Fluvial processes and changes in the floodplain vegetation of the Vjosa river (Albania)

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The floodplains of the Vjosa River in the south of Albania count as one of the most magnificent riparian ecosystems of the Balkan peninsula, standing out due to their natural hydromorphodynamic fluvial processes. A broad main stream with anabranches, open gravel bars and islands, and pioneer vegetation, as well as bushes of willows, poplars and tamarisks give Vjosa's floodplain an extraordinary distinction. Combined with large grasslands and small-area softwood forests, they build the vegetation mosaic along the river. A hydropower station chain is planned at the Vjosa River. Already initiated building measures have since been interrupted due to international protests, however the natural heritage is still threatened. There is scarcely any basic research about the vegetation ecology so far. Hence, throughout this documentation the vegetation of the bank zone and floodplain of a section between Poçemi und Mesaraku was recorded first, followed by a documentation of the main physical habitat parameters and fluvial processes.

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Die Auen der Vjosa in Südalbanien zählen zu den großartigsten Wildflusslandschaften der Balkanhalbinsel. Sie zeichnen sich durch eine nahezu ungestörte Hydro- und Morphodynamik aus. Ein breites Band von Hauptfluss mit Seitenarmen, offenen Schotterbänken und Pioniervegetation sowie Weiden-, Pappel- und Tamariskengebüschen prägen die Flusslandschaft der Vjosa. Zusammen mit ausgedehnten Grasfluren und kleinflächigen Weichholz-Auwäldern bilden sie das Vegetationsmosaik entlang des Flusslaufes. Eine durchgehende Kraftwerkskette ist an der Vjosa geplant. Obwohl begonnene Baumaßnahmen zwischenzeitlich aufgrund internationaler Proteste eingestellt wurden, ist das Naturerbe stark bedroht. Bislang liegen kaum vegetationsökologische Grundlagenuntersuchungen vor. Im Rahmen dieser Arbeit wurden daher in einem ersten Schritt die Ufer- und Auenvegetation für einen Abschnitt zwischen Poçem und Mesarak aufgenommen sowie deren prägende Standortfaktoren dokumentiert.

Keywords: floodplain vegetation, hydromorphology, braided river, Vjosa River, Albania.

Introduction

Although the Balkans are so close to the rest of Europe, their magnificent nature has been visited by relatively few people, and studied by even fewer. This counts especially for the, as yet, wild and almost pristine creeks and rivers. The floodplains of the Balkan Peninsula, with their numerous endangered and endemic flora and fauna, count as one of the ecological hotspots of our continent and they are justifiably described as the "blue heart of Europe" (Abromeit 2015). Nevertheless, this natural heritage is seriously threatened. Beside the hundreds of hydropower plants already in existence, more than 2000 future installations are being planned – many in protected areas, 113 even within the present national parks (Eichelmann & Vienna 2015, Sikorova & Gallop 2015). Through the upcoming realization of these plans, it is conceivable that countless natural habitats and rare species will be lost. Nature protection organizations such as RiverWatch and EuroNatur therefore introduced the campaign "Save the Blue Heart of Europe" to preserve this unique floodplain vegetation of the Balkan peninsula from destruction (Riverwatch & EuroNatur 2017).

One of the larger rivers flowing from Greece to Albania is the Vjosa (Albanian: Vjosë; Greek: Aoos). It is renowned as one of the grand arteries within the region and has been called the "last big complete torrential stream system of Europe" (Abromeit 2015). Despite its uniqueness, the floodplain vegetation has not yet been studied in detail. This aroused our interest in making the first step to document the vegetation of the bank zone and floodplain, as well as the fluvial processes for a section downstream of Poçemi.

The publication is based on the thesis of Rössler (2017, see also Rössler et al. 2018).

Study site

The Vjosa River has its source at the Pindus mountains in Epirus of Greece, passes the Greek Albanian border and then flows northwest. In the lower course, between the cities Fieri and Vlora, the Vjosa transits the lowlands of Myzeqe. The river is expanded in this section and forms widely outbound meanders. The river delta is located north of Narta Lagoon. For further details, see Schiemer et al. (2018 this volume).

