Island development in a mountain river recovering from channelization and channel incision: the Raba River, Polish Carpathians

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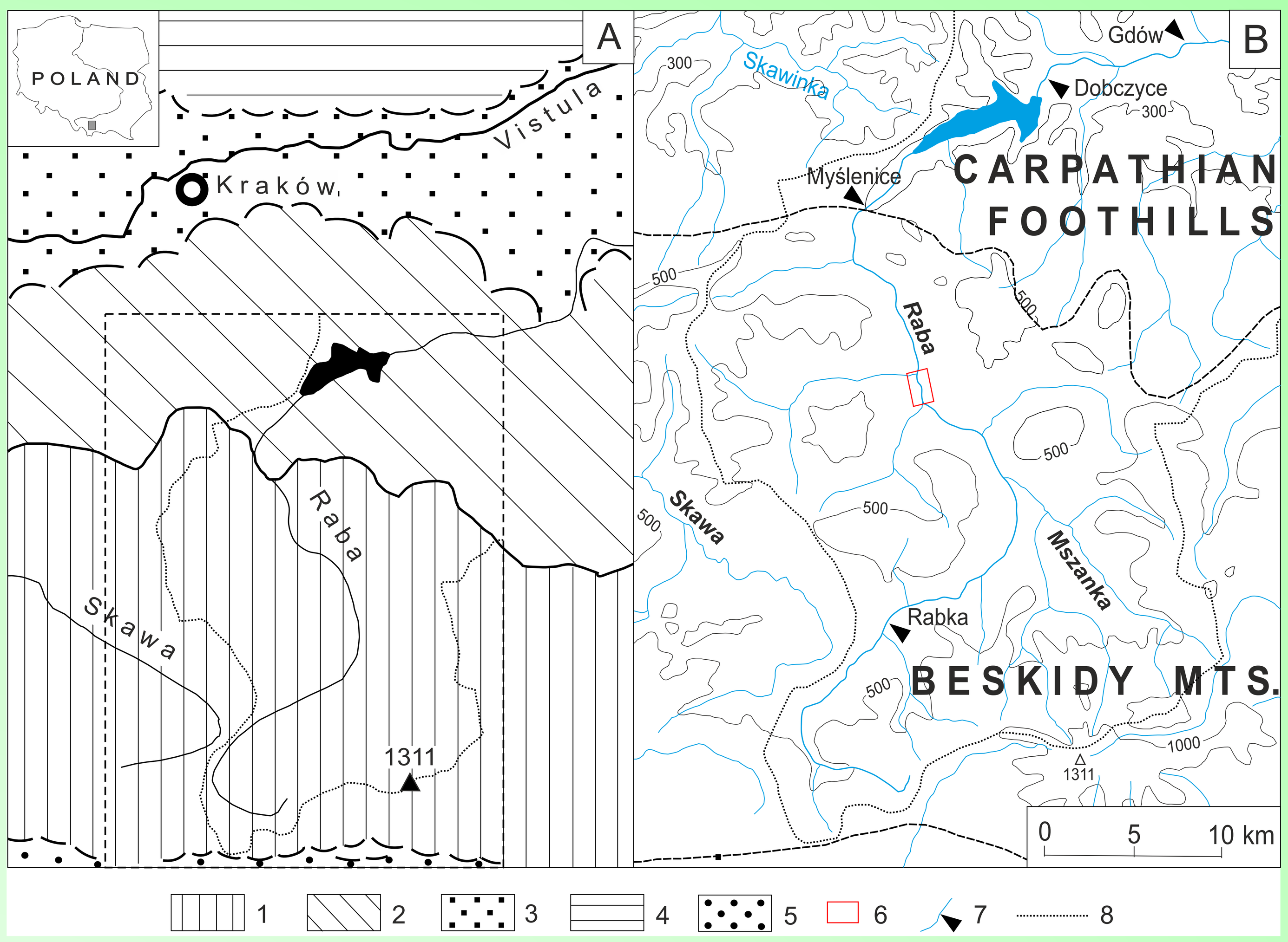
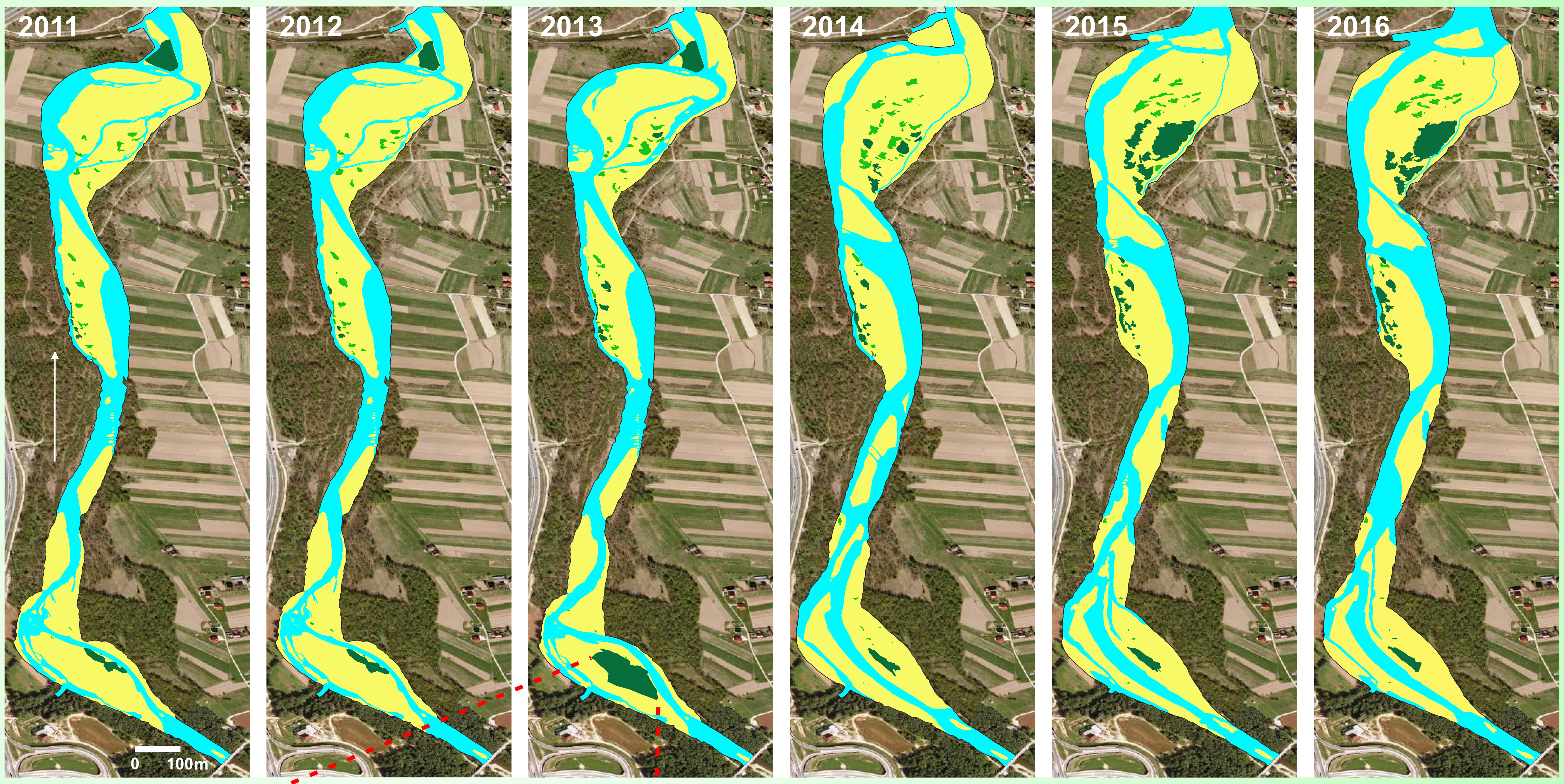
The Raba RIver, Polish Carpathians (1) is a gravel-bed river with an island-braided channel pattern in investigated 3-km lenght erodible corridor. Resignation from the maintenance of channelization structures and the passage of two large floods resulted in up to threefold increase in channel width, re-establishment of a multi-thread channel pattern and development of islands in the river reach within the erodible corridor. Origination of pioneer islands is correlated with major flood events, but the evolution and expansion of already existing islands also takes place during the years with low and medium flows (2). Pioneer (3A) and building (3B) islands occur in the study area and in result of vegetative regeneration of living driftwood. Monitoring of islands performed every year between 2011 and 2016 documented an increase in the morphological parameters within the studied islands (4). Building island can keep its shape and area over the long period of time (4), but young seedling and saplings growing around the island are very sensitive to flooding (5). Increase in the mean area and perimeter of pioneer island after each flood event can be caused by consolidation of island with the participation of resprouting living driftwood (6). A plant inventory of the islands at different stages of development and of the adjacent riparian forest was performed (7) to determine the role of islands in maintaining the overall floristic complexity of the river corridor.
Re-establishment of islands may be an important factor in the restoration of hydromorphologically degraded mountain rivers.



