Restorative regeneration of woody ornamental plants in the historical gardens of Peleș Royal Castle, Romania

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Abstract

Historical gardens’ restoration is a complex process including not only built features of the layout, but also vegetation. Climate changes, air pollution, new pests and other factors have an important impact on vegetation and make sometimes impossible to restore the garden to the original model. Therefore, vegetation restoration requires investigations, to establish the tendencies, dynamics and resilience of different species in the garden, and decisions to adopt sustainable solutions. Woody plants from Peleș Royal Castle Gardens (Sinaia, Romania) were investigated to reveal the diachronic transformations of the vegetation and to establish an objective starting point in garden restoration. Despite of decades of neglected maintenance, historical events and changes in building function, the garden has a considerable number of old valuable trees and shrubs. Woody plants located on terraces were in a significantly poorer condition compared with those planted on the lawn. Natural forest surrounding the garden and native species cultivated in the garden acted as a source of landscape regeneration. Climate changes, affecting the mountain zone, allow the cultivation of woody species of warmer climates. Results of present study will be essential for all the future decisions about woody vegetation and gardens restoration.

Keywords: climatic changes; garden restoration; regenerative landscape; resilient ecosystem; shrub; terraces; trees

Introduction

Beyond historical evidence, royal gardens always revealed the personality of the owner. From ancient times, royal gardens delineated living spaces and ceremonial stages beyond the walls of buildings, a living
artform and a testimony of the richness and power of a country and owner (Mukerji, 1997; Novak, 2002). These gardens reflect through their design, plants and features, the new opportunities of an epoch, the tastes and preoccupations of the monarchy, being an all-consuming passion (Lane, 2020). Today, historical gardens became a resource of cultural interest (Santos and Álvarez, 2020) and a relevant cultural heritage (Carneiro et al., 2012).

Historical gardens' reconstruction is a complex process including not only built features of the layout, but also vegetation. True testimony of political, social and cultural events, with significant importance for heritage landscapes, historical garden is considered a cultural asset. The Florence Charter of 1982 suggests that historic gardens should be ‘considered as a monument’ consisting mainly of living components, plants (ICOMOS, 2021). The vegetal constituents evolve and change continuously, but historical gardens may be preserved in an unchanged condition for a long time with constant maintenance and replacements. In addition, trees themselves became monumental when age, size, botanic rarity, or other criteria, differentiate them in any other gardens (Asciuto et al., 2015; Zapponi et al., 2017; Ciaffi et al., 2018; Vasile et al., 2020). In this context, preservation and restoration of a historical garden impose specific guidelines that need to be respected.

Restoration was defined as ‘the methodological moment of recognizing a work of art’ (Brandi, 1996). As in any work of art, gardens’ restoration requires discernment and expertise. The principle of maximum preservation of authenticity at the prosperity age of garden was applied in the case of some historic gardens' restoration (Shellenhamer, 2004; Halbrooks, 2005; Ignatieva et al., 2015). However, unlike constructions that are faithfully restored, in the case of gardens, the reconstruction solutions must consider as close as possible the original model, if available (Sales, 1995), but also accepting the changes and observing their dynamics (Jacques, 2014). This is because ecosystems constantly shift and change in unpredictable ways (Cronon, 1993) and historical gardens’ vegetation may not be always easy to restore especially in the case of rare and exotic species (Gullino et al., 2020), due to climate change, air pollution, new pests, and other factors. Nevertheless, the past may provide clues about environmental change and it is an indispensable guide for understanding a world in flux (Alagona et al., 2012) and for this reason investigation about vegetation dynamics are necessary before starting the restoration process. Long-term vegetation dynamics over past decades may be studied by monitoring the historical plots (Kapfer et al., 2017). In the case of Peleș Gardens, Romania, the restoration of historical landscape must consider these dynamics and understand the changes of ecosystem over 100 years. In this approach, the periodic inspection of elements of the historical monument, and consequently the vegetation, is absolutely necessary. Therefore, in the present research a complete inventory and investigation of the vegetation was made, in order to obtain a preliminary scientific database and an overall assessment of the gardens. The main objective was to inventory the woody vegetation and determine its dynamics in the last 140 years, in the Peleș Royal Castle Gardens, in order to establish their role and landscape importance. The results of this study will be essential for the restoration plan of historical gardens.

