

# NATURE AND CULTURE IN LANDSCAPE ECOLOGY

(EXPERIENCES FOR THE 3<sup>rd</sup> MILLENIUM)



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## Nature-culture interactions in river landscapes: a role for ecologists

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### Abstract

Ecologists have a role in providing information that may direct attention to aesthetic properties in river landscapes. This information should focus on the fact that ecological health of river landscapes requires attention to the natural variability of flow regimes, to the natural diversity of river margins, and to the human perception of river landscapes.

*Keywords:* river landscapes, riparian ecosystems, human perception, floodplain, natural diversity, nature-culture interaction

### Introduction

Rivers generate landscapes that form corridors most often dominated by trees. Under natural conditions, these wooded corridors can vary in extent from huge forests such as those edging the Amazon to galleries as along desert streams. However, many rivers have lost their capacity to regenerate landscapes, essentially because they are regulated by dams. Therefore, river landscapes are more and more perceived as deserving restoration, which implies reintroducing the seasonal variability of water flow, including occasional floods that are essential to maintain riparian ecosystems (Poff et al. 1998).

At the same time, everywhere in the world, river floodplains are increasingly dominated by humans and, consequently, the survival of riparian ecosystems depends on human attention. As emphasised by Joan Nassauer (1997): « landscapes that evoke the sustained attention of people -that compel aesthetic experiences- are more likely to be ecologically maintained in a world dominated by humans ». For people are interested by landscapes « not only for what they produce but for how they look and how they are supposed to look. » Whence the importance of aesthetic experiences.

A central hypothesis here is that aesthetic experiences of landscapes may be increased by ecological knowledge. In other words : « Just as critics and educators help to sustain and regenerate attention to artworks by discussing them in a variety of ways that may direct attention to aesthetic properties, so ecologists provide information about ecosystems that may direct attention to aesthetic properties in the landscape » (Eaton 1997).

As a consequence, a question to address is : as ecologists, what information do we have to provide about ecosystems that may direct attention to aesthetic properties in river landscapes. The aim of this paper is to show that this information should focus on the fact that the ecological health of river landscapes requires attention to: (i) the natural variability of flow regimes, (ii) the natural diversity of river margins, (iii) the human perception of river landscapes. We discuss these requirements on the basis that a healthy river landscape is a

landscape that performs its ecological functions, that is : protect the river banks against erosion, filter diffuse pollution coming from nearby cultivated fields, and contribute to maintain high levels of aquatic as well as terrestrial biodiversity.

#### **Natural variability of flow regimes**

A first information ecologists have to provide is that ecological health of river landscapes requires attention to the natural variability of flow regimes.

Loss of this natural variability results in dramatic changes along river landscapes. For example, in the Alps, riparian woods are expanding so that river landscapes are reverting to conditions similar to those of some decades ago. Such an expansion can invade the channel, as along the Ouveze, a river in the southern Alps known because of a catastrophic flood event in 1992. Along this river, downstream the village of Vaison-la-Romaine, between 1947 and 1991, the mean width of the riparian woods increased from 50 to 92 m, whereas the mean width of the channel decreased from 83 to 48 m, thus reducing the ability of the river to evacuate the largest floods (Piégay and Bravard 1997). Along other more wandering rivers, such as the Ain and the Ardèche, dead trees accumulate in various parts of the channel (Piégay and Gurnell 1997), obstructing the channel bed, particularly when they occur upstream of narrowing sections such as where there are bridges.

Other examples have been described of short to long term modifications of riparian landscapes all over the world (Décamps 1996), including expansion of exotic species, elimination of native ones, and loss of species richness. They are mainly due to flow regulation, that is elimination of the natural variability of flow regimes. After several decades of modification of water flow, we are beginning to realise that ecological integrity of river ecosystems depends on their natural dynamic character, as emphasised by Poff et al. 1997. We are also beginning to realise what important consequences the natural variability of flow regimes may have on the health of river landscapes.

#### **Natural diversity of river margins**

A second information ecologists have to provide is that ecological health of river landscapes requires attention to the natural diversity of river margins.

For example, one of the most popular models in river management is the riparian buffer zone model (Lowrance et al. 1995). It consists in intercalating a wildlife corridor between cultivated fields and rivers in order to purify the water running off cultivated fields. Clearly, the riparian buffer zone model may be applied in various parts of the world, (Décamps et al. 1999), but a prerequisite for its successful application is to consider the natural diversity of river margins at the different levels of site, drainage basin and climatic region.

