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The model of trees for the restoration of historical manor parks in Estonia

Nele Nutt, Ardo Kubjas, *Tartu college, School of Engineering, Tallinn University of Technology*

Abstract. The aim of this article is to work out the methodological basis for the restoration of historical manor parks according to the requirements of the Florence Charter. This is why the park is not studied as an object of biodiversity but as a built monument and an architectural piece, whose composition is mainly created by woody plants particularly trees.

The purpose of the current research was to clarify the proportion of examples of distinct tree species in manor parks today and to determine the main tree and shrub species originally used in manor parks. Working out the model for the composition of stands of trees in a historic park. The model for the composition of stands of trees in a historic park was developed. The article summarizes the results of a survey what is a part larger study that explores and understand the key characteristics of Estonian Manor Ensembles and parks.

Keywords: historical parks; dendrology; tree species; manor park; natural species

Introduction

Manors and their parks as a legacy have been an interest of Estonian researchers and restorers since the 1970s when an extensive inventory of manors was carried out [1-4]. A lot of scientific research has been done about parks, including theses. There have been studies about the structure, style and plant material of parks [5-21], the iconography of parks, its meanings and aesthetics [22-29]. The problems of invasive tree species have been pointed out [30-33] botanical composition of parks have been dealt with [34-38] and issues concerning biodiversity and restoration have been dealt with [39-40]. The studies have also included research about large-scale trees, diversity of species and alien species [41-56]. The researchers have described manors' and manorial parks' history [57-40], paid attention to the national protection of parks [64] and put together encyclopedic overviews [65-66]. In addition suggestions for park restorations have been compiled and they include lists of recommended species [67-68].

Different authors have studied biodiversity [69] both in national parks [70] and urban parks [71] and recreational values of parks [72] but they have not studied the park as an architectural piece whose architectural character is primarily created by stand of trees.

Regardless of the previously mentioned long list, which describes the variety of studied questions, the researchers have not focused on the main volume of the park and on the material that forms it. The park benches, pavillions and flowerbeds have been destroyed, but the enduring trees give a good idea about the layout and general historical look of the park. Many manorial parks, which date back more than 150 years, have been unkept for a long time. As the parks get older, the matter of renewing the stands of trees become more topical and the need for historic object materials research results increases. This article is based on the results of a study [10] about the planning of Estonian Manor Ensembles.

Material and Methods

The input data was received from the detailed inventories in 2003-2009 and all of these parks an additional inventory was carried out in 2012 when the information was renewed and specified.

The criteria for the selection of inventories included in the research were as follows:

- the inventory was carried out less than ten years ago;
- the inventory dealt with individual trees, not groups of trees;
- the inventory specified the species and the diameter at crest height or the perimeter at crest height of trees;
- the inventory was carried out using similar methodology;
- the park was in the countryside;
- the park was a historical manor park;
- the park was founded in English style or redesigned to English style in the 19th century.

Secondary data was used in the research. The arrangement of information consisted of summarizing and concentrating the primary data. The information about groups and allotments were removed and the data from additional inventories was added (specifications about the allotments). Descriptions about the species (sp) and the most common specie were summarized (mainly with the indigenous specie). The final selection of 14582 specimens included the nominal characteristic which was the name of the specie (total of 206 species). The sample included 14582 specimens from 17 historical parks of different size (3.0 to 21.0 hectares), of different diversity of species (12 to 120 species) where the amount of growing specimen range from 211 to 1754 and of different eras ranging from 18th to the beginning of 20th century all located in different parts of Estonia (Table 1).

TABLE 1

Summary table of descriptive values of the sample

Queue no.	Object name	Year of the inventory	No of trees	No of species	Area (ha)	Foun-dation period	Location coordinate	
							X	Y
1	Hummuli manor park	2008	1263	39	11.0	19.-20. c.	6420226.3	622066.4
2	Härgla manor park	2007	211	16	5.0	19. c.	6551702.7	551469.3
3	Kiidjärve manor park	2009	602	26	3.0	17.-18. c.	6447826.1	677311.7
4	Kukruse manor park	2009	1318	41	5.5	19. c.	6587874.2	690912.1
5	Kuremaa manor park	2006	1174	48	21.0	19. c.	6513608.0	646771.0
6	Lõhavere manor park	2009	228	25	11.5	19. c.	6490570.1	586415.2
7	Mäetaguse manor park	2004	716	13	9.5	19. c.	6569682.4	687886.9
8	Pagari manor park	2007	1517	48	8.0	19. c.	6573781.9	692717.0
9	Püssi manor park	2009	532	43	7.0	19. c.	6585561.8	673083.1
10	Riidaja manor park	2006	1074	33	9.0	18.-19. c.	6441002.6	611874.2
11	Rogosi manor park	2003	220	28	3.0	18.-19. c.	6392434.4	684388.6
12	Rõngu manor park	2008	958	29	10.0	18.-19. c.	6448102.3	631189.6
13	Räpina manor park	2010	1754	120	8.5	19. c.	6444810.7	703400.0
14	Saku manor park	2007	890	60	9.5	19.-20. c.	6573613.6	537981.9
15	Sürgavere manor park	2008	255	12	3.0	18.-19. c.	6483863.6	588411.0
16	Unipiha manor park	2010	515	18	4.0	19. c.	6460174.0	653205.9
17	Õisu manor park	2008	1355	47	12.5	18.-19. c.	6452002.5	590769.1
	TOTAL		14582		141.0			

