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SZENT ISTVÁN UNIVERSITY

THE COMPLEX ENVIRONMENTAL SURVEY AND THE RESEARCH OF POTENTIAL LAND-USE POSSIBILITIES OF THE PANNONHALMA WORLD HERITAGE SITE

THESES OF PH.D. DISSERTATION

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BACKGROUND AND OBJECTIVES

"The Caretaker of the monastery has the charge of everything, let him neglect nothing" says Saint Benedict in the Regula (Holy Rules for Benedictine Monks). Although the Regula was written in the 6th century, its approach is still relevant: the problems of today can still be solved through thoughtfulness, responsibility and temperance.

The World Heritage Site in Pannonhalma is affected by many different land-use methods, which are detailed and multifaceted. The first 3 complex roles must be considered in all plans, strategies and cultivation schemes, whilst the 3 minor functions can help the site to develop as a living entity. The main land cultivation tasks are the following:

- **Sacral Center:** The foremost and all-encompassing primary function of the Site, which dominates in importance above all other developments and cultivation schemes.
- **Significant historical location of Hungarian culture:** Dominated by historic monuments, the site is of paramount significance not only to Hungarian culture, but to all of Europe - the stage of worldwide historical events.
- **Protected Conservation Area:** the majority of the World Heritage Site is part of the Pannonhalma Landscape Protection Area.
- **Residential Site:** Besides the monks, the Benedictine College dorms provide accommodation for around 360 students, and numerous elderly citizens reside in the social residential apartments. The monastery can function as a home for approximately 500 people.
- **Work place:** The Arch abbey is among the regions' largest employers, with many different job opportunities presented by the varied employers located throughout the World Heritage Site.
- **Touristic attraction:** the monastery is one of the most visited touristic sites in Hungary, with approximately 150 thousand guests visiting in a year. One of our most important daily challenges is harmonizing the functionality of our tourism related goals and plans.

The habitat structure of the World Heritage Site is very complex. In the interest of understanding this complicated structure, my goal was not only to make environmental surveys, but also to analyze the historical land-use methods and spatial structures of the area, reaching as far back as 260 years.

The results provided by these historical studies give us clear answers to many of the questions presented by the present habitat and land-use structures that sit side by side.

Thanks to the thoroughness of the present land-cultivation systems in place, and to all the former historical surveys gathered from the past (which were more than innovative for their time) a unique chance is presented for scientific researchers to study the past 200 years of the World Heritage Site's finds.

The evaluation process of changes to the landscape can be based on the results of different remote sensing technologies. The first photograph of the Monastery was made in the first half of the 19th century. The static visuals captured in the photographs can be ordered in a timeline, in which the topographical changes are made visible as in a cinematic film, which helps us to understand the past changes leading to its present structure. When sorted in order the photographic data and documents within the archive provide an invaluable record for research.

To understand and develop the site in a sustainable way it is absolutely necessary to have a firm knowledge about the past. In the last 1000 years it was the Monastery's farming system which dominated the façade of the surrounding lands. The rich diversity of climate and soil conditions made it possible to create a diverse sustainable farming network in the region. As well as crop produce, animal breeding also has a strong past in this region, therefore it is possible to observe not only the former crop fields, but the former pastures and meadows as well, which are amongst the most important conservational areas today.

The traditional land use systems were in existence since the foundation of the Monastery in 996 until the 1950's. The sustainable land-use system was socialized, then the fields went under industrial agricultural use. Even though the natural and physical characters of the region (steep hillsides, high sensitivity to erosion and deflation, etc.) are not ideal for industrial use, damaging cultivation practices were continued until the 1990's. Along with those results, today we can find 2 to 3 big scale fields among the monastery, where traces of the historical holding-structures can also be recognized amongst the ruins.

One of the most important goals was to become acquainted with the site's pedological characteristics, as the different layers of soil shed light on the footprints of the past climatic, social and economical effects – like

agriculture. By analyzing the soil we can study the former natural and social environment that created and used the land in the past.

The goals of our botanical surveys were to create an extensive list of the local species, an overview of the surrounding natural habitat, and to map the naturalness of the Site as well. The main goals of the habitat-mapping are the following:

- To discover and document the botanical values of the World Heritage Site;
- To create a "0-point" diagram with the aid of current documentation, which can then be used in future developments and surveys;
- Using an international method (GHC) it is possible to compare this Site with other National and International World Heritage Sites;
- To be able to show those areas of the World Heritage Site where future development of the environment is planned, to ensure the Site receives as little disruption and destruction to the natural environment as possible.

