River Conservation
Challenges and Opportunities

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Chapter 13 Offprint

Good News: Progress in Successful River Conservation and Restoration

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Chapter 13

Good News: Progress in Successful River Conservation and Restoration

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Worldwide, examples of successful river conservation range from almost complete protection (e.g. Paroo River, Australia) to substantial large-scale restoration of channel form and flow regime (e.g. Kissimmee River, USA). Applying a framework of Strategic Adaptive Management across these examples will help us more consistently succeed in river conservation and restoration.

13.1. Successful river restoration

What is successful river conservation and restoration? In this chapter, "successful" is defined as more than improvements in biodiversity (Chapter 1) and in ecological criteria (e.g. for ecologically successful river restoration, Palmer et al. 2005); we also include improvements in social, economic and political values of rivers. These latter three values encompass protection of aesthetic, natural and functional economic aspects (i.e. ecosystem goods and services, Chapter 1) of rivers. Success in attaining these social values is underpinned by political resolution of the tension between solely economic development of river systems versus the protection and conservation of their natural values. Although ecological science and communication have crucial roles to play in the resolution of this conflict (Chapter 12), successful river conservation and restoration also requires robust institutions and effective political governance, often across borders.

Successful river conservation means improving social, political and economic values of rivers as well as ecological aspects. It is a broad and complex task

Further, we define "conservation" more broadly than simply protecting species diversity in an area. In this chapter, we regard conservation to include activities such as active restoration, removal or mitigation of threats, and active management. Successful conservation relies on effective management, supported by well-designed monitoring and evaluation programs with clear goals and an underlying model of how the conservation actions are intended to benefit the ecosystem, increase biodiversity, and enhance resilience (Chapter 11). For true success, there must be explicit links with learning from the conservation strategies and their management, assessing how these can be improved and generalised to other rivers. This is the central theme of our chapter.

In this chapter, we outline a framework for considering the spectrum of river conservation needs and approaches – ecological and sociological – that matches the extent of anthropogenic development of different rivers. This framework is presented at the scale of the entire catchment but acknowledges that most conservation and restoration efforts occur at the local scale, with varying catchment-scale benefits. We present six case studies of successful conservation across the world. These studies focus on: 1) setting and defining the desired future condition and goals for conservation, 2) identifying management options, 3) planning and implementing one or more strategies to conserve each river, considering the resources available and the spatial and temporal scales of the conservation efforts, and 4) evaluating and learning from the process. We conclude by reviewing the challenges to improving the success of future conservation of rivers and their catchments.

13.2. Using Strategic Adaptive Management to successfully conserve rivers

River ecosystems and human livelihoods are tightly linked and complex social-ecological systems. They must be managed together. Chapters in this book so far have described the many threats to river biodiversity conservation, painting a gloomy prognosis for most of the world's rivers. To address these problems, the insertion of rigorous and timely science in effective conservation has been emphasised. However, adoption of scientific information must be balanced with adopting social, economic and political values in a strategic approach. This approach needs to formalise, institutionalise and operationalise adaptive management across integrated natural and human systems that operate at large spatial scales (e.g. multiple adjacent drainage basins) and that persist for long periods of time (e.g. decades to centuries). Although there is no panacea for conserving all aquatic ecosystems, Strategic Adaptive Management (SAM) is a management framework that has great potential because of its interlinked processes for navigating complexity and learning (Kingsford et al. 2011; Kingsford and Biggs 2012).

Adaptive management acknowledges the inherent uncertainties of dynamic and unpredictable ecosystems such as rivers but tests these uncertainties through progressively improving management. After nearly three decades of adaptive management promoting scientific experimentation as the central strategy, emphasis is changing to promote a strategic approach that focuses more on the adaptive *integration* of science into social, economic and governance processes. Managers, rather than scientists, play the central role. The key is the progressive value-laden identification of goals and objectives through a hierarchy, leading to scientific understanding. This quantification of systems and measurement of indicators stimulates action when thresholds of potential concern are exceeded or when targets for rehabilitation are required (Kingsford and Biggs 2012).

Broadly, SAM follows four steps. The first is setting the desired future condition (Box 13.1), informed by the context of STEEP (Social, Technological, Economic, Environmental and Political) values and feedback from the subsequent steps (Figure 13.1). The second step identifies the management options, predicting outcomes, testing their acceptability and selecting an option or combination. In the third operational step, we plan and then implement the management option(s) and measure and monitor the identified indicators, ensuring the human and financial resources are available to achieve these objectives. The final step, evaluation, is an iterative learning process that feeds back into the other three steps (Figure 13.1). After intervention (e.g. environmental allocation of water), indicator data are analysed to assess the intervention's effectiveness in progress towards the desired ecological condition. This may include adjustment of the models or objectives, a process that must be communicated to all stakeholders for learning.

Application of SAM to rivers in South Africa and Australia (case studies in Kingsford et al. 2011) has shown promising results but is severely challenged by the complexity of river ecosystems, the size of their drainage basins and overlapping governance complexity. However, the framework is valuable because it integrates across institutions, promotes co-learning, provides explicit decision-making and increases the confidence and morale of managers. Most importantly, SAM can incorporate the intractable and complex social and ecological dimensions that have often led to management failure in previous efforts at river conservation. It also provides a way of linking science explicitly to management.

Box 13.1

Setting goals for a "moving target"

Restoration ecologists agree that all conservation and restoration strategies must have a clear target or "guiding image" (e.g. Palmer et al. 2005). In SAM, this guiding image is termed the **desired future condition**, a "moving target" because ecological systems are constantly changing, often unpredictably. Consequently, setting this target means setting a series of interim targets and refining these over time in response to changes in the ecosystem. As the desired future condition is likely to negatively affect water access by some stakeholders, setting these targets must include effective engagement to establish institutional, cooperative and governance processes (Figure 13.1).

The desired future condition must include **an explicit vision** of the expected endpoint, the **vital attributes** of the endpoint (to focus planning) and the factors that constrain or threaten these attributes at multiple scales. It also needs to incorporate **a hierarchy of measurable objectives** where higher-order objectives capture intent and lower-order ones link to "on-the-ground" interpretations. For example, a lower-order objective may be to fence off riparian zones from cattle-grazing to fulfill the higher-order objectives of promoting recovery of riparian vegetation from the seedbank, reducing erosion and compaction from cattle access, and reducing nutrient inputs from cattle excretion. Finally, setting the desired future condition entails agreement on **a set of key thresholds/targets and indicators** that can be measured adequately to demonstrate progress towards the target (Kingsford and Biggs 2012).