Methodology

Dendrological inventory

In order to get an overview of the condition and the composition of the historical park, data was gathered on the basis of dendrological inventory methodology. Inventory was made up of two phases: fieldwork and camera work. Data collected during fieldwork was put together as a summarizing report. Actualized plan of trees stands for the inventory level (single tree in scale of 1:500) was used as the base plan for fieldwork. All the trees with a diameter larger than the agreed size (usually 6 cm) and groups of shrubs growing in the area were marked on this plan.

All the trees and shrubs were evaluated in order to assess them on a single tree level. The diameters were measured with the precision of one centimetre. On a tree level, the plot was evaluated separately and its composition of species was described with the compositional formula. All main species' average diameters at breast height, heights, main parametres and locations of significant specimens, conditions of trees (by species if neccessary), health, density (pcs/surface measurement unit) and et cetera, were measured. The diameter at breast height (1.3 m from the root crown), the height and the width of the crown was measured on trees. For multi-trunk trees all the diameters of different trunks and the estimated trunk height were measured. If the branching started from the ground, they were considered as separate trees. If that height was between 0.7-1.3 m, then the diameters were measured 0.6 m above the branching point. The shrubs' diameter was measured only when the plant was shaped as a tree and the diameters were more than 6 cm. Tree caliper with an accuracy of 1 cm (diameter) or a flexible tape measure (circumfernece) was used for measurements.

This research uses the tree diameter at breast height data based on the dendrological inventory methodology and the level of accuracy depends on the precision of the tree caliper (cm), the experience of the person who inventorys and the tree's peculiarities (the shape of the trunk's cross section).

Dendrological inventory

The results of statictical analysis of data collected in dendrological inventories enabled to create a compositional formula for stands of trees in parks, on which scientific restoration can be based on.

Statistical data processing package R was used for data processing.

Descriptive statistics were used to characterise the division of woody plant species park by park. The woody plants were counted by species and the frequency of species appearances was described with a histogram of distribution. On the histogram

the species were ranked in growing order of occurence frequency on the y-axis and the percentage of occurence frequency on the x-axis.

In order to analyse the occurence frequency of species with a same type identifier, the data was grouped and coded.

The data was grouped as follows:

- by the shape of the stem or development: tree, shrub or other;
- by the phylum: angiosperms and gymnosperms;
- by heritage: indigenous or exotic.

In order to analyse the occurence frequency of different groups and sub-groups, the percentage of distribution for each park, for the whole sample and the difference between the park and the sample, was calculated.

Regression analysis was used for creating a mathematical model that describes the relations between characteristics. Simple random sampling was used for data collection to compile a system of equation based on 100 samples. The equation was solved. Linear regression equation coefficients were found by using the least squares method. The model was evaluated through the average deviation of dependent variable values. The model was tested for 17 parks.

Results

Proportional distribution of woody plants according to the type

Although there are 206 names of species in the species list (Table 2), majority of the park consists of a small part of them. Regardless of the number of species in the park, there is one main specie dominantly prominent in every park, a couple of species with a little bit smaller frequency of occurence than the main specie and a large quantity of species with a very low frequency of occurence.

TABLE 2

Overview of the research results

Item	Sum	Percentage
Number of species	206	100.0
Number of tree species	106	51.5
Number of deciduous species	75	70.8
Number of coniferous species	31	29.2
Number of shrub species	100	48.5
Total number of examples	14582	100.0
Total number of examples trees	13721	94.1
Number of deciduous trees	12285	89.5
Number of coniferous trees	1436	10.5
Total number of examples of shrubs	861	5.9