During the complex surveying of the natural environment it is necessary to focus on the fauna of the Site as well. The surroundings of the Monastery have been heavily cultivated during the past few centuries; as a result the natural habitat of the local fauna has been drastically decreased.

One of the most valuable treasures of the region is the remarkably high number of bird species found in the area. Undoubtedly the most important habitat in the region for the bird population is the 200 years old Botanic Garden of the Monastery, where ornithological surveys and population monitoring has been carried out by the monks, students and professors of the Benedictine Higher School throughout the ages, both past and present. Because of the affluent variety and excellent monitoring systems I chose to focus on the birds out of the available fauna for my studies.

The main goals of the dissertation are the following:

1. To describe the historical structure of the land-use methods employed at the World Heritage Site;

2. To understand and describe the effects of the former land-use changes on the present structures;

3. To create a complex description of the World Heritage Site's natural worth – especially focusing on soil, botanical and ornithological abundance.

4. To document and create a data-map of the habitat's - and their natural state, found in the World Heritage Site;

5. To develop a sustainable and detailed land cultivation system for the World Heritage Site – based on former cultivation structures and natural worth;

6. To provide solutions on how to handle the different coexisting land-use functions and to solve the virtual antagonism of landscape protection and land-use;

7. To create a virtual base databank for future landscape conceptions of the Monastery.

MATERIALS AND METHODS

THE OBSERVED AREA AND ITS SURROUNDINGS

The surveys and observations were made on the world heritage site of Pannonhalma city. The northwest-southeast located hilly micro-region of Pannonhalma sharply stands apart from its surroundings; its composition and morphology are also unique. Thanks to the geomorphologic and natural endowments the region is described as an independent geographical entity (Stefanovits 1992):

- Macro region: Transdanubian Mountain Range
- Mezzo region: Bakony Region
- Micro region: Pannonhalma Hillside

The loess-covered hills are built up from pennon sediments. The soils are developed on these loess sediments, with the most typical soil types being the brown forest soils.

Due to agriculture the original forests have disappeared, subsequently the soil layers were destroyed by erosion. Pannonhalma and its surroundings are part of a historical wine region – viniculture contributed heavily to the severe impacts of erosion.

The climate of the region is also transitory between the Bakony Mountains and the Kisalföld Lowlands. While the Bakony has a colder climate, the Kisalföld is warmer and dryer (Marosi and Somogyi 1990).

Botanically the area is part of the *Arrabonicum* and *Vesperimense* micro regions. (Soó 1960) Between the mountains and the lowlands the flora is heterogenic: both mountain (*Carex Montana, Viola montana, etc.*) and lowland (*Adonis vernalis, Orchis purpurea, etc.*) species can be found here. Up until now approximately 1500 plant species have been found in the Pannonhalma hills.

The Pannonhalma Landscape Protection Area was established in 1992; both the Botanic Garden and the Park Forests of the World Heritage Site belong to it.

The transition characteristics of the region are noticeable in its fauna as well. The bird fauna of the area is extraordinary in the Carpathian Basin: rarities such as the wallcreeper (*Trichodroma muraria*) and common crane (*Grus grus*) have been observed here. However, populous European species

like the European bee-eater (*Merops apiaster*) and the raven (*Corvus corax*) are bountiful in the area as well.

The Archabbey of Pannonhalma has been a protected monument since 1949. It is part of the UNESCO World Heritage List since 1996. The World Heritage Site is 47,4 hectares, and is surrounded by a 310 hectare large Monumental Area.

ANALYSIS OF THE PHOTO ARCHIVES

One part of my landscape-history research was the analysis of the entire photo archives of the Monastery. 55 normal and 9 aerial photos were selected from the approximate 40.000 pictures, which are informative in landscape-history. The selected photos were grouped by their dates:

- Early images (made before 1896 – paintings, copper engravings, etc.)
- Photos before 1896 (1896: Millennium building operations)
- Photos between 1896 and 1939 (1939: Building operations of the Secondary School)
- Photos between 1940 and 2000 (The division and socialization of the former farming structure)
- Aerial photos (Photographs of particular interest from various time points)

The first step of the photo analysis was to appoint the geographic location of where the photo was captured and to re-take the photo from the same place. The changes and trends of land-use were described after the comparative analysis of the two pictures. I made 5 photo sequences from those photos, which were taken nearly in the same place at different times.

