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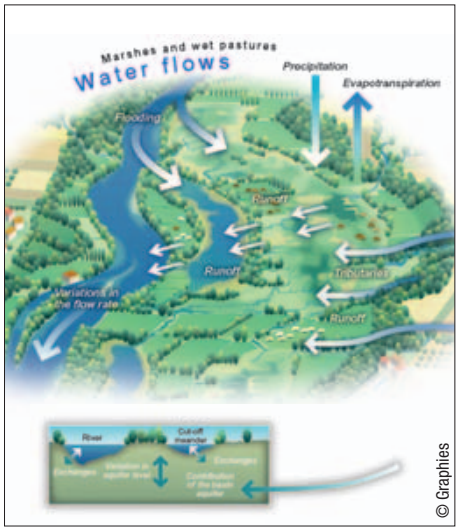
MEETINGS

Engineering the water continuum

A symposium organised by Gaié (Ecosystem engineering group) and Onema on 13-14 December 2011.

Water is an environment and a resource that has structured life from its inception and served as a vital support for biodiversity. It can be used in many ways, but it has also become a vector and receptacle for pollutants. The notion of an aquatic continuum has become critical to understanding aquatic ecosystems in that it emphasises the need for an integrative approach, spanning both the spatial and temporal scales, to water management. Incorporating this concept in ecosystem engineering is a major challenge. In addition to mobilising integrated, multi-disciplinary scientific methods, this approach must take into account not only the fact that human uses of water are highly diverse and interconnected, but the many stakeholders as well. Gaié and Onema examined the position of ecological engineering in sustainable water management during the symposium organised in the partnership with the Paris region, the French limnology association and Parisian universities.

Water quality and, more generally speaking, the good functioning of aquatic environments are a major environmental concern. The European Water framework directive requires that each Member State achieve good status for its water bodies by 2015. Management of the aquatic continuum must acknowledge social concerns and be based on integrated and multi-disciplinary scientific approaches. Within this management system, ecological engineering, which may be defined as environmental management through the design of sustainable, adaptive and multi-functional systems, based on the natural mechanisms governing ecological systems, stands out as a crucial component.



The aquatic continuum includes a number of dimensions.

The continuum, a key concept

The concept of an aquatic continuum was developed by the ecological sciences and is now acknowledged by the entire scientific community. The origin of the concept goes back to the 1980s, when R. Vannote (Vannote et al., 1980) suggested that the physical gradient of a river from its source to its mouth elicited responses from the populations living in the river. The aquatic continuum includes a number of biological, physical and chemical characteristics along the entire river (i.e. longitudinally), in the form of gradients of organic matter, mechanical energy, primary producers or invertebrates and fish.

The continuum includes other dimensions as well, e.g. a lateral dimension spanning the normal and flood channels, a vertical dimension due to the circulation and exchanges between the surface and the hyporheic zone (generally defined as the water-saturated sediment located beneath and along a river, containing a certain proportion of surface water) and a temporal dimension depending on the water level (high or low flows).

Defining the limits and producing a functional description of the continuum is a complex matter. Daniel Gilbert, an ecologist at the Franche-Comté University, illustrated this complexity in his presentation on how sphagnum bogs function.

What is Gaié?

The Gaié association federates ecosystem-engineering professionals from both the public and private sectors. It disseminates scientific knowledge and promotes new, environmentally friendly management methods. Gaié recently changed its name and became the Group of ecological-engineering professionals.

The ecosystems involved may take on many forms, ranging from swamps to wet forests, and give rise to many interactions between the terrestrial and aquatic environments. Bogs require a comprehensive and integrated approach both to understand how they function and to manage them.

Researchers from many different disciplines, ranging from anthropology to the engineering sciences and agronomy, have since illustrated the importance of this concept for management in all environmental contexts.

An often poorly perceived continuum

The concept of the aquatic continuum is now fully acknowledged by the scientific community and should lead naturally toward an integrated management system, however, practically speaking, the perception of the aquatic continuum differs from one person to the next, depending on their work, where they live, etc. The vast differences in contexts and in landscapes result in different approaches and the point of view changes depending on the sector or issue at hand, e.g. drinking water, agriculture, industry, urbanism, etc. This has led to a division between water as «natural and a living environment», water as an «industrial» commodity and «polluted» water, thus forgetting that they are all the same resource.