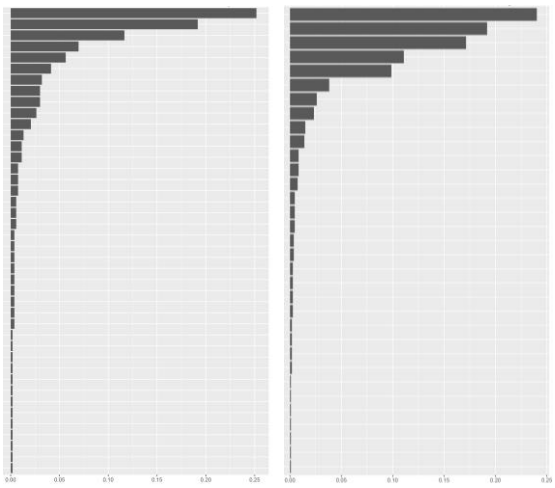

Fig. 1. Histograms of species' occurence frequency on the Püssi (left) and Riidaja (right) manor park

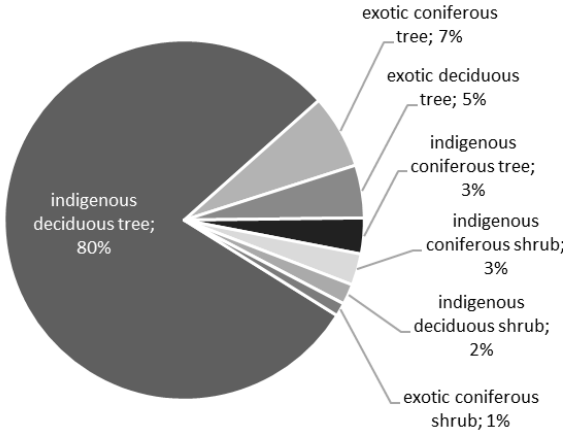

Fig. 2. The distribution of woody plant types

The species distribution of plant material in a park is portrayed by frequency of occurence histograms (Fig. 1). The occurence of species in one study object is characterized by a non-linear distribution which rises from left to right and portrays the increasing proportion of species in the park.

Descriptive statistics showed that six species form approximately 80 % of all species and five out the six are indigenous deciduous trees and only one indigenous coniferous tree. All of the five indigenous deciduous trees were broad-leaved species (there are 6 indigenous borad-leaved deciduous tree species growing in Estonia and all of them can be found in parks) and four of them formed 69 % of the total number of park trees.

Based on the results of the analysis it can be said that the material that forms today's general architectural appearance is largely of the same type.

The majority of the park consists of woody plants which are trees (average of 94 %). The percentage of shrubs was small (average of

6 %). The origin of tree species is predominantly indigenous (average of 86 %) and trees of exotic origin made up only 14 % of species. The deciduous trees significantly exceed the number of coniferous trees (average of deciduous trees is 87 % and of coniferous trees 13%, indigenous trees 86 % and 14 %). The combination indigenous deciduous tree made out of three types forms at average 80% of the park (Fig. 2). A comparatively small part of the population (average of 20 % in total) contains rest of the combinations.

The regression analysis done park by park showed that the proportion of deciduous trees frequency of occurence in parks is very similar and remains close to 80 %. The results are similar park by park.

The proportion model of majority tree species

Preservation of a park expects long-term periodic renewal programmes which are derived from the indigenous park species and customs developed in the region [73]. In order to follow this principle it is neccessary to have an exact knowledge about the region's typical composition of stands of trees in parks. When compiling restorational principles for a historical park, it is not enough to identify the special accent and exotic trees but it is inevitable to evaluate the part which forms the main volume of the historical park. Thus, the species that are typical (indigenous) to the region and form the majority of the park were assessed. The results of the analysis enabled to create a park model which describes the composition of trees in the park and which can be used as a basis for park renewal.

Taking into account the large proportion of indigenous broad-leaved tree species (Acer platanoides, Fraxinus excelsior, Quercus robur, Tilia cordata, Ulmus glabra, Picea abies) they were considered to be majority tree species. Regression analysis was used to create the mathematical model for majority tree species. Simple random sampling of 100 samples was used to compile a system of equation which was solved and the result was a straight line y=0.6924x.

Linear regression equation coefficients were found by using the least squares method. The model was evaluated through the average deviation of dependent variable values.

The model for the composition of stands of trees

A composition formula of park trees was compiled based on the research results. It describes the distribution of most common woody plant types in percentages. The stand of trees in the historical parks is composed of 80 % of the indigenous deciduous trees of which 70 % are indigenous broad-leaved deciduous trees Tilia cordata (Pä), Quercus robur (Ta), Acer platanoides (Va), Fraxinus excelsior (Sa) and 10 % are the rest of the indigenous deciduous trees.

