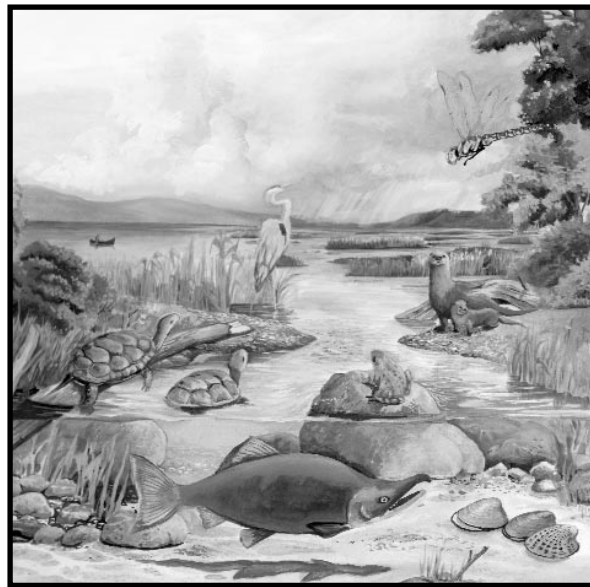


New Currents in Conserving Freshwater Systems

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POSTER ABSTRACTS



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Abstracts are listed alphabetically, by first author. Names appearing in all capitals are of presenting authors. Contact information appears after author affiliation in the byline. Following the abstracts is the name of the topic area to which the poster is most closely associated (Innovations In Understanding Freshwater Systems, Innovations in Planning for Conservation, Innovations in Putting Plans Into Practice, Innovations in Evaluating and Monitoring Outcomes). Although many posters are appropriate for multiple topic areas, only one is listed.

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MANAGING FRESHWATER RESOURCES FOR SUSTAINABLE DEVELOPMENT IN PAKISTAN

Water is a key to our health, our spiritual needs, our comforts, our livelihoods and our ecosystems. Yet every where water quality is declining, and the water stress on humanity and our ecosystems is increasing as the time passes – More and more people live in fragile environments. Freshwater is the main source to meet all these unavoidable requirements. The global warming and climatic changes are further intensifying the hydrological cycle, impacting on the water availability. Increasing variability in precipitation could endanger species, leading to declined food production. These water issues, all the developing countries need to address urgently during the 21st century. There are grave concerns that fierce national competitions over freshwater as well as groundwater resources contain the seeds of violent conflict. Two third of the world's major rivers, 261 river basins comprising nearly half the population of the world are shared by two or more states. The water problems faced by the world can catalyze cooperation. Freshwater management is one of humanity's most ancient activities with tangible and intangible marks on all-cultural settings. In today's world, it is closely linked to the world security and is a key to sustainable human development. Undoubtedly strong linkages do exist between water and poverty. Role of Freshwater in human civilization development and lifestyle uplift is invaluable. In the context of Pakistan, the paper will focus on the water situation and major challenges towards Integrated Water Resources Management (IWRM). It will describe freshwater resources' major role in Pakistan's GDP and gives facts and figures about water availability for domestic and agricultural needs. It will also cover potential of harvesting rainwater for irrigating areas outside the Indus Basin. It will highlight the role of women and suggest an optimal use of freshwater flows to overcome hydro energy gaps.

■ INNOVATIONS IN PUTTING PLANS INTO PRACTICE

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INTEGRATING WATER SUPPLY MANAGEMENT AND ECOLOGICAL FLOW WATER REQUIREMENTS

Balancing human and environmental water resource needs is critical to environmental sustainability and has attracted

attention at the national and global level. We are developing a methodology that will enable states, communities and cities to more sustainably manage their water supplies by balancing human and ecosystem needs. This goal will be achieved by developing a decision support system (DSS) that enables water managers to optimize multiple objectives by simultaneously maximizing the use of water storage capacity, strategically using demand management measures, and adaptively meeting key ecological flow needs based on real-time environmental conditions. The DSS will demonstrate that by refining the quantity and timing of reservoir releases, actively managing demands through adaptive drought management and conservation measures, and by defining key ecological flow parameters more precisely, the reliability of a water supply yield can be substantially maintained and ecological flows requirements can be met on a more consistent basis. Our methodology combines: (1) recent advances in optimization algorithms and decision support systems with (2) established software for planning and management of water supply systems, and (3) recent advances in defining variable ecological flow needs with (4) a multi-objective decision oriented approach for balancing two disparate objectives in socially optimal terms, using the concept of the Pareto Frontier. Our initial evaluation of this methodology includes the concept of an "ecodficit" which is used to quantify the impact of changes to the natural flow regime resulting from human withdrawals. This metric provides a numerical and graphical representation of the tradeoff between human and ecological needs for available water. We use this metric in a case study and demonstrate that by refining the quantity and timing of reservoir releases the reliability of a water supply yield can be substantially maintained while improving the satisfaction of ecological flows requirements.

■ INNOVATIONS IN PUTTING PLANS INTO PRACTICE

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FRESHWATER CONSERVATION PLANNING IN THE NIGER RIVER BASIN

The Niger River is considered "the cultural, economic, and ecological backbone of West Africa;" human populations having depended on its vital supply of fresh water in this essentially xeric region for thousands of years. The Niger Basin Initiative (NBI) is an environmental partnership that was forged between World Wide Fund for Nature (WWF), Wetlands International (WI), and Nigerian Conservation Foundation (NCF) in May 2001 to address biodiversity conservation of the Niger River on a basin-wide scale. A cooperation agreement was

signed in October 2003 between the international organizations working on nature conservation within the basin (WWF, WI, BirdLife, and IUCN) and the Niger Basin Authority (NBA). The partner organizations are working together to ensure that biodiversity conservation and sustainable use of natural wetland and forest resources are built into development plans for the basin. In April 2002, the NBI convened about forty scientists from the region to identify areas of high priority for conservation based on their biological and hydrological values. Since that time, eight new Ramsar sites have been designated within identified priority areas; four sites in Guinea (Niger-Mafou, Niger-Niandan-Milo, Niger Source, Niger-Tinkisso), three sites in Niger (Dallol Bosso, Dallol Maouri, and Middle Niger II wetlands) and one in Mali (Inner Niger Delta). Additionally, management plans have been completed for the following Ramsar sites: the Middle Niger I in Niger, the Niger Source in Guinea, Akassa Coastal wetland in Nigeria, and Mare d'Oursi in Burkina Faso. The Niger Basin Authority, made up of its member nations, has recently committed to developing a "shared and clear vision" for sustainable development that will preserve the environment and natural resources of the basin and its social and economic development. The NBI is supporting this work and facilitating the participation of civil society in the building of this vision.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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IDENTIFYING FRESHWATER PROTECTION GAPS IN SOUTH AMERICA