Yet all water follows a cycle and the different «types» of water interact. Divisions in water management can lead to problems. For example, Bernard Chocat (INSA Lyon) presented the situation with rainwater in cities, which have long been considered closed systems with no links to the natural environment.

The resulting management decisions led to sealing off cities and accelerating water flows to the point that flooding occurred in lower sections. The lack of an overall understanding of the problem produced malfunctions.

The presentation on the changes in water-management policy in Paris by Bernard Barraqué (CNRS, Marne-la-Vallée) demonstrated that the solutions selected over time followed a precise pattern. The initial need concerned quantities of water. Once that goal had been achieved, the engineering services turned to a health-oriented approach to provide a satisfactory quality of water. As a result of the changes in needs and techniques, breaks and shifts in the management of the aquatic continuum occurred.

Today and in the future, given the complexity arising from the construction of multiple, interconnected networks spanning ever larger areas, management systems must adopt new approaches.

New relations between stakeholders?

This would require looking at problems differently to solve them differently and targeting integrated systems on all scales. To that end, greater interaction is necessary between the many stakeholders:

– between researchers in the various fields as well as between fundamental research and concrete applications;

– between system design, understanding of the phenomena involved and field work;

– between researchers and local managers, notably through stronger links between research, business, State services and local governments.

These links must be created in a precise regulatory framework and adapt to organisational structures for territories and funding that must also be updated.

Management of the continuum thus leads to serious questions concerning the adequacy of current management structures.

Diverse management structures in need of harmonisation

A number of laws have contributed to structuring the various public entities that oversee the management of the aquatic continuum. The 1964 and 1992 Water laws laid down the basic configuration for French water policy by creating several institutions and organisations such as the National water committee, the basin committees and the Water agencies. The choice of river basins as the basic spatial unit for the management of water resources was confirmed by the European Water framework directive and the 2006 Law on water and aquatic environments.

The latter two created the river-basin management plans (RBMP) that are still in effect today, but above all they shifted from goals in terms of the means employed to goals expressed in terms of results and quality by setting the good status of aquatic environments as the target to be reached by 2015. This goal must, however, take into account the expectations of the various stakeholders on each management level, as well as in each sector, and the current modifications in human and environmental needs. Because management of aquatic environments is organised according to its specific rules and boundaries, it does not always have the necessary contacts and relays for operational implementation on a given scale. It may even find itself in opposition with other economic sectors that are themselves organised according to other divisions (notably administrative) or that pursue other goals.

Given the obligation to preserve or restore the good status of water and aquatic environments, the challenge is to reform the existing distribution of responsibilities and current management systems in a manner consistent with the interrelations created spontaneously by water in the territories. The different ecosystems, whether terrestrial or aquatic, must have a consistent set of management systems operating in parallel.

The French ecological network for better territorial organisation

By highlighting the French ecological network (FEN) which is now written into national law, legislators wanted to emphasise the importance of ecosystem structures and operation, as well as the need to «halt the loss of biodiversity by participating in the preservation, management and restoration to good status of the environments required for ecological continuity, while taking into account human activities» (Environmental code, article L. 371-1). The FEN is based on the regional ecological-continuity plans for its implementation on the regional and local scales. A special round-table discussion was organised to examine these relatively new policies.

The purpose of the FEN is to maintain diverse habitats and to link natural areas via ecological corridors. Success will depend on not simply marking green and blue lines on a map without first thinking about their impact on how land and water are organised and used. If the perception of the aquatic continuum is over-simplified in order to communicate on the subject, there is a risk of missing the primary objective (*see Zoom 1*).

Zoom 1. The FEN is a territorial project. Jean-Baptiste Narcy, ASCA, RGTE ENGREF, Paris

«There is a tendency to limit the concept by speaking more about longitudinal ecological continuity and less about the restoration of hydromorphological functions. It is necessary to transform the political object FEN into a policy that has meaning in terms of territorial development, while maintaining the ecological goals.»