SAM can be applied to the conservation and management of all rivers, across the disturbance spectrum from almost pristine systems through to rivers that are heavily exploited for human needs or that flow through heavily urbanised areas. Depending on the desired ecological condition (step 1), management options for conservation (step 2) and their operation (step 3) can draw from a range of physical and institutional management actions (Table 13.1, Pittock and Finlayson 2011). Physical management actions are active changes "on the ground" (e.g. controlling invasive species, recovering more natural flow regimes) that seek to restore fundamental components of the river ecosystem's biodiversity, integrity and function. Institutional management actions (e.g. policy development, education and training, financial management) aim to improve governance and legislative processes and focus on social, economic and political aspects.

The relative demand for each form of management action varies according to the degree to which the ecosystem is impacted. For example, management of a river system with minor flow disturbance may focus on other threats (e.g. invasive species) and only need limited institutional management (e.g. land use planning, monitoring and research, flow protection, etc.) whereas a seriously

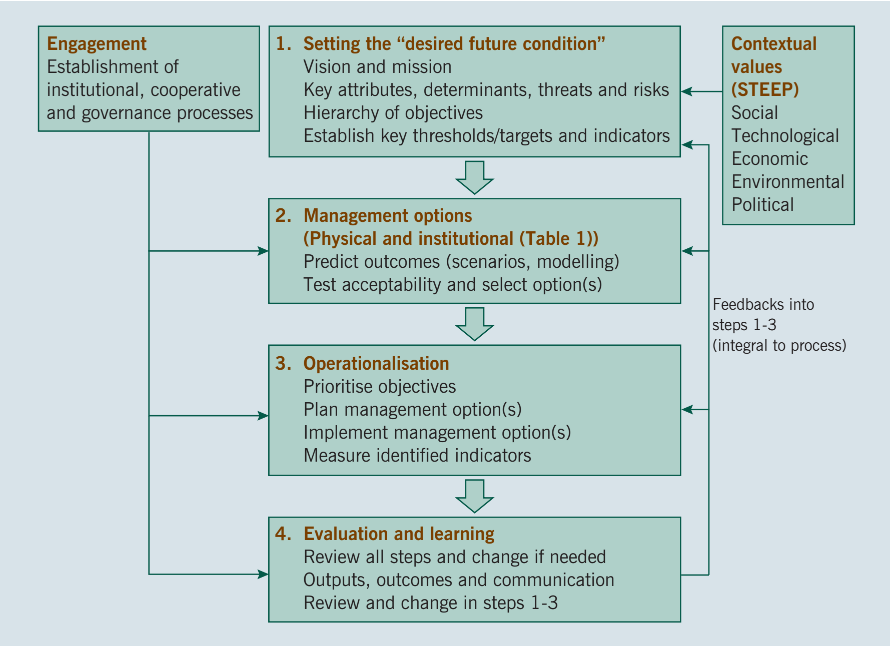


Figure 13.1: *The four steps in the Strategic Adaptive Management (SAM) framework*

Source: Modified from Kingsford et al. (2011) and Kingsford and Biggs (2012).

impacted system may require a full suite of physical and institutional management actions, supported by effective and clear policies (Pittock and Finlayson 2011). Table 13.1 illustrates the spectrum of the varying degrees to which these approaches are or may be used in the case studies that follow.

13.3. Work in progress: Six success stories

Below, we present six case studies ("works in progress") from around the world (Figure 13.2) as examples of successful river conservation or restoration. These span the spectrum from protecting areas that have had little human impact through to severely degraded rivers that need active management and restoration. Each example has elements of SAM and varies in its need for physical or institutional management (Table 13.1).

13.3.1. Murray-Darling Basin's last free-flowing river: The Paroo River, Australia

The Paroo River is a northern tributary of the Murray-Darling Basin (Figure 13.2) and drains a semi-arid catchment of 73,600 km^2, from the state of Queensland

Table 13.1: *Actual or potentially useful physical and institutional management actions (from Pittock and Finlayson 2011) applied to six case studies of successful river conservation. Relatively unimpacted rivers (e.g. Paroo) may only need a few institutional management actions to continue to protect them whereas heavily altered rivers (e.g. Lower Rhine, Cheong Gye Cheon) will require a fuller suite of physical and institutional management actions. X = actions already done, I = intended actions*

Actual or potentially useful action	Paroo River (near-natural)	Kissimmee River (restoration)	Napa River (restoration)	Kushiro River (restoration)	Lower Rhine (restoration)	Cheong Gye Cheon (urban)
Physical management						
Recover flow regimes		I			X	
Reconfigure channels, floodplains and/or associated wetlands		X	X	X	X	X
Improve water quality (e.g. reduce pollutants and nutrients)		X	X	I	X	X
Conserve natural vegetation (including riparian zones)		X		X	I	
Control excessive erosion		X	X	X	X	X
Recover lost surface water-groundwater linkages		X		I		
Nurture and maintain "protected areas"	X	X		X	X	
Adopt native species recovery programs				X	X	
Removal or mitigation of in-stream barriers to dispersal		X	X		X	X
Flood control (to protect assets and restore river integrity)		X	X	X	X	X
Restore in-stream and riparian habitats		X	X	X	X	X
Institutional management						
Research, monitoring and assessment		X	X	X	X	X
Management institutions (e.g. support and guidance by government agencies, local community)		X	X	X	X	X
Integrated river-basin management		X	X	X	X	
Financing for management and water buy-backs		X	X			X
Legal and legislative protection (e.g. Ramsar, national parks)	X			X		

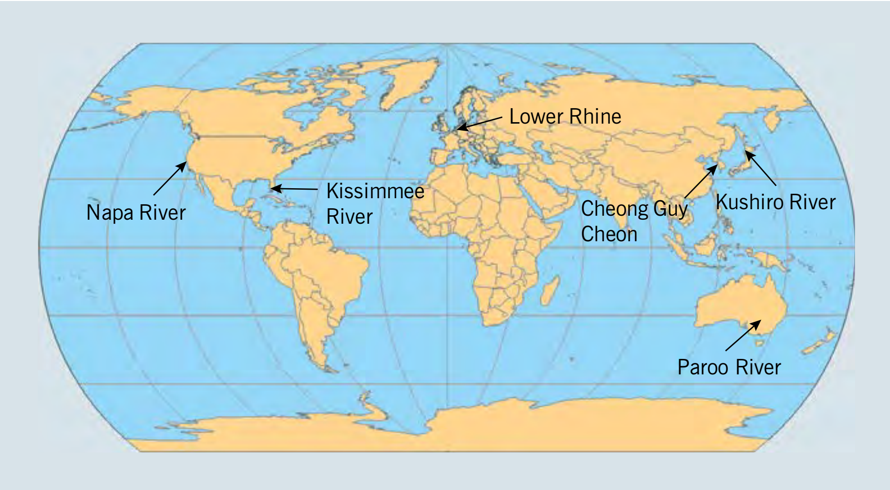


Figure 13.2: *Locations of case studies of successful river conservation and restoration*

