Conservation Biology for the Biodiversity Crisis: a Freshwater Follow-up

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Introduction

In their essay "Conservation Biology for the Biodiversity Crisis," Olson et al. (2002) identify critical research gaps hampering effective conservation planning, with an emphasis on the terrestrial realm. The situation for freshwater biodiversity is so grave that an additional plea for freshwater research is warranted. Freshwater fish alone comprise one-fourth of all living vertebrate species, and recent assessments suggest that over 30% of them are threatened (World Conservation Union 2000). The situation is even more dire for other freshwater faunal groups. On average around the world, freshwater habitats and their species are more imperiled than their terrestrial counterparts (McAllister et al. 1997; Ricciardi & Rasmussen 1999).

If the conservation community acknowledges the freshwater biodiversity crisis, current research fails to reflect it. A quick tally of papers published in *Conservation Biology* from 1997 through August 2001 shows that only 7% have some relation to freshwater species and habitats, including wetlands. Excluding papers focused on use of riparian habitats by terrestrial species, the number drops to 4%. The remaining papers are heavily skewed toward the topics of amphibian declines and exotics, and particularly the effects of exotics on amphibians. Questions involving the design and success of large-scale conservation strategies are rarely addressed. Some specialized journals, such as *River Research and Applications* and *Freshwater Biology*, feature articles on freshwater biodiversity and conservation more often, but the paucity of freshwater research in *Conservation Biology* suggests that the mainstream conservation community has not given this critical issue the attention it requires.

Many of the key questions that hamper freshwater conservation planning involve both scientific inquiry and landscape planning and will require considerable effort to answer. Fortunately, even incremental advances can contribute meaningfully to conservation planning and action on the ground. Here I outline several of the more pressing research questions.

State of the Natural System

Distribution of Freshwater Species and Habitats

For all but a fraction of the world's freshwater habitats, there is a dearth of information on numbers or types of species, the habitats they use, or broader biogeographic patterns. Rapid biodiversity assessments are too resource-intensive to undertake everywhere, making predictive models an essential tool, particularly in inaccessible regions. Intensive surveys can be targeted at those poorly known areas expected to reveal a wealth of biodiversity. In the Congo Basin, for example, experts have identified the vast Cuvette Centrale as a priority for surveys once political stability returns to the region. In the meantime, uncataloged specimens collected half a century ago may provide data for a predictive model.

Ecosystems facing impending threats such as major impoundments are particularly important research targets. Even if surveys cannot prevent the construction of new projects, baseline information is critical to assessing effects and thereby influencing future development decisions. In the lower Mekong River Basin, consultants assessing the effects of 10 proposed hydropower dams on fishes concluded that the biological data were insufficient to evaluate or prioritize among the sites (Hill & Hill 1994). This is hardly surprising, given that at least one pre-impoundment fish survey was reportedly conducted during a helicopter overflight. Whether or not this particular account is entirely accurate, there is ample precedent for developers and governments employing grossly inadequate biological information. When this happens for lack of better data, conservation biolo-

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gists have missed an opportunity to inform and influence decision-makers.

Key Habitat Requirements of Focal Species

Even when we know what needs saving, in many cases we don't know how to save it. Conservation biologists often identify focal species to define target spatial and compositional landscape attributes (Lambeck 1997). In the terrestrial realm, these focal species frequently take the form of wide-ranging, large-bodied umbrella species used to estimate minimum areas for protection. In the freshwater realm, likely umbrella species may also be wide-ranging (e.g., long-distance migratory fish), but key habitat requirements may not be measurable by area. River species that undertake lateral or longitudinal migrations as water levels change often require access to particular seasonal habitats, which in turn are created and maintained by particular flow regimes. Without documentation of the movements of key migratory species, we cannot make informed recommendations regarding activities such as hydropower development, interbasin water transfers, and channelization. Recent efforts to understand the population structures, movements, and life histories of the Mekong giant catfish (*Pangasius gigas*) and the morocoto (*Colossoma macropomum*) in the Orinoco, using radiotracking and microsatellite DNA analysis, exemplify the kinds of research that can inform conservation efforts for entire river basins.

Lack of information about habitat requirements hampers conservation planning in other types of freshwater systems as well and relates equally to focal species that are neither large nor wide-ranging. In lake systems where bottom-up processes can exert substantial controls, plankton and other small but abundant organisms may be far more important research targets than top predators.

Characterization of and Species Adaptation to the Natural Hydrologic Regime

Developing a conservation strategy for a given system requires understanding the fundamental characteristics of the hydrologic regime, including its natural range of variation and timing of events. Knowing how flows shape habitats and trigger biotic processes permits identification of targets. However, a recent conference sponsored by The Nature Conservancy on managing river flows for biodiversity revealed that even in places like the United States with a long history of flow data and species-level investigation, unequivocal flow targets are notoriously hard to determine.