The FEN must become a basic organisational component in territories by making possible discussions and collaboration on local projects. A one-size-fits-all solution for all territories does not exist. Given the differences between territories, solutions must be tailored on the regional level, territory by territory.

Conflict as a stimulus for action

Different stakeholders hold different viewpoints that may be contradictory, even conflictual. Discussions and negotiation are essential not only to transform an ecological project into a territorial plan, but also to encourage the various parties to take an active part (*see Zoom 2*).

Zoom 2. Conflict Fabienne Wateau, CNRS, Paris

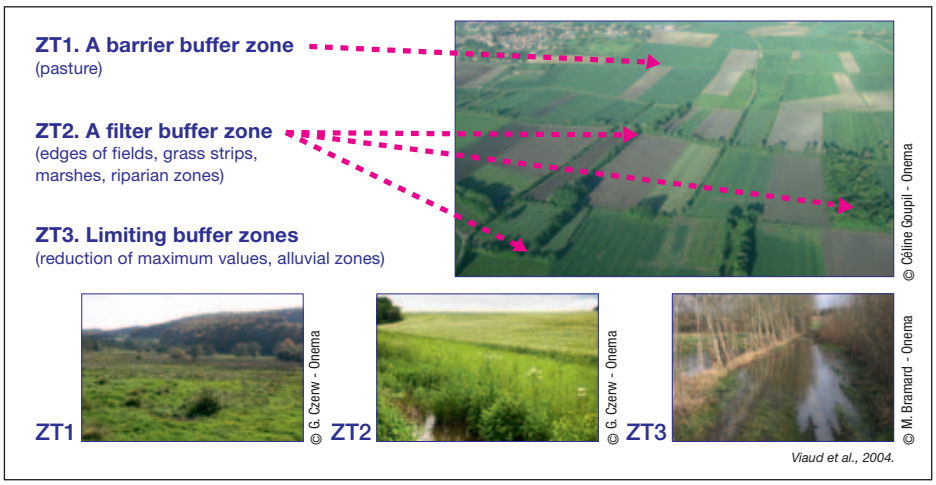
«Above and beyond its relative abundance, water is a precious resource because it is tied to so many traditions. (…) More than societal issues, today water raises a number of economic and environmental issues. (…) Water is a wonderful detonator for conflict which in itself serves to structure the debate.»

To be ecologically effective, a project must have an impact on existing practices. Disagreements are thus unavoidable in the process of accepting the project and adapting it to local conditions. A project that does not stir up any dissent is not one that will change much. People's awareness of environmental problems is indispensable in the effort to interest decision-makers and public opinion in general in the management of the aquatic continuum. Local stakeholders may be directly concerned by projects and in a position to propose solutions. It is therefore necessary to ensure that the goals and technical solutions are understood and accepted by all in most transparent manner possible. At this point in the project, a number of tools are available to assist in defining the options based on different scenarios.

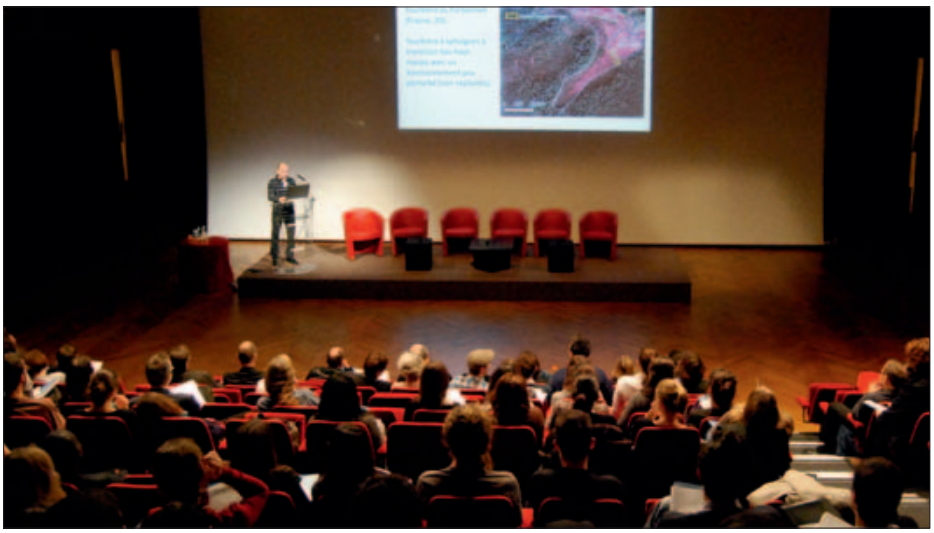
Modelling to assist action

For the management of aquatic environments, the best spatial unit is the river basin (the watershed draining to a single outlet). This complex system may be presented as a set of «elementary» sub-basins that interact and contribute to environmental quality.