The coordinates of the starting point and the end point of the studied river section are:

Start at Poçemi bridge [40° 49′ 28″0 N 19° 72′ 83″ E]; end near Mesaraku [40° 55′ 84″ 39 N 19° 58′ 02″ 99 E]. The mean altitude of the study area is 45 m a.s.l., the mean catchment elevation is 849 m a.s.l.

The investigated river stretch lies within the Ionian geotectonic zone (Ministry of Development 1996). The geological conditions of the Vjosa catchment area are shaped by limes and covered with flysch as well as Messinian evaporites and Pliocene molasse facies (see Pano et al. 2008, Durmishi et al. (2018 this volume).

Fig. 1: Panorama of the Vjosa River taken from a hill of 520 m, close to Hekali settlement, south direction (Photo: N. Rössler 2016). – Abb. 1: Panorama der Vjosa in Richtung Süden von einem Hügel (520 m über Meer) nahe der Siedlung Hekali (Foto: N. Rössler 2016).

The discharge characteristics are affected by massive seasonal fluctuations. The low water runoff varies from 11 m^3/s to 41 m^3/s. The mean water flow adds up to 148 m^3/s, whereas the fluctuation range was measured from 66 up to 324 m^3/s within the period of 1958–1990 (gauge station Doreza, a few km upstream of Poçemi). The maximum discharges are in December, whereas the minima occur throughout August and September. The discharges consist of between 21 % and 25 % snowmelt and 66 % rain (Tockner et al. 2009). HQ_1 is 1820 m^3/s, HQ_5 2620, HQ_{10} 3130 and an HQ_{100} flood event is 4860 m^3/s (Pano 2008). In the last 40 to 50 years, a significant decline of runoff was observed. For example, the Vjosa's mean water decreased by 24 % in Greece and 19 % in Albania between 1964 and 1987 (Tockner et al. 2009).

Following the Natura 2000 network categories, the main woody riparian habitat types along the Vjosa River are:

Platanus orientalis **and** ***Liqidambar orientalis*** **woods (Platanion orientalis) (Annex I Code 92C0):**

The tree layer is dominated by the Oriental plane (*Platanus orientalis*). *Salix alba*, *Alnus glutinosa*, *Salix purpurea*, *Populus nigra*, *Populus alba, Hedera helix* participate in the tree layer. The shrub *Tamarix parviflora* remained as a relic of pioneer stages. *Melissa officinalis, Parietaria officinalis*, *Urtica dioica, Phragmites australis, Typha latifolia, Lythrum salicaria, Mentha aquatica* and others prevail in the herbaceous layer. In some areas along the river Vjosa, the Oriental plane occurs as solitary trees or in groups, while in the others area it forms larger and more preserved communities.

Salix alba **and** ***Populus alba*** **galleries (Annex I Code 92A0):**

Patches or small areas of this habitat type are found along the Vjosa River. This habitat type, which colonizes poorly stabilized, periodically flooded alluvial deposits, is characterized by a dominance of *Salix alba, Alnus glutinosa*, *Platanus orientalis* and *Tamarix parviflora*. Accompanying woody species include *S. elaeagnos*, *S. purpurea*, *Populus nigra, Populus alba,* and *Hedera helix.* The herb layer is dominated by *Phragmites australis, Typha latifolia, Lythrum salicaria, Mentha aquatica, Rubus sanctus, Arum italicum*, *Calamintha grandiflora, Pteridium aquilinum* and others.

15.5 % of the catchment are protected areas (Tockner et al. 2009). Information about the forms of land use is given in Table 1.

The comprehensive survey was conducted for a section between Poçemi (Albanian: Poçem) up to Mesaraku altitude shortly before the estuary of Shushica (Albanian: Shushicë) river

Tab. 1: Land use in the Vjosa catchment. – Tab. 1: Landnutzung im Einzugsgebiet der Vjosa.

Land use characterization of the Vjosa River system (% of catchment) (Tockner et al. 2009)	
Urban	1.0
Arable	16.0
Pasture	0.5
Forest	35.7
Natural grassland	39.3
Sparse vegetation	6.9
Wetland	0.1
Freshwater bodies	0.5

(Fig. 2). The stream range is approx. 31.5 km long, the average width of the near-natural river landscape corridor is approx. 1.5 to 2 km, covering approx. 1380 ha, or 3170 ha including agricultural fields within the morphological floodplain.