Materials and Methods

Geographical location and general presentation

The Peleș Castle is located in Sinaia (45°21’00”N and 25°32’33”E), a town on the South-Eastern versant of Bucegi Mountain, in Prahova Region, Romania. The average altitude of this town is 860 m. In Sinaia, the annual average temperature is 6.1 °C and the annual rainfall is 800 mm (PS, 2021). The dominant landcover of the area representing by forest during 19th century, changed dramatically after the collapse of the socialist regime, when urban pressure increased due to both residential dynamics and mass-tourism (Pătru-Stupariu et al., 2011). These changes have implications on local climate, which registered in the last decades an increase in temperature, a snow depth variation and extreme weather events (Surugiu et al., 2011).

Situated in a discreet and calm place in the Bucegi Mountains, surrounded by forests, Peleș Castle Domain was the summer residence of the Romanian Royal Family. The palace was built in the style of
The gardens of Peleș Castle were meticulously imagined and created under the guidance of a great historical personality, King Carol I (the first King of Romania, from 1881 to 1914) and completed by King Ferdinand I, a passionate botanist (Stan, 2003) and Queen Mary, an art and plants lover (Mandache, 2004), his successors. Designed in terraces that surround the palace and a great lawn, the gardens were realized in decades. Over time, from 1881, when the construction of terraced gardens began, until 1914, when the last terrace was built and planted (Haret, 1924), the garden experienced different transformations and the vegetation as well. Located on slop and crossed by underground springs, the site chosen for building, required multiple technical solutions to stabilize the ground. The first garden was organized on the south terrace of the palace and several plans of vegetal compositions were adopted by Wilhelm Knechtel, the garden architect, in the following years. Also, the great lawn was planted with several exotic woody species from America and Asia (Bachelin, 1908). In 1890, when the palace was modernized, new terraces were added. In the following years, the terraced gardens were decorated in architectural style with flowers and roses, woody climbing plants and shrubs. The last terraces were added in 1910-1914 and several changes in vegetal composition were made. At the beginning of twenty-century landscape architect Friedrich Rebhun had a major contribution to the gardens' vegetal composition (Haret, 1924; Mandache, 2004). He introduced new exotic species and cultivars of trees and shrubs. The historical events that led to the abolition of the monarchy in 1947, had a significant impact on Peleș Castle Gardens. The permanent efforts of the royal family to maintain and improve the gardens, and also, the interest for the newest species and cultivars of both woody plants and flowers, were dramatically lost in the communist period (1948-1989). In 1953, the building became a museum (MNP, 2021) and the gardens were populated with much more resistant species. Some of the statues and other garden art objects were removed or replaced. The museum was closed in 1975 (MNP, 2021) and the interventions in the gardens were gradually diminished, vegetation being poorly maintained and, in some parts, completely abandoned. After Revolution in 1989, the museum was reopened (MNP, 2021), but the gardens were almost neglected, except for the vegetation on the terraces which received minimal care. In 2007, the property reverted to the royal family (MNP, 2021).

Castles' gardens, division of zones and data collection

The gardens of Peleș Royal Castle have an area of almost 4 ha, surrounded by mixed forests (*Fagus sylvatica*, *Abies alba* and *Picea abies*). Research was started in 2015, when the garden was evaluated and divided into five zones: zone A, zone B, zone C, zone D and zone E (Figure 1).

In each zone, field studies and analysis, including the inventory and assessment of woody plants, were initiated in 2019. Previous to data collection, an initial study based on the interpretation of historical sources (plans, photographs, chronicles and other documents) was made. Unfortunately, the gardens were not found represented in a single and complete planting plan, because of the permanent works of transformation, modernization and planting, that were carried out over time.

