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Editorial

Defying Water's End: do we need different conservation strategies for aquatic systems compared with terrestrial?

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In August 2000 a group of people got together at California Institute of Technology (Caltech) to contemplate global conservation (Pimm *et al.*, 2001). Their brief was to see how costly it would be to save Earth's biodiversity and how they might go about it. They decided to concentrate on biodiversity hotspots and some other areas of high diversity. They then proceeded to evaluate the costs of acquiring these areas and of buying out conflicting interests, such as logging. The overall message was quite positive: the potential cost of acquiring and conserving a sizeable part of the world's biodiversity was not astronomical compared with the budgets for some other human activities (such as the defence budget of the USA). The estimate was $US30 billion. The practicalities of doing this were not addressed, and indeed if they had been the exercise would have attracted more criticism from countries that felt their national integrity challenged by such an approach. But the message came through clearly: you can conserve by protecting land (Pimm *et al.*, 2001).

Inspired by this initiative, another conference was planned to address the issues of marine conservation: Defying Ocean's End, in Los Cabos, Mexico, 29 May to 3 June 2003 (Glover and Earle, 2004). Right from the start the workshop recognized that conservation of the oceans could not have the same strategy as the conservation of terrestrial biodiversity. The general questions of ocean conservation do not lend themselves to specific allocation of space. The sea by its very nature is connected; what happens in one part potentially affects other parts. The body of water that you might protect in one place does not stay there, but moves with currents to other places. Thus most of the main questions in marine conservation have to do with processes — of pollution, fishing, ecosystem functioning, transport, etc. This is not to say that different regions of the marine environment do not have to be treated separately and distinctly. Indeed the Los Cabos conference was structured into five regional case studies and the recommendations and continuing efforts call for various types of marine reserves. But the seven thematic working groups dealt with processes as much as with allocation of protected areas. The recommended Large Marine Ecosystem areas are so vast that they require integration of exploitative uses (such as fishing and mining) and other impacts (such as coastal run-off).

I am not suggesting that we need another conference along the lines of Defying Water's End and I am not about to approach Conservation International and the Gordon and Betty Moore Foundation to mount such an exercise. Yet I suggest that the thought experiment might be interesting — how might we expect that an initiative along these lines could be structured. I do not intend my brief comments to be in any way comprehensive of the available literature and initiatives, and I will necessarily emphasize my region of the world (south-east Brazil) and my area of expertise — streams and rivers rather than lakes and wetlands.

The conservation of inland waters shares characteristics of both terrestrial conservation and marine aquatic conservation. The interface of inland waters with inland land is necessarily great, and no practical scheme for aquatic conservation can ignore the terrestrial component. Marine conservation increasingly takes the land–sea interface into account, but this factor is obviously smaller than in the case of inland waters. On the other hand, conservation of inland water shares characteristics with ocean water which have to do with the medium. Water runs from place to place and carries materials with it, and this influences how we conserve the systems contained by it. River water tends to be much more vectorial and unidimensional than sea water, which needs to be treated in two and three dimensions, but both media do not stay in the one place.

Aquatic ecosystems tend to be very interactive and have rapid dynamics and turnovers. This implies that in many cases the understanding of the system dynamics can be researched more rapidly and the recovery of the system after restoration can be relatively rapid (Bernhardt *et al.*, 2005). Unfortunately, this simplistic view turns out not to be the case in certain marine ecosystems, which appear to be much more complex

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than initially thought and appear to take a long time to recover from overfishing (Fogarty and Murawski, 1998).

The conservation of inland waters can be seen to be intimately linked to terrestrial conservation and have characteristics of marine conservation. There are differences, however, in the way it is enacted. First, water in itself is a resource, and in many if not most cases the questions of water usage have to be made compatible with its conservation and the conservation of the ecosystem contained in the water. Indeed the older usage of the term 'water conservation' pertained to the conservation of water itself as a resource and not necessarily to the conservation of the associated biodiversity and ecosystem. Second, the conservation of inland aquatic systems is often enacted within the conservation of the surrounding terrestrial systems.

