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Tree-ring study of the island formation and riparian forest along a gravel-bed river in the Polish Carpathians

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Introduction

The Białka River is one of the last relatively undisturbed, gravel-bed rivers in Central Europe (Baumgart-Kotarba 1980, 1985). Although its riparian zone and floodplain are partly subject to human activities, the character of both island vegetation and the river channel remain typical of the formerly widespread, semi-natural, braided rivers in the Carpathians (Fig. 1). Such conditions give an opportunity to investigate islands remaining in an almost undisturbed form as well as their development. The study aims at reconstructing spatial and temporal dynamics of the island evolution in a gravel-bed river.

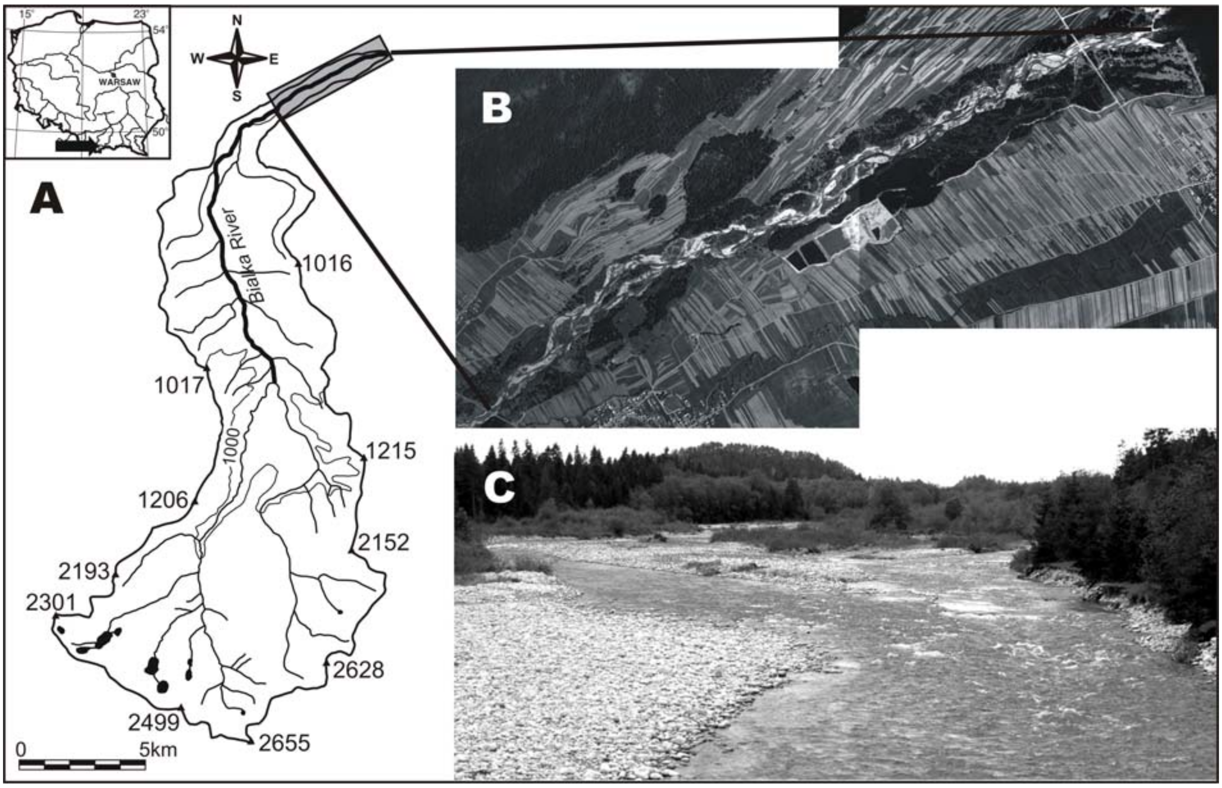

Figure 1: Catchment of the Białka River with location of the studied section (shaded) (A). Island-braided channel of the Białka River as shown on an orthophoto (B) and a ground photo (C).

