10 River Ecology and Restoration

Abstract
The biological community of a river ecosystem is determined by the characteristics of both terrestrial and aquatic ecosystems. The terrestrial ecosystem depends mainly on the plant community and the aquatic ecosystem comprises aquatic plants, benthic invertebrates, and vertebrates. The main ecological functions of rivers are habitat, conduit, filter, barrier, source, and sink. Ecological stresses are defined as the disturbances that bring changes to river ecosystems. The ecological stresses are natural events or human-induced activities that occur separately or simultaneously. The structure of a system and its capability of carrying out important ecological functions may be changed by stresses, regardless of whether they act individually or in combination. Damming, gravel and sand mining, channelization, water diversion, habitat fragmentation, exotic species, landslides and debris flows, and intensive fluvial processes are the most common stresses on stream ecology.

For quantitative assessment of river ecology indicator species are selected, which are defined as a set of organisms whose characteristics are used as an index of attributes or environmental conditions of interest, which are too difficult, inconvenient, or expensive to measure for other species. Benthic invertebrates and fish are used as indicator species for most stream ecology assessment. The ecosystem can be assessed by monitoring the species richness (number of species) and the number density (or abundance) for each species. Many parameters representing biodiversity of river ecosystems have been proposed. Management and restoration of river ecosystems are based on an understanding of the relations between physical, chemical, and biological processes at varying time scales. Often, human activities have accelerated the temporal progression of these processes, resulting in unstable flow patterns and altered biological structure and function of stream corridors. Various strategies for ecological restoration are discussed in this chapter.

Key words
Stream corridor, Ecological stresses, Indicator species, Benthic invertebrates, Ecological restoration, Biodiversity

10.1 River Ecosystems

10.1.1 Spatial Elements of River Ecosystems

Ecosystems of rivers vary greatly in size. Taking a deeper look into these ecosystems can help to explain the functions of landscapes, watersheds, floodplains and streams, as shown in Fig. 10.1. In ecosystems movement between internal and external environments is common. This may involve movement of materials (e.g. sediment and storm water runoff), organisms (e.g. mammals, fish and insects) and also energy (e.g. heating and cooling of stream waters).

Many sub-ecosystems form a river ecosystem which, in turn, can also be part of a larger scale landscape ecosystem. The structure and functions of the landscape ecosystem are in part determined by the structure and functions of the river ecosystem. The river ecosystem may have input or output relations with the landscape ecosystem, thus, the two are related. In order to plan and design a river ecosystem restoration, it is vital to first investigate the relations between the ecosystems. Landscape ecologists use four basic terms to define spatial structure at a particular scale:

1. Matrix—the land cover that is dominant and interconnected over the majority of the land surface. Theoretically the matrix can be any land cover type but often it is forest or agriculture.

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2. Patch—a nonlinear area (polygon) that is less abundant than, and different from, the matrix.

3. Corridor—a special type of patch that links other patches in the matrix. Usually, a corridor is linear or elongated in shape, such as a stream corridor.

4. Mosaic—a collection of patches, none of which are dominant enough to be interconnected throughout the landscape.

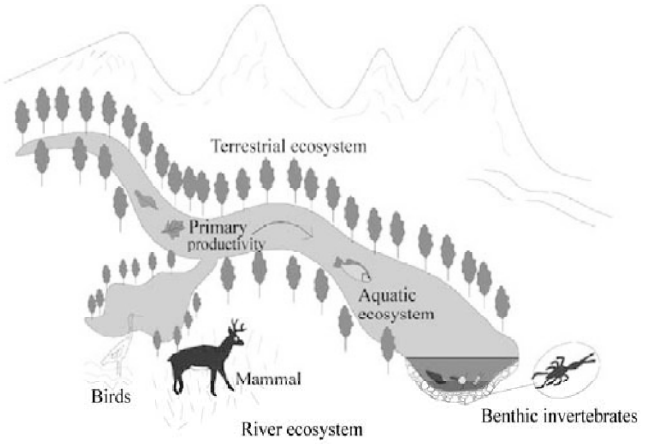

Fig. 10.1 A river ecosystem consists of the terrestrial ecosystem and the aquatic ecosystem, which is affected by and impacts on the landscape ecosystem through input and output (after FISRWG, 1997)

Figure 10.2 shows examples of a forest matrix, a city patch, a stream corridor, and a mosaic consisting of a lake, island, forest and hills. One may see a matrix of mature forest, cropland, pasture, clear-cuts, lakes, and wetlands on a landscape scale. However, on a river reach scale, in a matrix of less desirable shallow waters, a trout may perceive pools and well sheltered, cool, pockets of water as preferred patches and in order to travel safely among these habitat patches, the stream channel may be its only alternative. The matrix-patch-corridor-mosaic model is a very useful, basic way of describing structure in the environment at all levels. When planning and designing ecosystem restoration, it is very important to always consider multiple scales.

The stream corridor is an ecosystem with an internal and external environment (its surrounding landscape). Stream corridors often serve as a primary pathway for the aforementioned movement of energy, materials, and organisms in, through, and out of the system. This may be accomplished by connecting patches and functioning as a conduit between ecosystems and their external environment. Movement in, through, and out of the ecosystem may be dictated by spatial structure, especially in corridors; conversely, this movement also serves to change the structure over time. Thus, the end result of past movement is the spatial structure, as it appears at any point in time. In order to work with ecosystems at any scale it is paramount to understand the feedback loop between movement and structure.

Many of the functions of the stream corridor are strongly interlinked with drainage patterns. So, many people commonly use the term ‘watershed scale’, and it will also be used in this chapter. A *watershed* is defined as an area of land that drains water, sediment, and dissolved materials to a common outlet at some point along a stream channel (Dunne and Leopold, 1978). Watersheds, therefore, occur at many different scales, ranging from the watersheds of very small streams that measure only a few km^2 in size to the largest river basins, such as the Yangtze River watershed. The matrix, patch, corridor, and mosaic