

In order to get a more detailed overview of the street trees in Berlin, the tree data of the geoportal will be processed so that they can be analysed with the software i-Tree. Special attention will be paid to relevant parameters needed in i-Tree, which cannot be derived from the Geoportal database.

2.1 Description of the data from Berlin Geoportal

The data source for Berlin's street and plant tree inventory in the Geoportal is the tree cadastre of the Berlin (Geoportal Berlin, 2018). More than 900,000 active trees and their data are recorded in the Berlin tree register.

For the further evaluation of the data in i-Tree, the trunk circumference is the most relevant. In total, the database was able to provide 559,903 values for this category. Another relevant value for the subsequent evaluation is the height of the tree. Here the database was able to output 362,793 values. Only 266,663 values provided information about Berlin's tree canopy. This means that less than half of the total tree population allows a statement about the tree crown.

2.2 Definition of the data requirements in iTree

i-Tree has been developed and configured for the USA and its domestic tree species. Nevertheless, the tool is used in European and Asian studies as well (Scholz, et al., 2016; Wang, et al., 2018; Moser, et al., 2017).

The only mandatory values required for an evaluation are the tree species and the trunk diameter. The values for size, health and thinning of the tree crown are also recommended by i-Tree (USDA Forest Service, 2021). However, these values are only available for some of the trees in Berlin. i-Tree will thus fall back on comparative values and interpolations. Furthermore, it is recommended to specify the tree height. This value is available for some of the trees. For the remaining trees, the height is estimated using the algorithm described in 2.3.

2.3 Adaptation and optimisation of the data set

The data set of the Berlin tree cadastre cannot be fed into i-Tree without adjustments. To achieve better results, some incomplete data points are supplemented by estimated values. This method is used for the tree height. This step is taken because out of the total 565,363 entries in the tree cadastre, about 36% do not have a value for tree height.
The following table summarises the missing entries in the data set necessary for our investigations.

Table 1. characteristics of the tree cadastre dataset

Data set total	Height missing	Art Botanically absent	Trunk circumference missing
565.363	203.010	1.198	5.932

For the used dataset, an attempt is made to determine the characteristic of tree height, which is missing for some trees, by means of the regression.
To evaluate the quality of the regression, the coefficient of determination R^2 was determined with the value 0.578. Thus, 57.8% of the variability of the tree height can be described by the independent variables tree species and trunk circumference (Lange & Bender, 2007).
i-Tree does not recognise some of the tree species from the tree cadastre dataset. Therefore, out of 475,856 trees, only 361,690 are taken over by i-Tree. To reduce the size of this gap, the tree species not recognised by i-Tree were extracted and a tree of the same genus with similar average height and diameter values was chosen as an alternative designation. This heuristic allowed 34,700 additional trees to be recognised when imported in i-Tree.

3 COMPARISON AND RESULTS

3.1 Ecosystem services of the tree species

In total, urban trees in Berlin sequestered 3,916 tonnes of carbon per year. The Littleleaf Linden stands out the most. Table 2 shows the 5 most important tree species of Berlin sorted by total number of trees in relation to carbon sequestration and oxygen production. Additionally, Wych Elm is listed as having the best values in the areas of carbon sequestration and oxygen production.

Table 2: Comparison of ecosystem services of tree species

Tree species	Numb Trees	Carbon bond [t]	per tree	Oxygen [t]	per tree
Littleleaf Linden	56.678	658,79	0,0116	1.756,76	0,0310
Norway Maple	54.422	550,30	0,0101	1.476,47	0,0271
English Oak	28.304	342,31	0,0121	912,82	0,0323
Horse Chestnut	17.381	280,53	0,0161	748,07	0,0430
Bigleaf Linden	17.176	224,22	0,0131	597,93	0,0348
Wych Elm	1.473	31,13	0,0211	83,01	0,0564

The Wych Elm has a small share of 0.4 % of the total tree population in Berlin. If the values of carbon sequestration per tree of the three trees listed first is compared, the low value per tree is striking. Trees that are not so frequently represented sometimes have a higher carbon sequestration.

4. CONCLUSION

In this study, the individual ecosystem services of Berlin's urban trees were examined and evaluated. It was found that the services can only compensate for a small part of the resulting emissions. Nevertheless, qualitative services, such as shade and the associated reduction of the temperature in the city, as well as the beautification of the cityscape and the resulting improvement in the subjective quality of life, speak in favour of optimising and expanding the tree population in Berlin. The type of tree is significantly responsible for the quality of the ecosystem service provided by a tree. Berlin should therefore take tree species and their benefits into account when designing the future tree landscape and the planting of new trees. In addition, the improvement and detailing of the existing data of the Berlin tree cadastre should be fundamental for further investigations. The improved data basis can provide political decision-makers with important information to improve the structure of the tree population and to enable a continuous benefit endowment of urban trees.

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