Geographical setting, data and methods

The Białka River drains an area of 230 km^2 in the Western Carpathians, including a part of the high-mountain Tatras. With high flow variability and a steep channel slope, the river is characterised by the occurrence of a cobble bed and a highly dynamic pattern of braids, bars and islands within its active zone. The research was conducted in a 5 km long section of the lowest river course, where the river is widest (up to 420 m) and islands and bars are most common. Willow and alder predominate on most of the islands, whereas spruce and pine grow on older islands and in the riparian forest.

Twenty-six established islands, their entire population in the section, and the associated pioneer islands were analysed. Initial investigations revealed the existence of two types of islands: (i) islands developing by vegetation growth on mid-channel bars; and (ii) those originating as a result of dissection of riparian forest or already existing islands by braids. Here, we present the results of a study focused on the first type, represented by the population of 12 islands located in the lower course of the investigated river section. Standard dendrochronological techniques were employed to determine the age structure of trees growing on the islands and in the riparian forest. The age of the oldest specimens was considered to represent a minimal age of the island. Age structure of the vegetation in five different zones of the islands was employed as a proxy of their spatial development (Fig. 2).

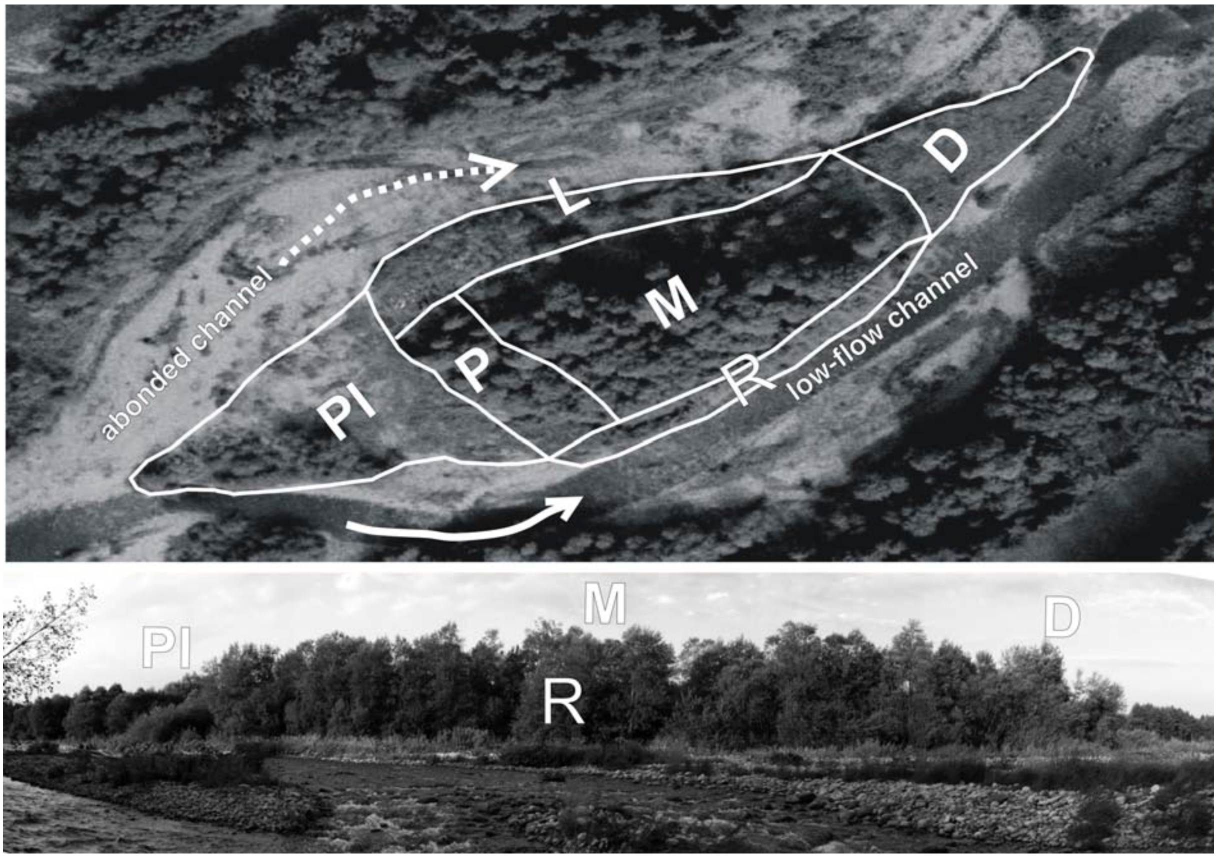

Figure 2: Sampled zones of islands: PI - initial proximal side of island, upstream zone, P - proximal zone with well-established trees/shrubs, M - middle part of island, R - right marginal zone, L - left marginal zone, D - distal, downstream part of island.

Results and discussion