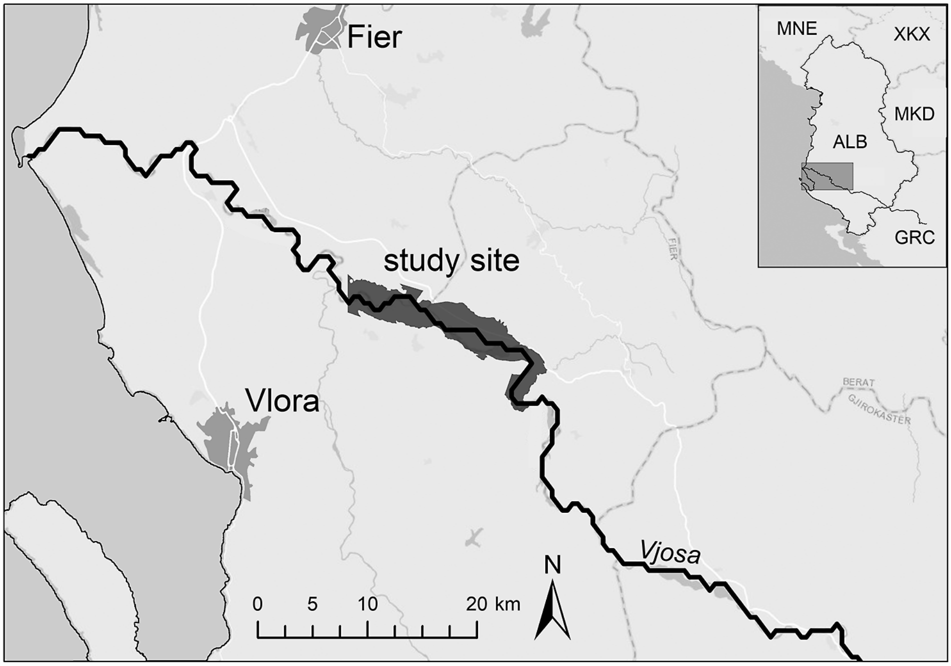

Fig. 2: Survey area of comprehensive field mapping (ALB: Albania, MNE: Montenegro, XKX: Kosovo/Serbia, MKD: Macedonia, GRC: Greece). – Abb. 2: Lage des Kartierungsgebietes (ALB: Albanien, MNE: Montenegro, XKX: Kosovo/Serbien, MKD: Republik Nord-Mazedonien, GRC: Griechenland).

Materials and methods

The comprehensive survey and field mapping of the floodplain vegetation (see legend of Fig. 4) and its physical parameters (geomorphodynamic disturbance, flood inundation; definition see Tab. 2 and Tab. 3) were conducted in August and September 2016 (Rössler 2017).

The key for the mapping units is based on the characterization of polygons in the aerial photo (see study design in the following papers: (Drescher et al. 1995, Drescher & Egger 2000, Dörwang 2016, Lewerentz 2016, Seifert 2016). The delimitation of the polygons with similar land cover was done before starting the mapping in the field. The data collection was focused on structural features. Among others, the following attributes were collected:

i) Vegetation (percentage of total cover as well as share of the distinguished layers)
ii) Maximum age of tree and shrub layer
iii) Succession series and succession phase
iv) Grain size composition of the uppermost 10 centimeters of sediment
v) Morphodynamic and hydrodynamic disturbance class

Tab. 2: Classes of geomorphodynamic disturbance (modified from Barth 2015). – Tab. 2: Klassen der geomorphodynamischen Störungen (Erosion versus Sedimentation) (modifiziert nach Barth 2015).