Gap analyses are often conducted to assess holes in protection for terrestrial species, but similar analyses are rare for freshwater taxa. We undertook a project to evaluate the degree of protection that South America's current protected area system is providing to known threatened and endangered freshwater. We overlaid the protected area coverage from the 2005 World Database of Protected Areas and the distributions of those South American freshwater species assessed as critically endangered, endangered, and vulnerable on the IUCN Red List. We then calculated the percentage of each species' distribution that was covered by protected areas across the continent. We repeated this analysis for species considered endemic to a single country (defined as having > 75% of their distribution within one country), given that protected area designation and management are normally administered at the country level and that species with limited ranges are susceptible to greater comparative losses than widespread taxa. We included mammals ($N = 11$), water birds ($N = 8$) and amphibians ($N = 307$) in the analysis. Fish and

invertebrates were not included in the analysis since their distribution maps were obtained as points rather than polygons. There were 290 country-level endemics among amphibians, 9 for mammals, and 7 for birds. The country with the overall greatest number of endemics was Colombia (96). The countries that contributed the most with the protection of endemic species by taxa were: for mammals Venezuela (59.86%), for birds Ecuador (96.18%) and for amphibians Bolivia (47.77%). The average area protected for mammals was 22.11% for birds 28.69% and for amphibians was 26.20%. The results suggest that the protected area system in some countries could be refined so as to cover the greatest number of freshwater species that are currently being left without protection.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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THE HEADWATER'S PROJECT: CONSERVING TERRESTRIAL AND FRESHWATER HABITATS OF THE WOOD TURTLE, *GLYPTEMYS INSCULPTA* USING RADIOTELEMETRY, GPS, AND GIS

The Headwater's Project is a proactive land conservation effort with the aim of protecting the structure and function of habitat mosaics surrounding free flowing streams within the Piscataquog River Watershed, New Hampshire. Working with local land trusts, the Piscataquog River Watershed Association, the Frankestown Land Trust, and the Russell Foundation, we use GIS mapping of habitat attributes and the terrestrial and freshwater locations and interactions of focal species, as criteria for selecting high priority conservation targets. Here we describe the first year results of a radiotelemetry study of the wood turtle, *Glyptemys insculpta* in one headwater stream. Habitat loss, degradation, and fragmentation, road mortality, and the pet trade have lead to the decline of wood turtle populations throughout its range. As baseline data we assessed stream water quality using indices of biotic integrity based on the fish and macroinvertebrate assemblages present as well as water chemistry. We have located over 25 wood turtles within an activity center that includes the confluence of streams, multiple wetland types, open fields, forested uplands, and an exemplary flood plain forest. We used GPS locations of 10 tracked turtles to identify nesting sites, feeding areas, and hibernacula and to determine distances traveled from streams, major activity areas and home range. We calculate and compare home range using (1) minimum convex polygon; (2) harmonic mean; and (3) fixed kernel methods. We intend to track 20-30 additional turtles during the second year of the study. Preliminary results of this study have been used to educate private landowners of the importance of the terrestrial-aquatic connection for maintaining both viable wildlife populations and high water

quality. These efforts have already contributed to the protection of conservation target areas through the donation conservation easements by private landowners.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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**CORRELATION BETWEEN MERCURY
CONCENTRATIONS IN BROOK TROUT AND
TWO SPECIES OF AVIAN FISH PREDATORS IN
NORTHERN NEW ENGLAND**

Atmospheric mercury originating from industrial sources is deposited in aquatic ecosystems in Northeastern United States and the Maritime Provinces of Canada. Regional waste management policies affect the way mercury contamination is distributed on a regional scale. Bioaccumulation of this element and subsequent trophic magnification poses neurological problems for top predator species in aquatic systems. Cascading trophic effects, caused in part by mercury loading and subsequent top predator mortality can significantly impact aquatic ecosystems. Generally mercury contamination varies from waterbody to waterbody within regions, but we were interested in a gradient of mercury contamination across a broader geographic scale. We obtained data from several mercury contamination projects in northern New England and estimated the correlation between mercury contamination in brook trout (*Salvelinus fontinalis*) and two species of avian fish predators, common merganser (*Mergus merganser*) and belted kingfisher (*Ceryle alcyon*). We conducted analyses on three geographic scales: county level, 1° by 1° blocks, and based on spatial interpolation across the region. We found a weak but positive correlation between trout mercury concentrations and avian fish predators on these scales. We also found that the blood mercury concentration in common mergansers was consistently higher than in belted kingfishers. This may be because mergansers feed at a higher trophic level therefore exposing them to higher levels of mercury. As mercury emission levels are currently a contested issue in U.S. policy it is important that those in policy making positions understand all possible ecological implications of this element. Because our results suggest both a large scale gradient as well as waterbody to waterbody variation, effective policy regarding mercury must address both atmospheric mercury and local sources such as landfills, mining, and waste water treatment.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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**THE PACIFIC NORTHWEST AQUATIC
MONITORING PARTNERSHIP: A FORUM FOR
REGIONAL COORDINATION**

The purpose of the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) is to provide a forum for coordinating state, federal, and tribal aquatic habitat and salmonid monitoring programs. Improved communication, shared resources and data, and compatible monitoring efforts provide increased scientific credibility, cost-effective use of limited funds and greater accountability to stakeholders. PNAMP provides leadership through the development and the advancement of recommendations and agency level agreements that are considered for adoption by the participating agencies. PNAMP has adopted the following goals: 1) improve communication between monitoring programs across state, tribal, and federal organizations; 2) improve scientific information needed to inform resource policy and management questions and decisions; 3) seek efficiencies and cost-effectiveness across monitoring programs through compatible and cooperative monitoring efforts; 4) promote science-based credibility of monitoring and assessment efforts; 5) share resources and information between monitoring programs across state, tribal, and federal organizations. PNAMP receives significant policy support and direction by member organizations, commitments of technical resources and staff time and funding for the coordination itself. As part of a monitoring coordination structure, PNAMP has identified and developed technical working groups for five key elements of monitoring: watershed condition monitoring, effectiveness monitoring, fish population monitoring, estuary monitoring, and data management.

■ INNOVATIONS IN EVALUATING AND MONITORING OUTCOMES

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**SYSTEMATIC COMPARATIVE ANALYSIS OF
WATERSHED HABITATS ACROSS REGIONS FOR
PRIORITIZING RESTORATION AND
CONSERVATION**

The types, abundance and diversity of riverine habitats are not uniformly distributed either within a single watershed or across populations of watersheds at the scale of landscapes, states, regions or nations. Identifying high value riverine areas for

restoration or conservation is often made *ad hoc* because of the absence of large watershed terrain databases that focus on key basin and valley segment-scale habitat forming processes and the lack of automated tools that utilize such data to make systematic comparative analyses among populations of watersheds. Key watershed attributes that govern intrinsic characteristics of riverine habitats include geology, climate, hydrology, topography, vegetation, network configuration, valley morphology, and basin connections (estuaries, lakes, reservoirs, etc.). Utilizing high resolution topographic data by new automated terrain analysis tools in combination with rapid aerial photo and field-based methods is now allowing development of large watershed terrain databases rapidly and at low cost. Watershed databases contain habitat information that can be displayed on maps or that can be queried to search, sort, rank, compare, and classify intrinsic habitat attributes. This information is used to locate individual watersheds or portions of them containing the highest habitat potential, highest habitat diversity, highest number and diversity of floodplain segments, and the most dynamic and stable sections of river networks. Hence, watershed terrain databases can support identifying the best areas for increased protection or conservation, prioritizing restoration activities, and stratifying landscapes for varying intensities of land use. In addition, comparative analyses of watersheds and river networks that identify the best habitats and the highest riverine diversity over large spatial scales may have the potential to influence governmental policies toward land use and environmental protection. Earth Systems Institute is pursuing a nation-wide watershed terrain database in support of landscape-level resource management, restoration, and conservation starting in the Pacific Northwest.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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LINKING ENVIRONMENTAL HETEROGENITY AND BIODIVERSITY TO RESTORATION EFFECTIVENESS: A COMPARISON ACROSS SITES IN THE UPPER KLAMATH BASIN

