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USE OF ORNAMENTAL TREES IN DATING OF ABANDONED CEMETERIES ON THE EXAMPLE OF *THUJA OCCIDENTALIS* AND *THUJA ORIENTALIS*

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Abstract. Due to the lack of maintenance, abandoned cemeteries are often incorporated into the landscape. In many cases the information about the age of the cemetery is unavailable. To find out the approximate time of the formation of the cemetery the information recorded in the annual tree and shrub rings can be used. One of the most common tree species, planted for ornamental and symbolic purposes on the cemeteries, are *Thuja orientalis* and *Thuja occidentalis*. Alien to the Polish flora, these species adapted well to the local habitat and climatic conditions. The paper presents an attempt to apply dendrochronological dating to determine the age of the abandoned cemeteries in the region of the Great Masurian Lakes, part of the Masurian Lake District (north-eastern Poland). The study included five abandoned cemeteries. In total, 15 cores were taken from the trees. After applying the standard dendrochronological method, local chronologies for the studied species were established. The research indicated that the oldest found specimens - over 70 yrs old - are *Thuja occidentalis* individuals growing at the Słabowo cemetery. At the other sites the specimens of both *Thuja* species date back to the 1960s and early 1970s. Compared to the historical information regarding the age and origin of the studied objects, thujas growing there are much younger than the age of the cemeteries foundation. The presented method proved to be very helpful in understanding the time of *Thuja occidentalis* and *Thuja orientalis* introduction at the investigated cemeteries.

Keywords: dendrochronological dating, *Thuja occidentalis*, *Thuja orientalis*, abandoned cemeteries, Great Masurian Lakes Region

Introduction

Cemeteries are an important element of the landscape. Because of their specificity, they have a number of natural and cultural values. Above all, however, they serve as the final resting place of our ancestors. Of particular note are abandoned cemeteries, where the processes of ecological succession and development of biocenotic systems occur (Majgier 2012). These processes, combined with the lack of maintenance, lead to seizure of the cemetery substance. Together with the acts of vandalism, which lead to the destruction of the cemetery infrastructure, it is often difficult to determine the origin and age of the object, especially when there are no other sources of information.

In order to determine the approximate age of a cemetery, it is possible to use the information stored in the annual growth rings trees and shrubs located at the cemetery with the use of the dendrochronological method. The dating method, based on the counting and analysis of the annual growth of trees and shrubs, is used to determine the time of the creation of archaeological and architectural monuments (Zielski & Krapić 2004). Den-

drochronological determination of the age of trees was also used in the studies of secondary succession (e.g. Dyrenkov *et al.* 1987, Douda *et al.* 2009) as well as in the study of the landforms creation (e.g. Van der Burght *et al.* 2012, Pierson 2013). Thus the dating of vegetation growing at a given cemetery also can be a good indicator of the time of its creation.

Due to the lack of preserved infrastructure the identification of a cemetery is often questionable. The identification of the object can be based on vegetation, as characteristic species and their composition may indicate the existence of the cemetery in a given place (Czarna 2004, Majgier 2009, Żurkowska 1999, 2000, 2008). One of the most specific cemetery tree species, alien to the Polish flora, are: *Thuja occidentalis* and *Thuja orientalis* (Żurkowska 2000, 2008). These species are present at the old and new cemeteries for their decorative value, as well as symbolic meaning.

Thuja occidentalis is a North American tree species, which was brought to today's Polish territory in the 17th c. (Seneta 1981). This species is adapted to different habitat conditions, including wetlands. In its natural environment it reaches the age of about 400 years (Seneta

1981). The use of this species for decorative purposes on a larger scale in the Polish lands is associated with its good adaptation to the local habitat and climatic conditions, including severe frost (Seneta 1981).

Thuja orientalis was imported to Europe from Japan in the 17th c. In the same period of time it was brought to the Polish territory. This is a low tree species coming from Southeast Asia (Seneta 1981). Due to poorer adaptation to the already existing habitat and lower resistance to climatic conditions it is a much less common thuja species in the Polish lands as compared to *Thuja occidentalis* (Seneta 1981). However, it is characterised by higher decorative values.