Definition classes of geomorphodynamic disturbance
Very high: Several times a year shifting of bed load respectively erosion and sedimentation processes of high extent; Gravel or sandbars with no A-horizon and no O-horizon; More or less equal to areas with no vegetation (partial abundance of pioneers).
High: Shifting of bed load mostly once a year; Erosion and Sedimentation processes in the range of HQ_1–HQ_3 are equal to the mean flood discharge; Populated by pioneer vegetation and Willow-Tamarisk-Shrub (dynamic-resistant species).
Moderate: Influenced by medium flood events (HQ_3–HQ_{10}), morphodynamic processes are restrained to sedimentation (sand) with local erosion processes with almost no shifting of bed load; Thin layer of O-horizon but mostly no A-horizon.
Low: Influenced by medium to large flood events (catastrophic events, HQ_{10}–HQ_{100}) with no shifting of bed load; Morphodynamic is restrained to local erosion activity (mostly side erosion) and sedimentation of fine material (sand/ lime); Mostly thin layer of A-horizon with a clear layer of O-horizon.
No, very low: Morphodynamic processes are restrained to rare catastrophic events ($>HQ_{100}$) with local erosion activity (mostly side erosion) and no shifting of bed load; Exclusively local low sedimentation of fine material; Mostly clear layer of A-horizon and O-horizon.

Tab. 3: Classes of flood inundation (modified from Barth 2015). – Tab. 3: Klassen der Überflutungshäufigkeit und –Intensität (modifiziert nach Barth 2015).

Definition of classes of flood inundation
Very high: Flooding several times a year; Discharge between mean water level and HQ_1; More or less high water depths and flow velocities; Regular appearance of flood indicators (woody debris, trees, root stocks); Mostly areas without vegetation; Sporadic appearance of flood tolerant species).
High: Flooding once a year (more or less HQ_1); Single flood events with higher water depths and flow velocities are dominant; However, the predominant areas are characterized by low water depths and moderate flow velocities; Sporadic flood indicators (woody debris); Flood tolerant species are dominant.
Moderate: Influenced by small to medium flood events (HQ10); Mostly low to medium water depths and flow velocities; Vegetation with some species moderate sensitive to flooding (mostly perennials).
Low: Influenced by medium to large flood events (catastrophic events, HQ_{10}–HQ_{100}); Rare flooding with low to medium water depths and low flow velocities; Flooding as stressor for plants plays a minor role.

Results

Geomorphodynamic disturbance

More than half of all mapped vegetation types related to the reviewed floodplains were characterized by their high to very high geomorphodynamic disturbance (very high 46 %, high 13 %). Almost one third was covered by moderate disturbance, where a thin layer of litter and humus was detected. The remaining vegetation types are characterized by morphodynamics that have already been interrupted for a long time, leading to an advanced stage of soil evolution (class low and very low each 5 %) (Fig. 3).

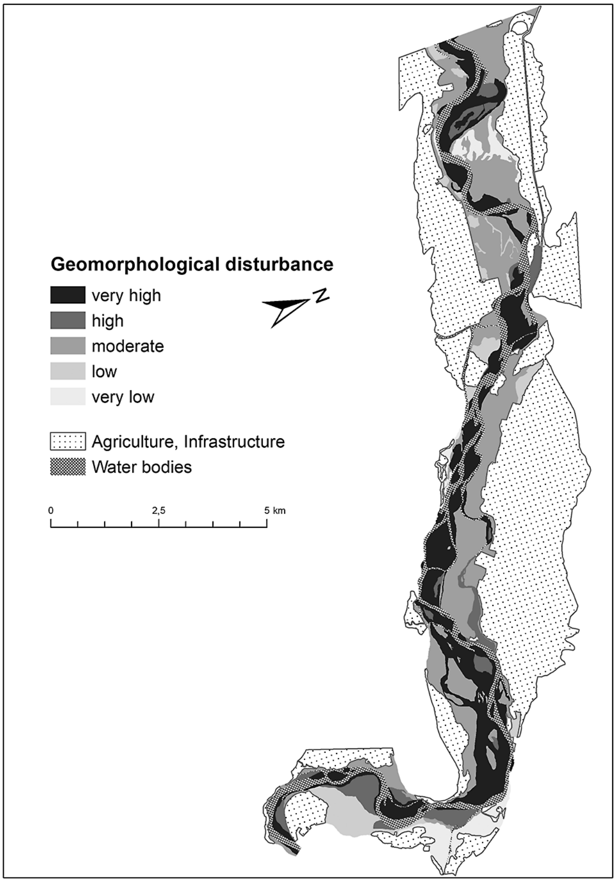

Fig. 3: Geomorphodynamic disturbance along the Albanian Vjosa River (modified from Rössler 2017). – Abb. 3: Verteilung der Flächen gleicher geomorphodynamischer Störungsklassen im Kartierungsgebiet der Vjosa (modifiziert nach Rössler 2017).