The consequences of this connection with terrestrial conservation flow in both directions: there are consequences for terrestrial conservation that stem from aquatic resources and consequences for aquatic conservation that follow from terrestrial conservation. Some of the former were forcefully shown by Pringle (2001), who examined several cases of parks around the world. Parks that were set up for terrestrial conservation but did not take cognisance of aquatic relationships were shown sometimes to have severe problems. This was especially so for parks that did not include conservation of the headwaters of the rivers that flowed through the parks, and in hindsight this is an obvious mistake. However, problems can also arise from not protecting the parts of the river system downstream from the park.

Are there conflicts of interest between terrestrial and aquatic conservation? I suggest that in theory there are not, but in practice they may arise. Park planning and management is mostly carried out by terrestrially-orientated professionals. Some of the theoretical underpinnings, such as species–area relationships and island biogeography are explicitly neutral with respect to features of the landscape. Naïve application of this theory to park size and corridors of connectivity has led to planning that defies good sense (as highlighted by Pringle, 2001). Recognition of the importance of planning based on catchments is widespread these days; it has important consequences for conservation of aquatic systems (Naiman, 1992; Moulton *et al.*, 2007). Yet in my experience, the resource-based, water-allocation side of catchment management may remain dissociated from biodiversity preservation and ecosystem integrity (Moulton, 2002).

Recently in my home state of Rio de Janeiro, we carried out an exercise of identifying needs for biodiversity conservation and planning of conservation areas. This was an update and expansion of an earlier initiative in this direction (Bergallo *et al.*, 2000). The participants were diverse in their areas of expertise — zoologists of many taxonomic groups, geographers, social scientists, etc. The procedures paid particular attention to dividing up the state into appropriate regions and georeferencing the data. The various areas were analysed for biological richness and uniqueness, threats, need for conservation areas, possibility for corridors, etc., and the result was an impressive body of knowledge and analyses to guide the conservation of Rio de Janeiro. However, for the two groups that dealt with aquatic fauna (divided into fish and invertebrates) these spatial divisions did not reflect well the reality of aquatic systems, which transgress the boundaries of conservation areas. Indeed, the situation with conservation areas in Rio de Janeiro, as in many parts of the world, is of relatively good protection of mountainous regions, but the lowlands and coastal plain suffer both from extensive human impact and lack of conservation areas. Many low-order streams are in the mountainous parks, but above third order, most rivers are not protected. Many species of fish and invertebrates inhabit the higher order parts of aquatic systems, and for some taxa the third and fourth order parts carry the highest diversity, but most parks do not include these parts. Also, certain important fish and crustacean species are migratory or catadromous and thus depend for their existence on the biological continuity of the river system. On the other hand, parks tend to be declared as 'all of the area above the 200 m contour', rather than with a definition that takes account of integrated landscape features or riverine continuity. To be fair, this is also a perceived problem for terrestrial conservation: scarce lowland forest patches were highlighted as biodiversity hotspots for birds in Rio de Janeiro (Jenkins and Pimm, 2005).

Returning to the general questions of aquatic conservation, I offer the following suggestions. First, there should be identification and conservation of 'hotspots', or at least whole river systems that are relatively intact (see Linke *et al.*, 2008 on detection and quantification of catchment uniqueness). This would be followed by implementing a policy of strict preservation. Unfortunately, opportunities to do this are limited; most river systems of the world are now impaired by dams, effluents, changed land-use, etc. We can visualize the comprehensive conservation of terrestrial and aquatic systems in the larger regions of the Caltech study, such as the Amazon (Pimm *et al.*, 2001), but for hotspots that have lost much of their former extent and are principally restricted to mountainous regions, there are perhaps no intact rivers left. Brazil's Atlantic Forest is in this predicament.