Source: Free World Maps: http://www.freeworldmaps.net/.

to New South Wales. Like many dryland rivers, it has a highly variable flow regime resulting in a "boom-and-bust" ecology, typified by brief but spectacular "boom" periods of rapid proliferation of plants and wildlife during floods that are then followed by long "bust" periods when all but a few crucial refugial wetlands dry out. Wetlands of the Paroo such as the Currawinya Lakes can support more than 280,000 birds of over 40 different species, including many breeding species such as the Australian pelican *Pelecanus conspicillatus* (Figure 13.3). At times, the lakes may sustain more than half the world's population of freckled duck *Stictonetta naevosa* (Kingsford and Porter 1994). The river has high conservation significance; there are two wetlands of international significance listed under the Ramsar Convention (Currawinya Lakes and the Paroo River wetlands, including Nocoleche Nature Reserve) in the mid part of the river, and the Paroo-Darling National Park contains the Paroo River overflow lakes.

There were early applications to divert water from the Paroo River for irrigation (Kingsford 1999), despite the likely devastating effects on this river ecosystem. The problem was exacerbated by political polarization across the borders of the States spanned by the Paroo River (Kingsford et al. 1998). A period of considerable argument followed within and outside government about the future policies for the river, primarily triggered by increasing interest in water resource development. Local landholders, dependent on natural (non-irrigation) flows for their grazing income, and scientists drove policy for the river towards protection. In 2003, the New South Wales and Queensland governments agreed to

Figure 13.3: *Australian pelicans take flight during an aerial survey of waterbirds of the Paroo River. Inundated riverine wetlands like these are crucial oases for wildlife that take advantage of the occasional "boom" periods when flooding occurs*

protect the flows in this river (and protect shallow alluvial groundwater) from extraction through an intergovernmental agreement, and in 2007 the wetlands were Ramsar-listed as wetlands of international significance.

Although not enshrined in legislation, the agreement influences water management planning in the two states and still has widespread support. Unfortunately, there is no national framework for the protection of free-flowing rivers in Australia and so the Paroo River remains vulnerable to changes in state policies. Despite this, the wetlands' status as Ramsar sites requires that any future development on the river is subject to assessment under the Commonwealth Government's Environment Protection and Biodiversity Act 1999, as a matter of national environmental significance.

The prognosis for the river remains good, given the considerable discussion and agreement developed to protect the river. There is also considerable opportunity to develop a SAM process for the different protected areas on the Paroo River which would allow a focus on other potential threats to the river and its dependent aquatic ecosystems (e.g. invasive species, tourism). To effect this approach requires commitment by management agencies to develop SAM planning for the key protected areas on the Paroo River. The process could also be scaled up to the entire catchment through intergovernment processes. Nonetheless, even with complete regional protection, the basin remains threatened by global stressors such as climate change and global pollutants (Chapters 1 and 5).

13.3.2. Restoration of channel complexity: The Kissimmee River, Florida

The Kissimmee River is the main tributary of Lake Okeechobee, which feeds the Everglades in southern Florida, United States (Figure 13.2). The Kissimmee River once meandered for 165 km through central Florida, and its floodplain (Figure 13.4), reaching up to 5 km wide, was inundated for long periods of time by heavy seasonal rains from July through December. Native wetland plants, wading birds and fishes thrived in the river and riparian wetlands. Prolonged flooding in the Kissimmee basin in the 1940s led to plans to deepen, straighten and widen the waterway. The Kissimmee River was channelized in the 1960s by cutting and dredging the C-38 Canal, 10 m deep and 100 m wide, straight through the river's meanders (Figure 13.5). Although the project provided flood protection, it also destroyed much of a floodplain-dependent ecosystem that nurtured hundreds of species of native fishes and wetland-dependent birds and animals. More than 90 percent of the waterfowl that once used the wetlands disappeared. After the waterway was channelised, it became depleted in oxygen during the warm months of the year and the fish community changed dramatically.

Figure 13.4:
Up until the 1950s, the Kissimmee River meandered across its floodplain, providing a variety of habitats for a high biodiversity of native birds, fishes and water plants

Figure 13.5:
The C-38 Canal, constructed in the 1960s, slashed through the original floodplain, altering natural patterns of inundation. Remnant meanders now starved of water can be seen in this aerial photograph taken circa 1990

The Kissimmee River Restoration Project (KRRP) was authorized by the US Congress in the 1992 Water Resources Development Act due to growing concerns about habitat loss and environmental degradation. After extensive planning, restoration began in 1999 with backfilling of 13 km of the C-38 Canal (Figure 13.6). Continuous water flow was re-established to 38 km of the meandering Kissimmee River, and seasonal rains and flows now inundate the floodplain in the restored area. Eventually, the KRRP will return flow to 64 km of the river's historic channel and restore about 12,000 ha of river-floodplain ecosystem. The restoration project – a 50-50 partnership between the South Florida Water Management District and the U.S. Army Corps of Engineers – is projected to be complete by 2015 at a cost of approximately US$980 million. Land acquisition of over 40,000 ha is mostly complete, costing about US$300 million.

Figure 13.6:
This photo, taken on February 9, 2001, shows the back-filled canal flanked by areas of degraded spoil. In the foreground, the remnant river channel has been reconnected across the back-filled canal to link up with an oxbow meander

One key element of the KRRP is a comprehensive ecological evaluation program, matching best practice in SAM. This program assesses achievement of the project goal of ecological integrity, identifies linkages between restoration projects and observed changes, and supports SAM as construction proceeds and after project completion. The comprehensive monitoring and assessment program uses relatively simple conceptual models to predict responses to restoration, the learning component of SAM (Table 13.1). To detect ecosystem changes, data were collected prior to major construction phases to establish a baseline for evaluating future responses. These baseline data are then compared to data collected after construction and re-establishment of pre-channelization hydrologic conditions. Observed changes in the system are compared to predictions described by individual restoration expectations to evaluate whether each expectation has been achieved (steps 3 and 4 in SAM, Figure 13.1). Performance measures to predict ecological changes that are expected to result from the project include changes in hydrology, water quality, and major biological communities such as plants, invertebrates, fish, and birds.