Flood inundation

Mostly, flood inundation of gravel banks, pioneer vegetation and Oriental plane pioneer shrubs was very high. All other vegetation types were also characterized by mostly high and moderate flooding impact, whereas the forests predominantly showed minimal flooding impact (Fig. 4).

Vegetation

Slightly more than half (1644 ha) of the almost 32 km² of comprehensively mapped reference section of the morphological floodplain are covered by agricultural fields and grasslands (Fig. 5). They are located on a higher floodplain level and are accompanied by near-natural plains crucially affected by floods in central parts of the floodplain area. They are characterized by broad and annually repetitively shifted topographic surfaces of non-vegetated gravel bars (171 ha, 12 % of near-natural banks) and pioneer vegetation (265 ha, 19 %) along both the main stream and the repetitively shifting anabranches (Fig. 5). Within these pioneer stages dominated by herbs and shrubs, typical woody species are white, purple and rosemary willow (*Salix alba, S. amplexicaulis, Salix eleagnos)*, smallflower tamarisk (*Tamarix parviflora*), white and black poplar (*Populus alba, P. nigra*) and oriental plane (*Platanus orientalis*). These woody pioneer species stabilize the substrate and lead to a further sedimentation of fine grained sediments. This leads to a more or less dense bushland on stands without extremely high morphodynamics (height 1 to 3 m). This pioneer bushland occurs with changing species composition and alternating dominance and cover, both as a mixed inventory and as a mosaic with alternating dominance conditions, and covers approx. 10 % (140 ha) of all near-natural plains.

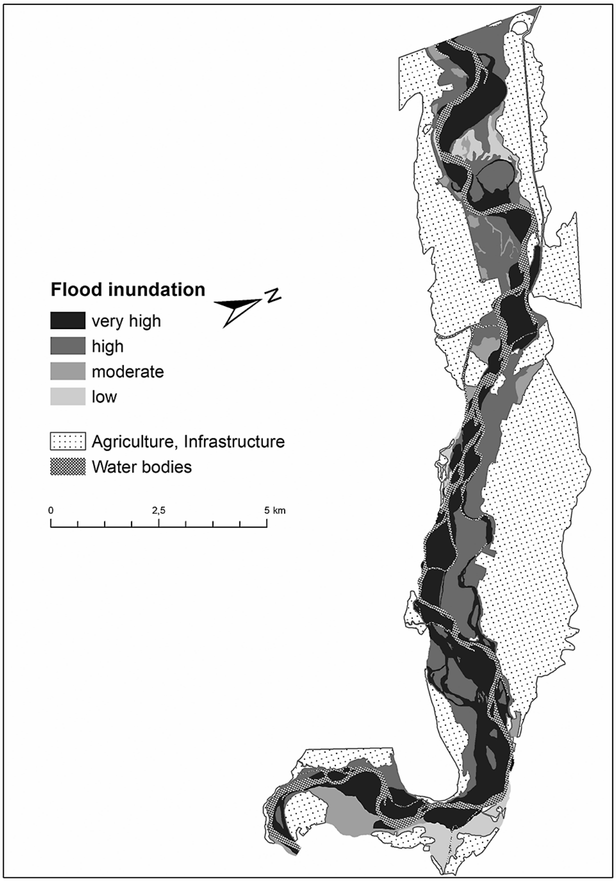

Fig. 4: Flood inundation of the study site (modified from Rössler 2017). – Abb. 4: Verteilung der Flächen gleicher Überflutungshäufigkeit und -intensität im Kartierungsgebiet der Vjosa (modifiziert nach Rössler 2017).

The most expansive vegetation type within the near-natural plains is cogon grassland (577 ha, 42 %). Mostly a soil cover of silt and sand higher than 1m shapes it, and the vegetation cover is dominated by cogon grass (*Imperata cylindrica*).

