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New Challenges for Historic Gardens' Restoration: A Holistic Approach for the Royal Park of Moncalieri Castle (Turin Metropolitan Area, Italy)

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Abstract: The paper illustrates a holistic approach for restoring historic gardens in urbanized contexts, from the historic analysis, to the knowledge of the present values, to the proposal of guidelines for restoration and future sustainable management. The Royal Park of Moncalieri Castle (Turin metropolitan area, north-west Italy) was used as a case study. The evaluation of the current structure, analysis of the botanical component and the recognition of historical permanences were performed. Following the criteria of specific interest (forestry, botanical and compositional) and historical importance, invasive species and specific critical issue, selected trees were described and mapped. Identifying the historical compositional elements, including a system of preferential paths and botanical species to be safeguarded should be considered the first step for future management planning process. Our results could be of interest both for methodological purposes and for the restoration of historical gardens' planning and management. During the restoration process, different critical issues exist. In this context, combining historical and compositional values with today's needs and problems is a scientific challenge that involve all the community. Historic parks and gardens must be considered as patches of the urban green infrastructure, able to provide a wide set of ecosystem services. Promoting the return of historic parks to the public fruition is of primary importance for the citizen well-being.

Keywords: landscape; UNESCO heritage; management; invasive plant species; ornamental plants; urban greening

1. Introduction

1.1. Historic Gardens Between Restoration and Management

The Florence Charter (ICOMOS/IFLA1981) classified historic gardens as "living monuments" with a particular public interest from a cultural point of view, independently from the historic style, the design, the surface and the property (public or private) [1]. For these sites, this document outlines the dynamic qualities of the biotic and abiotic components that contribute to change their original structures and design over time. Historic gardens can be considered one of the most complex creations realized by the man in which aesthetic values play a significant role [2]. The International Council on Monuments and Sites (ICOMOS) and the International Federation of Landscape Architects (IFLA) classified (1990) historic gardens as cultural heritage that required specific rules, protection measures and scientific studies. Additionally, the United Nations Educational Scientific and Cultural Organization (UNESCO)

considers historic gardens for their tangible and intangible values. In particular, the Convention for the Protection and Promotion of Cultural Diversity (UNESCO 2005) emphasizes the protection of cultural diversity through time and space, as well as the protection of cultural heritage, including domestic and public parks [3].

Scazzosi (2004) explained how the European Landscape Convention (ELC) underlined that all landscapes, including historic gardens, required protection, management and overall planning [4]. According to Sá Carneiro et al. (2012), historic gardens, recognized as cultural objects, constitute a living file that ensures the permanence of plant material and compositional features [5]. Concerning these themes, the development of new interests can be traced through the XX century [6,7].

Since the early 1900, the Italian conservation laws had included churches, villas and castles as monuments, together with historical town centres, industrial archaeology, vernacular architecture, and at least historic gardens. In this context, developing sustainable actions and specific programs for preserving cultural heritage are imperative for both conservation and management processes. However, the restoration of historic gardens is particularly complex due to, at local level, the lack of knowledge, and low management investments, and at global level, issues related to adaptation to climate changes, and to control invasive species.

Indeed, several critical issues affect these sites: often they are abandoned spaces, neither managed nor used, and assuming wild characters. These main dynamics cause the loss of their historic original structure and identity. For these main reasons, the question about the governance of domestic and historic gardens is an open challenge [8–10]. Concerning historic gardens' restoration different studies were carried out. With the aim to valorise the Great Park in Sarajevo, an historic public park devasted during the war of the 1992–1995, a botanical investigation was carried out to identify the species present (trees and shrubs) and their status. Avdić et al. (2013) evaluated the forestry measures and actions to adopt [11]. Recently, a research project was performed in Liguria Region (Italy) to tackle lethal diseases that have attacked palms contributing to change landscape and gardens 'structure. In this perspective two public gardens - designed and realized by Ludwig Winter (1846–1912), the nurseryman and gardener that introduced exotic palms in this territory, were valorised. Through a historical and archival analysis, Gullino et al. (2020) identified Winter's projects including plans, notes and many botanical species of exotic plants collected by Winter. These elements combined with Winter's compositional features and design intentions have defined the restoration process [12]. A similar historic approach was also applied for restoring Barnsley Gardens in Georgia (USA) by [13]. While, the historic gardens in Tabriz (Iran) were examined using another methodology: through the study of project plans and representations (photographic and artistic) the authors identified the major factors that have influenced the original design for proposing guidelines for their restoration [14].

On the basis of the current scientific literature concerning the restoration of historic gardens, a methodological holistic approach that evaluates at the same time the historical, compositional, and botanical featured in relation to the new need and critical issue is still missing. A lack of knowledge in the scientific literature on this topic was detected. Historic gardens are important elements of the urban green infrastructure. They contribute to provide several ecosystem services able to enhance citizens' well-being. Adopting new holistic approaches for restoration and management of historic gardens in urban contemporary contexts is a priority for the whole community.

1.2. Research Aim

This paper illustrates a methodological holistic approach for restoring historic gardens in metropolitan contexts, from the historic analysis, to the knowledge of the present values, to the proposal of guidelines for restoration and future sustainable management. Moreover, related to historic gardens' sustainability, it is important to identify both a methodological framework and sustainable approaches combining new needs and critical issues with compositional and historical values. In our research we have developed an innovative methodology for restoring historic gardens, using a holistic approach.

A methodological framework was defined for identifying new sustainable solutions for historic garden restoration. The innovative method of addressing garden restoration presents challenges for preserving historic gardens, since cultural heritage is imperative overall for the Royal gardens recognized as Outstanding of Universal Value by UNESCO.

The Royal Park of Moncalieri Castle (Moncalieri municipality, Turin Metropolitan Area) was used as a case study. In order to propose sustainable guidelines for its historical restoration and valorisation, a research project was carried out (2018–2020) with the aim to define the preliminary sustainable guidelines for the Royal Park of Moncalieri Castle' restoration and valorisation, we have examined the main critical issues and defined the interventions' priority.

1.3. The Royal Park of Moncalieri Castle

The Residences of the Royal House of Savoy located in the green crown of the city of Turin (Piedmont region, North-West Italy) were recognized by UNESCO as a cultural heritage in 1997. This serial site comprises 22 palaces and villas developed for administrative and recreational purposes within and around Turin by the dukes of Savoy from 1562 to 1926. Indeed, the Residences of the Royal House of Savoy are an outstanding example of European monumental architecture, including the most representative castles and buildings constructed and renovated by the Savoy dynasty from the XVI to the XIX century [15]. In 2010 new buffer zones were created (Valentino Castle, Villa della Regina, Moncalieri Castle, Govone Castle), and others were expanded (Rivoli Castle, Reggia di Venaria Reale, Agliè Castle and Racconigi Castle) including parks, gardens and historic town centres, elements that complete the original value of these Residences. Reggia di Venaria (Venaria Reale municipality, Turin Metropolitan Area) (2007), Villa della Regina (Turin municipality, Turin Metropolitan Area) (2007) and Racconigi Castle (Racconigi municipality, Cuneo province) (2010) were restored and valorised as public heritage [16,17].

By contrast to the other Savoy Royal Residences, which are located in the flat areas (countryside or town centre), the Castle and the park in Moncalieri are located on a slope. The Royal Park is composed of three main parts at different levels: the rose garden (1 ha), the formal garden (2.5 ha) and the landscape park (7.5 ha). Figure 1 shows the aerial image with the indication of the three parts. Figure 1 reports also the park/estate geographical location. By observing the aerial image, it is noticeable how the Royal Park is nowadays partially included in the urban context of the Moncalieri Municipality.

Despite each of the architectural components of the Residences of the Royal House of Savoy is protected by national, regional and local regulations, the historical Royal Park of Moncalieri Castle was not managed over time, losing its original structure. Since 1945, this site has been a military headquarter, part of the park has been not accessible, not used and managed for long time. Since 2016 it has been included also in the UNESCO Man and Biosphere (MAB) site called "The Collina Po Biosphere Reserve", which covers the Turin stretch of the River Po and its main tributaries and the Collina Torinese hillside. The River Po is the main reservoir of biodiversity in the Turin plain and the Moncalieri Municipality is part of this system for its ecological and natural value. These physical and morphological features highlight to some interesting visual openings, panoramic points and perceptive views both from the Castle towards the park and vice versa. In collaboration with the Municipality of Moncalieri, the park was the object of our research project towards its valorisation and restoration. This case study is considered representative of many historic gardens in Italy because characterized by botanical, historical and cultural features but not managed for long time.