Identification of woody plants and their attributes: statistical analysis

The field studies and investigations regarded the identification of woody plants and their attributes. In the case of trees, height, diameter at breast height (dbh), crown base height and crown diameter were individually measured. For shrubs, only height and diameter were measured. Plant condition was categorized as good (healthy, vigorous plants, with perfect structure), fair (healthy, vigorous plants in general, with maximum 25% wounds or dead branches), poor (plants vigour affected, unhealed wounds or chronic parasitic attack to maximum 50%), irreversible decline (plants with large dead branches, cavities or signs of internal decay to maximum 75%) and dead.
Chi-square tests were performed on species counts to reveal any disproportional use of native and exotic species, and to emphasize differences in plants’ condition, between the two major zones in the garden, The Great Lawn (zone A) and Terraces (zone B, C, D and E). Correlations regarding the relationship between the planting date and plants’ state of health were investigated using Pearson Test at $P \leq 0.05$ and linear regression analyses.

**Results**

The inventory of a total number of 124 trees and 165 shrubs revealed the existence of 35 species, 12 cultivars and 2 hybrids, from 17 botanical families, in the Historical Gardens of Peleș Royal Castle (Table 1). Most of the species (60%) are exotic, being native to Asia and North America. Significantly more exotic plants than native ones were found in terraces compared to The Great Lawn ($\chi^2 = 112.3783; df = 1, N = 271, p < 0.00001$). A remarkable share of 45% of the total number of plants was represented only by five species: *Thuja occidentalis*, *Juniperus sabina*, *Cornus sanguinea*, *Buxus sempervirens* and *Picea abies*. Except *Thuja occidentalis*, these species were not found distributed uniformly in the garden. A greater diversity of species was noticed in zone A, where together with the 22 different species, appear also five of the twelve cultivars of the garden.

In zone A (The Great Lawn) were measured the tallest trees in the garden: *Fagus sylvatica* of 33 m height, *Larix decidua* of 29 m and *Acer pseudoplatanus* of 28 m (Table 2). All these species are native and perfectly adapted to the mountain region of Romania. The remarkable exotic trees of *Cupressus nootkatensis* (zone E, The Western Terrace) and *Aesculus hippocastanum* (zone A, The Great Lawn) were found in the garden, reaching a height of 24 m and 21 m, respectively.

Even if the total height was not extremely high, there were several individuals with exceptional dbh values, reaching 210 cm at *Picea abies*, 185 cm at *Platycladus orientalis*, 180 cm at *Chamaecyparis lawsoniana*, 120 cm at *Thuja occidentalis* and 117 cm at *Acer platanoides*. About 35% of the total number of trees were found with dbh values larger than 50 cm. Most trees with high dbh values were noticed in zone A (The Great Lawn), zone B (The Southern Terrace) and zone C (The Eastern Terrace).
The crown base height values varied with the species, ranging from 0.1 m to 8.0 m. The crown diameter was greater than 10 m at some individuals of deciduous trees such as: *Fagus sylvatica*, *Fraxinus excelsior*, *Acer pseudoplatanus*, *Aesculus hippocastanum* and *Betula pendula*. Some individuals of conifer trees reached values over 10 m at *Larix decidua*, *Taxus baccata*, *Cupressus nootkatensis* and *Picea abies*.