Repetitive burning, canker of plane caused by *Ceratocystis platani* and illegal logging have reduced the woods to small edge fragments within the morphological floodplain built exclusively of softwood species. The existing floodplain forests are dominated by mixed stands of white willow, white and black poplar with 85 ha (6 % of near-natural surface) as well as oriental plane, poplars and black locust forests (*Robinia pseudoacacia*) with approx. 43 ha (3 %).

Habitat change from 1980 to 2016

The evaluation of the map of 1980 compared to the distribution pattern of 2016 within the morphologic floodplain shows an increase of approx. 176 ha or 12 % (from 1468 ha to 1644 ha) regarding areas used intensively for agriculture (Fig. 5). Also, areas of open gravel bars, pioneer vegetation and herbs increased by approx. 130 ha or 13 % (from 970 ha to 1100 ha). In contrast, bushland decreased by nearly 70 ha or 30 % (from 211 ha to 140 ha). Floodplain forests show the most obvious loss of area. Here, within the last 35 years, a reduction of 354 ha took place – that equals almost one quarter of the original area in 1980 (from 491 ha to 137 ha). The detailed analysis shows that the lost forest area was intermediately grubbed up and transformed into both crops and grasslands for intensive agricultural use (104 ha) or into cogon grass meadows for extensive grazing (180 ha) (Rössler 2017).

The Vjosa stream course has probably been relocated within the active channel, and former side channels are now desiccated and new ones have been formed. However, the total area of water bodies has remained roughly the same. This indicates that processes of river