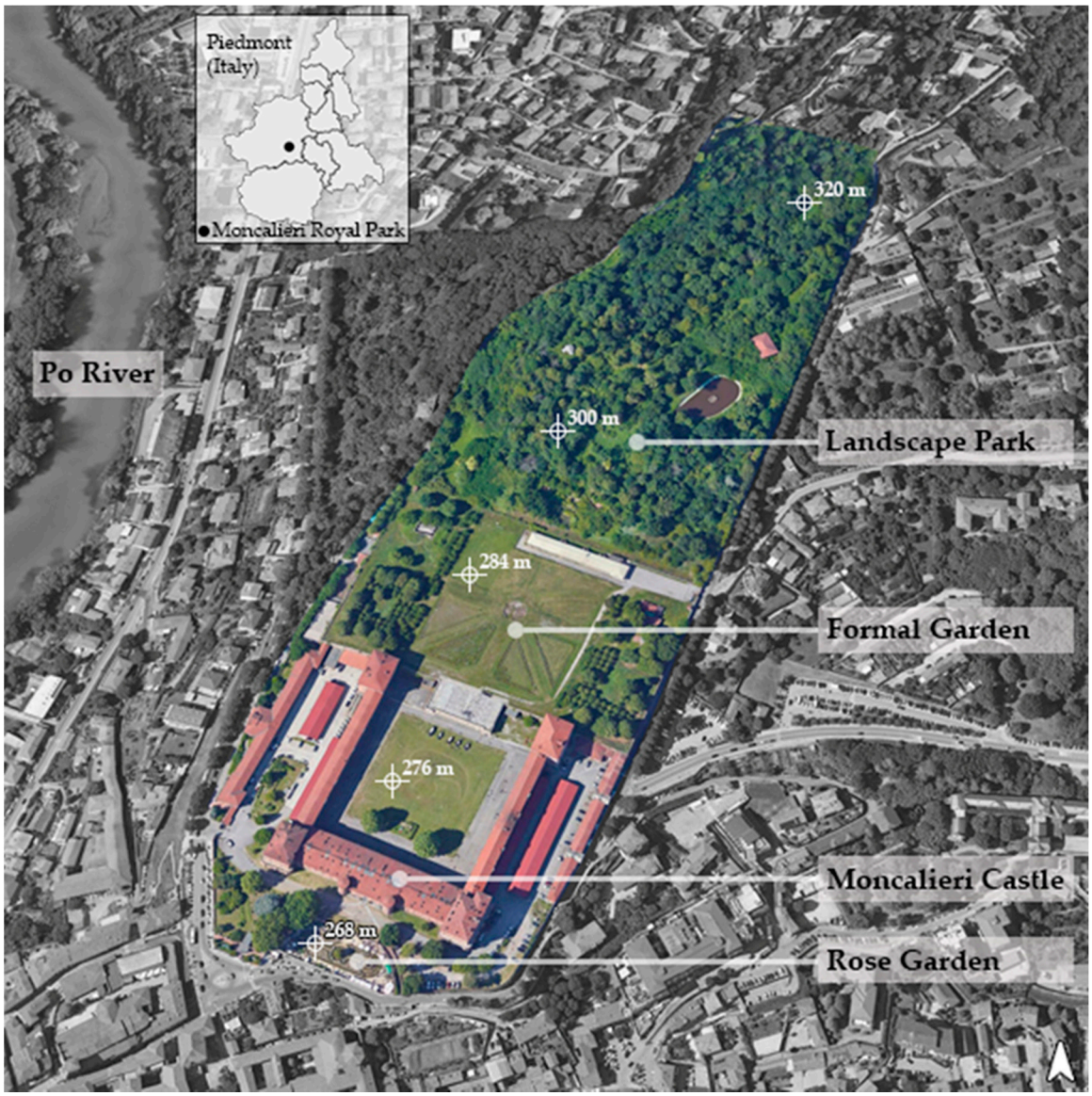


Figure 1. The aerial image of Royal Park of Moncalieri Castle with its rose garden, the formal garden and the landscape park.

2. Materials and Methods

Methodological Framework

Managing historic gardens requires a systematic process and a continuous monitoring on changing processes occurring. According to Birnbaum (1994), the methodology should involve the following steps: historical research, inventory and documentation of existing conditions, site analysis and the development of a preservation maintenance guide [18]. Concerning methodological framework applied in this study, several analyses were performed regarding both the historic park's structure and the current *status*.

For identifying new sustainable solutions for historic garden restoration, the methodological framework applied in this research project is illustrated (Figure 2). The activities and research performed, the tools used, the meta results, and the final results acquired are reported.

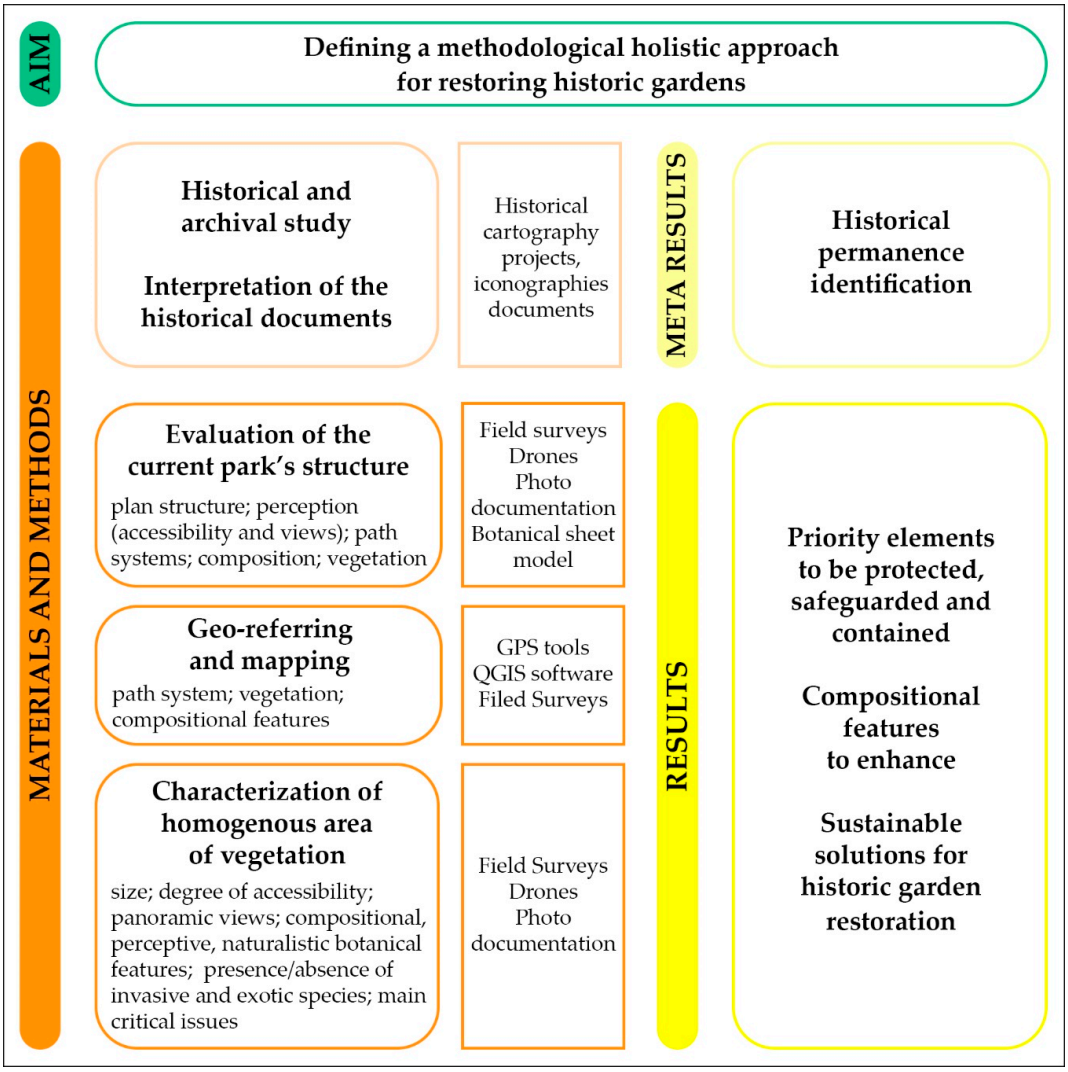


Figure 2. The methodological framework applied in the research.

