River Conservation
Challenges and Opportunities

Edited by

SERGI SABATER
Professor of Ecology at the University of Girona, Spain

ARTURO ELOSEGI
Professor of Ecology at the University of the Basque Country, Spain

---

Chapter 14 Offprint

Concluding Remarks on River Conservation

ARTURO ELOSEGI
SERGI SABATER
ANDREW BOULTON

First published: July 2013
ISBN: 978-84-92937-47-9

Fundación BBVA
http://www.fbbva.es

Chapter 14

Concluding Remarks on River Conservation

Arturo Elosegi, Sergi Sabater and Andrew Boulton

We have pragmatic and ethical obligations to conserve rivers and their biodiversity. This chapter outlines how and why river conservation is important. To make a difference, we must act as individuals and groups, using water wisely and protecting vulnerable assets such as water quality, riparian zones and aquatic biodiversity.

14.1. Problems and solutions

We take our environment, including our rivers, for granted. Even if we see or hear about the problems of pollution or invasive species in our local rivers, we dismiss the problems as someone else's responsibility. Instead, we focus on our own day-to-day issues while the broader environment around us and our children deteriorates. But we can make a difference and we *can* start to do something *now*.

In this book, we have read about how rivers and their biodiversity face many challenges from human exploitation (Chapter 1), including threats to their hydrology (Chapter 2), structure and architecture (Chapter 3) and water quality (Chapters 4 and 5). We now live in the Anthropocene epoch where human demands for water have severely degraded most rivers and impaired their biodiver-

sity (Chapter 6). This, in turn, has compromised the ecosystem functioning of rivers (Chapter 7), limiting the goods and services on which we rely as a species. These goods and services include the provision of clean water, fish and other aquatic life; sustained aesthetic and recreational pleasure; and the support of healthy catchments, estuaries and groundwaters. Lose these goods and services and we go extinct. There are many pragmatic reasons for conserving rivers.

We have also read about the further problems that beset our rivers. Invasive species occupy many flowing waters and impose severe economic and ecological burdens (Chapter 8). Along the edges of rivers, the riparian zone and its vegetation harbour unique biodiversity and provide crucial ecological functions (Chapter 9) but are vulnerable to pressures on both sides from human uses of the land and the river. At a broader landscape scale, the connectivity within and among river networks and their catchments and marine connections are also disrupted by human activities (Chapter 10).

But there are solutions. There are ways to restore ecosystems to recover the goods and services provided by rivers (Chapter 11). Effective integration of science into planning and policy provide the critical social governance needed in river conservation (Chapter 12), and there are heartening examples of suc-

Figure 14.1: *An oxbow lake in the floodplain of the Colombian Amazon. It hosts a huge biodiversity, including two species of river dolphin, and provides essential ecosystem services to the local societies*

cessful river conservation and restoration (Chapter 13). We must move beyond looking for some-one to blame or waiting for some-one else to fix the problem. Instead, we have the tools and opportunities to start to fix the problem ourselves, and this final chapter explores how we as individuals can all make a difference across a number of levels. We must acknowledge our ethical obligations to protect and preserve species and ecosystems. Conservation is "virtuous" (van Houtan 2006), socially and morally just, and a practical necessity.

14.2. An historical perspective of river use and conservation

It is often said that the past informs the present and the future. By considering how humans have used rivers in the past, we can start to understand why our present attitudes to rivers tend to be so utilitarian; we think of a river as something to exploit and use for economic gain rather than as something we should conserve and protect for its own intrinsic ecological value. Ideally, effective management allows us to do both; conserving rivers while sustainably exploiting goods and services within the systems' capacity to provide them.

Throughout history, humans have acted as thorough transformers of landscapes, forests, rivers, lakes and seas. This action has been gaining momentum (Chapter 1), but the path has been historically consistent since the very onset of the human species.