ANALYSIS OF ARCHIVED MAPS

Beside the photos I observed and made comparative analysis of archive and up-to-date maps and ortophotos. *For the sake of comparison,* all the digitalized maps were formed to 1:10.000 size. From the time-line of the studied maps it is possible to follow and detect the landscape changes. During my observations I used the following maps:

	Name	Date
1.	The first military map (1:28.000)	1784
2.	The second military map (1:28.000)	1847
3.	The supervised third military map (1:25.000)	1922
4.	Map – 1:25.000	1950
5.	Map – 1:10.000	1981
6.	Ortophoto	2000
7.	Ortophoto	2005

ANALYSIS OF LAND-USE CHANGES

The analysis of photos and maps made it possible to show the land-use changes over time. The separated items of the World Heritage Site were classified in Natural / Cultivated / Built categories. The transformations between categories were also marked. The boarders of the items were defined with a GARMIN GPSmap60CSX instrument; and the maps were drawn with Garmin MapSource 6.12.4 software.

SURVEYS ON PEDOLOGY

The in situ soil examinations (apr. 100 pcs.) were done by the Pürckhauer type soil core sampler (Finnern 1994) mostly on the examined botanical squares. (Szabolcs 1966, Baranyai et al. 1989) To define the types of soil and to describe the core samples we used the methodology of Stefanovits (1992) and Szodfridt (1993). The physical types of soil were defined with on-site measurements and with the soil-water capacity method (Stefanovits et al. 1999).

To examine the relationship of erosion, land-cover and land-use I designated a pedological sample area. Beside the Pürckhauer sampler I gained soil samples from the upper, middle, and lower part of the hillside, which were examined in the laboratory of the Saint Stephan University Dept. of Landscape Ecology – following the valid regulations (Búzás 1988, 1993). The pH was measured with electrometric technology; the total amount of $CaCO_3$ was measured with the method of Scheibler. K_2O was measured with flame-photometry. The amounts of different organic contents were determined with heating technologies.

To allocate and define the sampling spots we used GPS equipment.

BOTANICAL SURVEYS

Based on former literary works I compiled the very first list of species, which was used as a base during our on-site examinations. (Polgár 1941, Ballay w.d., Varga 1969, Hortobágyi 1988, Schmidt 2005) The on-site examinations were made throughout the whole year; all the found plants were recorded. The name of the species were used following the work of Simon (1992, 2000), the name of the associations were used following Borhidi and Sánta (1999). The names of the species were ordered in a chart, which – thanks to the special date columns – made it possible to define conclusions about the presence of the plants.

The Botanic Garden was one of our most important botanical areas; it was divided into 25 smaller plots (Rékási 2000). All the protected or endangered species were described and mapped, the GPS coordinates were saved.

ORNITHOLOGICAL SURVEYS

For the sake of reaching the original goals of the Dissertation the zoological surveys were confined to the observation of birds. We researched throughout the whole year, the list of species is constructed from the records of on-site observations, netting and lair programs. The birds, caught by our nets were ringed with the supervision of József Rékási Ph.D. The area was one of the sample areas of a monitoring program, coordinated by the Hungarian Birding Association (Nagy 1998).

The list of bird species contains only those birds, which are nesting, migrating, wintering, or through flying above the World Heritage Site. The species of the wider region are not on the list.

The species were defined following the Collins book (Hermann et al. 2000).

HABITAT MAPPING

During the habitat mapping I followed the methodology of the General European Habitat Monitoring Concept (GHC). The first step of the

habitat mapping was to determine those habitat elements of the World Heritage Site, which can be classified among the GHC categories:

- **Aerial element**: minimum 400 m^2 with minimum 5m width
- **Linear element**: wider than 0,5 m and longer than 30 m
- **Spot element**: other smaller elements – like smaller lakes

The second step of GHC mapping was to classify the recorded elements into the 6 major GHC habitat type:

- URB: urban areas
- CUL: cultivated areas
- SPV: sparsely vegetated areas
- TRS: trees, shrubs
- HER: herbaceous – minimum 30% covered with wetland
- Other HER: maximum 30% is covered with wetland

The third step of GHC mapping is to give special GHC codes for the elements, which shows the category of habitats. (DEC – deciduous, CON – conifer, etc.)

