Habitat Dynamics in the Val Roseg Flood Plain

Flood plains are among the most complex and dynamic but also one of the most endangered ecosystems worldwide. They are characterized by a high level of habitat heterogeneity and diverse biota adapted to this heterogeneity. In the glacial Val Roseg flood plain heterogeneity results from a diversity of channel types and a pronounced expansion and contraction cycle of the entire channel network.

Most investigations on river-floodplain systems have been restricted to large lowland rivers. These studies have shown that flood plains are centers of high biodiversity and bioproduction [1]. Flood plains may, however, develop at different locations along a river corridor. The 2.6 km long flood plain in the upper Val Roseg was formed in the glacial outwash of the Roseg and Tschierva glaciers (Fig. 1 and Fig. 2 p. 12). Does a flood plain at high altitude provide a similar variety of habitats compared to lowland rivers, and does it increase overall regional diversity within an otherwise harsh environment? Hence, a major goal of the Val Roseg project was to quantify the spatio-temporal heterogeneity of the floodplain system and to link it to biological diversity (see article p. 22) and principal ecosystem processes such as transformations of nutrients and organic matter (see article p. 18).

Channel Network Diversity

Six distinct channel types were identified, based on hydrological connectivity with the main channel and the relative proportion of individual water sources (Tab. 1) [2]. In summer, each of these channel types contributes to the total channel network. In winter, however, tributaries, side channels and intermittently connected channels dry up. The remaining mixed and main-channel segments are transformed into groundwater channels lacking upstream surface connectivity. Each of the individual channel types contributes, single and in concert, to the remarkable high biodiversity in this glacial flood plain [3; see also articles p. 16 and p. 22].

R. Zah, EAWAG

Fig. 1: Location of different channel types in the Val Roseg flood plain (upper section): M = main channel, S = side channel, I = intermittently-connected channel, X = mixed channel, G = groundwater channel, T = tributary (see also Tab. 1).

The Flood Plain as an Expanding and Contracting Ecosystem

The Val Roseg flood plain is characterized by distinct expansion and contraction periods that are associated with major changes in channel network length; a common phenomenon in lotic systems that has been given only scant attention by river ecologists. In the Val Roseg flood plain, channel network length increases from about 5 km in winter to more than 20 km in summer. Hydrochemical indicators were employed to link the expansion/contraction cycle with shifts in dominant hydrological processes. Indicators include sodium (groundwater contribution), nitrate (snowmelt water) and particulate phosphorus (glacial meltwater). The relative proportion of the major water sources to total floodplain discharge changes during the annual cycle [4], with subglacial and hillslope ground water dominating in winter, snow-melt water in spring and glacial meltwater in summer (Fig. 2). Based on a mixing model [5], the relative contribution of hillslope ground water to total floodplain discharge ranges from <10% in summer to >70% in winter. Therefore, the entire flood plain shifts from a uniform groundwater-dominated system in winter to a heterogeneous glacial-meltwater dominated system in summer. The seasonal shift in the relative proportion of water sources control the availability of key ecological resources such as nutrients, organic matter and temperature (see article p. 18).

Inundation Dynamics and Floodplain Complexity

Based on the relationship between discharge, channel network length and channel diversity – also called riverscape heterogeneity – we developed a simple model to predict the availability of channel types and aquatic habitat heterogeneity over a 3-year

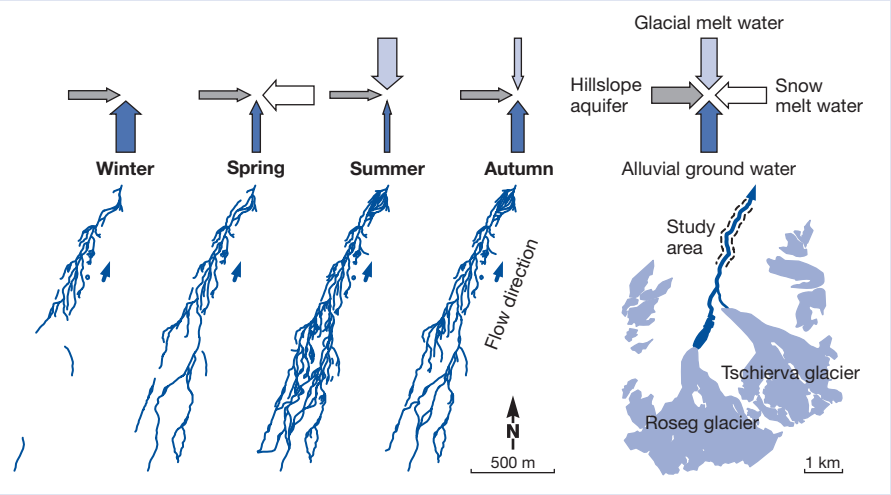

Fig. 2: Expansion and contraction cycle of the channel network of the Val Roseg flood plain (four seasons) and the relative contribution of different water sources to total floodplain discharge.