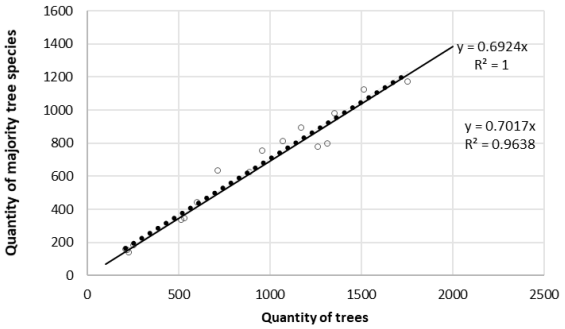

Fig. 3. The proportion of majority tree species in 17 parks is similar to the model (R^2=0.9638)

The combination of exotic and coniferous trees and shrubs form the rest of the 20% of stands of trees.

80 indigenous deciduous trees (70Pä+Va+Ta+Sa; 10 others) 20 others (needle, exotic, shrub).

Discussion

The dendroflora of parks has been studied for a long time. Dendrological inventories have been carried out by Paivel in 1952-1973 and by Ellik and Roht in 1983-1989 [49; 50]. Since 1961 inventories of trees have been done under Tallinn Botanic Garden [74]. The specie or its lower ranking taxon was recorded and larger trees were measured during field work. The character of woody plants turned wild was determined and the renewal of species by seeds or stolons was evaluated [49; 50]. Reviews of parks and woody plant collections (arboretums, dendrological garden) dendrofloras based on inventory data have been published [75-77]. Published articles talk about species richness, the presence of introduced species and the occurence of large specimens. Coniferous alien tree species have been discussed separately. One of the goals of species richness inventories has been the study of species richness which is the basis for dividing the parks into three groups: high, medium and low richness in species [78]. At the same time the species richness is not a measure of value in a historical park, also in the context of the Florence Charter, because the number of species is directly linked to the architectural style of the park. When in the Baroque style it is presumed to use high number of woody plants of same specie, then the diversity of species is inherent to the English park. As architectural objects Baroque and English park are equal in value. The age value of the Baroque park, which is poor in species, may be considered higher because it was established earlier. The species richness in parks has been considered valuable from the point of view of nature protection. Hereby it is interesting that exotic species form a major part of the species richness and some of them pose a potential risk of/for invasion. Therefore, the values in parks can be controversial as the value

of biological diversity, important from the nature protection point of view, comes directly from exotic species. There are 81 indigenous woody plant species in Estonia, but in parks there have been found more than 350 different species (including subspecies, varieties). The collected material gives a very throrough overview of the diversity of species in woody plant collections (including parks) but it does not portray the proportion of species, therefore it is not enough to resolve the issues related to the authenticity of the historical park.

Conclusions

As a result of this work methodological bases for the model of trees were created for the restoration of historical manor parks according to the principles stated in the Florence Charter. The sources and materials used enabled to conduct analyses based on scientific principles resulting in types and ages of woody plants and further analysis of the composition of park trees. On the basis of this, it was possible to create a model for the trees composition in the park.

The material of the park is made up of 80 % of woody plants with a bright foliage and trunk and the rest of the 20% contains the diversity of species in the park formed by exotic trees, coniferous plants and shrubs. This proportion of distribution (20/80) characterizes historical parks regardless of the establishment period, size, number of trees growing there, species diversity and location of the park. The first layer of stand of trees in the park is described by the compositional formula: 80 indigenous deciduous trees (70 Pä+Va+Ta+Sa; 10 others) 20 others (needle, exotic tree, shrub).

The Florence Charter states that the preservation of a park among other things expects long-term periodic renewal programmes which are derived from the indigenous species and customs developed in the region [73]. The results of this work are neccessary for the planning of maintenance, preservation, restorational and reconstructive work in Estonian historical parks.

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AUTHORS:
Nele Nutt, PhD, senior lecturer and researcher at Tartu collage, School of Engineering, Tallinn University of Tehnology, Puiestee 78, Tartu 51008, Estonia; nele.nutt@taltech.ee, ph. +372 620 4800
Ardo Kubjas, PhD student at Tartu collage, School of Engineering, Tallinn University of Tehnology, Puiestee 78, Tartu 51008, Estonia; E−mail: ardo.kubjas@taltech.ee

Kopsavilkums. Raksta mērķis izstrādāt metodisko pamatu vēsturisko muižu parku atjaunošanai atbilstoši Florences hartas prasībām. Tāpēc parks netiek pētīts kā objekts no bioloģiskās daudzveidības puses, bet gan kā būvēts piemineklis un arhitektūras elements, kurā sastāvu galvenokārt veido kokaugi. Pētījumā izvērtētas koku un krūmu sugas, kuras sākotnēji izmantotas muižu parkos. Rakstā apkopoti respondentu rezultāti, kas ietver lielāko pētījuma daļu, kurā tiek pētīti Igaunijas muižu galvenie raksturlielumi un parki.