The habitat mapping of the Pannonhalma world Heritage Site included the following sub-exercises:

- Analysis of maps, photos, literature
- Preliminary surveyances
- On-site measurements, mapping
- Data processing, graphic works
- Post-on-site measurements, corrections on maps

ANALYSIS OF NATURAL STATE

The natural value of a habitat is influenced not only by the number of species, but by its natural state as well. The natural state categories of the habitats were defined following the classifying system of Seregélyes: totally

perished / heavily perished / perished / close-to-natural / natural (Seregélyes 1995).

The 1st category contains the non-natural, the 2nd and 3rd contain the close-to-natural, the 4th and 5th categories contain the natural habitats.

RESULTS

As part of my research I analyzed the photo archives of the monastery from a landscape-aspect. By comparing the photographic data and maps from different ages I was able to map and conclude trends of landscape changes.

During the complex environmental observation of the World Heritage Site I described the pedological and erosion aspects of the Site. For the purpose of completeness I compiled the list of plants and birds of the Site.

Based on the environmental surveys I drew the GHC habitat and the natural state map of the World Heritage Site

The new scientific results of the Ph.D. dissertation (comparing with the main goals) are the following:

Goal (1): To describe the historical structure of the land-use methods employed at the World Heritage Site;

Goal (2): To understand and describe the effects of the former land-use changes on the present structures;

New scientific results – connected to the goals:

1. I analyzed all the 40.000 photos of the Monastery Photo Archives according to the historical changes over time visible on the landscape. I separated, digitalized, retouched and renovated those photos, which give us important data about the landscape or the land-use of the World Heritage Site or the Monumental Area. The chosen photos are ordered in timeline.

2. I analyzed the different photos, maps and ortophotos according to the history of the landscape and land-use. I concluded their value based upon the differences, which were caused by significant landscape changes.

3. Based on the chosen photos and maps I described and determined the value of the land-use changes of the observed area from the 1780's until the present day. The results of the timeline analysis are showed on maps I created. The changes of the land-use categories were also systemized and depicted on maps and diagrams.

Goal (3): To create a complex description of the World Heritage Site's natural worth – especially focusing on soil, botanical and ornithological abundance.

New scientific results – connected to the goal:

4. Based on nearly 100 sampling spots and a pedological model site I described the soil characteristics of the studied area. With the laboratory analysis of soil samples gathered on-site, I was able to ascertain the sensitivity to erosion of the different sites with variant vegetation cover.

5. Based on the records of botanical surveys – made in different times and with different aims – I compiled a complex list of plant life. The lists found in various literary sources mentioning plants are complemented with the list of the plants of my own surveys. Besides the names of the plant species I recorded the changes of their presence (appearance, vanishing) as well. The list contains 1261 species, 94 are protected, 133 of them are neither mentioned in the documented literature, nor by the previously compiled plant lists.

6. I compiled a list of birds that were recorded on the World Heritage Site and on the Monumental Area. The 137 species, which are on the list, expand the 34% of the total bird fauna of Hungary. Considering the relatively small extent of the observed area this is more than impressive.

Goal (4): To document and create a data-map of the habitat's - and their natural state, found in the World Heritage Site;

New scientific results – connected to the goal:

7. Using the novel GHC methodology, which had previously been used only sparsely in Hungary, I prepared a habitat map of the whole World Heritage Site in Pannonhalma.

8. I prepared a natural-state map of the observed area. The conclusions and tendencies of this mapping are systemized and recorded.

Goal (5): To develop a sustainable and detailed land cultivation system for the World Heritage Site – based on former cultivation structures and natural worth;

Goal (6): To provide solutions on how to handle the different coexisting land-use functions and to solve the virtual antagonism of landscape protection and land-use;

New scientific results – connected to the goals:

9. Based on the results of my environmental and landscape history surveys I compiled the environment-related chapters of the Development Plan of the Pannonhalma World Heritage Site.

10. Using the results of my environmental and landscape history surveys I developed and constructed a demonstration path (*Eranthis Path*), which introduces the natural and topographical worth of the World Heritage Site. Based on the results of my botanical surveys I placed 100 information tables under the most valuable plants within the Botanic Garden.

