

Twentieth-century development of floodplain forests in Polish Carpathian valleys

Développement des forêts alluviales dans les vallées polonaises des Carpates au vingtième siècle

Hanna Hajdukiewicz , Bartłomiej Wyżga

Institute of Nature Conservation, Polish Academy of Sciences, al. Mickiewicza 33,
31- 120 Kraków, Poland

RÉSUMÉ

Les changements de l'étendue des forêts dans les corridors de quatre rivières des Carpates polonaises au cours des 130 dernières années et leur relation avec les changements de la géométrie des rivières en plan ont été étudiés par l'analyse de cartes à l'échelle 1:25000 datant des années 1870 et d'images aériennes du milieu du 20e siècle et de 2009. Les proportions moyennes de la rivière, de la plaine d'inondation et de ses caractéristiques de couverture terrestre dans la largeur/superficie totale des corridors fluviaux analysés ont été déterminées pour les trois dates. Toutes les rivières analysées ont rétréci de manière significative au cours de la période d'étude. La superficie des plaines d'inondation a augmenté tandis que les parties latérales des anciens canaux larges se sont boisées. La proportion de forêt dans la zone totale des corridors fluviaux a augmenté et l'expansion de la forêt a été principalement motivée par les travaux de canalisation qui ont récupéré des parties des anciens canaux des rivières. Une réduction du débit et de la dynamique sédimentaire des rivières des Carpates au cours du 20ème siècle a permis le développement d'îles ; cependant, les travaux de canalisation ont éliminé les îles de la plupart des tronçons de rivière et les îles n'ont donc persisté que dans les rares tronçons non gérés. L'expansion des forêts de plaine inondable dans les vallées des Carpates améliore le fonctionnement des écosystèmes fluviaux, mais l'apport accru de gros bois dans les canaux fluviaux qui en résulte peut générer des risques d'inondation. Une gestion optimale des rivières devrait éviter la suppression des arbres riverains mais permettre le transfert non perturbé du bois flotté à travers les sections de pont afin de minimiser le risque d'inondation.

ABSTRACT

Changes in forest extent in the corridors of four rivers of the Polish Carpathians over the last 130 years and their relation to changes in planform river geometry were investigated through the analysis of 1:25000-scale maps from the 1870s and aerial images from the mid-20th century and 2009. Average proportions of river, floodplain and its land cover features in the total width/area of the analysed river corridors were determined for the three dates. All the analysed rivers narrowed significantly over the study period. Floodplains area increased while lateral parts of the former, wide channels became afforested. The proportion of forest in the total area of the river corridors increased and the forest expansion was mainly driven by the channelization works that reclaimed parts of the former channels from the rivers. A reduction in flow and sediment dynamics of Carpathian rivers over the 20th century enabled development of islands however, channelization works eliminated islands from most river reaches and thus islands persisted only in scarce unmanaged reaches. The expansion of floodplain forests in Carpathian valleys improves functioning of the river ecosystems but the resultant increased delivery of large wood to river channels may generate flood hazard. Optimal river management should avoid removal of riparian trees but enable undisturbed transfer of driftwood through bridge cross-sections to minimize the flood hazard.

KEYWORDS

channelization, floodplain forest, forest expansion, river corridor, river island

1 INTRODUCTION

A considerable increase in forest cover that occurred in the Polish Carpathians over the 20th century reflected not only the increase in the proportion of forest on hillslopes but also on valley floors. In the second half of the 19th century, valleys of Polish Carpathian rivers were typified by a lack or only scarce occurrence of floodplain forest (e.g. Wyżga et al., 2012). This situation was also typical of other mountain areas in Europe (Rinaldi et al., 2013). The lack of floodplain forest in major river valleys in mountain regions resulted from the formation of wide, highly mobile river channels and the use of riparian areas for cultivation and grazing. In the 20th century, floodplain forest developed in the valleys of major Carpathian rivers. This study aims to determine the course and causes of the 20th-century expansion of floodplain forest in the river valleys using the examples of four rivers draining various parts of the Polish Carpathians.

2 STUDY METHODS

The development of floodplain forests in the 20th century was analysed in the middle course of the Czarny Dunajec draining the Inner Carpathians, in the lower course of the Koszarawa and the upper course of the Biała flowing in the western and eastern parts of the Outer Western Carpathians, respectively, and in the middle course of the Raba within the Carpathian Foothills. The analyses were performed with the use of: (i) map of the Third Military Survey of the Austro-Hungary at a scale of 1:25000 from the 1870s, which was scanned and georeferenced in the PL–1992 coordinate system using control points, (ii) orthophotos produced from archival aerial photographs taken at around the mid-20th century at scales varying between 1:10000 and 1:24000 and (iii) orthophotos from 2009 at a scale of 1:10000. The boundaries of floodplain and active zone of the rivers shown on the historical map and the orthophotos were digitized using ArcGIS software. The following land cover categories were subsequently distinguished and digitized within the active river zones: low-flow channels, channel bars and islands. In turn, the floodplain areas were subdivided into floodplain forest, unforested area and built-up area. The width of active river zone, total area and width of river corridor, area of floodplain and river and floodplain land cover categories as well as a combined area of floodplain forest and islands were determined in 100-m-long segments of the river corridors. Then, the percentage of individual land cover categories in the total area/width of the river corridor in each segment was calculated and mean proportions of these categories at particular analysed dates were determined for the study reaches of the four rivers.