Riparian ecosystems and freshwater fauna have undergone a significant decline in Oregon over the past thirty years. Ecosystem recovery efforts often include exclusion of livestock grazing and instillation of large woody debris, to improve water quality, and fish and wildlife habitats. Yet, few studies have examined how these actions change stream processes, biological communities, and associated effects within contiguous reaches. In the Klamath Basin of Oregon, we evaluated reach scale channel adjustment from active and passive restoration on 60 stream segments from 1995-2004 considering hydrologic regime, and aquatic fauna. Analysis of cross-section channel adjustments following

land management (passive) or active restoration activities appears to be decades (15-25+yr). We have found the thalweg depth range measured at the reach scale varies annually and appears to respond to the hydrologic regime and watershed function. More importantly, variation in thalweg depth range/mean channel width (channel metric) is highly correlated ($R^2 = 0.83$, $p < 0.0001$) with native salmonid biomass (redband trout g/m^2). Conversely, the proportion of non-native fish decreased with an increased channel metric $R^2 = 0.75$, $p < 0.001$. Fulton's condition factor for redband trout (*Oncorhynchus mykiss*) has increased in these same reaches over the period of this research. Using the channel metric we identified a threshold (0.060) necessary to sustain viable populations of endemic mussels and their host fish, native salmonids, which correlated with indices of biotic integrity for macroinvertebrates. The channel metric provided an accurate annual prediction of the carrying capacity (g/m^2) for each reach, which can be used to evaluate the success of restoration projects or land management changes to sustain biodiversity.

■ INNOVATIONS IN EVALUATING AND MONITORING OUTCOMES

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PROMOTING LAKE BIODIVERSITY EDUCATION AND SCIENCE: AN ON-GOING EFFORT TO BRING ZOOPLANKTON TAXONOMY TO A WIDER AUDIENCE

When speaking of biodiversity, the ability to easily and accurately identify organisms is a key consideration. In order to classify freshwater zooplankton using traditional taxonomic keys, a user must already be familiar with a large body of specialized terminology. The expertise necessary to use such keys is acquired only after great effort, effectively constituting a barrier for their common use outside a group of specialists. In order to facilitate both educational and scientific efforts in lake biodiversity, the UNH Center for Freshwater Biology has developed an interactive, image-based key to the freshwater zooplankton of the Northeast (USA). Our goal was to create a key to serve audiences ranging from novices to taxonomic experts. Although it is important to remove some of the technical barriers that prevent new users from learning about zooplankton diversity, it is also of vital importance to maintain scientific accuracy. To achieve this goal, our key is based on clearly-labeled digital images of zooplankton, and although knowledge of taxonomic terms is not necessary for its use, many of the terms are present. We believe this combination of ease of use and taxonomic detail provides an ideal setting for learning how to identify zooplankton, while at

the same time, facilitating even the most rigorous of scientific surveys. In addition, the interactive nature of the key allows for easy navigation, internet availability, and the incorporation of media such as videos and flash-based movies. As a result of recent collaborations with various taxonomic experts we have expanded the key to include 72 crustacean species and 79 rotifer species. We plan to continue development of the key to incorporate an even wider range of organisms and to develop a more diverse set of educational and scientific tools.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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STREAM CHARACTERIZATION & FISH SPECIES ASSOCIATIONS IN RAINFOREST RIVERS OF SW CAMEROON

*I*ncreasing human pressure and resource degradation are leading to habitat loss and deterioration in the standard of living of rainforest communities in Central Africa. Forest rivers are a rich resource in terms of biodiversity, that might be better managed to improve livelihoods options, particularly through the ornamental fish trade. To compare the biodiversity in streams variously affected by human activities and determine the extent to which improved management and profitability might create incentives for conservation, a survey of fish abundance and species diversity was conducted in first and second order streams in the watershed of Mt. Cameroon. Key biotopes were runs, riffles and pools. In total, 33 species of fish representing 21 genera and 14 families were captured. By biotope, runs averaged 279 fish (7 ± 1.6 species), riffles averaged 67 fish (3 ± 1.3 species) and pools averaged 563 fish (6 ± 2.4 species) per 20 meters. Riffles contain significantly ($P < 0.02$) fewer species than either runs or pools. Shannon's Index was similar for runs and pools, averaging 1.46 ± 0.317 and 1.44 ± 0.356 , but differed significantly ($P < 0.05$) in riffles, averaging 0.84 ± 0.300 reflecting the lower species richness in this biotope. There were no significant differences in number of individual fish, number of species or Shannon's Index among stream orders. Number of species and the Shannon Index were significantly ($P < 0.05$) higher in sites with more structure (or habitat complexity). Multiple regression of habitat descriptors against Shannon's Index found that, overall, structure explained 44% of the variability in species richness among sampling sites. Disturbed sites, up to a limit, did not have less fish diversity than pristine sites, although the degraded

Limbe River sites had significantly fewer species and a much lower Shannon Index (averaging 0.704 across all biotopes) than other sites. Despite high species diversity, African rainforest streams have generally low species abundance, particularly for those of high commercial value in the ornamental fish trade. Consequent to these findings, a number of ornamental fishing villages have been engaged in a project to develop a viable business plan for the aquaculture of ornamental fishes.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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CONSERVING THE FRESHWATER ECOSYSTEMS OF LADAKH HIMALAYAS WITH INVOLVEMENT OF INDIAN ARMY AND INDO TIBETAN BORDER POLICE

*H*igh Altitude Lakes of Ladakh, which are situated at an average altitude of 4000 to 5000 mtrs. are facing a large number of problems due to various anthropogenic activities. The population in the area is increasing which is putting adverse impacts on the limited grasslands in the area. As most of the economy of the locals depends on the livestock rearing. Presence of Large number of troops around these lakes and wetlands is also putting tremendous pressure on these lakes. Moreover, recent opening up of some of the lakes to tourism activities has further aggravated the problem.

In year 2000 WWF-India initiated a major project for the conservation of these unique ecosystems. As there is a huge presence of armed forces in the area, so they were identified as a major partner in this conservation project.

At present the conservation of all the major lakes along with upper Indus is a routine work for the armed forces in the area. To keep this momentum going after every two years WWF-India organizes special training programmes for the officers posted in the area. At present army is taking over even the organization of these training programmes.

The present paper presents the detailed history of this successful initiative taken up with the armed forces for the conservation of High Altitude Freshwater Ecosystems and associated species like Black-necked Cranes. The paper also presents an account of the alternate sources of livelihood provided to the locals with the help of armed forces.

■ INNOVATIONS IN EVALUATING AND MONITORING OUTCOMES

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VIKRAMSHILA GANGETIC DOLPHIN SANCTUARY: TURNING CONVENTIONAL WISDOM ON ITS HEAD

*In the Vikramshila Gangetic Dolphin Sanctuary (VGDS) of Bihar, India, a local group of conservationists from Bhagalpur University together with the Whale and Dolphin Conservation Society, UK, has initiated a project to turn a 60km segment of middle Ganges from a Sanctuary that till recently existed only on paper into one that provides meaningful protection for Ganges river dolphins *Platanista gangetica gangetica* and other aquatic fauna. Threats in the Sanctuary include both accidental and deliberate killing of dolphins. We started the project with an aim to strengthen community awareness of conservation value of river dolphins and other biodiversity, and to develop and promote a conservation action plan. We developed expertise through training initiatives and established a project team. Demonstration of street theater proved a very effective tool for educating the people. We initiated research, including a comprehensive assessment of the dolphin population, their habitat and the threats they face. We discovered a rich diversity of other threatened aquatic wildlife in the sanctuary including gharial crocodilians *Gavialis gangeticus*, Smooth Indian Otters *Lutrogale perspicillata*, a variety of hard shell turtles, 78 number of fish species, 2 species of crustaceans and 134 avian species including globally threatened Greater Adjutant Stork *Leptoptilos dubius*. During our research and education programs from 1998 to 2004, we promoted the dolphins as a flagship species of the ecological and spiritual health of the river Ganges. Success indicators are, increase in the dolphin population ($98 \pm$ in 1998 to $135 \pm$ in 2004), and the self-enforcement of environmental regulations by the fishing community themselves. Local resources-users have realized that dolphins can play a strong role in bridging the gap between the spiritual life and reverence for an increasingly threatened riverine environment. Dolphins and people, both need healthy rivers, and action to save the former can only benefit the later.*