1 (A) Location of the Raba River in southern Poland. (B) Drainage network and physiography of Raba catchment and detailed setting of the watercourse. 1 – Beskidy Mountains; 2 – Carpathian Foothills; 3 – Sandomierz Basin; 4 – uplands; 5 – Orawa-Nowy Targ Basin; 6 – study reach; 7 – water-gauge stations; 8 – boundaries of the Raba River Basin.

3 (**A**) An example of pioneer island developed in result of vegetative regeneration of deposited poplar log. (**B**) Building island located in the upper part of erodible corridor is a stable channel form which despite two major flood events didn't reduce its area within discrete *Salix* spp. vegetation.



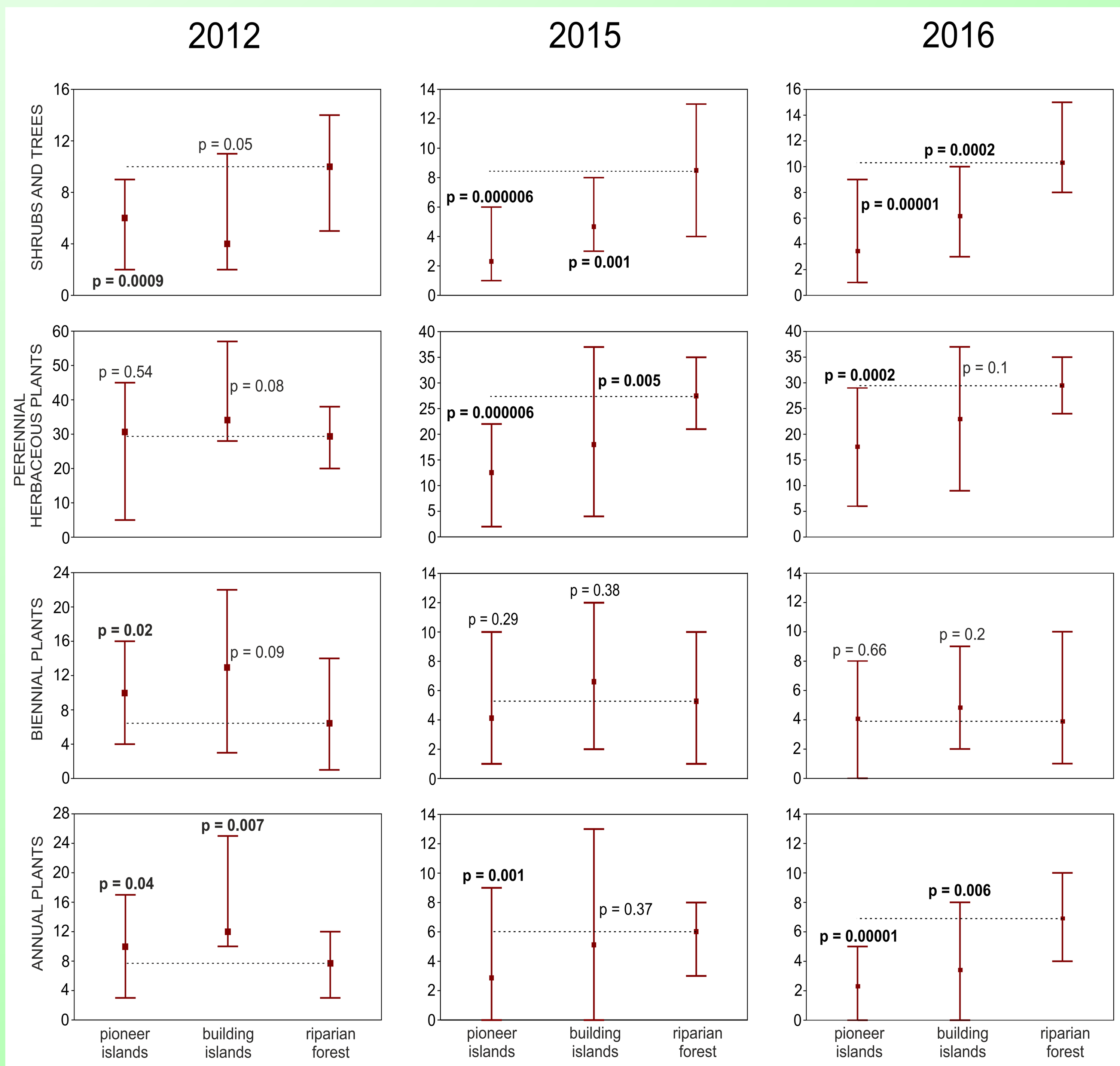
2 Numerous LWD particles were deposited on gravel bars during the flood event in 2010, giving rise to many pioneer islands. Moreless stable pattern of bars and low-flow channels within the erodible corridor allowed the survival of this initial forms. Large flood in 2014 supplied a new portion of LWD, which by vegetative regeneration of living *Salix*, *Alnus* and *Populus* spp. resulted in rapid development of the new pioneer islands. As during the last two years no major flood occured, this islands survived and began to increase their area by merging several neighboring pioneer islands into one bigger.

5 In 2013 rapid growth of *Alnus incana* seedlings took place around this building island that considerably increased island area. This new element of the island was very impermanent andalmost entirely disappeared after the passage of a large flood in 2014.