Conserving rivers is both a requisite for a sustainable future as well as an ethical issue. River heterogeneity and diversity must be passed intact to our heirs

Lets focus this historical perspective on the arid and human-pressed Mediterranean basin which includes most of Southern Europe, Northern Africa, and a small part of west Asia. Most of the Mediterranean basin was densely forested (pine trees, evergreen oaks, cedars) prior to the expansion of human settlements during the Bronze Age. This has been confirmed through pollen records that show significant vegetation disturbance already at 2,000 years before present. The impacts of clearance and the advent of agriculture were not uniform throughout the basin. First, the Cretan expansion and then the establishment of the Greek cities and Rome substantially transformed their immediate landscapes. Wood and metals were raw materials for building houses, weapons and ships, and their search triggered trade and conquest. The Egyptian empire lacked wood and established a large-scale trade with Lebanon (Phoenicia), where they imported the impressive cedar logs necessary in shipyards. In the centuries before the current era, the Tartessos, a people settled in south-western Iberian Peninsula, started mining and smelting metals at an industrial rate in what is called today "Rio Tinto". It was the sheer magnitude of human actions that gave the river its red-wine color, resulting from toxic concentrations of heavy metals. The effects of the Tartessos on water quality can be detected as far away as in sediments in Antarctica, showing that global environmental change is not a 20th century phenomenon.

Therefore, vast clearance of the Mediterranean forests started as soon as in the Late Bronze Age, and continued during the Iron Age until contemporary times. Access to wood in large quantities permitted industries to develop; furnaces for pottery and weapons proliferated. Knossos, the center of the Crete development, was completely deforested by the Late Bronze Age. One city after another overharvested the surrounding landscape, either leading to their decline or to their expansion to less-populated areas. Soil became deprived of vegetation cover, and erosion increased as forested areas were converted to farmland. These were probably the first large-scale land changes in the Mediterranean basin, comparable only to those occurring in the Mesopotamian region at that time. Erosion, flooding and silting of downstream areas were probably common, forcing abandonment of cities and the search for new places to settle.

The pace of environmental change increased during the early years of the current era, when Romans expanded through Gallia, Britannia and Hispania in search for wood, metals and farmland (Perlin 1989). This expansion irreversibly changed the landscape across most of the Mediterranean basin. Romans converted forests into farmland to produce wine, oil, and wheat, and mined metals (iron, silver), stripping large areas to bare soil. They implemented irrigation to cope with the variable Mediterranean rainfall, a trend that was continued later by Muslims of Arab origin. Springs, percolation wells, weirs and reservoirs were built (Figure 14.2), and examples of Roman engineering persist in Mérida (Spain) or Nimes (France).

Figure 14.2: *The aqueduct of Segovia (Spain), a huge waterwork built by the Romans*

The collapse of the Roman Empire brought only a temporary reduction in human population and forest clearance. Modification of the landscape resumed and then increased during Medieval times. Agriculture dramatically changed the landscape; in the Mediterranean basin, agricultural terraces were popular and often favored erosion. Eroded topsoil, transported by the increased frequency of deluges, reached the valley bottoms and filled estuaries.

The spatial scale of transformation became larger and larger. The major aggradation of river channels in Modern times had climatic components but also derived from human activities. As an example, the Ebro River delta increased greatly in size in the Middle Ages and later as a result of forest clearance for livestock. Rivers became a preferred energy source in factories, from smelting to mills (Figure 14.3). As a consequence, the connectivity of streams and rivers was broken by innumerable weirs and dams, resulting in, for instance, reduced salmon runs even

Figure 14.3:
The arms factory in Orbaizeta (Navarre, Spain) is one of the many places where rivers were harnessed to use hydraulic energy. Most streams and rivers were thus dammed and channelized

in rivers where water quality remained high. Although other regions remained agricultural, their forests still decreased and riparian areas were converted for agriculture, leading farmers to protect their lands with dikes and levees. In turn, this disrupted floodplain connectivity, affecting river habitats and their dynamics.

Since the Industrial Revolution, the amount of energy allocated to changing the landscape has increased sharply (Steffen et al. 2007). Such an investment reached its maximum after World War II, and has not ceased since. Its effects increase in extent but vary in intensity. The current percentage of urban, arable and pasture land in the large Mediterranean basins ranges from a mere 15% in the Turkish Gediz to the 69% in the Iberian Guadiana River (Table 14.1). The population density surpasses 200 people per km^2 in the Júcar, Arno and Po (Table 14.1). As a result, most large rivers in the Mediterranean basin are heavily managed, their flow regulated through dams, and natural areas reduced to a minimum. The riparian vegetation in the middle section of the Ebro River presently barely covers 4.5% of the original area, compared to ca. 40% in the 1950s (Ollero 2007).