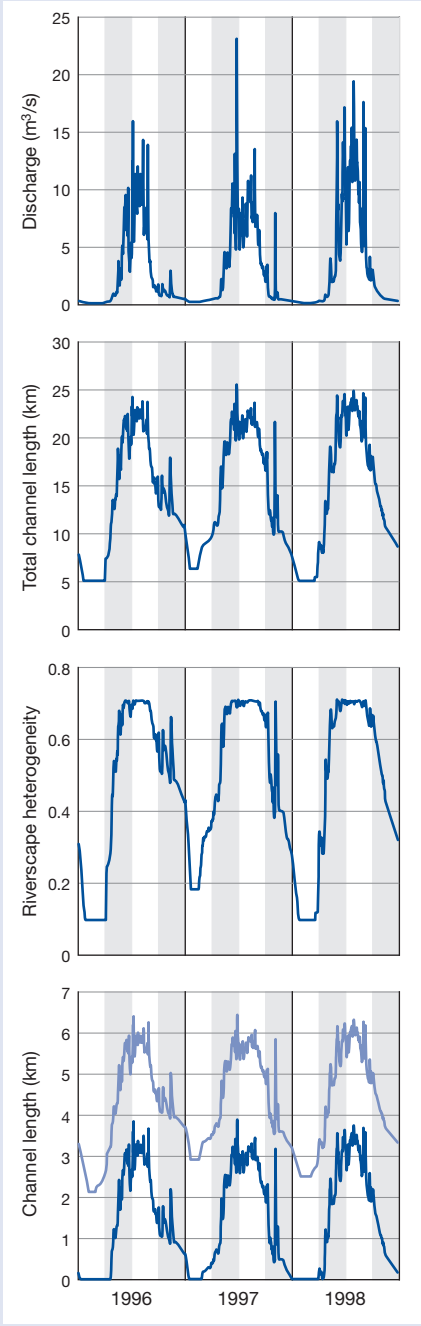

Fig. 3: Seasonal dynamics of daily discharge (A), total channel length (B), riverscape heterogeneity (C). Groundwater (light blue line) and intermittently-connected (dark blue line) channel lengths (D) were predicted from discharge-channel length and discharge-heterogeneity relationships.

period (Fig. 3). Channel heterogeneity was calculated using a diversity index with 8 turbidity classes representing "species" and the proportion of channel length in each class representing "abundance" [4]. Results demonstrate a high seasonal predictability of channel types and diversity. Channel heterogeneity is highest during high flow in summer ameliorating the negative effects of diurnal flow peaks associated with high sediment loads. In contrast to lowland flood plains, the seasonal shift in water sources primarily contributed to the remarkable heterogeneity found in the high alpine Val Roseg flood plain.

Compared to single-thread high alpine rivers, flood plains are presumably more resistant to expected changes in flow regime and land use. Therefore, they provide regional ecosystem stability to otherwise extremely sensitive and rapidly changing ecosystems. Glacial flood plains deserve particular attention in conservation and management programs, as emphasized by the present initiative of BUWAL to inventory the high alpine flood plains that are of national importance.

Klement Tockner is a limnologist with a special emphasis on river-floodplain ecosystems and biodiversity. Since 1996, he is member of the Department of Limnology at EAWAG and lecturer at ETH Zurich.

Coauthors:
U. Uehlinger, F. Malard

[1] Ward J.V., Tockner K. (2000): Biodiversity: towards a unifying theme in river ecology. Freshwater Biology *46,* 807–819.

[2] Tockner K., Malard F., Burgherr P., Robinson C.T., Uehlinger U., Zah R., Ward J.V. (1997): Physico-chemical characterization of channel types in a glacial floodplain ecosystem (Val Roseg, Switzerland). Archiv für Hydrobiologie *140,* 433–463.

[3] Klein B., Tockner K. (2000): Biodiversity in spring-brooks of a glacial flood plain (Val Roseg, Switzerland). Verhandlungen der Internationalen Vereinigung für Theoretische und Angewandte Limnologie *27,* 704–710.

[4] Malard F., Tockner K., Ward J.V. (2000): A landscape-level analysis of phycio-chemical heterogeneity in a glacial flood plain. Landscape Ecology *15,* 679–695.

[5] Tockner K., Malard F., Uehlinger U., Ward J.V. (2002): Nutrients and organic matter in a glacial flood plain (Val Roseg, Switzerland). Limnology & Oceanography *47,* 266–277.

Channel type	Parameter					
	Water source	Temperature (°C)	Turbidity	Channel stability	Nutrients	Expected biodiversity
Main channel (M)	Valley glacier	2–4	High	Low (bedload transport)	Low	Medium–low
Side channel (S)	Valley glacier	2–4	High	Low–medium	Low	Low
Intermittently-connected channel (I)	Valley glacier	2–5	High–medium	Medium–low	Low	Low
Mixed channel (X)	Glaciers, groundwater	3–5	Medium	Medium	Medium	Medium–high
Groundwater channel (G)	Alluvial, hillslope groundwater	4–8	Clear	High	High	High
Tributary (T)	Hanging glacier	4–8	Clear–medium	High	Medium–high	Low–medium

Tab. 1: Floodplain channel types, their characteristics during high summer flow and their expected biodiversity [for detailed information on channel types see 2].