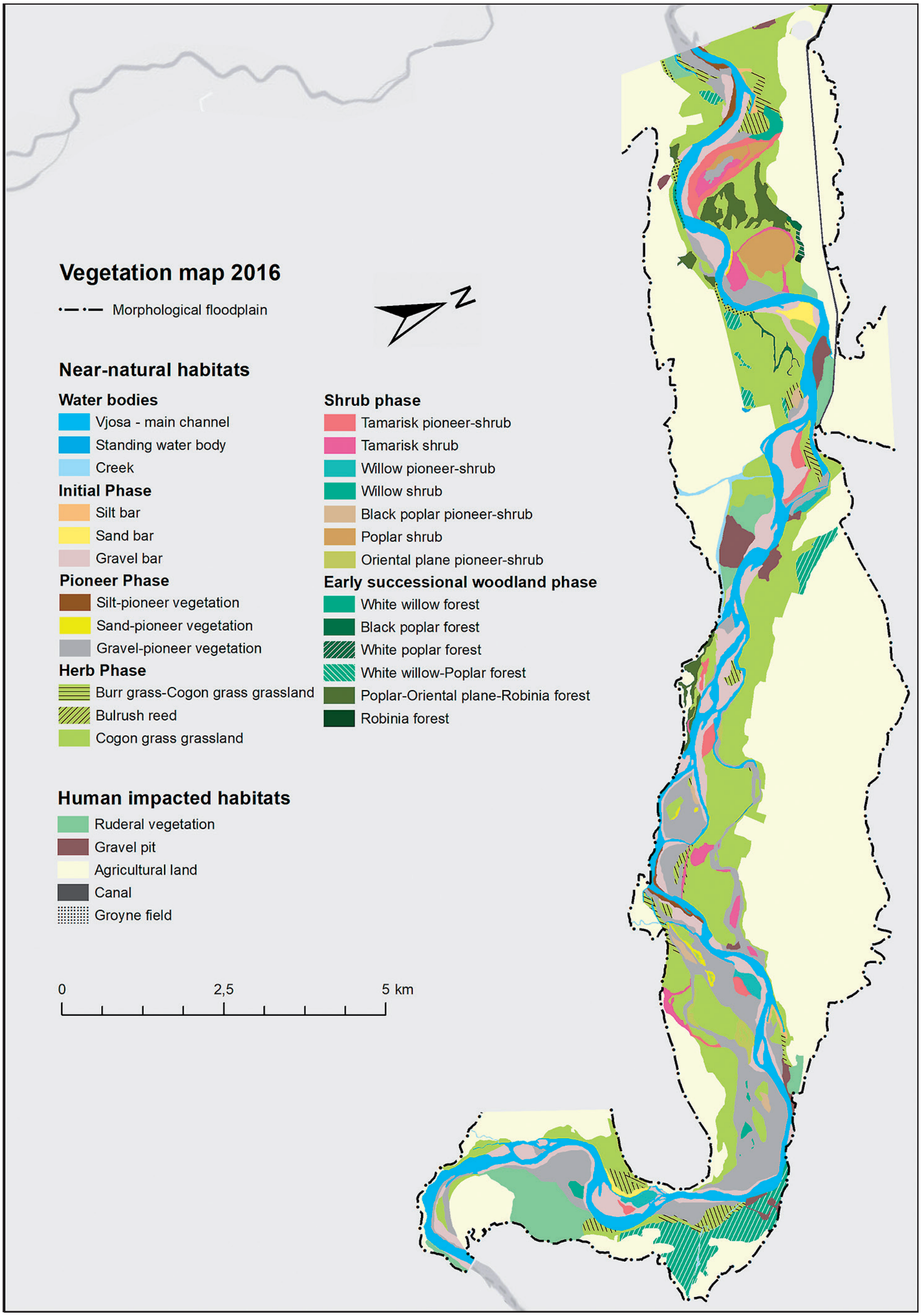

Fig. 5: Map of current vegetation (modified from Rössler 2017). – Abb. 5: Karte der realen Vegetation des Untersuchungsgebietes (modifiziert nach Rössler 2017).

bed forming did not change over a longer period and is also an indicator of, as yet, sparsely changed morphodynamics (Fig. 6).