So-defined minimal age of islands is related to the occurrence of major floods that effectively change the pattern of a braided channel. On the Białka River, such floods last occurred in 1997 and 2001. Although a signal of previous floods is less apparent in tree-ring dating, a comparison of the age of the islands (average age of sampled trees amounts to 7 years, n=216) and the riparian forest (34 years, n=60) reveals significant differences in the factors controlling development of both elements of the riverine landscape. The age of islands is related to the occurrence of floods, whereas that of the riparian forest is more independent of a natural dynamics and largely determined by human activity. While the river has an ability to form braids within its active zone freely, lateral migration of the entire channel is limited in many locations by channelization structures.

In most of the cases, the youngest trees grow on the head of island (PI) and age of trees gradually increases through the proximal zone (P) to the middle zone (M) (Fig 3). The downstream zone of island (D), less protected from the action of flood waters than the middle one (M), is overgrown by younger trees than both M and P zones. No significant difference between the age of trees on both sides of island (R and L) was found. The island head is the place where gravel and woody debris are trapped during floods. That process, observed on all studied islands, implies their growth in the upstream direction, by which new space for vegetation succession is created.

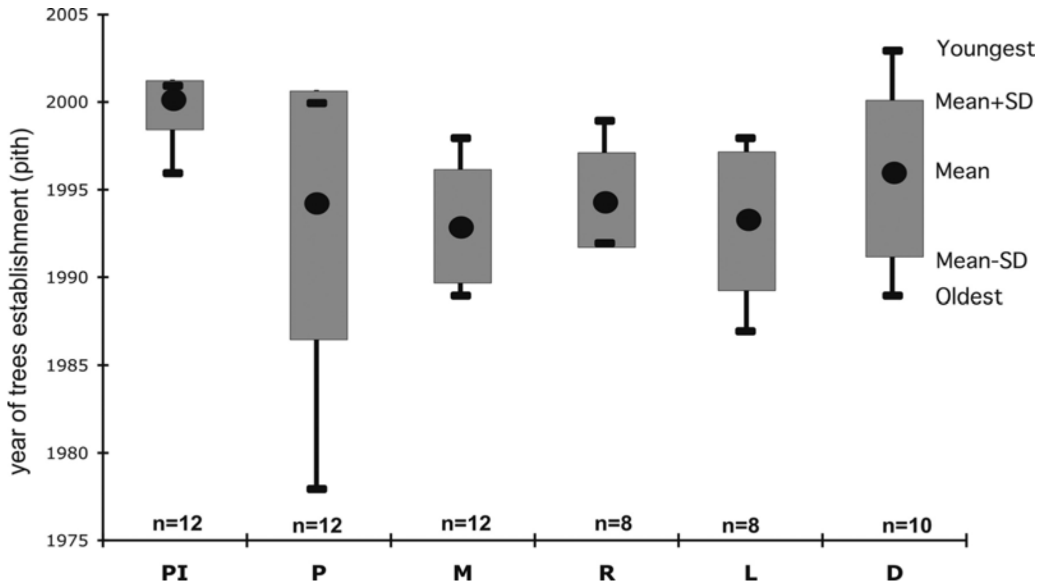

Figure 3: Age structure of trees in particular island zones as a proxy of spatial island development. The age of oldest specimens represents a minimal age of the island. Island head (PI), where gravel and woody debris are trapped, is the youngest, whereas the well-protected, middle zone (M) is the oldest one.