The aim of this study is to present an attempt to apply the dendrochronological method to determine the age of the abandoned cemeteries using *Thuja occidentalis* and *Thuja orientalis* specimens on the example of the Ryn commune, the Warmińsko-Mazurskie voivodeship. It is the first such study undertaken to determine the age of the abandoned cemeteries using the dating of living trees. This is also one of the few works concerning the *Thuja* genus (Gławenda & Koprowski 2012). The article addresses the question whether the proposed method can be used to verify the historical data or to obtain the approximate date of establishing the cemetery in the case where there are no other sources of information about the object.

Study area

The study was conducted at five abandoned evangelical cemeteries (Table 1) in the Ryn commune located in the Great Masurian Lakes Region, which is the mesoregion in the central part of the Masurian Lake District (Kondracki 2009) (Fig. 1). The landscape of the Great Masurian Lakes is characteristic for the areas formed during the last glaciation. The terrain is undulating and hilly, with many lakes (Kondracki 2009). The climate of the discussed area is classified as lakeland climate, which is characterised by high humidity, cold, long winters and frequent spring ground frosts (Romer 1949).

The investigated objects are mid-field and mid-forest cemeteries. According to the existing *Cemetery Cards* (Karty cmentarzy..., 1985), they were founded in the 19th and early 20th c. by the population of German origin. After the end of World War II they were abandoned and presently no longer perform their original function because their original founders had left the Polish lands. Currently, most of the objects are destroyed and completely integrated into the landscape.

Methods

The field studies were carried out in 2011. Five cemeteries were chosen for the investigation. Tree cores were collected at the height of 1.3 m with the Pressler's borer (400 mm long and has 5 mm in diameter). The holes created in the trunks were protected against the negative influence of biotic factors. In total, 15 samples were collected, which then were prepared according to

the standard dendrochronological procedures. After the preparation of the wood samples, the measurements of the width of annual rings were performed to the nearest 0.01 mm using the dendrometer Lintab 6 Rinntech. The measurement and processing of the data was performed using the TSAP Professional software.

Table 1. General characteristics of the investigated cemeteries; **Source:** own elaboration based on *Cemetery Cards* (Karty cmentarzy..., 1985) and fieldwork

Name of the cemetery	Period of foundation	Area [ha]	Location	Comments
Canki Cemetery	II part of 19 th c.	0,26	- northern part of the village Canki, on the hill - cemetery in the forest	- 22 complete concrete tombstones with tables
Mioduńskie Cemetery	19 th /20 th c.	0,1	- a small hill on the outskirts of Mioduńskie – cemetery in the midst of agricultural fields	- 6 concrete tombstones and 4 ground graves - very destroyed cemetery
Rybical Cemetery	end of 19 th c.	0,1	- 2.5 km on the south of the village Rybical – cemetery in the forest	- 3 very destroyed tombstones, without preserved tables - very destroyed cemetery
Słabowo Cemetery	1906	0,24	- a small hill, about 200 m from the village Słabowo – cemetery in the midst of agricultural fields	- 11 concrete tombstones and 11 ground graves - very destroyed cemetery
Wejdyki Cemetery	1891	0,39	- edge of the forest, 1000 m on the north-east of the village Wejdyki - cemetery in the forest	- 51 concrete tombstones and 19 ground graves