Primarily, according to Sales (1995), the analysis of the historical documentation on the park structure was done [7]. As suggested by different Authors, archives' documents were collected, consulted and analysed. [19,20]. Firstly, in our research with the aim to identify historical permanence (within the Royal Park of Moncalieri Castle and its surrounding) an historical analyse was performed. The first part of the research was carried out by analysing documents and references from historical archives and libraries: historical cartography, iconographies, and documents from the XVIII and XIX centuries were collected. Several documents such as cadastral maps, projects, plans, and maps located in Turin public archives were deeply studied. Through the analysis of the historical documents, it is possible to recognize the historical features, and to detect the actual permanence in the garden. In Table 1 are listed the archives consulted the original name, the documentation type and information acquired.

Table 1. The list of archives consulted, original name, year, the type of documentation, and the information acquired.

Archive Name and Localization	Year or Historical Period	Original Name	Documentation	Information Acquired
Historical library of Turin Province	XVIII century	Castello Reale di Moncalieri	Iconography	Moncalieri Castle and River Po
Royal Academic of Agriculture (Turin)	XIX–XX century	Historical catalogues of nurseries, floral and horticultural exhibitors	Catalogues	List of nurseries and plants cultivated (Moncalieri Municipality)
State Archive of Turin, Corte (Turin)	1757	Tipo di corso del Pó principiando dal ponte di Moncalieri	Iconography	View of Moncalieri Castle
	1788	Tipo di corso del Pó principiando dal ponte di Moncaglieri persino alla Barauda e alle Giarasse il tutto esistente nelle dette fini di Moncaglieri	Iconography	View of Moncalieri Castle
	XVIII–XIX century	Piano regolare del proseguimento da farsi della strada nuova di Stupiniggi, colli Siti, Case, Strade, acque, ponti ed altri oggetti attorno, il'tutto in vicinanza della città di Moncalieri	Iconography	Moncalieri hilly and landscape system
	XIX century	Carta topografica del Castello di Moncalieri sino all'Osterietta	Cartography	Formal parterre realization. Informal park project.
State Archive of Turin, Riunite (Turin)	1802	Commune de Moncailer	Cadastral map	Moncalieri Castle with its park. Formal parterre completed and park with the lake.
	1864	Real Castello di Moncalieri planimetria generale	Plan of the project	Original plan of informal Royal Park (project)
	1867	Mappa Originale del Comune di Moncalieri	Cadastral map	Moncalieri Park with its different gardens (formal and informal park)
	1867	Planimetria del Parco Real Castello di Moncalieri	Plan of the park	Original Map of informal Royal Park
	1867	Prospetto riepilogativo delle piante presenti nel Reale Giardino e Parco di Moncalieri	List of plants	Botanical name of the plants planted and cultivated in the informal Royal Park
	1887	Inventario delle piante in vaso esistenti nel Giardino di Moncalieri	List of plants	Plants cultivated in pots in the greenhouses of the Royal Park
Historical Archive of Turin Municipality	1791	Carta corografica dimostrativa del territorio della città di Torino	Iconography	Vineyards cultivated in Moncalieri hills and historical farms

Secondly, concerning the current structure of the Royal Park of Moncalieri Castle, and according to the Florence Charter (1981) [1], we have decided to evaluate different features: plan structure, perception (accessibility and views), path systems, compositions, and vegetation.

These analyses were performed with field surveys drones (DJI Mavic Mini model), and photo documentation. Related to vegetation component, a botanical sheet model was developed. According to Boriani and Cazzani (2004), it is essential to provide accurate surveys to understand the current characteristics of the site, its botanical, perceptive and landscape components [21]. To identify the compositional features of the Moncalieri Royal Park, we have identified plan's structure through the path systems' reconstructing. Due to the system 'complexity, these analyses were performed on the informal park in this landscape area which will be the first open to the public in the future.

According to Paar and Blaik (2008) and Yang and Han (2020) mapping and georeferencing are fundamental tools for framing the site and defining the strategic lines of intervention [10–22]. Using View Ranger app, QGIS 2.18.1 and field surveys, we have analysed and mapped these following features: path system (routes); composition features and vegetation. In this step concerning plan structure, we have traced and georeferred the still recognizable routes. From the routes identified, homogenous area of vegetation has been defined and characterized. For each area, we have analysed these features: the size (m^2), the degree of accessibility and the panoramic views, the main compositional, perceptive, naturalistic and botanical features, the presence/absence of invasive and exotic species and the main critical issues.

Related to the vegetation, the arboreal, shrub and herbaceous components were explored as main compositional elements. We have georeferenced using View Ranger app and QGIS 2.18.1 software the vegetation component by following these criteria: specific interest (forestry, botanical and compositional) and historical importance, invasive species and specific critical issue. Related to the vegetation, the arboreal, shrub and herbaceous components were deeply investigated. For analysing the vegetation, we have developed and filled for each botanical species identified in the Royal Park, a botanical sheet model. We have reported in the model, as an example, the botanical sheet relating to *Tilia cordata* Miller (Figure 3). For each botanical species, the following features were evaluated and analysed:

- the botanical name;
- a representative photo of a specimen presents in the Royal Park;
- the botanical family name;
- the main botanical characteristics of the species;
- the longevity of the species;
- the historical and cultural importance;
- the reasons of interest (botanical, position of the specimen, invasive species or rarity of the specie);
- the ornamental features;
- any phytosanitary problems encountered.

Using View Ranger app and QGIS 2.18.1 software we have also georeferred and mapped the specimens most representative. As illustrated in Figure 3, the nine specimens identified of *Tilia cordata* were mapped. Moreover, for specimens identified, the trunk size was measured (cm) and other remarks noted.

As a final analysis, for recognizing historical permanencies, as priority elements, related to the path systems, the plan structure, the compositional features and the vegetation were compared the current status with the historical documentation collected. This investigation allowed identifying the cultural and compositional values to conserve/valorise/contain.

Botanical name:
Tilia cordata Miller

Botanical family name: Tiliaceae

Common name: Wild linden

Tree species: Broad-leaved, autochthonous, deciduous

Tree forms: Columnar with oval foliage

Longevity: 200 years

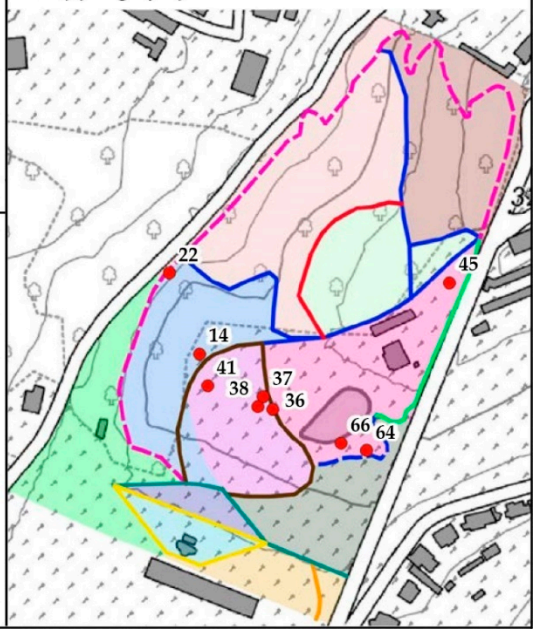
Historical and cultural importance: Yes, historically present but as a genus and not as a species. In 1876 two other species and 584 specimens were present (583 *Tilia europaea* L. and 1 *Tilia platyphyllos* Scop.

Reasons of interest:
Scenic-perceptive and compositional aspect. The linden in picture is near the *Roccolo*.

Ornamental features:
The bark is gray-brown and smooth when young. Over the years it presents longitudinal cracks. Alternate oval leaves are simple, corded, with an asymmetrical base and serrated at the margin. Flowers are carried by a characteristic elliptical and membranous bract.