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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AQUATIC ECOSYSTEM CLASSIFICATION FOR BRITISH COLUMBIA, CANADA: ECOLOGICAL AQUATIC UNITS — BRITISH COLUMBIA (EAU BC)

British Columbia has an exceptional wealth of aquatic biodiversity and resources. However, there is growing pressure on their use and extraction. It is therefore urgent that a framework is created for assessing aquatic biodiversity and resources in BC and for setting management priorities on these resources. Nature Conservancy of Canada in partnership with the provincial government, has developed a hierarchical aquatic ecosystem classification for BC, entitled Ecological Aquatic Units BC (EAU BC). EAU BC classifies aquatic ecosystems into major system types across three biogeographic scales: broad ecological drainage units, 1:50,000 3rd order watershed polygons, and lakes and stream reaches. It is an aquatic coarse filter approach to capturing the range of variability in physical habitat and environmental processes that drives aquatic biodiversity in BC similar to biogeoclimatic classifications that characterize variation in terrestrial systems. Specifically EAU BC will be used to: provide a spatially explicit data management system for aquatic resources in BC; inform strategies for conserving aquatic biodiversity and resources; enable regional comparisons of aquatic systems; help inform species - habitat relationships; provide a stratification framework for aquatic inventory initiatives; and establish management priorities for aquatic resources in BC. This product is the first of its kind in Canada.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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GOING AGAINST THE FLOW: IMPLEMENTING AN ECOSYSTEM APPROACH TO RECOVERY PLANNING

Recovery of nationally endangered wildlife, both in Canada and the United States, is facilitated by the development of comprehensive, scientifically sound, recovery strategies. Three approaches have been identified to address the legal responsibilities and obligations of developing recovery strategies under the American Endangered Species Act and the Canadian Species at Risk Act: single-species, multi-species and ecosystem approaches. Although it has been recently suggested that single-

species recovery strategies may be more effective at recovering species at risk than their multi-species or ecosystem counterparts, these more comprehensive approaches are attractive for ecological, as well as, practical reasons. The recovery of a species cannot be accomplished without regard for its interactions with the physical, chemical and biological environment. Recovery objectives for co-occurring species may conflict or counter-act when developed species by species. Furthermore, limitations of time, personnel and financial resources can make single-species approaches prohibitive. In Canada, we have successfully implemented multi-species and ecosystem recovery approaches for aquatic species by carefully choosing appropriate scales with respect to ecological, geographical and political boundaries. Through similarity analyses of habitat requirements, primary threats and responsible management agencies, we show that multi-species and ecosystem recovery approaches can be efficient and effective choices for recovering aquatic species at risk; thereby providing direction for recovery planners in choosing an appropriate recovery approach. We argue that under the right circumstances, multi-species and ecosystem recovery approaches can be highly effective tools for freshwater recovery planners.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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MULTI-SCALE APPROACHES TO FRESHWATER DIVERSITY ASSESSMENT AND MONITORING

The need to measure river health has led to the development of diversity based monitoring tools that relate differences in species number to differences in some sort of stress variable between reference and impacted sites. Two shortcomings of these approaches are their site specificity and failure to address more than one habitat type. The scale of impacts, as well as impacts on different types of habitat are potentially ignored or underestimated. Here we identify several key challenges in the development of large-scale freshwater diversity assessment and monitoring programs and ways to address these challenges. We then present a model approach for multi-scale, multi-habitat freshwater diversity assessment, using predatory invertebrates. The challenges to large-scale assessment are 1) Poor understanding of micro-habitat preferences for many species and how the landscape influences the distribution of these micro-habitats; 2) Standardizing between different collection methods required for different types of habitat; 3) Obtaining sufficient sample sizes 4) Extrapolating from location specific collections to landscape patterns. Our approach will involve the use of GIS data to identify the distribution of major 'types' of freshwater habitat in the Nashwaak, Canaan, and Kenebecasis catchments of New Brunswick, Canada. Sampling in each habitat type will be

conducted along an environmental and land-use gradient, using time-based sampling to standardize between different collection methods. This method will also attempt to account for other factors known to influence species diversity, including habitat size and the spatial distribution of habitat patches. Accurate diversity assessments are a necessary first step in any monitoring program. Ideally, a diversity assessment protocol will uncover all species within taxa of interest, as well as their relative abundances and spatial distributions. Further, this approach will lead to ways in which freshwater biomonitoring can incorporate a greater spatial context and diversity of habitats.

■ INNOVATIONS IN EVALUATING AND MONITORING OUTCOMES

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REMOVING THE BIODIVERSITY INFORMATION BOTTLENECK FOR CONSERVATION PLANNING IN INLAND WATERS: A PILOT STUDY IN EASTERN AFRICA

Freshwater ecosystems are one of the most threatened due to major impacts from introduced non-native species, habitat alteration, loss, and destruction, water pollution, and water withdrawal for irrigation and other urban and commercial uses. Lack of available biodiversity information is often cited as the major bottleneck in conservation planning efforts to deal with these impacts. The Freshwater Biodiversity Assessment Programme of IUCN/SSC (Species Survival Commission) has conducted a pilot study in Eastern Africa to demonstrate how the large body of existing, but widely dispersed and often inaccessible, biodiversity information can be mobilised, analysed, and made available for integration within the conservation and development planning processes. Existing information was collated and analysed to allow an assessment of the conservation status and distributions of 1090 fish, 304 odonate, 230 mollusc, and 37 crab taxa. Species reports include information on threatened status (IUCN Red List Status), taxonomic status, habitat preferences, major threats, country distributions, modes of utilisation, and general ecology. Species ranges are mapped and presented in GIS format. This information is to be made widely available through the IUCN/SSC's Species Information Service (SIS), a custom made database and data management system, in the short-term on CDROM and ultimately on the World-Wide Web. Throughout the project 48 regional scientists were trained in the application of biodiversity assessment tools, such as the IUCN Red List Categories and Criteria, and use of the SIS database thus building regional capacity for conservation of freshwater biodiversity. Long-term sustainability and updating of the informa-

tion set is enhanced through development and expansion of the IUCN/SSC network of experts within Specialist Groups.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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EVALUATION OF MULTITEMPORAL LANDSAT IMAGES FOR WETLANDS MAPPING AND FLOOD MONITORING IN THE SENEGAL RIVER DELTA