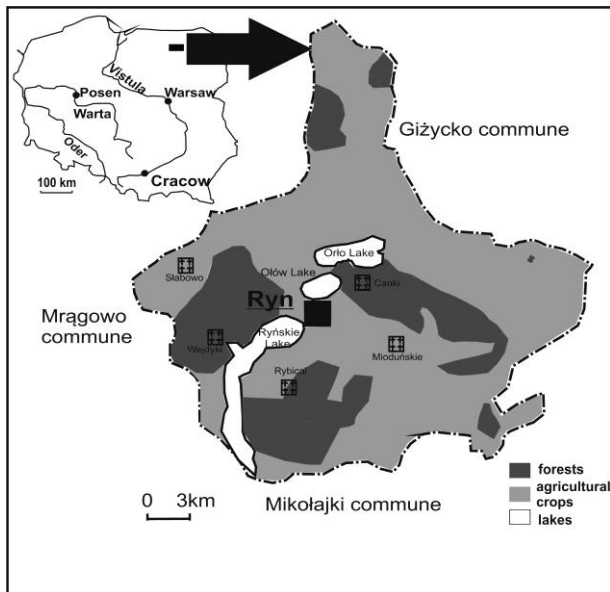


Fig. 1. Location of investigated cemeteries in the Ryn commune

The sequences of the annual growth ring widths for each tree, which are a record of its age at the same time, were obtained. The individual annual rings were synchronised with the calendar years (Stokes & Smiley 1996). From the obtained incremental curves the reference scales for each species were constructed. In order to identify tree-ring anomalies (e.g. missing rings, false rings), which could affect the accuracy of determining the age of trees, individual tree chronologies were compared with the reference chronology (Schweingruber 1998, Zielski & Krąpiec 2004). If the pith is reached the age of the trees is determined with an accuracy of up to one year. In other cases, the age of the tree is an estimation obtained by adding the number of few to several missing years. For the age estimation a simple method that uses the curvature of tree rings was applied (Applequist 1958).

As it was not possible to take samples from the butt of the trunk, one should keep in mind that the age obtained at a height of 1.3 m is slightly lower than the actual age of a tree. Taking into account the average growth rate of *Thuja* it was estimated that the height of 1.3 m is reached approximately at the age of 5 years (Senneta 1981). Therefore five years is added to every dating result.

The resulting age of the studied trees was compared with the information coming from the *Cemetery Cards* established in 1985 during the inventory conducted by the Archive of the Office of the Monuments Documentation in Suwałki.

Results

The investigated trees are of two species: *Thuja occidentalis* and *Thuja orientalis*. The wood of these species was characterised by clearly visible annual ring boundary, clearly darker late wood, and the lack of resin canals. The average growth rate of the investigated trees was from 0.4 to 3 mm. The analysis of the samples revealed no evidence of tree-ring anomalies. In addition, incremental sequences were characterised by a very high compliance (the average correlation between the series was 0.5). The age of the first ring at diameter at breast height of analysed trees is shown in Table 2. The synchronisation of individuals curves from different sites with reference scale (the example of *Thuja occidentalis*) is presented in Figure 2.

Table 2. List of datings of particular incremental sequences of *Thuja* from the investigated sites

Sample name	Species	approximate date of planting*
CANKI_01	<i>Thuja occidentalis</i>	1945
MIODUŃSKIE_01	<i>Thuja occidentalis</i>	1955
MIODUŃSKIE_02	<i>Thuja occidentalis</i>	1957
MIODUŃSKIE_03	<i>Thuja occidentalis</i>	1968
MIODUŃSKIE_04	<i>Thuja occidentalis</i>	1967
SŁABOWO_01	<i>Thuja occidentalis</i>	1949
SŁABOWO_03	<i>Thuja occidentalis</i>	1933
SŁABOWO_04	<i>Thuja occidentalis</i>	1959
SŁABOWO_05	<i>Thuja occidentalis</i>	1930
SŁABOWO_06	<i>Thuja occidentalis</i>	1941
RYBICAL_02	<i>Thuja occidentalis</i>	1957
SŁABOWO_02	<i>Thuja orientalis</i>	1959
RYBICAL_01	<i>Thuja orientalis</i>	1960
WEJDYKI_01	<i>Thuja orientalis</i>	1963
WEJDYKI_02	<i>Thuja orientalis</i>	1966