Since completion of the first phase in 2001, there have been increases in dissolved oxygen levels, reductions in floating plant cover within river channels, reductions in accumulated organic-rich sediments on the river bottom, recovery of wetlands, and increased populations of waterfowl, wading birds, bass and sunfishes. Monitoring results suggest that after pre-channelization hydrologic conditions are fully restored in 2014, the primary goal of restored ecological integrity in the Kissimmee River and its floodplain will be successfully attained. Restoration of broadleaf marshes along the restored reach of the Kissimmee River has had mixed results. The restoration of signature broadleaf species like arrowhead *(Sagittaria lancifolia)* and pickerel weed *(Pontederia cordata)* has been variable with some marshes having low percentages of these signature species. Reasons for the limited success of broadleaf marsh restoration along the restored Kissimmee River may include flood-induced mortality, establishment conditions not being met, and invasion by an exotic shrub (Peruvian primrose-willow – *Ludwigia peruviana)* (Toth 2010a, 2010b).

13.3.3. A "living" Napa River restores ecosystems and human communities

The Napa River in central California flows through agricultural and small urban landscapes before entering the San Francisco Bay estuary (Figure 13.2). The basin of the 88.5-km river is famous for its wineries and tourism. However, over a century of altering the Napa River for urban, industrial and agricultural needs transformed the once-meandering river into a straight, constrained and incised river. These alterations harmed the river's "health", degrading water quality and fish and wildlife populations.

Within the City of Napa (population 77,000), the river was squeezed by urban development, with little room to expand during winter storms. As a result, Napa has suffered 22 serious floods over the past 150 years (Figure 13.7, Riley 2011), prompting the federal government to authorize the U.S. Army Corps of Engineers (Corps) to develop a flood-control project. The Corps proposed to channelise the Napa River into a straighter, deeper river through the City of Napa, and asked the local Napa community to pay half the project's cost. The community voted to reject the proposed project in 1976 and again in 1977. After a major flood in 1986, the Corps re-proposed their project, but voters again rejected the project (Viani 2005). What came next was a remarkable demonstration of community cooperation, resulting in a river conservation success story.

Key community leaders and diverse stakeholders banded to form the Community Coalition for Napa Flood Management. This group comprised 400 participants, including members of 40 federal, state and local agencies; local architects and engineers; environmental non-profit organizations; agricultural interest groups; and the local chamber of commerce (Riley 2011). After more than 50 meetings between January 1996 and May 1997, a flood-management plan was

Figure 13.7:
In 1940, the Napa River flooded down Main Street and surrounding streets (Napa, California), causing thousands of dollars of damage to businesses and homes

developed that satisfied all stakeholders (Daily and Ellison 2002). The cornerstone of this plan was a set of "living river" principles that value the vitality of fishes and wildlife, connectivity of the river to its floodplain, and the relationship of people to the river.

Dedicated leadership from community members and agency staff underpinned the development of a cooperative "living river" flood management plan. Among those dedicated leaders was Moira Johnston Block, a local citizen, author and founder of the Friends of Napa River, a non-profit organization responsible for inspiring the "living river" principles. She opened the first public meeting to review the Corps proposal with a simple question, "We are a world class community with our wines, towns and quality of life – why can't we have a world class project that benefits all parts of our society?" This statement transformed the discussion from a single-objective flood management issue to discussion about what could be achieved at the basin scale. Another leader was Leslie Ferguson of the Regional Water Quality Control Board who was instrumental in opposing the channelization of the river and helped lead the charge for considering a multi-objective flood control project at the basin scale. A third leader was Karen Rippey, a local resident and Friends of Napa River member, who persistently rallied support from public officials and motivated local community participation

(Daily and Ellison 2002). These individuals were the "champions" who inspired the development of goals and objectives for a "living" Napa River System, which became the guiding image for the Napa River Flood Management Plan, satisfying all the contextual values of SAM (STEEP in Figure 13.1).

The guiding image was an innovative engineering and landscape design project, aimed at simultaneously returning life to the river and its community. The design included an attractive waterfront promenade above floodwalls on one side of the river and riverbank terracing on the other side, allowing flood flows to spread horizontally into designated areas. A dry oxbow bypass diverted floods during large storms as well as providing additional wildlife habitat and recreational trails during dry periods. Additional design features included downstream tidal wetland restoration (Figure 13.8) to both provide habitat to native species and to hold large floods, replacement or removal of several bridges, and realignment of the railroad through the city. During construction, old industrial sites would be cleaned up and some commercial and residential structures would be removed or relocated.

On March 3 1998, the "living river" plan was approved by a two-thirds vote by the Napa County citizens, who committed to a 20-year 0.5% sales tax increase to

Figure 13.8: *Restoration of tidal regimes and floodplain access by the Napa River has recovered over 200 ha of wetlands as well as providing crucial flood control during winter storms. The top photograph, taken in 1998, shows how levees blocked the tidal action, constraining the river. The bottom panel, photographed in 2002, shows part of the vast area of wetlands restored by the Napa Valley "living river" project*

pay for the flood control and basin improvements. Dave Dickson, a Napa County employee, was instrumental in developing the funding mechanism required from the local community for the federal flood management project which required demonstrating that the project would benefit the entire Napa community – not just those at risk of flooding. Another agency leader, Anne Riley of the Regional State Water Quality Control Board, introduced a key concept into the group's process: despite the complexity of the issues, planning should be completed in 12 months. Community excitement and political will might have waned if the planning process had been extended longer.

In July 2000, work began to improve 9.6 km of the Napa River and 1.6 km of Napa Creek, including the creation of over 160 ha of emergent marsh and 60 ha of seasonal wetlands. Nine bridges were replaced and nearly 70 homes and 30 commercial buildings were removed as part of the restoration (Riley 2011). With further grants from the California Coastal Conservancy, the city restored 243 ha of former floodplain and tidal marsh that had been leveed off and grazed since the late 1800s (Viani 2005). As a result of the initial restoration, 3,000 properties gained protection from 100-year flood events, flood insurance rates fell significantly and waterfront businesses began to thrive (Daily and Ellison 2002; Riley 2011). Additionally, a five-year fish monitoring program found that the restoration was providing habitat to some 75,000 larval, juvenile and adult fishes of 37 species.

The plan has received several awards and inspired additional restoration efforts in the Napa basin, elsewhere in the United States, and around the world (Daily and Ellison 2002). The well-designed and implemented plan has returned life to the lower Napa River. The "living river" is now supported by functional floodplains, best management practices in the agricultural lands, reductions in contaminant loading to the river, healthy ecosystems that support fishes and birds and, perhaps most importantly, proud local communities. Important lessons have been learned in this example of SAM where social, technological, ecological, economic and political values have been combined to yield a mutually successful outcome.