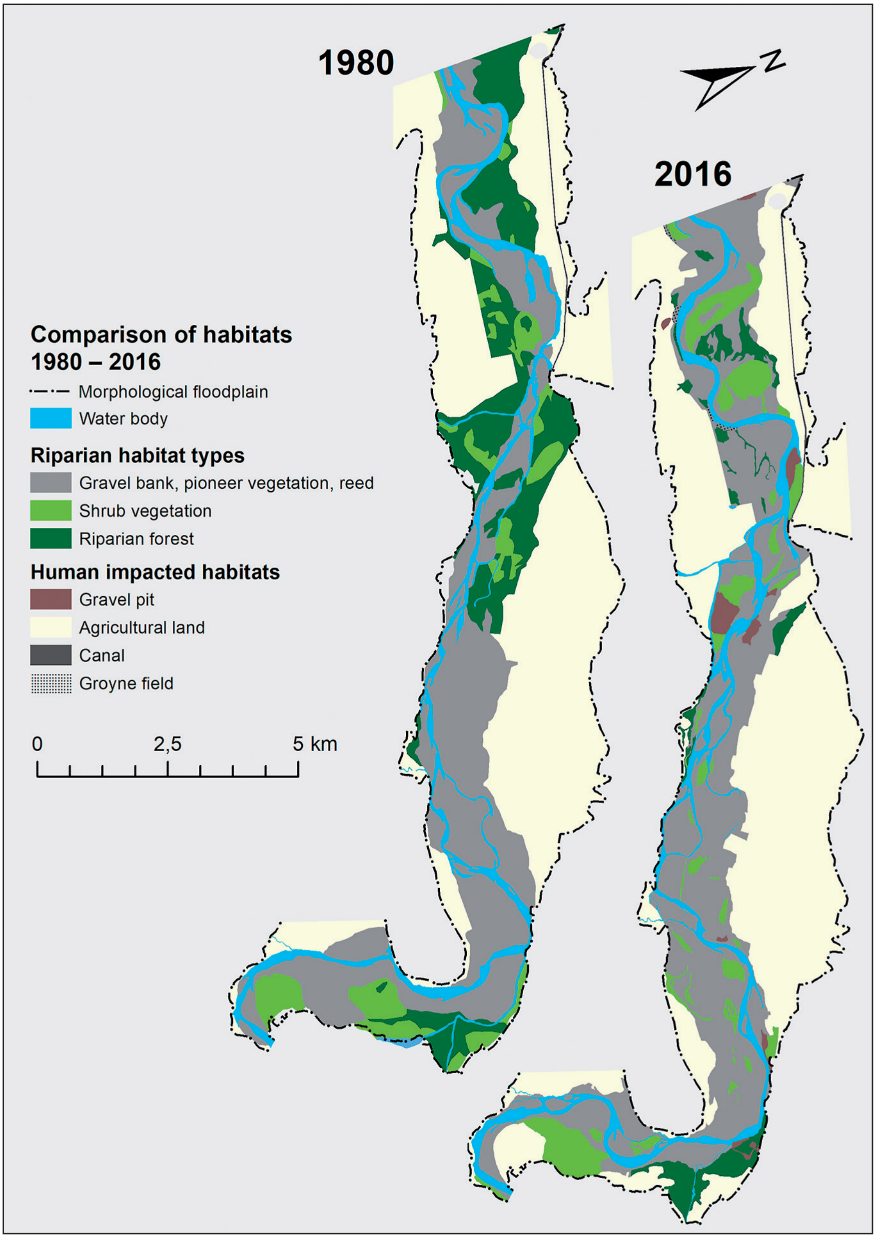

Fig. 6: Habitat maps from 1980 (Original map source: Mapbasis: People's Socialist Republic of Albania, State system of coordinates; Kesh & Sogreah Consultants 2008) and 2016 (modified from Rössler 2017). – Abb. 6: Habitat Karten von 1980 (Original: Volksrepublic Albanien, Staatliches Koordinatensystem; Kesh & Sogreah Consultants 2008) und 2016 (modifiziert nach Rössler 2017).

Discussion and conclusion

In Greece as well as in Albania, the Vjosa River mainly flows through a landscape extensively used for agriculture. However, even the valley floors and the river banks are partially used both agriculturally and, in sections, for intensive grazing with goats and sheep. The pressure of using the river landscape is huge – the proportion of remaining floodplain forest is small due to a massive intervention into the riparian ecosystem. Furthermore, the open grassland areas are burnt down periodically in order to maintain these areas for grazing with goats and sheep and to keep up the feeding quality. For this reason, there is a permanent interference with both the rejuvenation of woody species and with the natural succession. Moreover, river water is withdrawn, diverted by channels and used for irrigation of the surrounding agricultural landscape. Gravel mining in the river bed leads to local damage of the bed-load balance as well as to a destruction of natural vegetation. Alongside the discharge of waste water from adjacent settlements, it is the massive insertion of waste that is most obvious. These manifold changes, which sometimes last for centuries, have left their traces: a distinctly reduced amount of forest and large grasslands with secondary vegetation next to natural extended areas with prolonged gravel bars, pioneers and bushes form the river landscape of the Vjosa. From an ecological point of view, both the open undisturbed areas and the influence of flooding, as well as the relatively unaffected hydrodynamics and morphodynamics must be particularly emphasized. These factors represent a driving force for natural processes. Therefore, the river landscape of the Vjosa is still characterized by large areas characterized by processes of regression and progression – a determinant element being the steady change and respectively adapted vegetation of both bank and floodplain zone.

However, the "modern" development does not stop within agrarian regions. Albania needs electric power, which is currently mainly imported (Bundesministerium für Wirtschaft und Energie 2016) – what makes more sense than producing it within the country as emission-free "eco energy" from hydropower? Moreover, the construction of hydropower plants is funded by European institutions (Sikorova & Gallop 2015). Incidentally, this funding is offered by the very countries that lack near-natural watercourses and are therefore executing river renaturation projects requiring enormous financial effort (Bundesamt für Naturschutz 2015). Within the Albanian section of the Vjosa alone, ten hydroelectric power plants are currently planned (Kesh & Sogreah Consultants, 2008), two of them in the study site around Poçemi and Selenica. In addition, two facilities are already under construction; however, they have already been interrupted due to international protests.

The ecological effects of following these "ambitious" plans are clear and are already visible in various ways in Central Europe. By now, the basin development of Alpine rivers such as the Isar, Lech, etc. have led to an almost complete loss of near-natural river landscapes and their unique flora and fauna (see Müller, 1995). Apart from the immediate loss of river landscape area, reservoirs act as sediment traps and cut off the bed-load discharge. Subsequently, the river bed is massively deepened which will lead to a jeopardized groundwater balance. In conjunction with the embankment of rivers, there is a reduction of both flooding effects and morphodynamic processes – a driving force to guarantee the continued existence of natural river landscapes. All of this leads to the effect of decoupling a river from its floodplain – representing the end of a unique floodplain landscape within the "blue heart of Europe"!

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