*_after taking into account the adjustments described in the methodology

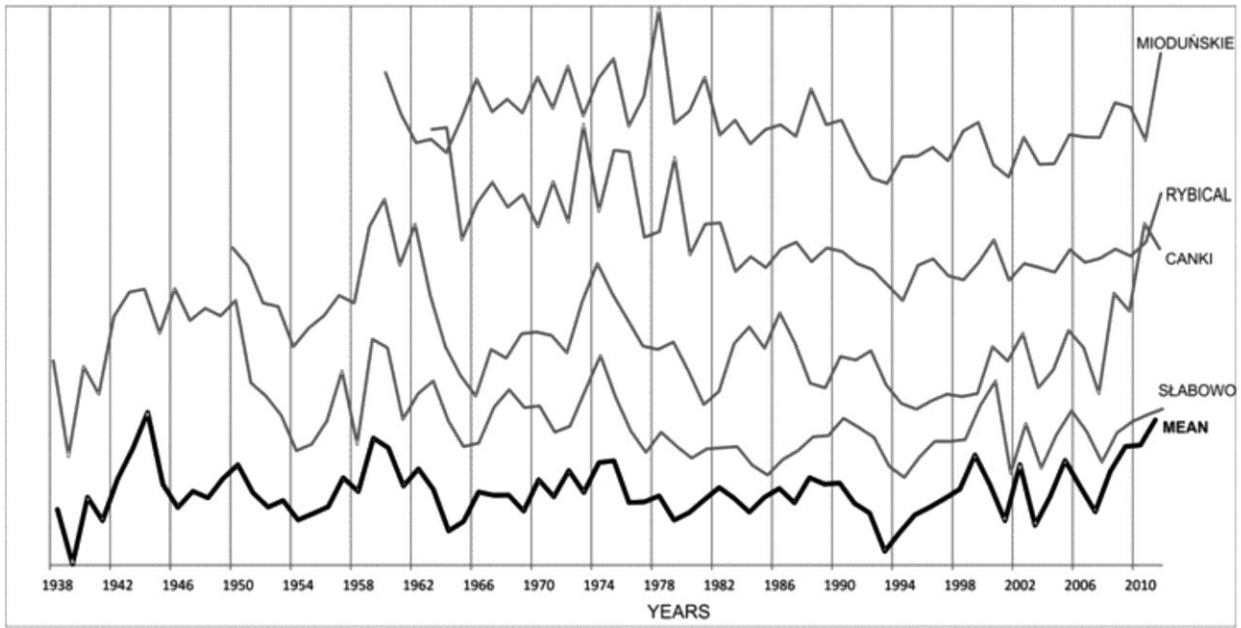


Fig. 2. Tree-ring width curves of wood samples from the selected abandoned cemeteries and the mean curve of *Thuja occidentalis* from the Great Masurian Lakes



Fig. 3. An example of *Thuja occidentalis* at the Słabowo cemetery

Discussion

The oldest analysed trees belong to *Thuja occidentalis* species (Fig. 3). They grow at the Słabowo cemetery, from which majority of the samples were collected. The oldest specimens from this cemetery, which are also the oldest among all the surveyed trees, date back to 1935 and 1938. At the other cemeteries the trees date back to the 1960s and 1970s. The youngest specimens were found at the Mioduńskie cemetery (see Table 1).

With regard to the species of *Thuja orientalis*, which occurs at the studied cemeteries much less frequently (single specimens at the cemeteries of Słabowo, Rybical and Wejdyki), all specimens are similar in their age dating back to the 1960 and early 1970s.

Comparing the obtained dendrochronological results with the age of the cemeteries from the *Karty cmentarne... (1985)* and the field verification on the basis of the existing tombstones, it can be seen that most of the trees were planted much later than the date of establishing the cemeteries. Only at the Słabowo cemetery thujas were used for ornamental purposes during the operation of the cemetery before World War II. At the other places thujas were planted about 20 years after the cessation of the cemeteries' use. At the most sites the last burials took place in 1945, however, single individual burials were conducted in the 1950s. Probably over the life of the cemeteries, that is from the mid-19th c. to the end of World War II, thujas were not used for ornamental purposes. They were planted by the descendants of the buried people in memory of their relatives already after the cemeteries had been abandoned. The founders and users of all cemeteries in the today's Ryn commune were the people of German and Masurian origin (Sapatka 2003). After the World War II, as a result of expulsions, they left the held lands. Hence, the cemeteries were left unattended (Płotek 2011). Starting at the beginning of the 1960s, the descendants of the population living in the area before World War II came to Masuria in order to search their roots, as well as visit the graves of their relatives (Wakar & Willan 1966). The greatest number of the examined specimens of the two species of *Thuja* date back to this period of time.