As this approach to restoration is applied across the Napa River basin and elsewhere, the challenges of meeting the contextual values of all stakeholders continues to require strong leadership and dedication to the living river principles despite the challenges associated with changing faces of agency and community stakeholders during multi-decadal restoration efforts. Also, support for monitoring and evaluation remains a challenge for assessing the hydrological (flood management and water quality) and ecological performance as well as the social benefits associated with the restoration actions and land use planning measures.

13.3.4. River restoration in Japan

The Kushiro River in eastern Hokkaido, Japan (Figure 13.2), drains from Lake Kussharo into the Pacific Ocean, with a lowland stretch of some 20 km through the Kushiro Mire. The mire, originally about 20,000 ha, is a distinctive landscape dominated by sedge fens and raised bogs interspersed with swamps and lakes (Figure 13.9). It harbours many unique species, including the endangered Japanese crane which is designated as a natural monument and attracts tourists from across the world. In the 1960s, the national government led a large-scale drainage project to convert marshy areas for human use by straightening tributaries and the main channel. About 30% of the mire landscape was lost in the upper basin and near residential areas. Eventually, the core of the mire was set

Figure 13.9: *The Kushiro Mire comprises a thick peat layer with a distinctive landscape of sedge fens, raised bogs, swamps and lakes. Unique species such as the endangered Japanese crane* (up) *and an endemic subspecies of the flowering plant* Polonium caeruleum (down) *inhabit the mire, attracting tourists from across the world*

aside as a national park in 1987 following the mire's designation as a Ramsar wetland in 1980. The mire seemed to be saved from further degradation.

However, the lack of a basin conservation strategy led to landscape degradation, largely through excessive input of fine sediment from the upper reaches where channel straightening exacerbated channel incision. Scientific studies revealed that abnormal rates of sedimentation entered the reserve area, gradually dried the land, and altered soil properties. This changed the landscape into one dominated by trees, reducing its wetland ecosystem values (Nakamura et al. 2002). Also of concern was the effect on the wetlands of excess nutrients from point sources in the upper basin (Takamura et al. 2003).

In 2003, dialogue began between governments at various levels, local residents, non-governmental organizations, and academics from various disciplines (including ecology, civil engineering, and hydrology) aimed at reviving the degrading mire landscape as a symbol of cultural and economic integrity in the region. The Kushiro Mire Ecosystem Restoration Project (KMERP) started in 2005 with a goal to restore the mire landscape of the 1980s. KMERP not only emphasized the value of ecosystem conservation of the mire, but also its balance with the local agricultural economy, encouraging regional development. Most important for a successful launch of the project was a shared vision among stakeholders that the mire landscape restoration would require measures at the basin scale (some ten times the mire area). This resulted in involvement of an initially reluctant agricultural sector in communities of the upper basin. The project paid as much attention as possible to the principles of SAM, especially in terms of public involvement, and degradation processes were quantitatively assessed prior to any actions (Nakamura and Ahn 2006).

River restoration was considered critical because the natural flow of rivers is the primary driver of the mire landscape. "Full process-based" restoration was impractical in the short term because a proportion of land with straightened river channels in the upper basin was needed for the regional economy. Therefore, a "partial process-based" restoration approach was implemented. Sediment loads into the mire were reduced through revetment works and the construction of settling ponds in the upper basin. In addition, a 2.4-km stretch of the main channel was re-meandered by reconnecting the remaining former channel and backfilling the straightened section in 2010 (Figure 13.10). Flood levee banks were also removed to promote river-floodplain interactions. This is expected to eventually restore wetland vegetation near the site and to trap sediment that otherwise accumulates in the core mire area downstream.

Ecosystem response to the re-meandering has been monitored for multiple years. Fish abundance and species diversity has increased in the mire and vege-