The study presented here is a part of my PhD ongoing research and the investigation site is located in the Senegal River flood-plain around the area of the Diama dam and the city of Saint-Louis, in the lower estuary. Since the construction of the Diama and Manantali dams in the end of the 80's, the runoff was modified in a large part of the Senegal basin due to the canalization of many water courses in the delta. As a consequence, wetlands functioning were completely changed, tributaries were intercepted and deviated and artificial canals were designed to evacuate drainage water. The nature of the existing drainage pattern and the nature of rains in the hupper valley show that the area suffers frequent, extended and prolonged floods and inundation. For example, the 1994 and 1999 events lasted from one to two months all along the Senegal River. By a multi-temporal image analysis and interpretation, we established a qualitative and quantitative evolution of wetlands areas in the delta and the yearly flooding impacts of the river. The study is based on many thematic maps of wetlands evolution and flood impacts derived from Landsat data from 1972 to 2003. Standard remote sensing methods have been used for preprocessing the satellite images and a GIS was set-up as a tool for decision making.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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ICHTHYOFAUNA OF THE LAKE HÖVSGÖL

Lake Hövsgöl is a typical formation of the Baikal system and largest lake in terms of the fresh water amount (383.3m³) and the second by the area (2760 km²) in Mongolia, maximum depth is 264 m. Lake Hövsgöl has more than 96 rivers entering the lake, but only 22 are flowing year around are suitable for spawning by fish. Ichthyofauna of the lake Hövsgöl is presented by 10 species. In the tributaries of the lake Hövsgöl fishes, which are typical to the Siberian water bodies, predominated, including Asian trout (*Brachymystax lenok*), Arctic grayling

(*Thymallus arcticus arcticus*), Roach (*Rutilus rutilus*), Perch (*Perca fluviatilis*) and Spiny Loach (*Cobitis melanoleuca*). Only the Hövsgöl grayling (*Thymallus arcticus nigrescens*) is endemic at lake Hövsgöl and the Arctic Cisco or Baikal Omul (*Coregonus autumnalis migratorius*) was introduced in 1956 (Dashdorj.A).

The survey was conducted to estimate the current status of fish spawning area, spawning ecology and feeding habitats in six study streams. Fish studies were done longitudinally along the streams. Fish were surveyed at 18 sites in streams. The spawning of Salmonids at the sites was largely determined by temperature, oxygen and hydrological condition and gravel bottom substrates. Some streams with lower river discharge, short length and reach and coarse substrates are not suitable for Salmonids spawning. The Asian trout, the Arctic grayling, the roach, the perch, the minnow (*Phoxinus phoxinus*), stone loach (*Barbatula toni*) and spiny loach are spring and summer grow fish. Annual air temperature in this of the region has warmed by about 1.50C. This factor was influence on spawning process of Salmonids species. For the spawning substrate and habitat the tributary of the Borsog and Dalbay are roach, perch and burbot (*Lota lota*) types, the Noyon and Turag are Asian trout and grayling types, Sevsuul is spiny loach type, and the tributary of the Shagnuul is spiny loach and stone loach types.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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ASSESSING CONTRIBUTING FACTORS TO WATER QUALITY IN THE UPPER LITTLE TENNESSEE RIVER WATERSHED

Drawing from fifteen years of observations, aquatic biologist Dr. Bill McLarney has hypothesized that National Forest lands in the upper Little Tennessee River watershed are not correlated with deficient Index of Biotic Integrity (IBI) scores – an opinion held by some in the community. Using Geographic Information Systems (GIS) and statistical analysis tools, Equinox Environmental and the Southern Appalachian Information Node (SAIN) of the National Biological Information Infrastructure (NBII) assessed Dr. McLarney's conjecture. Seventeen IBI sites were selected for the analysis and for each a corresponding upstream subwatershed was determined. Five variables were gathered for each subwatershed: IBI score,

percent National Forest, percent forest, sum of road lengths, and average slope. A stepwise regression analysis of the data identified average slope and length of roads in a watershed as the only significant variables, explaining 71.2 percent of the variation in IBI score. These findings lend support to Dr. McLarney's assumption that National Forest land is not directly causing stream degradation in the watershed, and suggest that slope and road density are far more accurate predictors of water quality in the study area.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

FARNSWORTH, MARGO

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SCIENCE TO ACTION: LOCAL OFFICIALS' SURVEY AND CURRICULUM AS A POSSIBLE CATALYST FOR BEHAVIOR CHANGE

There exists today, an increasing body of scientific work attesting to the importance of our freshwater systems not only to preserve biodiversity for its own sake, but also for the sake of our health and our economy. Streams, rivers, lakes and their inhabitants face pressures from non-point sources such as rapid urbanization, agricultural and forestry practices and point sources such as municipal sewage treatment plants and industries. Still, the public is slow to change behaviors which would ultimately enhance water quality and quantity. Local officials, both elected and hired, partially shape local behaviors through public policy. The Cumberland River Compact designed and implemented a Local Officials' Survey to find out what level of water quality/quantity knowledge these individuals have, educational tools they perceive as being available to them, programs they feel are needed, and venues and program format they consider most effective. Basic water quality/quantity information is sometimes misunderstood or not understood by local officials. If it is understood by these officials, it is not necessarily understood by their governing boards or communicated adequately to the voting public – a critical point. What the Cumberland River Compact found as a result of this survey provided the basis for developing a Local Officials' Curriculum. Curriculum classes – in "Lite", "General", and "Technical" class levels are being collected from a variety of pre-existing courses and taken directly to local governing boards, officials and public employees. Survey results indicated both a need and willingness in local officials and public employees to learn more about water quality and quantity issues. In this age of vast emerging technologies and a barrage of commercial messages, the Local Officials' Curriculum is being provided to shape public policy on water quality/quantity. Through easy, understandable language local officials are being given the tools in their communities to, "Just do it".

■ INNOVATIONS IN PUTTING PLANS INTO PRACTICE

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THE USE OF LIDAR DATA TO MAP MORPHOLOGY AND LAND COVER IN THE SPRAGUE RIVER BASIN, OREGON

Light Detection and Ranging (LiDAR) data were acquired in the Sprague River Basin, Oregon in November 2004. This poster illustrates the spatial models that were derived from a total of 1,469,351,015 laser points surveyed (each with a first and last return) over a study area totaling 185,000 acres. The models depict bare earth surfaces and first return laser points colored by elevation and intensity of the laser return. Each pair of images shows oblique views of the bare earth model labeled with pertinent features (top images), and the first return laser points over the bare earth model (bottom images). The last laser returns, from which the bare earth model is built, represent the shortest (closest to the ground) surface measured by the laser pulse. Similarly, the first return laser points represent the tallest surface encountered by each laser pulse. At this resolution and accuracy, riparian vegetation, morphology, land use, road crossings, culverts, dikes, et cetera, are clearly articulated in the data. Key habitat parameters that can be characterized with these data include:

- Riparian (tree type, canopy cover, height, density, shade patterns)
- Morphology (stream location, sinuosity, bank-full width, incision, meander belt width barriers)
- Floodplain (vegetation patterns, land use patterns, transportation corridors)

These data accurately reflect current conditions and provide a foundational dataset for use in assessments in restoration planning.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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CONCRETE RESULTS: LOW-HEAD DAM REMOVAL ON THE CAHABA RIVER, ALABAMA, USA

For over 40 years, an obstruction known as the Marvel Slab stretched across the Cahaba River in northern Bibb County, Alabama. Originally constructed as a bridge for large mining trucks, the slab functioned ecologically like a dam by altering habitat and flows in one of the most sensitive and

biologically important reaches of the Cahaba River. Stretching 220 feet across and six feet tall, the concrete structure created a vertical drop of water which was a physical barrier to fish migration and a hazard to boaters. The pooling affect upstream and the scouring velocities downstream significantly altered habitat and disturbed the connectivity between populations of fish, mussels and snails that historically inhabited this stretch of Ridge and Valley stream. Utilizing a Section 206-Ecosystem Restoration Program, the US Army Corps of Engineers and several partners including The Nature Conservancy, World Wildlife Fund, Cahaba River Society, Alabama Department of Conservation and Natural Resources, Presbytery of Sheppards and Lapsley and the US Fish and Wildlife Service mechanically removed the Slab in October 2004. Prior to removing the Slab, scientists worked to assess the fish and mollusk communities in nearby reaches. Before deconstruction, over 12,000 snails and mussels were collected from the demolition zone adjacent to the dam and moved to a nearby refuge shoal. Monitoring efforts will continue to document physical and biological changes at the site which has been restored to its historical, natural condition. Populations of the following taxa protected under the federal Endangered Species Act were observed in the vicinity of the Marvel Slab and benefit by its removal: Cahaba shiner, *Notropis cahabae*; goldline darter, *Percina aurolineata*; triangular kidneyshell, *Ptychobranhus greenii*; finlined pocketbook, *Lampsilis altilis*; round rocksnail, *Leptoxis ampla*; flat pebblesnail, *Lepyrium showalteri* and cylindrical lioplax, *Lioplax cyclostomaformis*.