### Table 1. Inventory of woody species, cultivars and hybrids in the Garden of Peleş Royal

| Scientific name        | Family*       | Origin* | Zone A | Zone B | Zone C | Zone D | Zone E | No. of individuals | Total plants |
|------------------------|---------------|---------|--------|--------|--------|--------|--------|-------------------|--------------|
| Abies alba             | Pinaceae      | native  | 3      | -      | -      | -      | -      | -                 | 3            |
| Acer palmatum ‘Aureum’ | Aceraceae     | cultivar| 1      | -      | -      | -      | -      | -                 | 1            |
| Acer pseudoplatanus     | Aceraceae     | native  | 3      | -      | -      | -      | -      | -                 | 3            |
| Acer pseudoplatanus ‘Purpureum’ | Aceraceae | cultivar | 2      | -      | -      | -      | -      | -                 | 2            |
| Aesculus hippocastanum  | Sapindaceae   | Europe  | 3      | -      | -      | -      | -      | -                 | 3            |
| Berberis thunbergii     | Berberidaceae | Asia    | -      | -      | -      | -      | -      | -                 | 2            |
| Betula pendula          | Betulaceae    | native  | 2      | -      | -      | -      | -      | -                 | 2            |
| Betula serotina         | Betulaceae    | Europe  | 4      | -      | -      | -      | -      | -                 | 10           |
| Chaenomeles speciosa    | Rosaceae      | Asia    | -      | -      | -      | -      | -      | -                 | 1            |
| Chamaecyparis lawsoniana| Cupressaceae  | N America| - | - | 6 | - | - | 6 | |
| Chamaecyparis lawsoniana ‘Ellwoodii’ | Cupressaceae | cultivar | 1 | - | - | - | - | 1 | |
| Chamaecyparis pisifera | Cupressaceae  | cultivar| - | 4 | - | - | 4 | 5 | 9 |
| Cornus sanguinea        | Cornaceae     | native  | 17     | -      | 4      | -      | 1      | 22               |
| Craugus mexicana        | Rosaceae      | N America| - | - | - | - | 1 | 1 | |
| Cupressus nootkatensis  | Cupressaceae  | N America| - | - | - | - | 1 | 1 | |
| Deutzia scabra          | Hydrangeaceae | Asia    | 1      | -      | -      | -      | 5      | 6 | |
| Fagus sylvatica         | Fagaceae      | native  | 5      | -      | -      | -      | -      | -                 | 5            |
| Fagus sylvatica ‘Purpurea’ | Fagaceae | cultivar | 4 | - | - | - | - | 4 | |
| Forsythia x intermedia  | Oleaceae      | hybrid  | - | 4 | - | - | 5 | 10 | 17 | |
| Fraxinus excelsior      | Oleaceae      | native  | 1      | -      | -      | -      | -      | -                 | 1            |
| Hedera helix            | Araliaceae    | native  | 2      | 4      | -      | -      | -      | -                 | 6            |
| Juniperus communis ‘Hibernica’ | Cupressaceae | cultivar | - | 2 | 1 | - | - | 3 | |
| Juniperus horizontalis  | Cupressaceae  | N America| - | 6 | 4 | - | - | 10 | |
| Juniperus sabina        | Cupressaceae  | native  | 21     | -      | -      | -      | -      | -                 | 21           |
| Laburnum anagyroides    | Fabaceae      | native  | 1      | -      | -      | -      | -      | -                 | 1            |