In presenting the efforts against eutrophication in lakes, Jean-Marcel Dorioz (INRA, Dijon) explained that the goal is to understand the operation of the river basin as best possible, identifying the sources of phosphorus and how it is transported, then modelling the phenomenon. A spatial and functional approach to the environment must accompany the models, in order to identify the processes involved and pinpoint their location. Emissions, the buffer effect of landscapes and delaying factors can thus be built into the models in view of testing project scenarios that are as complete as possible. The river basin is conceptualised in order to produce models that can be used to organise projects that include an engineering component (*see the figure below*).



Understanding and modelling pollutant transfers (phosphorus) on the scale of a river basin (drawn from Dorioz, 2011).



Models can help in developing different scenarios to assist in making decisions on goals and projects. However, the notion of uncertainty must be seen as an essential element in the results.

Selecting goals in an uncertain context

In defining goals, collective choices are an important aspect that must be taken into account. The goals for management of the aquatic continuum may be quite diverse, ranging from the protection of flagship species to conservation and the improvement of quantitative management. Certain goals, such as the quality of water and aquatic environments, also provide information on continuum operation. For many years, emphasis was placed on habitats and flagship species, but today goals must target ecosystem operation and resilience (*see Zoom 3*).

Zoom 3. Species or functions? Daniel Gilbert, Franche-Comté University

«Peat bogs were initially managed by botanists intent on preserving protected species. Blocking drains and raising water levels are fundamental factors in ensuring correct operation of bogs and of the continuum, but some species are eliminated. In my opinion, maintaining the operation of environments is more important than saving flagship species.»

It is also necessary to set ecological goals that are compatible with project implementation. For example, eliminating mill gates is one way to restore continuity, but is not in itself a goal. Other solutions may be adopted in other contexts to achieve the same result.

Finally, modesty is required in attempting to control ecosystems. The point of engineering is to control systems, however absolute predictability is generally not possible with natural processes. It is necessary to allow for a certain degree of autonomy in systems and to keep in mind that projects are largely experimental and that time is required to produce effects, because ecosystems sometimes react over long time spans.

The challenge is to take into account and to integrate the uncertainty factor in public decision-making and in the expectations of society.

Conclusions

On the basis of the symposium discussions, it would appear essential to adopt an integrated approach to ecological and hydromorphological functions in order to manage the aquatic continuum. It is also important to keep in mind that technical and planning tools exist, but they should be implemented on the local level and adapted to the context of each territory. Finally, two factors are deemed essential for the future. The first is that the message concerning goals transmitted by all stakeholders must be consistent (*see Zoom 4*). The second is that, given the unpredictability of ecosystems, a degree of uncertainty concerning final results must be accepted by decision-makers and the general public.

Zoom 4. Does the approach to management need improvement? Alain Dutartre, IRSTEA, Bordeaux

«The success of projects depends on the consistency of the approach by the various partners. Each partner in management has its own rationale and consequently, the goals of projects are not limited to environmental management alone. In addition, projects are often fairly empirical in nature and their implementation is only rarely followed up with a critical analysis of the results that could reduce the empirical aspects.»

For more information…

Vannote, R., Minshall, G., Cummins, K., Sedell, J., & Cushing, C. (1980). The river continuum concept. Canadian journal of Fisheries and Aquatic Sciences, 37, 130-137.

The presentations and abstracts of the meeting may be found at www.ingenierie-ecologique.org, in the «Colloque 2011» section.

Meeting organisation

The members of the Gaié organising committee and, for Onema, Véronique Nicolas, policy officer for ecological engineering in the Research and development department.

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