The 20th century saw a large increase in the human population in the Mediterranean basin, but it was very uneven because the population of rural areas often decreased while that of cities and coastal areas grew steadily. It was also a century of intensified soil use, of increased use of fertilisers and pesticides in agriculture, and of increased pollution in industrial areas. By the end of the 20th century, Mediterranean rivers were among the most degraded in the world. The last few decades have seen improvements in water quality in the richer Mediterranean countries but much less in poorer ones. However, there have been very few advances in other aspects of river conservation, such as the restoration of river habitats.

Although we have focused the history of human river use in the Mediterranean basin, parallel trends in human settlement and subsequent decline in river health have occurred across the world. For example, accelerated soil erosion and sharp declines in river water quality occurred soon after European settlement of many areas of North America, New Zealand and Australia. Only in areas where steep terrain or isolation inhibited population expansion have river landscapes remained relatively intact, and it is these areas that we treasure today as conservation reserves and reference sites for restoration. However, even these are under threat from invasive species and the effects of global climate change.

14.3. Turning the tide: Conserving species and ecosystems

In recent decades, we have become more aware of our impacts on our natural environment. Many of us are motivated to try and protect natural areas and

Iberian Peninsula	Catchment area (km^2)	Population density (hab/km^2)	Non-natural land use (urban+arable+pasture)
Ter	3,010	108	33.7
Ebro	85,362	34	49.6
Júcar	21,208	207	52.3
Segura	19,182	78	55.1
Guadalquivir	57,527	69	63.1
Guadiana	67,048	24	69.1
Tagus	80,600	136	47.6
Mondego	6,670	96	37.4
Duero	97,290	37	56.8
Rhône River basin			
Upper Rhône	8,018	190	19.4
Main Rhône	90,538	141	45.1
Ain	3,713	61	40.3
Saône	29,498	94	63.1
Isère	11,865	82	22.7
Durance	14,322	22	23.5
Balkan region			
Kamchia	5,338	48	48.5
Evros	53,078	69	61.2
Axios	24,604	87	43.5
Evrotas	2,418	30	35.3
Pinios	10,743	54	54.8
Italian Peninsula			
Tagliamento	2,580	50	18.4
Po	73,974	224	49.3
Arno	8,230	243	57.0
Tiber	17,156	238	55.0
Turkey			
Seyhan	20,450	92	32.0
Ceyhan	21,982	91	38.4
Gediz	18,000	113	15.3
Australia			
Swan	80,531	11	86.0
Murray	7,898	2	61.0
Collie	3,771	9	31.0
Blackwood	21,587	1	81.0
Warren	4,395	1	33.0

Table 14.1:
Catchment area, population density and proportions of non-natural land use (urban, arable and pasture) in selected rivers in the Mediterranean basin and Australia

Source: Data assembled from different chapters in Tockner et al. (2008), and Cooper et al. (2013).

to restore degraded rivers back to some semblance of their original state. This desire to conserve species and ecosystems is not alien to human nature. Many traditional societies set aside reserve areas or protected emblematic animal species for different reasons, including mythological and religious ones. Some of these areas have been crucial to the protection of biodiversity. For instance, the lowland forest of Białowieza, in Poland, has been preserved during centuries as a royal hunting ground, and became home of the last remaining population of European bison, apart from hosting one of the few old-growth forests in the continent, home to unusually high biodiversity. In other cases, the preservation of a species has been related to its economic value. This is the case for several species of the Pacific salmon in regions of the American NW, whose protection also encouraged actions to restore the river habitats. In Australia, indigenous nomadic tribes declared particular edible plants and animals as taboo in different areas, thus protecting food supplies from over-exploitation.

However, often there are not species of apparent economic value (Figure 14.4), traditional approaches to managing wildlife have gone or ecosystems are not favoured by special protection for their unique scenery. Why, then, should we protect those species and ecosystems? *The ultimate reason to move and act is ethical.* We need to move from strictly utilitarian and economic relationships with exploiting natural systems to an approach that recognizes our moral obligations. The American conservationist Aldo Leopold (1949) suggested that extending ethics to environmental issues was both an evolutionary possibility as well as an ecological necessity. Such a land ethic could enlarge the boundaries of human community to include soils, waters, plants and animals. A land ethic could not prevent alteration, management and use of resources, but it would affirm all species' right to continued existence.