Goal (7): To create a virtual base databank for future landscape conceptions of the Monastery.

New scientific results – connected to the goal:

11. Summarizing the results of the pedological, botanical, ornithological and land-use research I compiled and published an up-to-date data-base environmental databank of the Pannonhalma World Heritage Site and its Monumental surroundings. This databank can be the base for development plans and land-use conceptions in the future – especially for the new development plan of the Site.

CONCLUSIONS AND SUGGESTIONS

The **surveys on former and present land-use systems** showed that the active use of the landscape decreased during the centuries, then the cultivated and grazed areas slowly transformed into natural habitats. The fact, that some parts of the Pannonhalma Landscape Protection Area were under intensive cultivation 50-60 years before, proves that it is possible to make decisions on the development of protected areas in this time period as well.

From an environmental aspect the conditions, which originated from the abandonment and dis-use of rural areas, can be expressly useful: lots of lost natural riches can be rediscovered. This possibility must be kept in mind during all kinds of rural development works.

We established that with a good amount of background documentation (photos, maps, etc.) it is possible to describe former land-use systems accurately. The photos, taken throughout different time periods can piece together the maps from the same era, so that the researcher can gain lots of additional information.

Our **pedological surveys** mostly correlated with the available literature data, but our detailed studies concluded with more accurate results.

Presumably the pedological diversity discovered within the examined area can be found in the whole territory of the Pannonhalma Hillside. This could be the reason for the high diversity of habitats as well.

With regards to the high intensity of the effects of erosion it is more than important to keep this in mind in all kinds of developmental plans, which focus on the World Heritage Site.

The **plant list** of the relatively small area contains 1262 species, which underlines the outstanding botanical potential of the region. The fact, that 39 of the literary documents mentioned protected species that could not be found during our investigations shows the degradation of the site. The elimination of the former sustainable and diverse land-use system led to the decrease of botanical worth.

The fact, that after a long time we were able to find 4 protected plant species, can be estimated as the success of the land-use system's restoration.

The list of those plants, which were recorded in the Botanic Garden, is an important databank for gardeners and landscape architects. These plants were adopted and selected during the last 200 years, these could be planted in the region with a great chance of success.

Our **ornithological surveys** proved that a landscape with diverse structure can provide a home for a far richer flora and fauna, like the big-scale cultivated landscapes. Both mountain and lowland species can be found on our list, which proves that the region is a corridor between the mountain and the lowland.

The 137 species have wide diversity of lifestyles. The richness of bird species proves the richness of other animal groups as well.

The high number of the recorded migrating and wintering species proves the importance of the site in the wider regional habitat network. In the middle of the agrarian desert of the Kisalföld the 200 year old habitats of the World Heritage Site draw the birds with a magnetic force, like an oasis.

The results of the bird-ringing studies proved that the habitats of the site are playing an important role in continental bird migration as well.

The results of the **habitat surveys** proved that the long existence of a sustainable, landscape-compatible land-use system will lead to a diverse and high number of habitats.

One of the most important conclusions of our work is that it is possible to renovate and re-establish the former sustainable habitat structure even decades after it was destroyed. However it is crucial to help it with professional experts, who are absolutely familiar with the present and past of the area.

The results of the **natural state mapping** showed that even 100% human-made habitats can play an extremely important role for local flora and fauna. In a well constructed and accurately sustained land-use system, the uses and protection processes are not antagonists, but strengthen each other.

The **results** of my surveys are appearing **in the present developments** of the Monastery. The *Eranthis Path* helps to control tourists within the protected areas and demonstrates the natural worth of the Site at the same time.

The results of our botanical surveys became the basis for the **dendrobotanical rehabilitation** process, and for the new touristic development of the garden. 100 species from our plant list were tabled with small information boards.

Noting the results of our ornithological surveys the **timing of the tourism development project** left the nesting period undisturbed. Lots of old and dry trees were left in the Garden to ensure hiding and nesting places for birds and other animals.

My **suggestions on landscape protection** correlate with the latest developments: the biomass heating plant was placed under ground; the hill of the restaurant was restored, etc.

In order to demonstrate the natural values of the World Heritage Site the Monastery introduced **environmental programs** for the visitors. The professional basis of these programs is the result of my environmental surveys.

Most of my results and suggestions are appearing in the environmental chapters of the official **Development Plan of the Pannonhalma World Heritage Site.**

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