| Larix decidua           | Pinaceae      | native  | 3      | -      | -      | -      | 2      | 5 | |
| Lonicera pilata         | Caprifoliaceae| Asia    | -      | -      | -      | 3      | 3      | 6 | |
| Magnolia kobus          | Magnoliaceae  | Asia    | -      | -      | -      | -      | -      | 8 | 8 | |
| Malus pumila ‘Niedwetzkyana’ | Rosaceae | cultivar | - | - | - | - | 1 | 1 | |
| Philadelphus coronarius | Hydrangeaceae | N America| - | 1 | 1 | 2 | - | 4 | |
| Picea abies             | Pinaceae      | native  | 10     | 1      | 3      | -      | -      | -                 | 14           |
| Picea pungens ‘Argentea’| Pinaceae      | cultivar| 3      | -      | -      | -      | -      | -                 | 3            |
| Pirus nigra             | Pinaceae      | native  | 3      | -      | -      | -      | -      | -                 | 3            |
| Platanus orientalis     | Cupressaceae  | Asia    | 3      | 3      | 3      | -      | -      | -                 | 9            |
| Prunus laurocerasus     | Rosaceae      | Europe  | -      | -      | -      | -      | -      | -                 | 4 | 4 | |
| Prunus serrulata ‘Kiku-Shidare-Sakura’ | Rosaceae | cultivar | - | - | - | 1 | - | 1 | |
| Prunus coccinea         | Rosaceae      | Europe  | -      | -      | -      | -      | -      | -                 | 1            |
| Prunus dentata ‘Emerald’ | Rosaceae | cultivar | - | - | - | - | 1 | - | 1 | |
| Rhodotypos scalens      | Rosaceae      | Asia    | 1      | -      | -      | -      | -      | -                 | 1            |
| Sambucus nigra          | Adoxaceae     | native  | -      | -      | 1      | -      | -      | -                 | 1            |
| Spiraea x vanhouttei    | Rosaceae      | hybrid  | 1      | -      | -      | -      | -      | -                 | 1            |
| Symphoricarpos albus    | Caprifoliaceae| N America| 1 | - | 3 | - | 2 | 6 | |
| Syringa jasitka         | Oleaceae      | native  | 1      | 1      | -      | 1      | 2      | 5 | |
| Taxus baccata           | Taxaceae      | native  | 3      | -      | -      | -      | -      | -                 | 3            |
| Thuja occidentalis      | Cupressaceae  | N America| 4 | - | 2 | - | - | 6 | |
| Thuja occidentalis ‘Columnaris’ | Cupressaceae | cultivar | 3 | 6 | - | 6 | - | 21 | |
| Thuja occidentalis ‘Woodwardii’ | Cupressaceae | cultivar | - | 3 | - | - | - | 3 | |
| Thuja occidentalis ‘Golden Globe’ | Cupressaceae | cultivar | 1 | 6 | - | - | - | 6 | |
| **Total plants**        |               |         | 113    | 39     | 44     | 27     | 66     | 289        |      |
Around 68% of the total woody plants inventoried at Peleș Royal Castle were in good condition. However, in zone E, most of the plants (about 90% of the total) were in fair condition, because of the presence of numerous shrubs, which were poorly maintained (no pruning, no watering, no fertilization) for a long time. The plants presented a significantly more altered condition in the terrace zones than in the lawn zone (Figure 2, $\chi^2 = 13.4154; df = 1, N = 289, p = 0.00025$). No significant relationship between age of plants and their state of health was found ($r = 0.0281; r^2 = 0.0008; p = 0.634$).