Phytosanitary problems:
The species is not particularly subject to phytosanitary problems. Howewer, it is often preferred host of aphids. They weaken the plant trough trophic activity and and produce honeyde, that stains street furnitures.

Mapping of specimens



Number of specimens: 9

n	Trunk Ø (cm)	Remarks
14	65	*Hedera helix along the trunk*
22	84	Root cavity
36	80	Low attachement of the crown
37	59	
38	64	Low attachement of the crown
41	65	
45	16	Probable instability
64	65	Presence of many shoots
66	75	Secular tree

Figure 3. Botanical sheet model related to *Tilia cordata* Miller, developed and completed in this study.

3. Results

3.1. Historical Analysis and Plants Inventory

It was possible to recognise the Moncalieri Park's evolution by analysing/through the analysis of the historical data related to the period ranging from the XVIII and the XIX century. The historical data collected provide information about the park's structure and design. The first information acquired in this study is related to the formal garden designed in the XVIII century. Concerning this topic, the cadastral map (1867) represents the complex parcel system with the historic buildings and farmhouses present. Specifically to the Royal Castle of Moncalieri, the detail of the cadastral map shows two different spaces: a garden recognizable by a geometric and symmetric design with a with a fountain in the middle and a green area above as confined space without specific details (Figure 4). The related legend of the map (1867) reported: formal garden for the first green space and informal garden for the second one. On this map we have also indicated in Figure 4, the architectural elements reported in the legend: the nymphaeum adjacent to the formal garden (A), the artificial lake (B), the "Roccolo" (C) and "Vignolante" house (D).

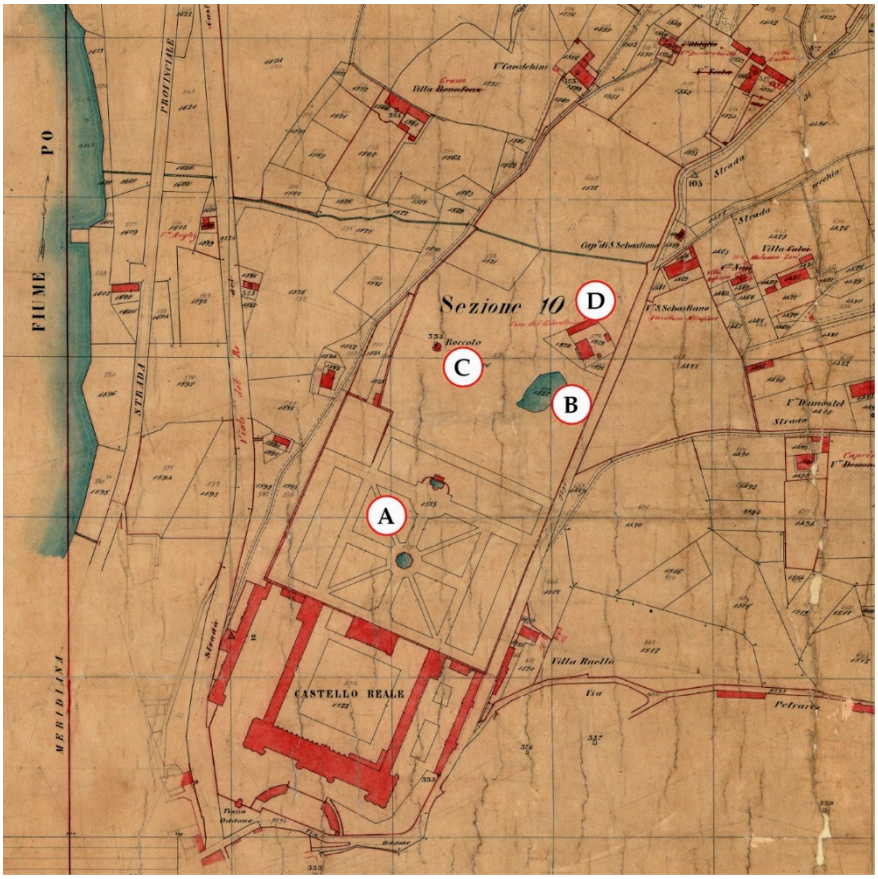


Figure 4. Detail of the cadastral map related to the Royal Castle of Moncalieri (1867). The nymphaeum adjacent to the formal garden (**A**), the lake (**B**), the "Roccolo" (**C**) and "Vignolante" house (**D**).

Concerning the landscape park, the final project "*Planimetria del Parco Real Castello di Moncalieri*" reported in Figure 5, provides detailed information on the Royal Park. The general plan, made with the watercolour technique, is dated 1876 (31 December 1876). It is possible to identify all the designed elements (compositional and architectural) specifically indicated by Roda brothers' project. Since 1867 the structure of the park became more complex, articulated and corresponded to the final one. The landscape park is characterized by an informal design with the wooded

areas, clearings and winding paths. These compositional features are clearly recognizable from the iconography.

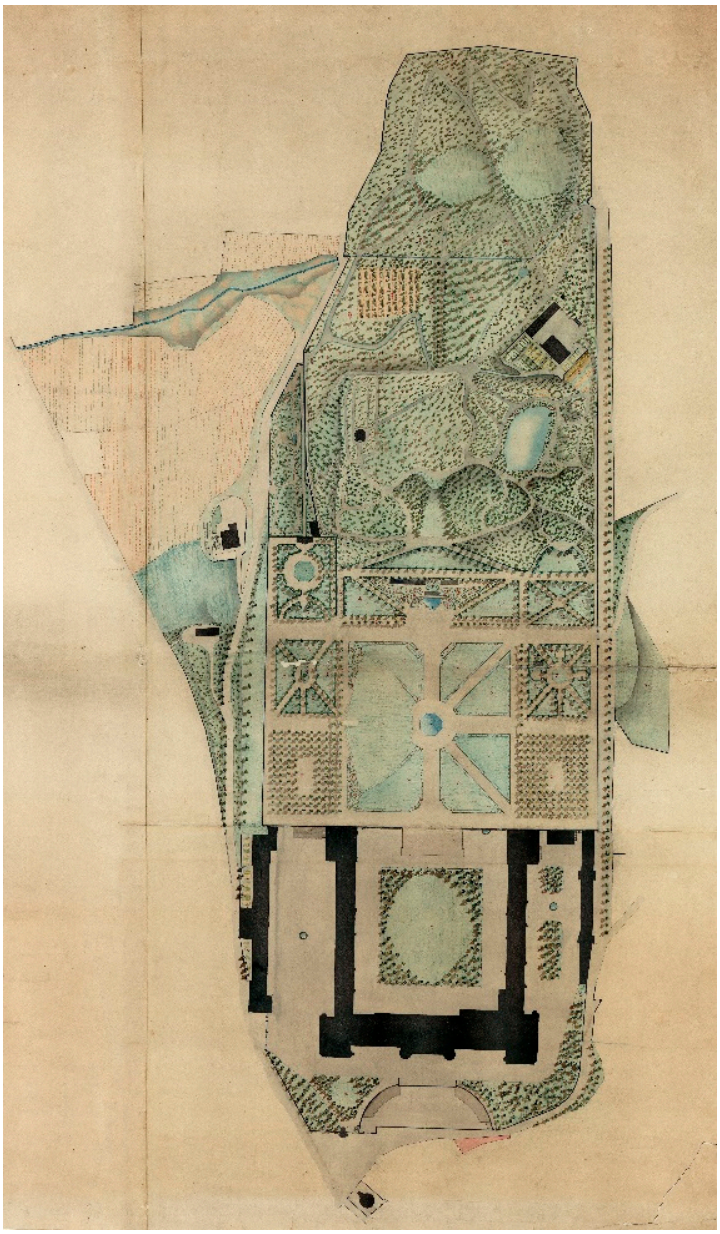


Figure 5. *Planimetria del Parco Real Castello di Moncalieri* the final project of Roda'brothers (1876).

Moreover, related to the landscape parks project, a plant inventory was listed (1876). The list reported the new trees planted (botanical name), the related number (*n*) and their sizes (trunk circumference). Table 2 shows for each botanical species, the original name, the current botanical denomination and the originally information reported in the archive's document. For providing the current botanical name, Pignatti (2011) was consulted as the main botanical reference [23].