Summary

The cores obtained from the two *Thuja* species occurring at the studied cemeteries, *Thuja occidentalis* and *Thuja orientalis*, allowed the researchers to determine the age of the trees. The oldest found specimens, over 70 years old, were *Thuja occidentalis* occurring at the Słabowo cemetery. The specimens of both species growing at the other sites date back to the 1960s and early 1970s. In comparison with the historical information about the age and origin of the studied sites, the thujas specimens growing there are much younger than the time of the establishment of the cemeteries. As a result, it can be concluded that these species were not used for ornamental purposes by the original founders of the cemeter-

ies, but might have been planted by their descendants some time after the period of the cemetery use.

The application of dendrochronological method for determining the approximate time of the foundation of the Protestant cemeteries, presented in this paper, is not entirely verified in this case. This is due to the later introduction of the studied species at the cemeteries than the period of their foundation. Therefore, in determining the age of the objects such as cemeteries the verification with the data received from other sources is required. In the absence of accurate historical documents, the dating of the founding of the cemetery can be based on the dating of wood elements found in burial coffins, as was documented in the works of Park & Lee (2009) and Ważny (2009). However, the presented method proved to be very helpful in understanding the introduction of *Thuja occidentalis* and *Thuja orientalis* at the surveyed cemeteries.

Methodologically the obtained results (chronology parameters, no ring anomalies, great similarity of the incremental pattern) also prove a great suitability of the *Thuja* sp., alien to the Polish flora, for dendrochronological studies and its research potential.

Acknowledgements

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- ki, doskonale zaadaptowały się do zastanych warunków siedliskowych i klimatycznych.
- W pracy przedstawiono próbę zastosowania metody datowania dendrochronologicznego do określenia wieku porzuconych cmentarzy z Krainy Wielkich Jezior Mazurskich. Badaniem objęto 5 porzuconych cmentarzy. Ogółem pobrano 15 wywierców z drzew. Po zastosowaniu standardowej metody dendrochronologicznej, utworzono lokalne chronologie przyrostowe dla badanych gatunków. Badania wykazały, iż najstarsze okazały się być okazy *Thuja occidentalis* występujące na cmentarzu Słabowo, których wiek wynosi ponad 70 lat. Na pozostałych obiektach rosnące okazy obydwu gatunków żywotników datowane są na lata 60. i początek lat 70.XX wiek. W porównaniu z informacjami historycznymi o wieku i pochodzeniu badanych obiektów rosnące na nich okazy żywotników są znacznie młodsze niż wiek założenia cmentarzy. Przedstawiona metoda okazała się być niezwykle pomocna w poznaniu czasu wprowadzenia żywotników *Thuja occidentalis* i *Thuja orientalis* na badanych cmentarzach.

Słowa kluczowe: datowanie dendrochronologiczne, *Thuja occidentalis*, *Thuja orientalis*, porzucone cmentarze, Kraina Wielkich Jezior Mazurskich

Abstrakt

Porzucone cmentarze w związku z brakiem pielęgnacji często wkomponowują się w krajobraz. Niejednokrotnie brak jest zachowanych informacji o wieku cmentarza. Aby poznać przybliżony wiek powstania cmentarza można posłużyć się informacją zapisanymi w przyrostach rocznych drzew i krzewów. Jednymi z najczęściej występujących drzewiastych gatunków sadzonych w celach ozdobnych i symbolicznych na cmentarzach są *Thuja orientalis* i *Thuja occidentalis*. Te obce dla flory polskiej gatun-