■ INNOVATIONS IN PUTTING PLANS INTO PRACTICE

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PROTOCOLS FOR THE ASSESSMENT AND CONSERVATION OF AQUATIC LIFE IN THE SUBSURFACE (PASCALIS)

The PASCALIS project (EVK2-CT-2001-00121) (2002-2004) was the first comprehensive proposal that specifically addresses the groundwater biodiversity (GWB) issue at the European scale. The main objective was to establish a rigorous and detailed protocol for assessing groundwater biodiversity and to develop operational tools for its conservation. More precisely, a

solid unmatched piece of work was provided by the PASCALIS database, that reflects our present-day knowledge on stygobiotic biodiversity distribution in six European countries (i.e. hotspots and coldspots of biodiversity, endemism, rarity...). It is an important backbone for further scientific research. The molecular approach of selected taxa has also been explored; it has revealed that cryptic diversity may represent a significant part of GWB. Furthermore, in using a rigorous sampling protocol, it has been shown that species distribution within hierarchical units differs from one region to another and that species similarity between regions is low or very low due to the high level of endemism and rarity. In addition, biodiversity indicators among stygobionts have shown to be a very useful tool to detect spatial patterns of species richness at a European scale with reduced costs and sampling effort. Significant improvements have been introduced in the GWB conservation strategy in proposing new methodologies relying on sound scientific results. Finally the ways to effectively implement a coherent, sustainable, and scientific solid conservation strategy have been explored in the framework of EU policies related to biodiversity and sustainable management of GW resources.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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CHARACTERIZING PROTECTED AREAS FOR FRESHWATER SYSTEMS — CONSERVATION POTENTIAL AND LIMITATIONS

Freshwater ecosystems contain a disproportionate fraction of the Earth's biodiversity, but also suffer a disproportionate load of conservation threats. Conservation responses to these threats are increasingly using protected areas as a tool for freshwater biodiversity conservation. After surveying the recent literature, we identified four main types of freshwater protected areas (FWPAs): Conservation Reserves, Harvest Reserves, Water Quality Reserves, and Aesthetic/Recreational Areas. The specific goals and characteristics of each type of protected area give them different potentials to contribute to biodiversity conservation. We present broad descriptions of each type of FWPA, along with some illustrative examples from around the world. We conclude that FWPAs have substantial potential to conserve biodiversity, preserve the harvest of freshwater resources, ensure water quality and provide opportunities for recreation. In addition, implementing FWPAs has the potential to contribute towards conservation efforts in the terrestrial and marine realms. However, we identify a number of factors that limit the capacity of FWPAs to contribute to conservation, namely: the unique nature of freshwater systems,

the large scales at which watersheds and associated threats operate, and a number of gaps in knowledge regarding freshwater ecosystems.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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VIABILITY AND THREAT ANALYSIS OF THE AQUATIC ECOSYSTEMS IN “MADRE DE LAS AGUAS” REGION, CORDILLERA CENTRAL, DOMINICAN REPUBLIC

The major rivers of Hispaniola: Yaque del Norte, Yuna, Nizao, Yaque del Sur y Artibonito, are born in Madre de las Aguas region. The upper parts of their watersheds and many of their tributaries are situated within that region. In order to effectively conserve the fresh water ecosystems we needed to characterize them and identify mayor threats. The analysis was done at the watershed and, where necessary, at the sub watershed level, after dividing the ecosystems in the following conservation targets:

- Headwaters: Stream order 1-3 above 1,800m elevation
- Headwaters: Stream order 1-3 between 600-1,800m elevation
- Medium size rivers: Stream order 4-6
- Lakes
- Wetlands

We have also chosen heavily harvested native crab, Epilobocera haitiensis, as the species level conservation target. For each conservation target its actual condition, the anthropogenic impacts it receives, as well as the sources of stress where evaluated. The actual ecological integrity evaluation was based on key ecological factors (processes that sustain a functional ecosystem) defined for Caribbean Ecoregional Planning. Headwaters above 1,800m elevation resulted to be best conserved (“very good” condition), with the exception of Nizao watershed. The most threatened and

in worst condition are headwaters between 600-1,800m in Yuna and Yaque del Sur watersheds. The sources of stress that cause most damage in all watersheds are unsustainable agricultural practices that result in high levels of sediments, nutrients and pesticides entering aquatic ecosystems. Other important sources are deforestation, excessive construction of micro ditches and untreated sewage. The information obtained serves to identify the conservation strategies that would be most effective across the region, and directs the action steps to preserve the best examples of freshwater ecosystems.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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RANKING VULNERABILITY OF WATERSHEDS TO ACIDIFICATION AND URBANIZATION IN THE MID-ATLANTIC HIGHLANDS

We present methods and initial findings on the characterization of watershed condition and vulnerability in the Mid-Atlantic Highlands from a collaborative research project of Penn State University and Canaan Valley Institute (EPA-STAR funding). The U.S. Environmental Protection Agency’s expressed purpose for a watershed classification system is to “diagnose the causes of biological impairment, and prioritize watersheds for restoration.” We have compiled and analyzed a large number of synoptic datasets for our region in order to (1) characterize all watersheds of 10,000 to 50,000 acres in size with respect to abiotic variables (i.e. climate, soils, landform, and stream morphology) using cluster analysis, (2) assess levels of human impacts or “stressors” within each watershed, and (3) assess feasibility of restoration or protection. For this poster we highlight two of our “stressor” datasets that assess vulnerability of watersheds for (1) acidification, and (2) urbanization. We rank watershed condition and vulnerability with respect to thresholds in the response of stream ecological integrity to stressor levels. We will integrate these three types of spatially explicit, derived data layers with Hasse diagram and CRF linearization methods to generate a series of

watershed restoration/conservation prioritization maps relevant to different stakeholder groups in the Mid-Atlantic Highlands.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

JOHN, KIMBERLY

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HOW EFFECTIVE IS JAMAICA'S PROTECTED AREA SYSTEM AT PROTECTING FRESHWATER HABITATS?