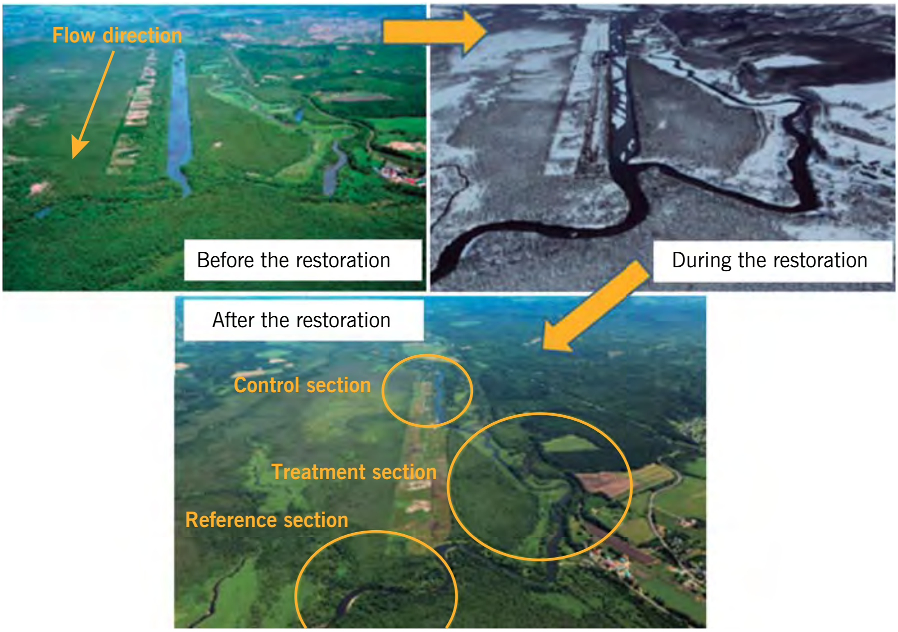


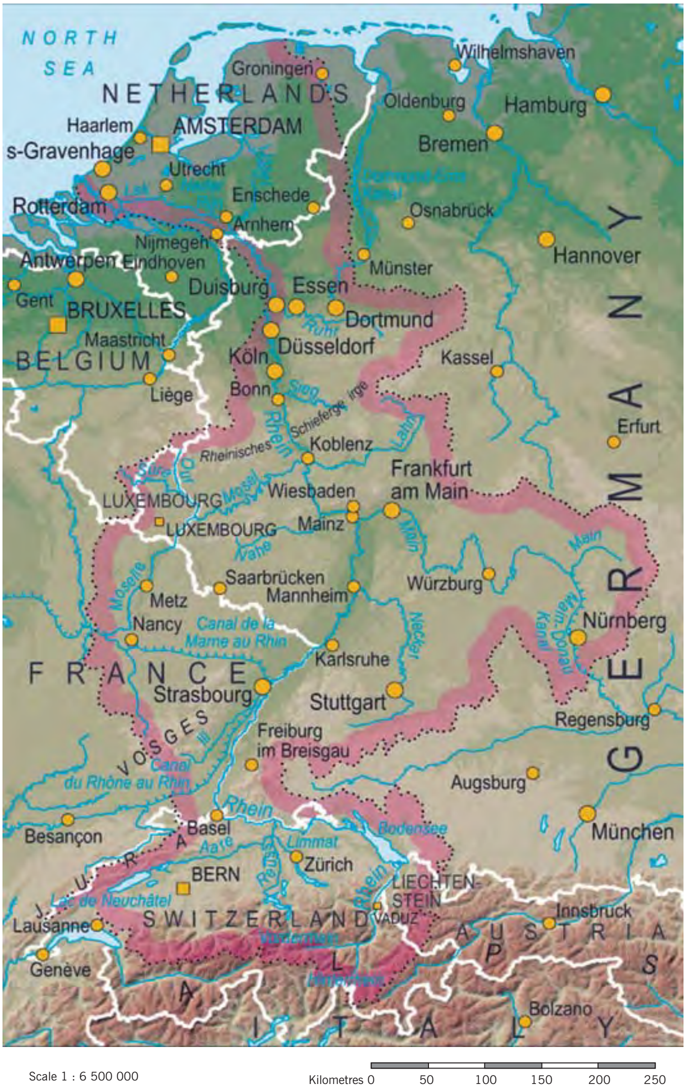
Figure 13.10: *A "partial process-based" restoration approach was implemented in the Kushiro Mire. The top left-hand photograph shows a 2.4-km stretch of the main-channel before it was re-meandered by reconnecting the remaining former channel and backfilling the straightened section* (top right-hand photograph). *Monitoring the effectiveness of the restoration entails comparing the treated section with an unrestored "control" section and a "target" reference section* (lower photograph)

tation characteristics of the mire landscape have partially recovered. Unique to KMERP are programs for local residents to participate in monitoring surveys; local communities benefit intellectually and involvement fosters a stewardship ethic towards the restored mire, matching the learning process advocated in SAM (Figure 13.1).

Restoration of fragile mire ecosystems that may require centuries to develop is made possible by concerted efforts by civil engineers minimizing the impacts of construction. For example, necessary land surface excavation was conducted during winter when land is covered by snow. Channel works were carried out by sequentially dewatering longitudinal channel sections so that heavy machinery caused minimal disturbance in ecologically sensitive riparian zones. Within a year, the landscape in the restored meandering channel resembled that in the reference section. However, it is too early to judge the full ecological success of KMERP because the mire will take decades to recover at the landscape scale. Yet, the launch of a collaborative framework among different stakeholders towards landscape restoration has been a success. This is typically a difficult step in systems with numerous socio-economic constraints where catchments are highly altered, and similar situations abound across an increasingly populated world. The Kushiro Mire case serves as an excellent example of a successful "work in progress" involving channel re-meandering in Asia.

13.3.5. Making Room for the river: Restoration of the Lower Rhine and Rhine Delta

The Rhine basin shares its drainage area of about 185,260 km^2 across nine countries (Switzerland, Italy, Liechtenstein, Austria, Germany, France, Luxemburg, Belgium and the Netherlands, Figure 13.11) with a population of ~58 million people (Uehlinger et al. 2009). The river flows for about 1,250 km with



Source: UNEP, The Global Resource Information Database (GRID): www.grid.unep.ch.

Figure 13.11:
As the Rhine basin's catchment spans nine countries, SAM at a whole-of-basin scale requires substantial coordination and cooperation

an average discharge of ~2,300 m^3/s and services a major economic region. These services include transportation, power generation, industrial production, drinking water for 25 million people, agriculture and tourism. Cioc (2002) characterizes the Rhine River as a “classic multipurpose waterway”. Successful SAM and restoration must operate within the constraints of these heavily developed riverine and floodplain ecosystems with their multiple uses, altered hydrology and water quality.

The Rhine basin has a long history of human interaction with the river. Pollution due to domestic and industrial wastewater increased alarmingly after World War II. A significant component to rehabilitating the Rhine has been nutrient and pollution abatement, starting in the 1970s. Improvement in water quality has increased the abundance of the majority of fish species including the return of Atlantic salmon *(Salmo salar)* that was formerly extinct. These fishes are now reproducing naturally in some areas of the basin, fulfilling a flagship role for a charismatic and publicly recognizable indicator of the general progress of improvement of water quality and ecology within the Rhine.

The Lower Rhine flows from Bonn, Germany, to the Dutch-German border (Figure 13.11). About 10 km into the Netherlands, the Rhine diverges into several channels, with water flowing into canals, the Waal River, the Nederrijn River (further downstream called the Lek) and the IJssel River. The surface area of Rhine channels in the Netherlands is ~36,700 ha, including about 28,000 ha of floodplains (Uehlinger et al. 2009). Land use in the Dutch branches of the Rhine floodplains is predominantly grass-production; human-built ecosystems make up about 80% of the floodplains. Water quality (phosphorus, nitrogen and silica) and ecohydrology affecting water-level fluctuations are important factors structuring plankton and plant communities in these floodplain ecosystems (Vanderbrink et al. 1994; Van Geest et al. 2005), and need to be managed for restoring the ecological integrity of this system.

“Room for the River” is an ambitious € 2.3 billion project that is being promoted as both restoration and flood control. It has three primary objectives: 1) improve the overall environmental quality of the Lower Rhine and floodplain, 2) increase discharge capacity for the rivers of the Lower Rhine, and 3) make permanently available extra room to accommodate increased discharge during flood events. Overall, the project is designed to bring greater safety for four million Dutch citizens while improving environmental quality to the lower reaches of the Rhine and the rivers it feeds. Near-catastrophic floods in 1993 and 1995 and the recognition that climate change is likely to increase peak flows in the Lower Rhine have driven the planning effort, providing social, technological and political context for the SAM.

The project involves a range of measures and sub-projects such as lowering floodplains, relocating dikes further inland and lowering groynes (protruding rock-jetties) in the rivers. Thirty-nine locations are targeted for providing more room into which the rivers can flow during times of high discharge. The flood protection measures and environmental quality improvements are scheduled for completion by 2015. The projects are in various stages of implementation with a final goal of increasing maximum discharge capacity of the Lower Rhine through the delta from its current capacity of 15,000 m^3/s up to a peak of 16,000 m^3/s.

One example of the various projects is the depoldering of the Noordwaard (Figure 13.12). A polder is a piece of land in a low-lying area that has been reclaimed from a body of water by building dikes and drainage canals. The Noordwaard polder is influenced both by tidal variations of the sea and discharge levels of the river. The project entails lowering of dikes to create inlets and outlets during times of high water. Parts of the current polder would be under water several times a year, particularly during winter high flow periods. Other parts of the polder would only flood during extreme high discharge periods. Land that is returned to more regular flooding will become floodplain habitat while rarely flooded regions will sustain current land uses (pasture and agriculture). Outcomes include reduced flood risk to the city of Rotterdam and increased floodplain habitat along the river.