Table 2. The list of plants (1876), the current botanical denomination, the trunk circumference' size (cm) category, the number of plants (n) planted for each category and the total number.

Botanical Name (1876)	**Current Botanical Denomination**	**Trunk Circumference' Size (cm); Number of Plants (n) for Each Category; Total Number (n)**										
		5 cm	10 cm	15 cm	20 cm	25 cm	30 cm	35 cm	40 cm	45 cm	Over 50 cm	**TOT**
Abies americana	*Tsuga canadensis* (L.) Carrière				1							1
Abies balsamea nana	*Abies balsamea* var. *nana* (J.Nelson) Beissn.	1										1
Abies morinda	*Picea smithiana* Boiss				2			1				3
Abies nigra	*Picea mariana* Mill.					1						1
Abies nordmanniana	*Abies nordmanniana* (Steven) Spach		1	7	1							9
Abies taxifoglia	*Abies alba* Mill.			4								4
Acacia julibrissin	*Albizia julibrissin* Durazz.	25	29	5								59
Acer campestris	*Acer campestre* L.	742	153	2	2							899
Acer negundo	*Acer negundo* L.	22	12	1	2			1	1	1		40
Acer platanoides	*Acer platanoides* L.	186	72	15	2	1						276
Acer pseudoplatanus	*Acer pseudoplatanus* L.	28	13	4								45
Aesculus hippocastanum	*Aesculus hippocastanum* L.	179	131	64	31	13	1	2	4	6	16	447
Ailanthus glandulosus	*Ailanthus glandulosa* Desf.	106	85	31	7	12	8	2		2	6	259
Amorpha fruticosa	*Amorpha fruticosa* L.	2										2
Armeniaca vulgaris	*Prunus armeniaca* L.	5	3	2								10
Broussonetia papyrifera	*Broussonetia papyrifera* (L.) Vent.	204	58	19	8	1	1					291
Buxus sempervirens	*Buxus sempervirens* L.	4										4
Carpinus vulgaris	*Carpinus betulus* L.	748	253	55	44	58	29	14	5	1	3	1210
Catalpa bignonioides	*Catalpa bignonioides* Walt.	108	160	36	14	3						321
Castanea vesca crispa	*Castanea sativa* Miller.	1	2		1							4
Cedrus libani	*Cedrus libani* A. Richard							1		1		2
Cercis siliquastrum	*Cercis siliquastrum* L.	19	10	8	1		1					39
Chimonanthus fragans	*Chimonanthus praecox* L.	1										1
Cytisus laburnum	*Cytisus laburnum* L.	11	12	3	1							27

Table 2. *Cont.*

Botanical Name (1876)	Current Botanical Denomination	Trunk Circumference' Size (cm); Number of Plants (n) for Each Category; Total Number (n)										
		5 cm	10 cm	15 cm	20 cm	25 cm	30 cm	35 cm	40 cm	45 cm	Over 50 cm	**TOT**
Cornus mascula	*Cornus mas* L.	19										19
Cornus sanguinea	*Cornus sanguinea* L.	12										12
Colutea globosa	*Colutea arborescens* L.	25										25
Crataegus azzerolus	*Crataegus azarolus* L.	140	5									145
Crataegus oxiacantha	*Crataegus oxyacantha* L.	15	1									16
Cupressus sempervirens	*Cupressus sempervirens* L.	14	2	2								18
Dyospiros lotus	*Diospyros lotus* L.	65	41									106
Dyospiros virginica	*Diospyros virginiana* L.	165	32	1								198
Evonimus europeum	*Euonymus europaeus* L.	1										1
Fraxinus americana	*Fraxinus americana* L.	13	5	2								20
Fraxinus eccelsa	*Fraxinus excelsior* L.	127	48	6								181
Gleditschia triacanthos	*Gleditsia triacanthos* L.	92	66	21	5	7						191
Hibiscus syriacus	*Hibiscus syriacus* L.	4										4
Koelreuteria paniculata	*Koelreuteria paniculata* Laxm.	39	46	5	6	3						99
Juglans nigra	*Juglans nigra* L.	100	65	14	17	2	1		1		1	201
Juniperus comune	*Juniperus communis* L.	274	2									276
Juniperus virginica	*Juniperus virginiana* L.	17	84	86	27	20	10	1				245
Larix europeum	*Larix europaea* DC.			1								1
Ligustrum vulgare	*Ligustrum vulgare* L.	1										1
Maclura triscupitata	*Maclura tricuspidata* Carrière			1								1
Malus communis	*Malus communis* DC.	9	2									11
Mespilus germanica	*Mespilus germanica* L.			1	1							2
Morus nigra	*Morus nigra* L.	9	8	15	6	4	2	2	1	1	2	50
Persica vulgaris	*Persica vulgaris* Miller	18										18
Philadelphia coronaria	*Philadelphus coronarius* L.	5										5
Pinus americana	*Tsuga canadensis* (L.) Carrière	5	20	6								31
Pinus austriaca nigra	*Pinus nigra* var. *austriac* (Höss) Badoux	5	23	26	32	41	17	9	7	2		162
Pinus australis	*Pinus palustris* Mill.				3	3	5	8	3	5	4	31

Table 2. *Cont.*

Botanical Name (1876)	Current Botanical Denomination	Trunk Circumference' Size (cm); Number of Plants (n) for Each Category; Total Number (n)										
		5 cm	10 cm	15 cm	20 cm	25 cm	30 cm	35 cm	40 cm	45 cm	Over 50 cm	**TOT**
Pinus eccelsa	*Picea abies* (L.) H.Karst.										1	1
Pinus nordmanniana	*Abies nordmanniana* (Steven) Spach				2							2
Pinus picea	*Abies alba* Mill.			1								1
Pinus sylvestris	*Pinus sylvestris* L.	1	1	9	11	4						26
Pinus strobus	*Pinus strobus* L.		6	28	69	63	39	13	13	3		234
Pinus taxifoglia	*Abies balsamea* (L.) Mill.		1		1							2
Pyrus communis	*Pyrus communis* L.	9		2	1							12
Platanus occidentalis	*Platanus occidentalis* L.	7	8	3								18
Platanus orientalis	*Platanus orientalis* L.	1	6									7
Populus alba	*Populus alba* L.	9	12	3	4	1		1				30
Populus carolina	*Populus deltoids* Marsh		1								1	2
Populus pina	*Populus tremula L*	2	29	35	23	7	4	1	1		3	105
Populus tremula	*Populus tremula* L.						1					1
Prunus cerasus sylvestris	*Prunus cerasus* L.	52	17	8	10	6	3		2		1	99
Prunus padus	*Prunus padus* L.	3	1	1								5
Ptelea trifogliata	*Ptelea trifoliata* L.	40	1									41
Quercus rubra	*Quercus rubra* L.	264	214	82	64	32	18	17	12	7	7	717
Robinia pseudoacacia	*Robinia pseudoacacia* L.	149	246	107	34	12	4	1	1			554
Robinia viscosa	*Robinia viscosa* Vent.				2	2						4
Salix babilonica	*Salix babylonica* L.	1	3	5		1	1			1	2	14
Salix virgatum	*Salix amygdaloides* Andersson			1								1
Sambucus nigra	*Sambucus nigra* L.		2									2
Syringa alba	*Syringa vulgaris* L.	28										28
Sophora japonica	*Sophora japonica* L.	1		1			1	1		1		5
Sorbus aucuparia	*Sorbus aucuparia* L.	5	32	7	1	1						46
Taxus baccata	*Taxus baccata* L.	6	6									12
Tilia europea	*Tilia europaea* L.	67	179	122	43	33	26	32	33	14	34	583
Tilia platiphilla	*Tilia platyphyllos* Scop.			1								1