Second, for most river systems, their conservation will resemble more the Los Cabos model, with recognition and management of the dynamic, functional and exploitative components of the system. A good example is found in the modelling of Australia's southern and eastern marine ecosystem in which the exploitation of fish is set within the functioning of the marine ecosystem and maintenance of marine biodiversity (Smith *et al.*, 2007; http://www.csiro.au/science/ps3i4.html). Such plans must span a huge range of scales and problems, from the international coordinated efforts in large rivers to the more local, such as those of my home territory (Moulton *et al.*, 2007). They may involve questions of triage — of preserving certain river systems by concentrating development in others, as potentially could be the case for dam development in Costa Rica (Anderson *et al.*, 2006).

Third, freshwater conservation will often take place in combination with terrestrial conservation and the two are reciprocally beneficial. However, a narrowly territorial approach can be inimical to the needs of aquatic systems, and aquatic conservationists must push for the incorporation of dynamic strategies based on ecosystem functioning to guarantee the integrity of aquatic systems.

Do we need a different conservation strategy for inland waters? Yes, to the extent that the terrestrial models do not adequately encompass the extent and nature of the aquatic systems. And no to the extent that landscape based models of dynamic interactions are being developed for comprehensive

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conservation and management in which aquatic systems are an integral part. Freshwater conservation biologists and managers need to be vigilant and creative to protect the special characteristics of aquatic systems.

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REFERENCES

Anderson EP, Pringle CM, Rojas M. 2006. Transforming tropical rivers: an environmental perspective on hydropower development in Costa Rica. *Aquatic Conservation*: *Marine and Freshwater Ecosystems* **16**: 679–693.

Bergallo HG, Rocha CFD, Alves MAS, VanSluys M. 2000. *A fauna ameaçada de extinção do Estado do Rio de Janeiro*. Editora da Universidade do Estado do Rio de Janeiro: Rio de Janeiro.

Bernhardt ES, Palmer MA, Allan JD, Alexander G, Barnas K, Brooks S, Carr J, Clayton S, Dahm C, Follstad-Shah J *et al*. 2005. Synthesizing U.S. river restoration efforts. *Science* **308**: 636–637.

Fogarty MJ, Murawski SA. 1998. Large-scale disturbance and the structure of marine systems: fishery impacts on Georges Bank. *Ecological Applications* **8**: 6–22.

Glover LK, Earle SA. 2004. *Defying Ocean's End*: *An Agenda for Action*. Island Press: Washington, DC.

Jenkins CN, Pimm SL. 2005. Definindo prioridades de conservação em um hotspot de biodiversidade global. In *Biologia da Conservação*: *Essências*, Rocha CFD, Bergallo HG, VanSluys M, Alves MAS (eds). Rima: São Carlos, SP; 41–52.

Linke S, Norris RH, Pressey RL. 2008. Irreplaceability of river networks: towards catchment-based conservation planning. *Journal of Applied Ecology* **45**: 1486–1495.

Moulton TP. 2002. What role should Ecology play in the conservation and management of inland water resources? *Aquatic Conservation*: *Marine and Freshwater Ecosystems* **12**: 253–256.

Moulton TP, Souza ML, Oliveira AF. 2007. Conservation of catchments: some theoretical considerations and case histories from Rio de Janeiro. *Neotropical Biology and Conservation* **2**: 28–35.

Naiman RJ. 1992. *Watershed Management*. Springer-Verlag: New York.

Pimm SL, Ayres M, Balmford A, Branch G, Brandon K, Brooks T, Bustamante R, Costanza R, Cowling R, Curran LM *et al*. 2001. Can we defy nature's end? *Science* **292**: 2207–2208.

Pringle CM. 2001. Hydrological connectivity and the management of biological reserves: a global perspective. *Ecological Applications* **11**: 981–998.

Smith ADM, Fulton EJ, Hobday AJ, Smith DC, Shoulder P. 2007. Scientific tools to support the practical implementation of ecosystem-based fisheries management. *ICES Journal of Marine Science* **64**: 633–639.

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