Figure 13.12: *The Noordwaard polder project includes "through-flow" areas and green wave-inhibiting dikes that are up to 65 cm lower than the original engineered dikes. Through-flow areas serve to divert some of the higher flows and reduce discharge volumes during winter. This involves a shift in concept from constraining all water in the channel using high levee banks to lowering the levees and allowing floodwater to spread out onto the floodplain but using levee banks to protect houses and infrastructure*

13.3.6. Restoring urban rivers: From freeway to waterway in the Cheong Gye Cheon

Most towns and cities started as settlements on the banks of streams and rivers. However, over time, most of these rivers become dammed and channelised, constrained by buildings and industry on the banks, and river health declines from urban runoff containing pollutants. In severe cases, the river becomes an open sewer or an enclosed drain hidden below roadways, car-parks and other impervious surfaces. Restoration of urban streams and rivers is notoriously difficult, largely because only recovering flow regime and structure (e.g. using some of the methods described in earlier sections) seldom resolves the problems of poor water quality and impaired biota. High prices of riparian urban property and the need to substantially alter bankside infrastructure further constrain restoration options and challenge SAM. Nonetheless, public pressure to restore urban waterways is usually intense. Where urban river restoration has occurred, local communities report an improved quality of life, tourism increases and values of surrounding properties rise (Özgüner et al. 2010).

One of the most dramatic river restoration projects of a heavily urbanised area is that of the Cheong Gye Cheon in Seoul, South Korea (Figure 13.2). Once an attractive river (Cheonggyecheon means "clear water stream"), by 1945 the Cheong Gye Cheon had become a silted drain filled with rubbish and contaminated water that offended local residents. The situation was aggravated by the Korean War which left Seoul in a serious crisis as refugees flocked to the city, settling along the banks and further polluting the stream. During the post-war recovery phase, the urban river underwent major transformation from the late 1950s to the early 1970s to cover it over, primarily with a 5.6-km, 16-m wide elevated freeway. This was acclaimed as an example of successful industrialisation and the commercial area burgeoned. However, by the late 1990s, the area was regarded as a source of serious health and environmental problems because of the dense traffic and intensive urbanisation. Carbon monoxide and methane were accelerating the breakdown of the cracking freeway which was considered beyond repair.

In July 2002, the then-mayor of Seoul initiated a project to remove the crumbling freeway and restore the covered section of the Cheong Gye Cheon, now almost completely dry after decades of sedimentation and neglect. Several committees and organisations were established to consider local opinions on the restoration process. The project had immense popular support. However, numerous problems arose during the restoration, including severe engineering difficulties compounded by the deteriorated concrete infrastructure that introduced serious safety issues. However, by late 2005, the "new" Cheong Gye Cheon was opened to the public (Figure 13.13). The water quality issue was

Figure 13.13:
The upper panel shows restoration work in progress on the Cheong Gye Cheon in Seoul (on June 24, 2005). Two years later (lower panel on June 7, 2007), water is flowing where a freeway once passed over the top of the river's course. Vegetation blankets sections of the restored bank and people stroll or sit along the edge of the waterway, once a contaminated drain

addressed by pumping massive volumes of treated water from the Han River and groundwater supplies. Fish species richness rose from 6 to 36 while the number of taxa of insects increased from 15 to 192. The restored stream has reduced local air temperatures and increased relative humidities compared with surrounding city areas (Kim et al. 2009), reversing the usual trends of urbanisation.

The project was expensive (values range from US$281-384 million) and has ongoing and increasing costs to maintain the water supply and sustain the stream. Extensive consultations and conflict-resolution meetings were held throughout the construction period. A detailed environmental monitoring program assessed factors such as air pollution, volatile organic compounds and noise before, during and after the restoration [http://english.sisul.or.kr/grobal/cheonggye/eng/WebContent/index.html]. Although most tourists and urban users consider the project a success, some Korean environmental organisations have criticised the high costs of the project and its limited scope, seeing it instead as purely symbolic and ecologically unsound (Cho 2010). The sides are still lined with concrete and the waterway is monitored for flood control. Further, only a relatively small section of the stream has been restored and the restoration is not ecologically sustainable. Although there is still plenty of scope for application of SAM principles to a broader area of the basin, this spectacular transformation within severe urban constraints has played a key role in changing public attitudes and can be interpreted as having been a successful conservation program in that context.

13.4. Emerging concepts

Worldwide, there are many examples of successful river conservation. We must be inspired by and learn from these, using Strategic Adaptive Management

There are two main themes to emerge from this chapter. The first is that there are numerous examples of successful conservation worldwide. These "success stories" warrant optimism and renewed efforts from stakeholders who seek to enhance ecosystem goods and services provided by protecting or restoring rivers and their adjacent wetlands. However, many restoration projects fail to document recovery and those that do seldom report complete success in all criteria (Berhardt and Palmer 2011). However, we argue that if further loss of biodiversity or degradation in ecological integrity was halted or slowed by a given conservation effort, then that can be deemed "successful".

We agree a common problem is that inadequate documentation or a lack of pre- and post-restoration data prevents assessment of the success and, worse, removes a crucial learning tool (Figure 13.1). When restoration efforts fail but have been properly assessed, managers and scientists can learn from their mistakes and improve future restoration or conservation efforts in light of approaches such as SAM.

The second main theme is the need for integration of rigorous science, community values and action, and effective governance in successful river conservation. This integration needs a framework because the process is seldom effective or efficient without one. We advocate Strategic Adaptive Management (SAM) as one framework for this integration because we believe the emphasis on management rather than science is a sensible direction for change. Of course, rigorous science is still essential. Aspects of this approach have characterised the case studies we present above. However, unless local community members and other "champions" become actively involved in protecting or restoring their rivers, no amount of rigorous science will ensure long-term success. Social, economic and political aspects are as important as ecological criteria to a successful conservation or restoration program. All too often, conservation programs are not limited so much by a lack of knowledge than a lack of public willingness.