Table 2. Dendrometric data of trees in Peleș Royal Castle Gardens

| Scientific name* | Total height (m) | Diameter at the breast height (cm) | Crown base height (m) | Crown diameter (m) |
|------------------|------------------|------------------------------------|-----------------------|--------------------|
|                  | mean range       | mean range                         | mean range            | mean range         |
| Abies alba       | 8.3 2.8-19.0     | 23.9 4.8-62.0                      | 1.2 0.3-3.0           | 3.0 1.4-6.2        |
| Acer palmatum 'Aureum' | 10.0 10.0            | 60.0 60.0                          | 2.5 2.5               | 8.0 8.0            |
| Acer macrophyllum | 6.0 6.0           | 56.0 56.0                          | 1.0 1.0               | 7.0 7.0            |
| Acer platanoides  | 8.5 2.0-15.0      | 55.0 40.0-70.0                     | 1.75 0.8-2.7          | 6.4 0.9-12.0       |
| Acer pseudoplatanus | 15.4 9.0-28.0    | 43.9 28.0-70.0                     | 2.9 1.4-4.1           | 11.9 6.0-18.0      |
| Acer pseudoplatanus 'Purpureum' | 21.00 20.0-22.0   | 50.3 31.0-70.0                     | 5.0 2.0-8.0           | 10.0 6.0-14.0      |
| Acer platanoides  | 15.8 8.0-21.0     | 55.3 26.0-90.0                     | 2.4 1.2-4.5           | 10.0 6.2-14.5      |
| Betula pendula    | 12.0 9.0-15.0     | 35.0 30.0-40.0                     | 3.1 2.6-3.6           | 8.0 5.0-11.0       |
| Chamaecyparis Lawsoniana | 8.4 7.0-9.0     | 114.5 78.0-180.0                   | 2.3 0.8-3.0           | 4.5 4.0-5.0        |
| Chamaecyparis Lawsoniana 'Ellwoodii' | 11.5 11.5        | 60.0 50.0                          | 2.5 1.4-4.1           | 8.0 5.0-11.0       |
| Cephalotaxus mexicana | 2.8 2.8           | 0.2 0.2                            | 0.9 0.9               | 3.9 3.9            |
| Cupressus nootkatensis | 24.0 24.0        | 121.0 121.0                        | 0.5 0.5               | 9.5 9.5            |
| Fagus sylvatica   | 18.0 17.0-20.0    | 81.0 80.0-90.0                     | 4.1 2.3-8.0           | 13.8 7.0-20.0      |
| Fagus sylvatica 'Purpurea' | 27.0 24.0-33.0   | 82.5 80.0-110.0                    | 3.0 2.0-4.7           | 14.0 7.5-19.5      |
| Fraxinus excelsior | 20.0 20.0         | 65.0 65.0                          | 2.3 2.3               | 18.0 18.0          |
| Juniperus communis 'Hibernica' | 2.0 2.0-4.0    | 0.7 0.6                            | 0.1 0.1-0.2           | 0.7 0.5-1.2        |
| Laburnum anagyroides | 7.0 7.0          | 15.0 15.0                          | 0.9 0.9               | 9.0 9.0            |
| Larix decidua     | 23.1 9.5-29.0     | 45.6 30.0-60.0                     | 6.1 4.0-7.2           | 7.8 6.0-12.0       |
| Magnolia kobus    | 11.6 10.0-13.0    | 36.8 31.8-41.4                     | 1.3 1.0-2.0           | 6.4 5.0-8.0        |
| Malus pumila 'Niedwetzyana' | 5.0 5.0         | 0.3 0.3                            | 1.0 1.0               | 8.0 8.0            |
| Picea abies       | 18.9 9.0-26.0     | 95.2 30.0-210.0                    | 4.8 2.7-7.0           | 7.2 3.0-10.0       |
| Picea sitchensis 'Argentea' | 16.5 16.0-17.0   | 56.6 40.0-65.0                     | 2.7 1.6-4.2           | 8.1 6.7-9.5        |
| Pinus sylvestris  | 17.0 14.0-19.0    | 41.0 28.0-90.0                     | 4.2 3.0-5.0           | 6.1 4.0-9.5        |
| Platycladus orientalis | 9.2 8.0-12.0    | 42.5 17.0-185.0                    | 3.3 1.0-5.0           | 3.1 2.0-8.0        |
| Prunus serrulata 'Kiku-Shidare-Sakura' | 3.5 3.5         | 35.0 35.0                          | 1.8 1.8               | 4.6 4.6            |
| Taxus baccata     | 7.9 5.0-9.2      | 23.1 9.6-45.0                      | 0.8 0.7-2.5           | 9.1 7.0-11.0       |
| Thuja occidentalis | 11.8 6.0-19.0    | 37.6 10.0-120.0                    | 2.2 0.8-5.0           | 3.9 2.0-8.0        |
| Thuja occidentalis 'Columnaris' | 6.1 6.0-8.0     | 22.2 15.0-74.0                     | 0.3 0.1-0.5           | 2.7 1.8-3.5        |

*Source of data: Iliescu (2008) and Hoffman (2016)

Figure 2. Number of woody plants situated in The Great Lawn and Terraces, according to their condition
A diachronic study of woody vegetation revealed that most of the plants (80%) in the garden were planted after 1948, when the royal domain was nationalized (Figure 3).