If this is true, how can we tackle such problems in countries where flow data are sparse or nonexistent? The good news is that in many instances flow regimes are less modified in these places, so the challenge is in describing rather than reconstructing them. The relatively undisturbed systems in developing nations represent unique but fleeting opportunities for large-scale proactive protection. In basins such as the Mekong, where some major waterways remain free-flowing for much of their length, one conservation strategy would be to focus immediate efforts on protecting the unimpounded rivers and their catchments. Selection of first priorities for protection could be based on relative biodiversity value, which takes one back to the need for species and habitat information.

Threats to the System

Even perfect knowledge of a system's biotic and abiotic processes is not enough to develop an effective freshwater conservation strategy. For the most part, we know too little about how threats operate at large scales to be able to prevent or mitigate them.

Conservation planning for freshwater biodiversity involves recommending how the terrestrial landscape should be managed. This requires asking questions about the transfer of water, materials, and energy. How are disturbances associated with different land uses attenuated over distance? What is the minimum amount of land in a catchment that should remain under natural land cover, and how should that land be located and configured? Can artificial vegetation types (e.g., plantations) provide services to freshwater systems similar to those of natural vegetation types? For groundwater-driven systems, where do threats originate and how can they be addressed? How can threats transmitted via wind or precipitation be mitigated? The answers to these questions will be location-specific, but well-designed studies may yield results that are transferable to similar habitat types.

Freshwater biologists recognize that gross modifications to aquatic habitats constitute threats to biodiversity, but there is insufficient empirical evidence to convince some policymakers. We need studies proving the obvious—such as that migratory fish populations will be adversely affected if lateral or longitudinal connections are severed. This will require studies either before and after or well-designed paired analyses.

No matter how enlightened policymakers are, foreclosing all development projects is not an option. For instance, hydropower will supply a large fraction of the developing world's growing energy needs. Conservation biologists can make recommendations for locating projects where they will do the least harm. Studies on focal species could supply the justification.

Overexploitation of freshwater species is such an obvious threat that it is sometimes forgotten, even though it remains a huge problem in many areas and may be one of the most tractable problems to solve. Sustainable harvest, perhaps employing carefully located and timed no-take zones, may be possible for some overexploited species. Identifying the parameters within which such a harvest would function requires information about life histories, habitat requirements, and population trajectories. Profitable harvest of species of high commercial value, such as the cardinal tetra (*Paracheirodon axelrodi*) of the Orinoco and Rio Negro, may forestall far more-detrimental activities such as logging and mining.

Finally, exotic species pose a well-documented threat to aquatic species, especially in certain types of habitats such as lakes and springs. Eradicating established exotic species is virtually impossible, and people have a propensity to augment freshwater communities with new species. So, addressing this threat may require timely educational campaigns as much as academic scientific study.

Crosscutting Planning Questions

Economic Value of Freshwater Biodiversity

For good or bad, freshwater species' best chance for salvation may lie in their individual or collective economic worth. The World Wildlife Fund recently held a workshop focused on applying economic tools to freshwater biodiversity conservation in the Asia and Pacific region. Participants found that exploring the full range of market and nonmarket values embodied in functional systems generated strong arguments for conservation. Economic valuation is not a magic bullet, and it certainly has its risks, but it can provide supporting arguments for protecting freshwater resources, particularly in places where humans rely heavily on them.

Integrating Conservation Planning across Realms

Most terrestrial conservation planning has overlooked freshwater biodiversity, in part because incorporating freshwater species and habitats adds several layers of complexity to an already complicated effort. Attempts to clearly define and address the needs of freshwater species and habitats have often resulted in freshwater biodiversity assessments being conducted separately, but this perpetuates a false dichotomy that inhibits effective conservation. Integrating conservation strategies will require a more sophisticated approach than simply adding sets of priorities together or highlighting areas of overlap. We need successful examples of this integration. Although this is admittedly more of a planning than a scientific issue, it will be increasingly important as plans are transferred from paper to practice. Conversations about conservation planning should include all relevant biological realms. Too many initiatives within conservation organizations presently take a myopic perspective that sees the world as terrestrial, freshwater, or marine, rather than an integrated whole.

Incorporating Scenarios of Global Climate Change into Conservation Planning

The consequences of climate change may be most severe in the freshwater realm, given that aquatic species have finite options for escaping warm water and dry places. In regions where water will become scarcer, aquatic species will also face rising competition with humans for the remaining drops. In those places predicted to experience increased flows and flooding, species may be equally at risk, both from altered flows and from human modifications to control and capture them. The design of conservation strategies that incorporate climate-change predictions is a virtually unexplored frontier, ripe with research possibilities.

Conclusions

Freshwater research may be less sexy than that in the terrestrial or marine realms, but trajectories of species loss make it arguably the most urgent. A small number of conservation biologists focusing on freshwater systems are trying to cover an enormous amount of territory, and they need help. This will not require a massive re-training effort of today's biologists. We can answer many of the critical questions about conserving freshwater species and habitats through integrated research in the terrestrial realm. The lack of information on freshwater biodiversity can be discouraging, or it can offer a world of possibilities for research strategically targeted at addressing the big unanswered questions.

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