One of the factors responsible for island initiation is the presence of large woody debris (LWD) in the river channel (Abbe & Montgomery 1996, Edwards et al. 1999, Gurnell et al. 2001). The size and amount of LWD is crucial for this process (Millar 2000). In the rivers of the western part of North America, draining pristine and old-growth forests, large fallen trees are stable in-channel features, which promote sediment deposition and vegetation establishment (Fetherstone et al. 1995). The relatively small size of LWD delivered to the Białka River is a consequence of young age of the managed, riparian forest. Moreover, removal of larger wood pieces from this, and also other European rivers, for firewood (cf. Piégay 1997, Kollmann et al. 1999, Gurnell et al. 2001) reduces wood quantity and increases its mobility. Small pieces of trees and bushes remaining in the rivers are unable to play a key role in island development. Under such conditions, vegetation is a major factor controlling island development. The age structure of vegetation on the investigated islands indicates island development in the upstream direction (Fig. 4A), rather than in a downstream one as is typically observed when large trees protect the head of island (Fig. 4B). This pattern of island formation seems to be representative of European braided rivers, in which the amount and size of LWD are strongly controlled by human activity (Edwards et al. 1999, Ward et al. 1999, Gurnell & Petts 2002).

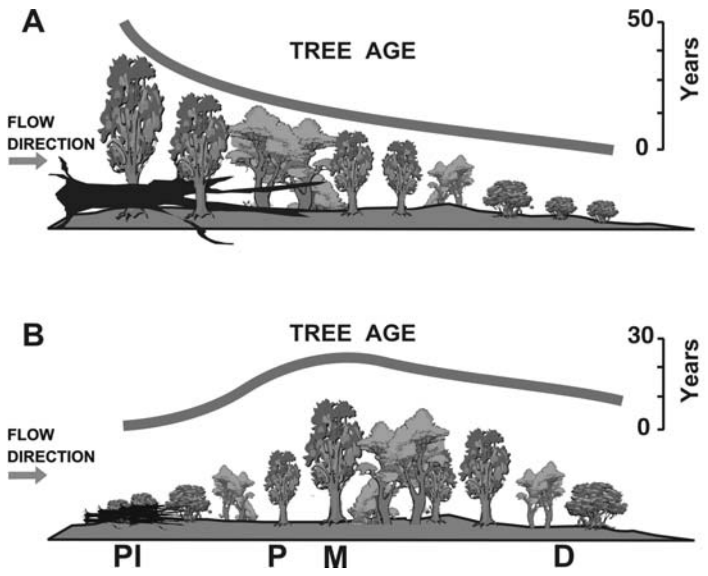

Figure 4: Models of island growth for: (A) rivers of the Pacific Northwest (bigger trees, important role of LWD in island development), (adapted from Fetherstone et al. 1995); and (B) European braided rivers (smaller trees and bushes, important role of vegetation in island growth).

Conclusions

1. Though preliminary results indicate different scenarios of the island initiation and development, registered in the tree-ring proxy, a common pattern exists - the oldest trees grow in the central, best protected part of the islands.
2. The decrease in tree age from the island centre is more pronounced in the upstream than in the downstream direction. Centrally growing trees play an important role in the island development as they trap wood and mineral sediment on the upstream island margin, hence stimulating growth of islands in the upstream direction.
3. That pattern of island formation seems typical of mountain European rivers, from which large wood pieces are typically removed and where the resultant lack of key-member fallen trees prevents initiation of bar and island formation in their hydraulic shadow.

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