One of the challenges in protected area network design is optimising the representation of biodiversity within the system. During the first iteration of ecoregional planning in Jamaica (May 2003 to 2005), a gap assessment was conducted to examine the representation of freshwater habitats in protected areas. The objective of this assessment was to establish priorities among aquatic habitats for protection under the National Protected Area System Plan Review. 17 freshwater habitats were identified as surrogates of freshwater biodiversity according to the Jamaica Ecoregional Planning framework. Spatial Optimisation Tool (SPOT) and Arc View GIS software were used to intersect seven declared protected areas and freshwater habitats. The degree of representation of these habitats under the current protected area system was assessed using two descriptors; 1) the number of freshwater habitats protected, and 2) the proportion of each freshwater habitat protected. Results showed that the present protected area network does not protect a representative number or proportion of freshwater habitats across Jamaica. Only 12 of the 17 (70%) freshwater habitats are represented in the current protected area system. IUCN recommends that a minimum of 10% of a habitat's total distribution be conserved in protected areas, however only six (35%) of Jamaica's freshwater habitats, particularly the headwaters of Blue Mountain streams and wetland complexes in western Jamaica, meet the IUCN benchmark. Six freshwater habitats are described as critical because they are completely excluded from the protected areas; these are large lowland rivers, wetlands, coastal springs and caves in the east, and, in the west, headwater streams. It is therefore recommended that the representation of freshwater ecosystems in protected areas be increased by 1) expanding existing protected areas to include adjacent and often connected aquatic habitats, and 2) declaring additional protected areas particularly for highly threatened habitats. The assessment will be further developed to evaluate the effectiveness of the management of freshwater habitats within protected areas and the extent to which the network preserves ecological connectivity between habitats.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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DEVELOPMENT OF A CONSERVATION ASSESSMENT FOR NORTH AMERICAN FRESHWATER GASTROPODS

In 1993 the American Fisheries Society (AFS) published a general conservation assessment of freshwater mussels of North America authored by J.D. Williams et al., 1993. This mussel assessment was followed by similar assessment for crayfishes (Taylor et al. 1996) and southeastern fishes (Warren et al. 2000). The AFS has granted permission to begin a conservation assessment for North American freshwater gastropods and an initial committee has been formed. The final conservation evaluation will be based on our current understanding of freshwater gastropod taxonomy. Breaking with earlier assessments, we seek to replace categorical rankings (i.e., Endangered, Threatened, Species of Concern...), with more definitive global conservation rankings (G rank), that are actively monitored by NatureServe, state Natural Heritage Programs, and UNITAS. A draft evaluation focusing on 655 species in all 50 states and 11 Canadian Provinces was completed in early 2004. This initial assessment determined 60 species of freshwater snails are likely extinct, and at least 310 additional species rank as G1 or G2. With another 75 species listed as G3, fully 70% of currently valid taxa are extinct, endangered, threatened, or of special concern (GX, G1, G2, or G3). This is the highest imperilment rate for any major taxa group in North America, including mussels. The initial draft checklist will be presented and comments from symposium participants solicited.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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DEVELOPMENT AND MANAGEMENT TOOLS FOR THE CONSERVATION OF FRESHWATER SYSTEMS AND HABITAT PROTECTION: THE VALUE OF EDUCATION AND PUBLIC OUTREACH

The overwhelming presence of water in everyday life erroneously gives the impression that freshwater systems are

neither fragile nor in need of protection. In particular, construction and land development programs, non-point source pollution and severe weather conditions have put freshwater systems at risk and have also led to habitat destruction; the public is often unaware that the stability and maintenance of freshwater systems have been severely threatened. It is essential that formal education and public outreach programs provide information aimed at improving awareness and understanding of the conservation and protection of the freshwater environment. Examples are provided of such programs created during an innovative environmental studies term for college students that examined coastal systems in Bermuda, Newfoundland, and Cape Cod in the United States. Special emphasis is given to human use and impact on freshwater systems as well as freshwater supply. Better understanding of wetlands, aquifers, acid rain and pollution as well as human intervention plans that contribute to the contamination of freshwater ecosystems are examined in each of these geographic locations.

■ INNOVATIONS IN PUTTING PLANS INTO PRACTICE

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**CONSERVATION PLANNING IN UPPER
AMAZONIAN FLOODPLAINS SUPPORTED BY
INTEGRATION OF LANDSAT ETM, JERS-1,
AND SRTM DATASETS**

The watershed of the Madre de Dios River in Peru and Bolivia is globally outstanding for its terrestrial and freshwater biodiversity. Aquatic and wetland environments are mostly associated with floodplains, which cover a substantial but unknown fraction of this remote region. The World Wildlife Fund (U.S.) has sought to characterize the freshwater habitat diversity for conservation planning purposes. In support of this effort, a mapping project was conducted based on remote sensing data. Data from the Landsat ETM (optical multi-spectral), JERS-1 (L-band radar), and SRTM (C-band interferometric Digital Elevation Models) sensors were integrated into a common georeferenced database and jointly analyzed. A novel, object-oriented classification approach was used to integrate the various data sources. Using eCognition software, a multi-scale hierarchical classification scheme was designed. Initial image segmentation

was based on joint inputs of high-resolution Landsat panchromatic data (15 m resolution), JERS-1 data (100 m), SRTM (90 m), and a Landsat Band 3/5 ratio-based water layer (30 m). Two segmentation levels were produced, one at a finer scale preserving small scale features like oxbow lakes and smaller vegetation units, and one at a coarser scale which predominantly separated macro-scale floodplain features from upland. At the coarser scale the separation of floodplains from uplands was mostly driven by the geomorphological characteristics derived from the SRTM data, while finer scale separation of the floodplain was driven by Landsat ETM and JERS-1 data. The final classification was partly field checked and agreed well with ground observations. Classes distinguished within the floodplain include early successional forest associated with migrating river channels, herbaceous aquatic plants, mature forest on meander belts, palm swamps (flooded and non-flooded), river bars, and other floodplain. This mapping forms the basis for systematic evaluation of how well existing protected areas represent the diverse aquatic and wetland environments of the watershed.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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**REHABILITATION OF THE ECOLOGICAL
FUNCTIONS OF THE SENEGAL RIVER DELTA**

The objective of this poster is to evaluate the options for rehabilitating the Ndiaël. In its simplest form, rehabilitation amounts to re-inundation. The Ndiaël has been severely impacted by lack of water, and the purpose of its re-inundation is to promote vegetation growth, refill aquifers, increase biodiversity and halt desertification. This will rehabilitate marine and continental fisheries, agriculture, pastoralism, tourism and hunting. The Ndiaël is broadly defined as part of the former floodplain of the Senegal River delta, from the coast to the Lac de Guiers, south of the Route Nationale 2 (RN2). It includes the Niety Yone, the Coastal Zone and the Trois Marigots, which represent approximately half the total area of the delta.

A desk study completed in November 2000 provided the scientific basis for further action. It drew on the rehabilitation of wetlands worldwide and the importance of estuaries for fisheries. Two month-long field missions in Senegal (May and August 2001) identified physical re-inundation channels and possible constraints to using them as well as the stakeholders in the delta, their activities and agendas.