Applying this principle of social justice to river ecosystems is to accept that we must find an ethical compromise in our use and conservation of rivers. In practice, this implies that all rivers should have their share of water resources, their dynamics should be maintained, and resident species should not be submitted to chronic stressors. Very often, the fate of water resources transported by rivers is hotly debated among farmers, industry and urban households. In these discussions, the amounts of water (and its quality and timing of availability) that are necessary for river ecosystems to survive and function is neglected. In Spain and elsewhere, it is said, and deeply rooted in the psyche of managers and politicians, that any water reaching the sea is a lost resource. It is also said that maintaining ecological flows is a fantasy in water-scarce regions. Such attitudes stray far from considering ecosystems in the delicate relationships with humans and are unethical, unjust and unsustainable.

Figure 14.4: *Many species, such as the Pyrenean desman* (Galemys pyrenaicus), *are not especially charismatic or economically important. Sadly, these species become the victims of the ignorance and neglect that threatens river biodiversity worldwide. This water mole is the only remaining species of a once diverse genus, and together with the Russian desman* (Desmana moschata), *is one of the only two desman species in the world. Desmans are strictly aquatic insectivores, and the populations of Pyrenean desman are declining swiftly, probably threatened by many of the stressors mentioned in the book, from pollution to disruption of connectivity. Because this species has little appeal to the general public, its prospects for survival are dim*

These attitudes are also economically flawed. They overlook the fact that river ecosystems provide essential services for humans, and that these services provide significant economic gains. Destroying or impairing these ecosystem services is detrimental to our own interests as well as those of many other companion species. However, we need to be aware that most current dangers to river biodiversity and ecosystem functioning are subtle, may remain unnoticed or may be hidden by pervasive but ill-informed economic reasoning. Several chapters in this book have shown that most disturbing alterations in river systems come from sediment disruption, riparian modification and water abstraction. Other chapters show that dissolved elements such as nutrients and pollutants produce chronic effects on the biota and alter their performance in the ecosystem. This opens the gate to the entry and settlement of invasive species, as well as favoring the disappearance of less-tolerant (usually native) species and impairing their genetic richness and connectivity.

Conservation has direct – even if not immediate – benefits for humankind, and our future generations will appreciate this. The conservation ethic is an attitude that goes beyond the immediate benefit to be obtained. The ecosystem goods, including species and the ecosystems that host them, are our common heritage. Accepting this heritage requires an ethical position because without it there are not sufficient scientific reasons to justify species' and ecosystems' conservation.

Conserving rivers requires a strong commitment from all sectors of our society. Our contribution to preserving them begins by recognizing that we both use and enjoy rivers and their benefits

The closing chapters of this book show that agreements can be reached between scientists and managers, and that successful river conservation may come together through Strategic Adaptive Management where all users become actively engaged towards a common goal.

Overall, our book has a number of key messages in river conservation (Box 14.1). These messages revolve around the theme that river conservation is not only ethically correct but also economically sensible in the longer term. Action is urgently needed, along with a change in public attitude and behavior. Prevention (i.e. conservation) is always better, cheaper and more sustainable than cure. Although we now face global problems of climate change and population growth against a backdrop of economic uncertainty and unequal access to the world's resources, we must strive to use our technology and intelligence to improve the quality of life of all humans and our supporting ecosystems, including rivers. We are optimistic that this is possible but we need everyone to share our vision, optimism and knowledge to bring this about.

14.4. How *you* can make a difference

We are optimistic about the future. We believe there is an accelerating change in our collective social tradition to move away from individualism, consumerism and nationalism, and embrace a broader global view of our situation as a species within a complex ecosystem. Part of this stems from wider public and political recognition of global environmental issues such as climate change and their economic and social implications. Part also stems from the relatively rapid change in public attitudes towards the environment. For example, in the 1970s, environmentalists were considered to be unconventional oddities and the name "greenie" was used in a derogatory sense. Today, major companies clamour to prove their "green" status in an economy where consumers seek products that can be shown to be derived in ways that are environmentally sustainable.