Year	2011	2012	2013	2014	2015	2016
Number of islands: total and (pioneer/building islands)	28 (24/4)	28 (22/6)	40 (33/7)	59 (43/16)	42 (24/18)	42 (24/18)
Average island age (year)	2.8	3.6	3.4	2.7	4.0	5.0
Total island area (ha)	3.9	4.6	14.6	9.5	15.7	17.5
Average island area (m^2)	139	166	367	162	375	418
Average island perimeter (m)	54	56	59	55	86	89
Total number of plant species on islands	161	198	202	195	158	142
Total number of plant species on plots of riparian forest	–	161	–	–	156	142

4 Morphometric parameters of islands and the total number of plant species on islands and plots of riparian forest recorded in the erodible corridor of the Raba River between 2011 and 2016.

6 After the passage of major flood in 2014 pioneer island started to consolidate in result of vegetative regeneration of living driftwood deposited between them.



7 The number of species from particular life-forms of plants recorded on pioneer and building islands and on riparian forest plots in the Raba River. Range plots show median (square) and extreme values (whiskers) of the species number distribution in particular habitat types. Horizontal dashed lines indicate median values of species on the plots of riparian forest. p-values indicate statistical significance of differences between the number of species associated with particular stages of island development and those growing in riparian forest, determined by a Mann– Whitney test; p-values <0.05 are indicated in bold.