At the site level, that multi-species buffer strips provide the best protection of streams against agricultural impacts (Haycock et al. 1997). Thus, three interactive zones make up a riparian buffer zone along a river: a herbaceous zone next to cropland provides spreading of overland flow, thus facilitating deposition of coarse sediments; a zone of managed shrubs and trees maximises infiltration and storage in woody vegetation; and a permanent forested zone influences the stream environment. Each of these three interactive zones must be also characterised by a high species diversity for long term sustainability. Moreover, these zones will not buffer all the pollutants in the same way and with the same efficiency, thus requiring different procedures, for example for conservative pollutants such as sediments, phosphorus, heavy metals, or for non-conservative pollutants such as nitrate. Diversity of riparian zones is

still necessary for their role in delivering other goods and services such as: flow regulation, water quality, fish production, wildlife habitats, landscape amenities, timber production (Naiman and Décamps 1997).

At the drainage basin level, rivers are not only linear systems changing progressively from sources to mouth; they also form networks throughout drainage basins (Figure 1). Headwaters provide most of channel length in these networks which are characterised by their density, connectivity and complexity (Forman 1995). The diversity of zones from headwaters to river mouth is important in controlling floodplain hydrology and therefore placement of buffers along river networks. For example, 1st to c 3rd-order streams in headwater zones develop narrow floodplains that provide both conduits and barriers to hillslope runoff, whereas higher stream orders in middle and lower zones develop wider floodplains themselves sources of runoff and water storage (Burt 1997). Clearly, this diversity of situations must be taken into account when establishing buffers against diffuse pollution along rivers, including the hydrological properties of the floodplain sediments on which depends buffer efficiency. Because headwater production zones are far more important in length when compared to downstream transfer and storage zones, their banks deserve particular attention as places for retention of water, sediment and organic material.

Diversity must be considered also at the level of climatic zones. Thus, the two major biological processes involved in regulating nitrogen fluxes through riparian systems - vegetative uptake and microbial denitrification - will develop differently in different climatic zones (Décamps et al. 1999). In the area of oceanic temperate climate (Bailey 1996), plant uptake retains nitrogen during the vegetative growth period, which corresponds to a low water table, and denitrification takes over during the high water period, generally winter and early spring. In the area of continental climate, the seasonal pattern is exacerbated, with three distinct periods: early spring, with high movement of water and nutrients and low nitrogen retention; summer, with retention by vegetative uptake; winter, with retention by denitrification during a short time period. In the area of wet tropical climate, there is no seasonal shift in the predominance of plant uptake vs denitrification, and significant reductions in total inorganic nitrogen do not occur until groundwater crosses the boundary of the riparian zone and the stream channel. Finally, in the area of arid climate, where precipitation is infrequent, most runoff comes in intense, short-lived surface flow directly into the stream channel, and most nitrogen retention by riparian vegetation occurs after water enters the stream channel and has moved back into the riparian zone.

### **Human perception of rivers landscapes**

A third information ecologists have to provide is that ecological health of river landscapes requires attention to human perception.

As we have seen, healthy river landscapes depend on natural variability and diversity at site, basin and regional levels. But this is not enough: the human perception must be considered. Introducing his book « Landscape and Memory », Simon Schama (1996) writes: « If by suggesting that over the centuries cultural habits have formed which have done something with nature other than merely work it to death, that help for our ills can come from within, rather than outside, our shared mental world, this book may not entirely have wasted good wood pulp. ».

Precisely, what is our shared mental world about river landscapes? Answer to such a question may differ in space and time. Indeed, only a few number of civilisations, such as China or Europe after the Renaissance, recognise landscapes (Berque 1995). But when we compare

perceptions of river landscapes, our shared mental world about them seems to be characterised by its diversity and variability.

Firstly, our perception of river landscapes is characterised by its diversity. Thus, among others, the famous Bernini's fountain of the four rivers, Piazza Navona in Rome, with the Danube, Nile, Ganges and Rio de la Plata, conveys this idea of diversity of river landscapes. Other perceptions may be remembered from landscapes devastated by floods to landscapes transformed by river regulation, and to images of the religious significance of rivers.