Often, many of us have a feeling of powerlessness and despair when we learn more about the state of the world's rivers and their ecosystems. But this should not paralyse us or prevent us from trying to do something about it. As individuals and groups, we can help to conserve rivers and their dependent ecosystems. Actions range from relatively simple everyday changes in behaviour through to major involvement in river conservation campaigns and restoration activities (Box 14.2). It is simply a case of making a personal commitment to act ethically.

Key messages in river conservation

Box 14.1

River conservation is not only about preserving scenic landscapes or beautiful fishes. Degradation of river condition exerts a harsh toll on human society. For example, poor river water quality is a major source of problems, from public health to economic issues.

In addition to these utilitarian values, we hold that river ecosystems have intrinsic values and, as such, humans should not destroy these values simply by neglect. As a society, we have a duty to pass on to our heirs the environmental wealth, including natural rivers, that we inherited from our ancestors.

There is no time to lose. Our generation, and at most the next, will be the last ones with the capacity to conserve a large fraction of current biodiversity. Channel form and water chemistry might be restored in the future, but once we lose species, they are gone forever.

It is always easier to prevent something from breaking down than to fix it after it is broken. For rivers, it is far easier to conserve than to restore them. This means that we should increase our efforts to conserve the few remaining near-natural rivers instead of trying to restore them once they have been degraded.

Even under the most environmentally friendly scenario, Earth will undergo profound changes by the end of the 21st century. Thus, we must devise ways to conserve and restore rivers, although their drainage basins will be far from "natural". Therefore, we must seek ways to conserve or restore functional ecosystems in landscapes that are no longer pristine. Recovering the "river territory" (the land adjacent to the channel where the river is free to adjust its dimensions and to migrate) will be one key step.

Our society will have to find the right technology to face current and future threats. Any vision of "returning to our ancient relationship with Mother Nature" cannot work, simply because we cannot sustain the current human population with ancient production methods. Technology is necessary, although it is a curse and a blessing at the same time. No technology is totally green, as shown by the example of hydropower, but a world without technology is not the solution to our problems.

In many fields, there is urgent need for more information. One example is the proliferation of new pollutants. We should apply the precautionary principle and not adopt a technology until we know how to manage the risks that it will create. This is not a new policy. For instance, in the issue of urban waste, in the last few decades we have changed our policies from total neglect to very strict controls on producing and dumping this waste. Other stressors, such as pharmaceutical drugs, will have to follow the same path.

Box 14.2

Ten ways that *you* can help conserve our rivers

1. **Be frugal with water**
   In your everyday use of water, even when it appears plentiful, try and reduce your use. Stand under the shower for less time and turn it off while you soap up. Fix dripping taps immediately. Install low-flush toilets and low-flow showerheads. For more ideas, see http://water.epa.gov/polwaste/nps/chap3.cfm

2. **Protect water quality at home and at work**
   We all live in catchments. Excessive use of pesticides and herbicides in our gardens can leach pollutants into waterways. Poorly maintained vehicles leak oil and noxious materials. Dispose of toxic materials (e.g. house paint) appropriately. Reduce paper use and recycle everything because production of material involves water. Never dump rubbish in waterways, even when they are dry.

3. **Help clean up local waterways and riparian zones**
   As individuals, we can pick up rubbish and be alert to sources of pollution. As groups, we can arrange "river clean up" days which also help build collective community support for river conservation and protection. If you see illegal dumping or unmonitored sources of pollution from industry, let your local council know.

4. **Volunteer to work on river conservation projects**
   Groups achieve more than individuals. Everyone brings different skills and strengths to a group, and you may also be a natural leader. Projects such as tree planting, bank stabilisation and removal of noxious weeds from the riparian zone help conserve rivers. Check council regulations before any activity and seek professional advice from natural resource agencies and local environmental groups.

5. **Be informed about environmental issues**
   Many local councils have excellent resource material about protecting and conserving local rivers. If your council does not have information on your river, encourage them to obtain it. Your requests will stimulate greater environmental awareness and responsibility in local government. Many websites (see later) also cover this topic.