Table 2. *Cont.*

Botanical Name (1876)	Current Botanical Denomination	Trunk Circumference' Size (cm); Number of Plants (n) for Each Category; Total Number (n)										
Thuia orientalis	*Thuja orientalis* L.	19	82	72	8	1						182
Thuia occidentalis	*Thuja occidentalis* L.	75	55	82	10	1						223
Ulmus comune	*Ulmus minor* Mill.	861	372	138	75	63	31	32	35	33	113	1760
Ulmus montano	*Ulmus glabra* Hudson.	473	259	55	63	19	25	4		1		899
Viburnum tino	*Viburnum tinus* L.	2										2
Vitis vinifera	*Vitis vinifera* L.	266										266
	TOTAL	**5933**	**2983**	**1207**	**635**	**417**	**233**	**143**	**119**	**82**	**196**	**11,910**

By analysing Table 2, we observe that in term of number of plants, the most species historically planted were: *Ulmus minor* Mill. (1760), *Carpinus betulus* L. (1210), *Ulmus glabra* Hudson (899), *Acer campestre* L. (899), *Quercus rubra* L. (717), *Tilia europea* L. (583) and *Robinia pseudoacacia* L. (554). Several shrub species were also present such as viburnum (*Viburnum tinus* L.), elder (*Sambucus nigra* L.), hibiscus (*Hybiscus* spp.) and lilac (*Syringa vulgaris* L.) instead, concerning the fruiting species, probably located around the "Vignolante" house, there were 266 vine plants (*Vitis vinifera* L.), 194 walnuts (*Juglans nigra* L.), 99 cherry trees (*Prunus cerasus* L.) and 24 black mulberries (*Morus nigra* L.). As indicated in the original plan, in the landscape park totally 11910 trees were planted.

Another archive document found for this study, lists the herbs and shrubs cultivated in pots into the Royal Park of Moncalieri Castle (1887). Historically these plants were propagated into the two greenhouses (hot and tempered) and cultivated into the park. In detail, this document reports each species grown in pots, the number of specimens, their location (hot greenhouse and/or tempered greenhouse), the unit cost and finally total cost. Into the greenhouses, there were numerous species and varieties, both herbaceous and shrubby. In particular, hydrangeas, fuchsias, roses, pelargoniums, camellias, rhododendrons, and citrus fruits were the most representative in terms of the number of cultivated specimens.

3.2. The Compositional Features Analysis: The Garden Structure Today

Relative to the present structure of the Royal Park of Moncalieri Castle, the first step was the path system's reconstruction. Nine paths are still totally accessible. Each path was georeferenced and mapped (Path 1, 2, 3, 4, 5, 6, 7, 8, and 9). For each path, we have analysed these physical and compositional features: its typology (main or secondary), the overall length (m) the sediment, the degree of invasion by vegetation (scale of value), the main compositional features (botanical, environmental and architectural component) and the critical issues highlighted. From the paths identified, eleven homogeneous areas of vegetation (Area A, B, C, D, E, F, G, H, I, L and M) have been defined. Following the criteria described in Material and Methods sections, we have georeferenced and mapped the specimens most representative. Figure 6 illustrates the plan elaborated through the paths identified and the homogeneous areas defined. We have reported also the specimens died and lived. Each specimen lived was numbered (1 to 67), botanically classified and mapped.

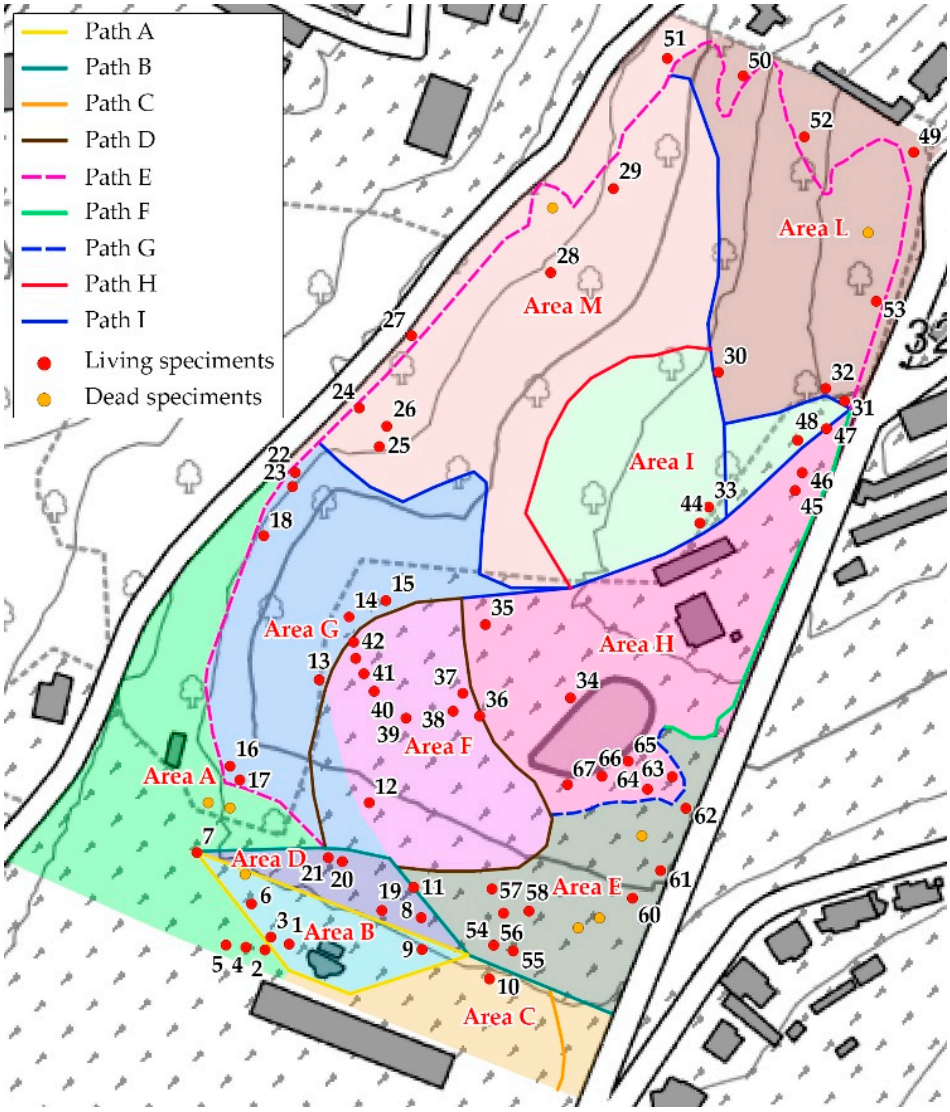


Figure 6. The map of the landscape park through the routes, the homogeneous areas defined, and the specimens mapped.

Interesting results emerge from the georeferenced and mapped species. Related current *status*, Table 3 reports the list of the botanical species georeferred, mapped and analysed. Related to Table 3, for each analysed species the following are indicated: the botanical name, the specific interest (botanical, forestry and compositional), the historical importance (presence in the historical documents collected), if invasive species, the critical issue and the number of specimens identified.

Table 3. List of species analysed. For each one the botanical name, the specific interest, the historical importance, if invasive species, the critical issue, and the number of specimens identified.

Botanical Name	Specific Interest	Historical Importance	Invasive Species	Critical Issue	Specimens Identified (n)
Tilia cordata Miller		X			9
Celtis australis L.	Botanical				8
Quercus robus L.	Forestry				7
Ulmus minor Miller	Botanical	X			7
Aesculus hippocastanum L.	Compositional	X		X	5
Acer platanoides L.	Forestry	X			4
Acer pseudoplatanus L.	Forestry	X		X	4
Acer campestre L.	Forestry	X			3
Gleditsia triacanthos L.			X		4
Piunus pinaster Aiton	Compositional	X			3
Fraxinus excelsior L.	Compositional	X			2
Quercus petraea (Mattuscka) Liebl.	Forestry				2
Taxus baccata L.		X			2
Ailanthus altissima (Miller) Swingle		X	X	X	1
Broussonetia papyrifera (L.) Vent.		X		X	1
Carpinus betulus L.	Compositional			X	1
Cedrus atlantica (Endl.) Carriére	Botanical and compositional	X			1
Colutea arborescens L.		X	X		1
Eleagnus spp.			X		1
Platanus hybrida Brot.	Botanical and compositional	X			1

4. Discussion

4.1. Identification of Historical Permanence

From the historical documentation collected and analysed it was possible to reconstruct the history of the Royal Park of Moncalieri Castle and the landscape of the Turin hill, that of Moncalieri. In some archival documents found (XVIII and XIX century), above all the cadastral and iconographic ones, the different land uses were reported. Analysing them it is possible to highlight that the Moncalieri hill was intensely cultivated, and viticulture represented the main land use practiced.