Earlier chapters in this book have painted a grim prognosis for rivers. Everywhere, there are deteriorating environmental conditions (Chapters 11, 12), increasing demands for water to support burgeoning human populations (Chapter 1), and many intensifying threats facing the world's rivers (Chapters 2, 3, 6, 7). We urge optimism, initiative and active conservation rather than passive and apathetic resignation to biodiversity loss. Most examples of successful river restoration rely on dedicated people – champions – who refuse to surrender the natural values of rivers in their region and who wish to restore at least part of the natural processes and biota crucial to rivers' ecological integrity and functioning. In our examples of successful restoration and conservation, although projects were planned primarily to benefit the river systems, they also were of benefit to local populations and have been a powerful tool in reshaping public opinion. We hope our examples of varying degrees of successful river conservation and adoption of SAM will help inspire action and indicate strategies that will succeed in other regions.

13.5. References

BERNHARDT, E.S., and M.A. PALMER. "River restoration: the fuzzy logic of repairing reaches to reverse catchment scale degradation." *Ecological Applications* 21 (2011): 1926-1931.

CHO, M.R. "The politics of urban nature restoration: the case of Cheonggyecheon restoration in Seoul, Korea." *International Development Planning Review* 32 (2010): 45-165.

CIAO, M. *The Rhine: An Eco-biography, 1815-2000*. Washington, USA: University of Washington Press, 2002.

DAILY, G., and K. ELLISON. *The New Economy of Nature*. Washington D.C.: Island Press, 2002.

Kim, K.R., T.H. Kwon, Y.H. Kim, H.J. Koo, B.C. Choi, and C.Y. Choi. "Restoration of an inner-city stream and its impact on air temperature and humidity based on long-term monitoring data." *Advances in Atmospheric Science* 26 (2009): 283-292.

Kingsford, R.T. (Ed.) *A Free-flowing River: The Ecology of the Paroo River.* Sydney: New South Wales National Parks and Wildlife Service, 1999.

Kingsford, R.T., and J.L. Porter. "Waterbirds on an adjacent freshwater lake and salt lake in arid Australia." *Biological Conservation* 69 (1994): 219-228.

Kingsford, R.T., and H.C. Biggs. *Strategic adaptive management guidelines for effective conservation of freshwater ecosystems in and around protected areas of the world.* Sydney: IUCN WCPA Freshwater Taskforce, Australian Wetlands and Rivers Centre, 2012.

Kingsford, R.T., A.J. Boulton, and J.T. Puckridge. "Challenges in managing dryland rivers crossing political boundaries: Lessons from Cooper Creek and the Paroo River, central Australia." *Aquatic Conservation: Marine and Freshwater Ecosystems* 8 (1998): 361-378.

Kingsford, R.T., H.C. Biggs, and S.R. Pollard. "Strategic Adaptive Management in freshwater protected areas and their rivers." *Biological Conservation* 144 (2011): 1194-1203.

Nakamura F., and Y.S. Ahn. "Landscape restoration: A case practice of Kushiro Mire, Hokkaido, pp. 209-233. In Hong, S.K., N. Nakagoshi, B. Fu, and Y. Morimoto (eds.) *Landscape Ecological Applications in Man-influenced Areas: Linking Man and Nature Systems.* Springer, New York: Springer, 2006.

Nakamura F., M. Jitsu, S. Kameyama, and S. Mizugaki. "Changes in riparian forests in the Kushiro Mire, Japan, associated with stream channelization." *River Research and Applications* 18 (2002): 65-79.

Özgüner, H., S. Eraslan, and S. Yilmaz. "Public perception of landscape restoration along a degraded urban streamside." *Land Degradation and Development* 23 (2010): 24-33.

Palmer, M.A., E.S. Bernhardt, J.D. Allan, P.S. Lake, G. Alexander, S. Brooks, J. Carr, S. Clayton, C.N. Dahm, J.F. Shah, D.L. Galat, S.G. Loss, P. Goodwin, D.D. Hart, B. Hassett, R. Jenkinson, G.M. Kondolf, R. Lave, J.L. Meyer, T.K. O'Donnell, L. Pagano, and E. Sudduth. "Standards for ecologically successful river restoration." *Journal of Applied Ecology* 42 (2005): 208-217.

Pittock, J., and C.M. Finlayson. "Australia's Murray-Darling Basin: freshwater ecosystem conservation options in an era of climate change." *Marine and Freshwater Research* 62 (2011): 232-243.

Riley, A. "Napa River Project: A national model." Presentation at the 2011 State of the San Francisco Estuary Conference, 2011.
http://www.sfestuary.org/soe2011/presentations/67-Riley.pdf (Last accessed 2 April 2012).

Takamura N., Y. Kadono, M. Fukushima, M. Nakagawa, and B.H. Kim. "Effects of aquatic macrophytes on water quality and phytoplankton communities in shallow lakes." *Ecological Research* 18 (2003): 381-395.

Toth, L.A. "Restoration response of relict broadleaf marshes to increased water depths." *Wetlands* 30 (2010a): 263-274.

—. "Unrealized expectations for restoration of a floodplain plant community." *Restoration Ecology* 18 (2010b): 810-819.

Uehlinger, U., K.M. Wantzen, R.S.E.W. Leuven, and H. Arndt. "The Rhine River Basin., pp. 199-245. In Tockner, K, C.T. Robinson, and U. Uehlinger (eds.) *Rivers of Europe.* London, England: Academic Press, 2009.

Vandenbrink, F.W.B., M.M. Vankatwijk, and G. Vandervelde. "Impact of hydrology on phytoplankton and zooplankton community composition in floodplain lakes along the Lower Rhine and Meuse." *Journal of Plankton Research* 16 (1994): 351-373.

Van Geest, G.J., H. Wolters, F.C.J.M. Roozen, H. Coops, R.M.M. Roijackers, A.D. Buijse, and M. Scheffer. "Water-level fluctuations affect macrophyte richness in floodplain lakes." *Hydrobiologia* 539 (2005): 239-248.

Viani, L.O. "A river lives through it." *Landscape Architecture*. January (2005): 64-75.

13.5.1. Additional references

Boon, P.J., and P.J. Raven (Eds) *River Conservation and Management*. Chichester: Wiley-Blackwell, 2012.

Darby, S., and D. Sear. *River Restoration: Managing the Uncertainty in Restoring Physical Habitat*. Hoboken, New Jersey: John Wiley, 2008.

13.5.2. Useful links

European Centre for River Restoration: A website that seeks to develop a network of national centres and to disseminate information on river restoration. http://www.ecrr.org/index.html

Global Water Partnership Toolbox: A database of background papers, perspective papers and case studies describing the implementation of better water resource management across the world. http://www.gwptoolbox.org/

Room for the River: Website describing restoration activities on the Lower Rhine http://www.ruimtevoorderivier.nl/meta-navigatie/english/room-for-the-river-programme/

The River Restoration Centre: UK-based advisory website on all aspects of river restoration, conservation and sustainable river management. http://www.therrc.co.uk/rrc_overview.php

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