Figure 3. Number of plants cultivated at different moments in time
However, a few old individuals of tree and shrubs continued to grow and survived over times and may be seen today especially in zone A. Lack of maintenance, in the last 50-70 years, led not only to the loss of some trees and shrubs, but also the advance of forest in the northern terrace of the garden (Figure 4).

The analysis of both plans and old photos revealed major changes in the structure of forest, too. Pictures taken in 1915 and 1919 from the northern terrace of the garden revealed a mixed forest, where the conifers were predominant. Today, at the forest limit, in the proximity of the terrace, *Fagus sylvatica* is more often seen. Also, the abandonment and lack of maintenance for several decades created a new and consistent layer of soil, in some parts almost 40 cm thick, which covered soil, alleys, stairs and retaining garden walls (Figure 5).

![Figure 4. The Northern Terrace and the forest](image1)

Old photos are post-cards of MNIR (2020)

![Figure 5. The new layer of soil (formed in decades of poorly maintenance) covering an alley](image2)

(A) vegetation removal; (B) alley clean up; (C) layer of 25 cm, visible near the cleaned alley
Discussion

The woody plants assortment recorded in the present garden of Peleș Royal Castle reflects the influences of time, climate, topography, geomorphology and management practices. In the royal period (1883-1947), many special, rare and exotic species were used to decorate terraces and The Great Lawn. Some individuals of these species are still found in the garden. Also, a considerable proportion of species native to Asia and North America (about 60%), planted in the period of King Carol I by landscape architects Wilhelm Knechtel and Karel Liman, remained in the gardens. However, predominant woody plants in the garden were common, native species, such as *Picea abies, Juniperus sabina* and *Cornus sanguinea*. This may be explained not only by the abandon of maintenance of garden during the communist period (1948-1989) and after Revolution in 1989, but also by the completing in this time of the assortment with native and much more resistant species. Furthermore, the natural forest, that surrounds the garden, subjected to minimal disturbance over the years, acted as a source of recolonization. Thus, ecological memory required for reorganization of forestry ecosystem was found both inside and outside the area of disturbance (Bengtsson et al., 2003). Also, the change of building function from the residence of the royal family to a museum had an important impact on the current composition of the garden. Peleș Royal Castle is one of the five most visited museums in Romania, according to Eurostat (2019). However, the opening of historic gardens to public required changes to improve the conditions of visiting by tourists and safety measures being implemented (Santos and Álvarez, 2020). For this reason, the tallest trees of the garden were found apart of the visitation area, in zone A, where no pruning work to reduce tree height was ever applied.

Although the garden is in a mountainous area, some species of warmer climates (such as *Acer palmatum, Chamaecyparis lawsoniana, Chamaecyparis pisifera, Magnolia kobus, Prunus laurocerasus*), which usually are not recommended in cold areas of Romania (Iliescu, 2008), were identified. The adaptation of exotic species to a different temperature regime as of their native range was observed and studied by some other authors (Kollas et al., 2014; Kreyling et al., 2015; Muffler et al., 2016), who found it into a close relationship with the occurrence of frost in late winter or early spring. In Central Europe, the incidence of late frost that damage plants were low in past decades, because of the global warming (Scheifinger et al., 2003; Wypych et al., 2017). Particularly in the Bucegi Mountains, winters were characterized as mild, with little snow and early springs, that significantly disturbed the plant communities (Sârbu et al., 2014). Anyway, climate changes may extend the list of species that can be adopted in colder climates (Messinger, 2015). In case of Peleș Castle, several species sensitive in the past to the mountain climate and lost over winter, such as *Rosasp.* and *Wisteria sinensis*, could be reintroduced in the gardens. Moreover, our investigation on plants condition revealed that species of colder climate, such as *Picea abies, Larix decidua, Betula pubescens* and *Acer pseudoplatanus*, are affected, and even lost, by current climate conditions and impose replacements with similar species much more adapted. Similar observations were reported by other authors for the northern zones of Europe (Kramer, 1995; Schuman et al., 2011; Thurm et al., 2018). In the case of Peleș Castle Gardens, alternative conifer species could be: *Pinus pungens, Pseudotsuga menziesii* and *Abies alba*, and for broadleaved species: *Betula pendula* and *Acer platanoides*.