By analysing how the Royal Park of Moncalieri Castle was changed over time, historical data provide important information. While in Europe garden style was changing, with the *parterres de broderie* gradually giving way to bowling greens and tree clumps, and straight alleys to curving paths, in Piedmont Region (north west Italy) the Renaissance tradition of the semiformal garden persisted until the second half of the XVIII century [24]. In the context of Royal Residences, this historical evolution is represented by the Royal Park of Moncalieri Castle because of the coexisting three different green spaces, the rose garden the formal garden and the landscape park. By analysing the cadastral map (1867) illustrated in Figure 3, we detected interesting architectural elements: the nymphaeum, the lake, the "Roccolo" structure historically used for hunting birds and the "Vignolante" house, used by the winegrower as a home. In addition, the use of water as the plan structure is a sign of the historical evolution of the garden. In the Royal Park, the idea of artificial elements inspired by Italian and French garden style was represented by the fountain located in the middle of the formal garden

and the nymphaeum, realized in the XVIII century [25]. Moreover, by analysing the original plan (1876), we confirm that the garden located behind of Castle's courtyard was realized as a *parterre de broderie* inspired to the formal French style gardens, characterized by an intricate and geometrical system (Figure 4). By contrast, in the landscape park, the lake was realized in the XIX century with the aim to create a natural effect and imitate the nature.

Concerning this topic, we noted that several features inspired to the English style garden, introduced by Xavier Kurten in Piedmont Region also characterize the Royal Park of Moncalieri Castle [26]. Although the landscaped park was designed and realized by the Roda's brothers, as illustrated by the original plan, many compositional elements are those that recall the English landscape style. In particular, the system of sinuous paths, the vegetation, mainly arboreal with a preference for native species, and the use of water (i.e., the lake) are common compositional features introduced by Kurten in the first half of the XIX century in Piedmont Region [26].

4.2. Holistic Approach for Historical Garden Restoration

By identifying the permanencies linked to the path system, we have compared the original path system (1876) with the current paths identified in this study (2019). Figure 7 shows the historical paths (coloured lines) still present. From the cartographic reconstruction of the path system, we noted that only a part (<50%) of these routes has been maintained over time. Some current routes coincide with the historical ones or some parts of them. For the definition of the guidelines aimed at enhancing and restoring the park, the paths recognized as historical permanence will constitute priority elements to be safeguarded and protected.

For Grbić et al. (2016) aerial photographs and model are a scientific method for evaluating the viewpoints of the garden [27]. In our study, from the analysis of drone's images. It was possible to highlight the different homogeneous areas of vegetation and on the arboreal component, any problems detected on the foliage. Figure 8 shows the architectural elements of interest present in the Park and four different perceptive views. It is possible to see the "*Roccolo*" and the adjacent path D (1) and "*Vignolante*" house and artificial lake, included in the area H (2). These elements are today well preserved. Instead regarding the nymphaeum—present in area B—the top and front view (3) highlight a worst state of conservation. The first two perspective views (a and b) illustrate the Park's vegetation, that is very dense. The view of the Castle and formal garden (c) is taken from "*Roccolo*" and is very important in terms of perception because represents the relationship between the landscape Park, the formal garden and the Castle. Finally, the last view shows the Royal Park's nearness with the Po River, that, as mentioned above, was fundamental for the UNESCO MAB site recognition.

According to several authors, the historical garden is considered a cultural heritage for the conservation of plant species collections [28–31]. Their studies are priorities and should be supported by specific management projects. In this perspective, the recognition of plant species planted in 1876 constitute a tool for defining the historical species present. By analysing the number of species and the number of specimens cultivated in the XIX century, it can be noted that today the plant component is considerably reduced, both in terms of species present and in numbers of specimens. This element is probably determined by a series of forestry and sanitary interventions occurred over time. Moreover, the use of plant species is also an important element of analysis. Analysing plant inventory (1876) and their botanical origin, we note that these plants were both autochthonous and exotic species. In the XVIII century, plant hunters (mainly English and German) travelled through eastern countries and discovered many exotic flowers, shrubs, and trees. Accati and Gullino (2010) showed how these plants were imported by nurserymen and introduced in private and public collections [32]. Analysing and comparing the current vegetation with the exotic botanical species, overall trees, we showed that in the Royal Park of Moncalieri Castle, only few of the exotic plants (*Aesculus hippocastanum* L. and *Platanus hybrida* Brot.) introduced in that period in Piedmont still exist. Analysing vegetation, it emerges that most of the planted species introduced in the 1876 were autochthonous. Moreover, few conifers (*Taxus baccata* L. *Pinus* spp. And *Abies* spp.) were present.

Additionally, some species present in the park are included into the Blacklist of Piedmont Region (2017) because invasive species (*Gleditsia triacanthos* L., *Ailanthus altissima* (Miller) Swingle, *Colutea arborescens* L. and *Eleagnus* spp.) [33].

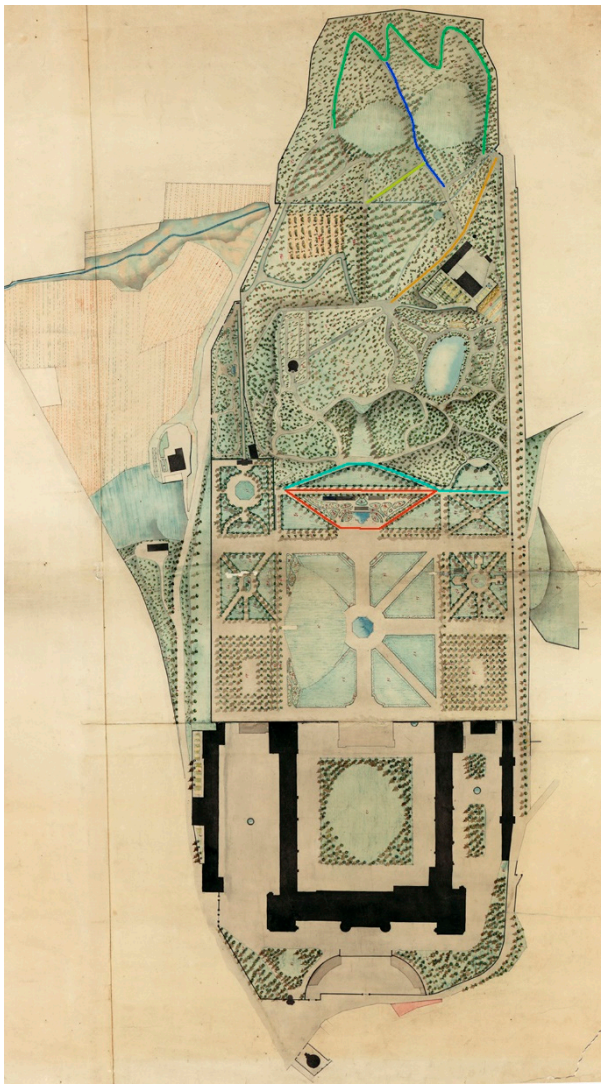


Figure 7. Cartographic reconstruction of the path system (original plan: 1876 and current *status*: 2019).

By evaluating and analysing the current plant component georeferenced and mapped, we can identify the priority elements to be protected, safeguarded and contained. In this context, we have indicated the actions/measures that should be adopted. Table 4 reports for each botanical species identified into the Royal Park of Moncalieri Castle the measures/actions to adopt.

Concerning the garden's restoration process, Klagyivik (2012) and Vonešová et al. (2018) highlighted the need to develop methods to achieve historic garden's authenticity [34,35]. Concerning monastic gardens restoration, new scientific approach able to combine historical data (cartographies and maps) with current evaluations of the gardens including the use of GIS is underlined [34]. In this context, Vonešová et al. (2018) showed the importance to evaluate also botanical and dendrological aspects [35]. Defining a methodological holistic approach for restoring historic gardens was our aim. As reported in the methodological framework (Figure 2) in this research different analysis were performed, using several tools. According to Cazzani et al. (2019) historical sources, surveys, thematic maps and interpretations are considered fundamental tools for studying historic gardens, considering complexity and vulnerability of the components and issues involved in

historic gardens and consequent multidisciplinary approach [36]. From a management perspective, these authors highlighted the role of GIS and WebGIS applications, for integrating the spatial component and databases about botanic inventories and conservation and valorisation treatments of historic public of public gardens. In our study the use of View Ranger app and QGIS allowed to map and georeferenced the path system, the compositional features and the vegetation component. In a future perspective, these dynamic data will constitute a preliminary analysis to define the first interventions and analyse the main critical issue.