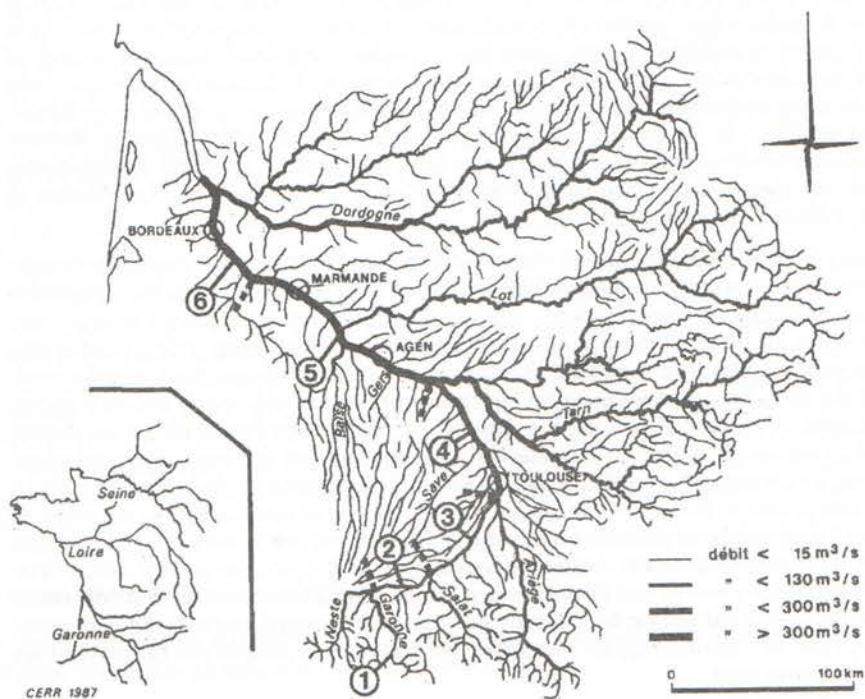


Fig. 1.- The river Garonne and its tributaries, France, as an example of the diversity of river networks in providing places for buffer zones in a drainage basin: about 50% of the entire length of the perennial river network consists in stream order 1 and about 80% consists in stream order 1 to 3. Numbers indicate the successive stream orders occurring along the Garonne.

Secondly, our perception of river landscapes has been entirely changed by understanding the hydrological cycle. In 1665, Athanasius Kircher guessed in his 'Mundus Subterraneus' that the ocean penetrated crevices in rock-walls and was carried thence through a vast system of underground passages where it was filtered into fresh water before being forced up by heat to issues through the surface at caves in the mountains (Schama 1996). In 1721, Pierre Perrault in his 'Origin of brooks and rivers' argued that rivers were simply the product of evaporated sea water condensed into rain and collected through drainage basins. Such a change in understanding the hydrological cycle may have influenced human invention of river landscapes, in a similar way that satellite imagery has deeply modified our vision of the world river landscapes.

However, the most important change in our present perception of river landscapes comes from basic understanding of the ecological functioning of river floodplains. This began when we realised that organic matter accumulating in rivers from the banks played a crucial role in river ecosystems, and that as stated by Hynes (1975) the river in its valley was an entity. The river continuum concept of Vannote et al. (1980) expanded on this idea, showing how the riparian vegetation can contribute to a continuum of functioning from the source to the mouth of a river. On the other hand, the concept of flood pulse of Junk et al. (1989) introduced the importance of the variability of the flow regime for the sustainability of river - floodplain systems, whereas the telescoping ecosystem model of Fisher et al. (1998) gives another image of material spiralling in stream corridors.

## Conclusion

Scientific concepts of ecological function differ from cultural concepts of nature (Nassauer 1995). Due to this difference, due also to the impact of freshwater on human societies (Naiman 1996), there is an important role for ecologists in being involved in the study of nature culture interactions in river landscapes.

- 1.- By providing information about ecosystems, ecologists may direct attention to aesthetic properties of river landscapes.
- 2.- Consideration of natural variability and diversity, as well as perception of rivers and their landscapes, may help facing critical issues of the next century that are taking place along rivers of the world: overpopulation, human health, floods, biological invasions.
- 3.- Healthy river landscapes require attention to their biocomplexity, also referred to as ecodiversity by Naveh (1994), including not only physical and biological, but also to social factors.
- 4.- An important role for landscape ecology is to help people understanding that there are as many healthy river landscapes as there are human perceptions of rivers, in fact as there are civilisations. This is crucial for sustainability of river landscapes, particularly when considering the future of developing countries.

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