3 RESULTS

Despite their different setting, all the analysed Polish Carpathian rivers experienced significant narrowing during the last 130 years, although they differed in the timing and the degree of the narrowing. The width of the Czarny Dunajec River decreased by three-fourths and the degree of the river narrowing was similar in both periods analysed (between the 1870s and the mid-20th century, and since then to 2009). The Raba River narrowed by more than three-fourths, with a greater part of the narrowing having occurred in the second period. The narrowing of the Koszarawa took place in the second half of the 20th century, while most of the narrowing of the Biała was recorded in the first half of the century. As a result of the river narrowing, the proportion of floodplains in the total area of the river corridors increased; in the case of the Biała, it doubled from 42% to 84%. The expansion of floodplain forest was reflected in a very significant increase in the proportion of forested area on the valley floors – in 2009 forest covered from 28.5% (Czarny Dunajec) to 46.5% (Koszarawa) of the total corridor area (Fig. 1). The most significant increase in forest area since the second half of the 19th century was recorded in the Biała valley. In the valleys of the Czarny Dunajec, Biała and Raba rivers, the increase in the area of floodplain forest between the 1870s and 2009 was almost the same as that in floodplain area (Fig. 1). Here, floodplain forest developed on lateral, higher parts of the former, wide channels that were reclaimed from the rivers as a result of river channelization and incision. In the Koszarawa valley, until the mid-20th century floodplain area did not increase but floodplain forest developed as a result of the abandonment of agriculturally and pastorally used areas. In the second half of the century, lands reclaimed from the river as a result of its channelization were also left for forest development (Fig. 1). In the first half of the 20th century, forest development on floodplains of all studied Polish Carpathian rivers was accompanied by the appearance or increased occurrence of islands in the active river zones. However, as channelization works have led to elimination of islands from the rivers, islands persisted only in the reaches that avoided channelization in the second half of the 20th century.

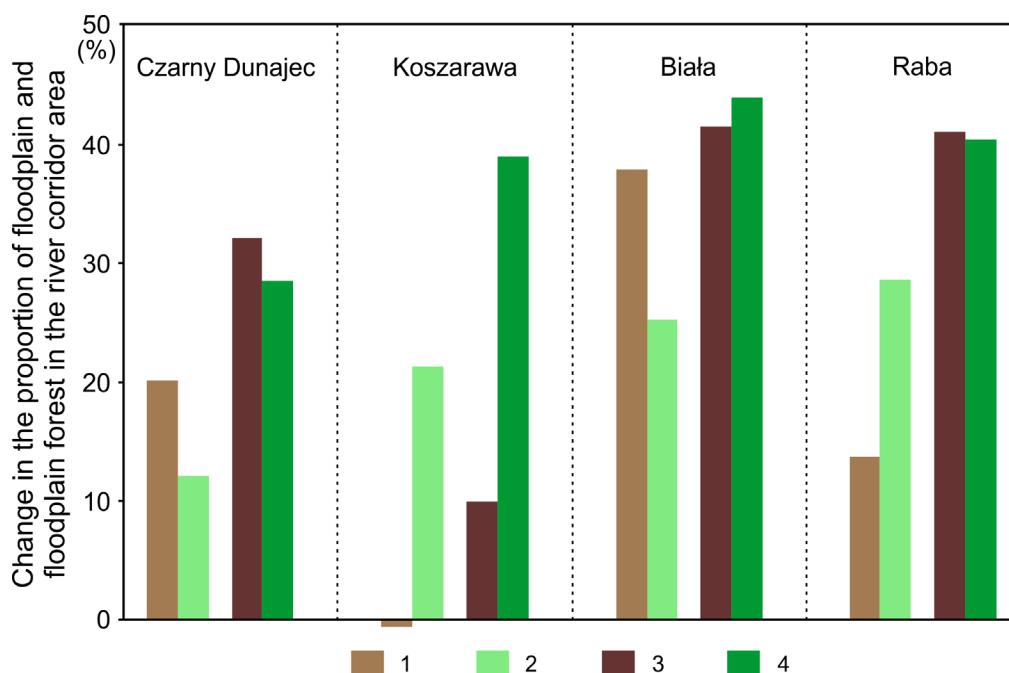


Figure 1. Changes in the average proportion of floodplain (1, 3) and floodplain forest (2, 4) in the total area of the corridor of the Czarny Dunajec, Koszarawa, Biała and Raba rivers between the 1870s and the mid-20th century (1-2) and between the 1870s and 2009 (3-4).

4 CONCLUDING REMARKS

In the 20th century, rivers of the Polish Carpathians narrowed considerably and the expansion of forest in their valleys was predominantly a by-product of the river narrowing. Forest encroached on lateral, higher parts of former river channels that were no longer disturbed by channel processes after river channelization and/or incision. Afforestation of riparian areas following the abandonment of their agricultural or pastoral use was a less important mechanism of forest expansion in the river valleys. Forest expansion in the valleys of Polish Carpathian rivers beneficially influences the functioning of river ecosystems. However, the most evident result of the development of floodplain forests is the delivery of considerable amounts of large wood to river channels during floods, which may be a cause of flood hazard (Wyżga, 2007). Recognition of these facts is essential for the improvement of river management practices that should take into account the resultant changes in physical processes in rivers, the beneficial influence of forest communities on the environmental values of river corridors, and the impact of large wood delivered to river channels on flood hazard in the valleys. Optimal river management should thus avoid removal of riparian trees but enable undisturbed transfer of driftwood through bridge cross-sections to minimize the flood hazard.

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