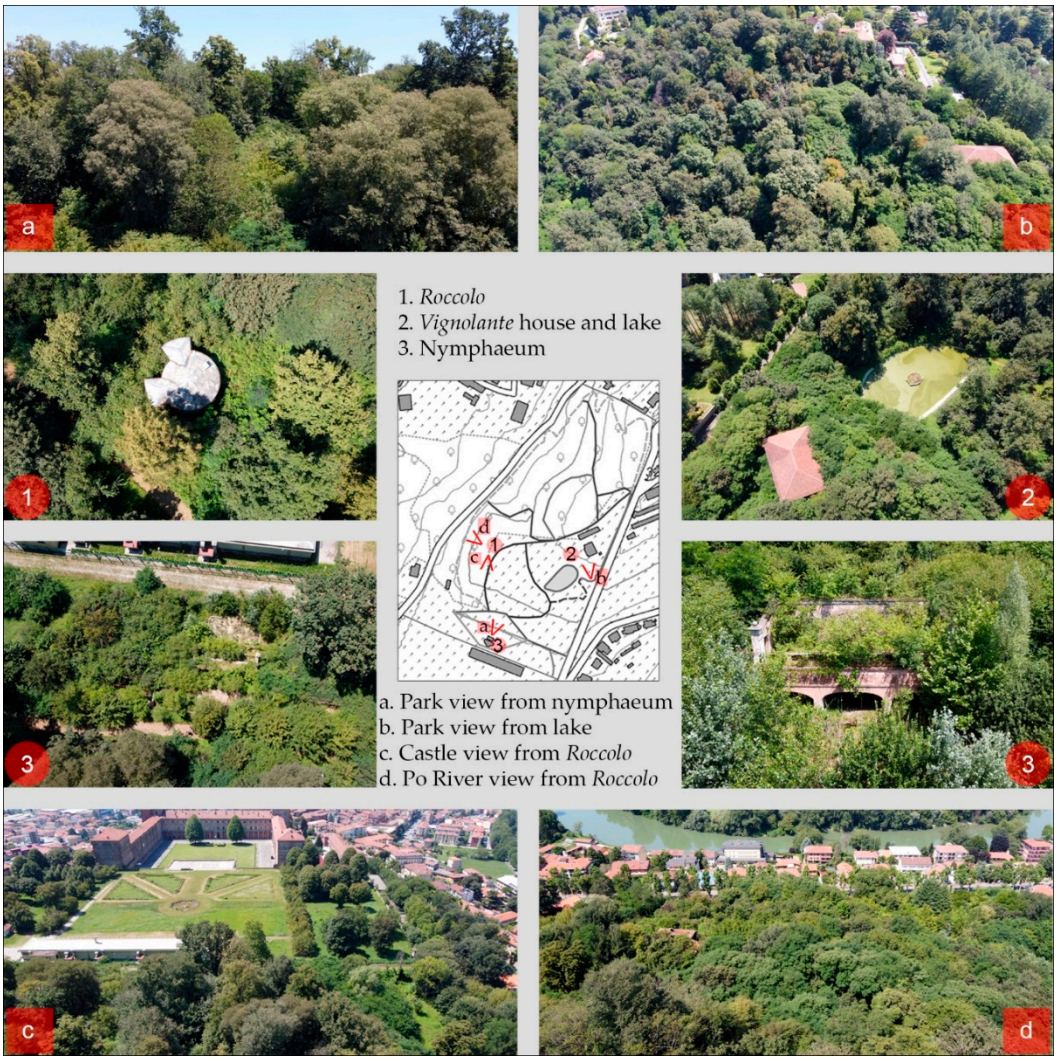


Figure 8. Architectural elements of interest and perceptive views made with drone.

We think that the historical and archival study should be the first step for restoring historic garden. For this study, historical cartography, cadastral maps, projects, plans, iconographies, and documents provide valuable information. The phase of knowledge and analysis of a historic garden must necessarily be the premise to any conservation or maintenance intervention. Comparing the historical documentation with the current documentation, it is possible to identify the historical permanencies still present. We have identified the paths, the species and some compositional elements. With a view to future restoration and use of the Royal Park of Moncalieri Castle, these priority elements must be safeguarded and enhanced. For defining sustainable solutions for historic garden restoration, the steps identified are not independent to each other and should be analysed in an integrated way.

Table 4. List of action/measures to adopt for each botanical specie identified into the Royal Park of Moncalieri Castle.

Botanical Name	Measures/Actions
Acer campestre L.	Protecting and safeguarding
Acer platanoides L.	Protecting and safeguarding
Acer pseudoplatanus L.	Protecting and safeguarding
Aesculus hippocastanum L.	Protecting and safeguarding. Controlling phytosanitary problem
Ailanthus altissima (Miller) Swingle	Containing—Black List—Management List
Broussonetia papyrifera (L.) Vent.	Containing—Black List—Management List
Carpinus betulus L.	Protecting and safeguarding
Cedrus atlantica (Endl.) Carrière	Protecting and safeguarding
Celtis australis L.	Protecting and safeguarding. Stability control of some specimens
Colutea arborescens L.	Protecting and safeguarding. Controlling in some areas their development
Elaeagnus spp.	Containing—Black List - Management List
Fraxinus excelsior L.	Protecting and safeguarding
Gleditsia triacanthos L.	Containing. Presence of thorns on the stem which may present problems in the future for the future use of the area
Pinus pinaster Aiton.	Protecting and safeguarding
Platanus hybrida Brot.	Protecting and safeguarding
Quercus petraea (Mattuscka) Liebl.	Protecting and safeguarding
Quercus robur L.	Protecting and safeguarding
Taxus baccata L.	Protecting and safeguarding
Tilia spp.	Protecting and safeguarding
Ulmus minor Miller	Protecting and safeguarding Stability controlling of some specimens

5. Conclusions

The preservation of a historic garden depends on the combination of several items that characterize its complexity and involves material and immaterial aspects. For this purpose, it is necessary to know in detail the garden components through the identification of attributes, followed by the recognition of heritage values. Moreover, historic gardens' preservation is concerned to protection and conservation combined with and constant management over time. Concerning the Royal Park of Moncalieri Castle for defining the preliminary specific management and maintenance programs and monitoring actions it is essential to adopt sustainable restoration interventions over time. Leaving the park and the lack of a management framework on which to base silviculture options have caused significant changes. With a view to safeguarding and protecting the park, the presence of the architectural elements already witnessed in the XIX century ("Roccolo", nymphaeum and "Vignolante" house) and of the artificial lake, as well as some sections of the original paths, represent the key elements from which to start restoration and public use of the park. Identifying the historical compositional elements, including a system of preferential paths, botanical species to be protected and safeguarded should be considered the first step for future management planning process.

Our results could be of interest both for methodological purposes and for the restoration of historic gardens planning and management. During the restoration process different critical issues exist, in this context combining historical and compositional values with today's needs and problems is a scientific challenge that involve all the community. In this study, we have showed the methodological framework applied and the analysis performed, following a holistic approach.

Nowadays with the pandemic linked to Covid19, the need for green areas has become increasingly felt. Historic parks and gardens must be considered as patches of the urban green infrastructure, able to provide a wide set of ecosystem services. Promoting the return of historic parks to the public fruition is of primary importance for the citizen well-being.

Author Contributions: P.G. collected historical documents, analysed research data and wrote the paper. E.P. georeferenced and mapped the botanical species and wrote the paper. W.G. georeferenced the botanical species, created the botanical sheet model and wrote the paper. M.D. and F.L. developed the original idea of this study, suggested appropriate methodologies for the overall analysis, and wrote the paper. All authors have read and agreed to the published version of the manuscript.

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