Results showed a significant difference between plants’ condition located on terraces and those on the lawn. Woody vegetation present on terraces appeared much more deteriorated. Terraces are built to preserve more water, to decrease erosion (Lasanta et al., 2001; Arnáez et al., 2015; Kovát et al., 2016; Qihua et al., 2020), to provide a larger surface area for the garden, to make walking much easier and comfortable and to create a large view of the garden (Cunningham, 1996). The environments created by terraces are not always favourable for woody species and, therefore, they react differently (Maikhuri et al., 2000; Siriri et al., 2010; Van der Sluis et al., 2014). In the case of Peleș Castle, some of the plants located on terraces were in a poor condition because of sum of factors, such as: species, age and lack of maintenance. Investigations regarding the species in relation to their age and state of health have shown some differences. In case of several species, such as *Acer pseudoplatanus, Buxus sempervirens, Larix decidua, Picea abies, Platycladus orientalis* and *Prunus serrulata,*...
their both planting time and condition were not related. For other species, such as *Chamaecyparis lawsoniana*, *Fagus sylvatica*, *Juniperus horizontalis* and *Thuja occidentalis*, their state of health has depended on their age.

Some of the plants on the terraces have no landscape value or function, at all and may be completely removed (in zone A: obstructive viewpoint and hazardous *Thuja*, obstructive viewpoint *Deutzia* and degraded *Picea* hedges; in zone B: hedges of *Buxus*, invasive *Hedera* and *Juniperus* shrubs, and degraded *Thuja* and *Juniperus* tree plants; in zone C: obstructive viewpoint *Chamaecyparis* and invasive *Hedera*, in zone D: degraded plants of *Lonicera*, in zone E: degraded plants of *Buxus*, *Juniperus* and *Forsythia*, weak trees of *Crataegus* and *Thuja*). Also, the line of forest in zone D must be reconfigured, due to the pressure exerted on the terrace.

Field observations and analysis of both pictures and plans revealed not only an important movement of forest to the terrace but also a change in time of forest edge composition. Lawn strip splitting the forest from the terrace was covered by *Fagus* trees, despite low density of these species in the forest at that time. Forest regeneration and replacement of conifers by *Fagus* in European forests were also reported by other authors (Paluch, 2005; Nagel *et al.*, 2006; Nagel *et al.*, 2010), and seems to be associated with edaphic changes. The new and consistent layer of soil formed in northern zone of the garden of Peleș Castle, created conditions for forest restoration. This natural regeneration of landscape should not be ignored, because it offers valuable clues about capacity of forest to recover and restore the environment.

Conclusions

Preserving the aspect of the historical garden of Peleș Royal Castle as a place for meeting the old times in modern times, it is a challenging issue. The future garden restoration must consider not only the historical landscape, which must send an authentic and strong message as the cradle of Romanian monarchy, but also the environmental changes, regenerative capacity of landscape and species resilience. Investigations revealed that garden has a reasonable biodiversity of species and contain old valuable trees and shrubs, despite of historical events and neglected maintenance. Therefore, restoration plan must include their control and protection on a regular basis. This also includes the removal of some plants with low landscape value, degraded or invasive and replant all the woody species that garden had lost by abandonment. Restoration of Peleș Royal Castle garden must consider the flux of visitors and their safety and adapt the old plans to the actual function of building, that of as a museum.

Authors’ Contributions

Conceptualization and writing: ED and CRM; Investigation: ED, MIG, FS, IT, SAP, FT, DMG. All authors read and approved the final manuscript.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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