6. **Join river conservation and protection campaigns**
   Campaigns involving media coverage and collective activity (e.g. river restoration works) help raise public awareness of river conservation. Residents living near rivers should be especially aware of their ethical responsibilities. Try and involve local schools in hands-on programs and help teachers promote river conservation in school curricula.

7. **Donate money or time to dedicated conservation groups**
   Most conservation groups rely on volunteers. They also need money to support campaigns, maintain offices and provide materials for river restoration activities. Every little bit helps and it is an excellent way to learn more about environmental issues.

8. **Share your knowledge and ethical beliefs in river conservation**
   Many of the major improvements in human rights became consolidated by public awareness followed by social endorsement. Being willing to share your views on the virtues of conservation helps empower others to feel the same way. Be optimistic.

9. **Press your elected person to act in favor on river conservation**
   Too often citizens have low participation in local politics. It is our right and our duty to talk to elected persons (from council representatives to national ones), and to ask them to work in favor of the environment. If politicians feel pressure, they are more likely to have environmental issues in mind in their everyday work.

10. **Think about nature conservation when going to vote**
    In most countries, environmental issues have little weight in the political agenda, and people tend to vote for one party or other following more general criteria. We think environmental issues should be more central to the political debates, and be incorporated in the main ideary of political groups. This will not occur unless conservation becomes a key element when deciding who to elect.

The most important point is to become actively involved. We hope that you have become motivated and inspired by the chapters in this book. Although there are many problems threatening our rivers, there are also solutions. All of these need you to become involved in some or all of the activities outlined in Box 14.2. They also need a change in cultural attitudes so that everyone accepts the virtue of conservation. We must face up to our ethical obligations. It is socially just that we share our water equitably and sustainably with the environment and other users. We must pass on to our children rivers that are as healthy or even more so than the ones we inherited. Will you accept this conservation challenge?

This chapter has benefited from results and ideas from the SCARCE project (Consolider Ingenio CSD2009-00065), funded by the Spanish Ministry of Science and Innovation.

14.5. References

Cooper, S.D., Lake, P.S., Sabater, S., Melack, J.M., and Sabo, J.L. "The effects of land use changes on streams and rivers in Mediterranean climates." *Hydrobiologia* (2012), DOI 10.107/s10750-012-1333-4.

Leopold, A. *A Sand County Almanac. And sketches here and there.* New York: Oxford University Press, 1949.

Ollero, A. "Channel adjustments, floodplain changes and riparian ecosystems of the middle Ebro River: Assessment and management." *International Journal on Water Resources Development* 23 (2007): 73-90.

Perlin, J. *A forest journey. The Story of Wood and Civilization.* Cambridge, Massachusetts: Harvard University Press, 1989.

Steffen, W., Crutzen, P.J., and McNeill, J.R. "The Anthropocene: Are humans now overwhelming the great forces of nature?" *Ambio* 36 (2007): 614-621.

Tockner K., Uehlinger U., and Robinson C.T. *Rivers of Europe.* London: Academic Press, 2008.

Van Houtan, K. "Conservation as a virtue" a scientific and social process for conservation ethics." *Conservation Biology* 20 (2006): 1367-1372.

14.5.1. Useful websites

The Nature Conservancy protects nature and preserves life across over 30 countries and their website has details about regional projects and specific activities in conservation, including river and riparian zone conservation. [http://www.nature.org/ourinitiatives/index.htm]

The River Network provides helpful hints on ways to conserve water and use it effectively. It also has useful links to current campaigns on river conservation (mainly in the US) and an active blog on many topics ranging from river protection laws to restoration strategies. [http://www.rivernetwork.org/resource-library/how-conserve-water-and-use-it-effectively]

Conservation Commons is a website that collates open access to data, websites, information and knowledge on general biodiversity conservation, including that of rivers and streams. [http://www.conservationcommons.net/]

Water Culture has a readable review of the general ethics of water use, linking cultural aspects with decisions about how we use water in domestic, agricultural and industrial situations. [http://www.waterculture.org/Ethics_of_Water_Use.html]

Water Footprint Network presents the context and a "calculator" for measuring our "water footprint" – the direct and indirect usage of water for the goods and services we use in everyday life. [http://www.waterfootprint.org/?page=files/home]

List of Figures