The work comes as preparation for the Environmental Management Component of the World Bank Long Term Water Sector Project and two other World Bank projects: the Coastal and Marine Biodiversity Management GEF project and the Senegal River Basin Sustainable Resource Use GEF project.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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MANAGEMENT AND RESTORATION STRATEGIES FOR THE EMIQUON FLOODPLAIN OF THE ILLINOIS RIVER, ILLINOIS, USA

*Intact large floodplain-river ecosystems are rare. In 2004, The Nature Conservancy began to convert the Emiquon area adjacent to the Illinois River, from row crop agriculture into a complex aquatic ecosystem. The Conservancy identifies historic floodplain areas, like Emiquon, that are currently isolated from the river and its vital flood pulse and develops strategies to restore the floodplain to a functioning mosaic of natural communities (e.g., bluff, floodplain and diverse aquatic communities) and to restore habitat that sustains native plants and animals (e.g., mussels, ancient fishes, and *Boltonia decurrens*). In a gradual process, these areas are allowed to revert to wetlands, sometimes in conjunction with a controlled reconnection to the river. The Emiquon restoration is unusually large (3005 ha), and will require innovative approaches to planning, implementation, and documentation. One innovation is the early establishment of aquatic vegetation critical to maintaining water quality in the new wetlands. In addition, scientists from the Illinois State Water Survey and Illinois Water Resource Center have developed innovative hydrological computer models that will help the Conservancy evaluate the effects of management decisions long before the decisions have to be finalized. At the University of Illinois at Springfield, scientists are studying a 9-year survey of nutrients on the Illinois River and its backwaters to better understand how to manage the Emiquon Restoration. Based on these approaches and on previous experiences (such as the Spunky Bottoms restoration), the Conservancy is devising novel restoration strategies and research plans that are sensitive to different spatial resolutions, long and short term concerns, and species diversity. By carefully documenting Emiquon before, during, and after its restoration, the Conservancy hopes to encourage practical innovations in future restorations.*

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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IDENTIFYING CONSERVATION HOT SPOTS FOR FRESHWATER SPECIES AT RISK IN CANADA

Priority watersheds for protecting freshwater species at risk in Canada were identified by creating a conservation hot spot

index based on the biodiversity of fishes and mussels the threats to these taxa. Of some 229 fish species and 55 freshwater mussel species found in Canada, the highest diversity is found in the Great Lakes basin where species diversity peaks at 102 fish and 34 mussel species at the watershed level. Patterns of species at risk listed by COSEWIC mirror this pattern with richness peaking at 16 fish species and 8 mussel species in the watersheds of southwestern Ontario. Such diverse aquatic communities in this region are primarily attributed to moderate climatic conditions and biogeographic history. Unfortunately, these areas of high biodiversity occur in the Great Lakes where threats from human impacts and aquatic invasive species are most severe. The human impacts were summarized for each watershed using a "human stress index" that incorporated measures of land use, population size and road density. The impacts of aquatic invasive species were summarized as the total number of introduced fish species by watershed. The conservation hot spot index was the sum of the equally weighted fish and mussel richness, fish and mussel species-at-risk richness, introduced fish species richness and human stress index. This analysis identified watersheds in the southern Great Lakes basin and southern Pacific Coast as priority watersheds for conservation.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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USING SMALL WATERSHED FISH, MUSSEL, AND CRAYFISH HISTORICAL AND CURRENT PRESENCE DATA TO DESCRIBE FRESHWATER BIODIVERSITY AND INFORM ITS CONSERVATION

Freshwater species are disproportionately at risk in United States, which is a recognized hotspot for global freshwater biodiversity. The conservation of these species and the freshwater systems they inhabit depends on knowledge of the factors that underlie their patterns of distribution and imperilment. Using a geographic information system we assigned all native freshwater fish species and all "at risk" (NatureServe ranked G1-G3) mussels and crayfishes as currently or historically-only present by 8-digit Hydrologic Unit within the conterminous United States. State and regional experts reviewed the data to refine the small-watershed distribution for these species. The dataset includes distribution information for 782 native fish species, 165 G1-G3 crayfish species, and 156 G1-G3 mussel species. TWINSPLAN classification was then used on the multivariate dataset to break watersheds into successive hierarchical groups to investigate patterns in aquatic species distribution, diversity, and rarity within and between these taxonomic groups. The database is currently

being used to create species distribution maps which are available on NatureServe Explorer (www.natureserve.org/explorer) and as a searchable map at www.NatureServe.org. Ongoing research projects using this database include exploring the relationship between the distributions of imperiled taxa within and between taxonomic groups; using the database to identify most critical watersheds for protecting freshwater biodiversity; exploring the relationship of species distributions to environmental and geographic variables; exploring how fish community composition changes across the United States at multiple scales and how these patterns are related to a variety of historic, geographic, and environmental factors; and using percent intactness of fish faunas as an indicator of trends in freshwater biota.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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INTEGRATING ECOLOGICAL RISK INTO REGIONAL PLANNING TO CONSERVE FRESHWATER FISHES OF THE UPPER TENNESSEE RIVER BASIN

Strategies for biological conservation have historically focused on reserves and species-specific approaches. Although such tactics have had positive results in terrestrial systems, they are impractical and expensive when applied to freshwater streams. Unique functional properties of streams (e.g. directional flow of materials) dictate the inclusion of both land and water uses in planning efforts, thus requiring novel approaches to watershed assessment and protection. Our approach combines projections of species occurrence data with a regional assessment of threats to stream biotic integrity as a tool for prioritizing areas in need of protection. First, data were obtained from existing databases and georeferenced to watersheds using the National Hydrography Dataset (NHD). Habitat affinity data were used in logistic regression models to predict reach-specific occurrences for each fish species. Concurrently, we developed a 5-step protocol that evaluates land/water uses based on their negative effects on the major drivers of biotic integrity: energy sources, physical habitat, flow regime, water quality, and biotic interactions. Our protocol uses expert opinion to score the severity of impact of each human

activity, or threat, to each driver. We analyzed twelve threats, including agricultural lands, urban areas, manufacturing-related sites, bridges, and dams. Our protocol 1) identifies mappable threats; 2) assigns severity scores based on potential impacts of each threat to biotic integrity; 3) estimates frequencies of each threat within watersheds; 4) computes a threat-specific index of ecological risk for each watershed; and 5) computes a composite ecological risk over all threats for each watershed. Index values can be readily mapped and integrated with projections of species occurrence to facilitate identification of watersheds most/least in need of protection. We illustrate application of our approach in the upper Tennessee River basin, USA.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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AN ANALYSIS OF SEDIMENTATION LOADING AT SELECTED STATIONS IN THE BEAR CREEK SYSTEM, ALABAMA AND MISSISSIPPI, U.S.A., 2003–2004

*Bear Creek, a system controlled by impoundments and a channel designed to limit flooding, continues to harbor a diverse mussel fauna, though dominance has apparently shifted from native Cumberlandian species (characteristic of high gradient rocky streams) to invasive Ohioan species (tolerating sluggish flows and unconsolidated substrates). Twenty-eight species currently occupy a short reach downstream of the lowermost dam, including populations of two Cumberlandian species (*Epioblasma brevidens* and *Lexingtonia dolabelloides*) considered critical to survival of those species. Significant and often excessive sedimentation occurs in the system, threatening the continued existence of mussels. All sites evaluated (two on Bear Creek and one each on three tributaries) showed some level of potential for continued habitat degradation due to sedimentation. However, the reach of Bear Creek including the floodway consistently yielded values of most concern, including (a) the largest volume of gravel bed material mobilized, (b) the highest mean streamflow velocity, (c) the largest suspended sediment load in total mass and in mass per unit area, and (d) the largest bedload in total mass and in mass per unit area. The lowest values measured were in the only unregulated stream studied. Gravel bed material moving through the floodway is composed of materials eroded from ridges in the mid and downstream reaches of the watershed and from the headwaters and, once mobilized by streamflow velocity, continues to move for up to one week after peak velocity. This suggests that disturbances of*

the land surface in those upland areas introduce large volumes of sediment into tributaries that transport it to Bear Creek and the floodway, which act as conduits for transport to the Tennessee River. To address these concerns we recommend: evaluating land use and establishing Best Management Practices in sedimentation source areas; establishing/maintaining riparian buffer zones; maintaining streamflow velocities below critical thresholds in regulated streams.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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**FRESHWATERS IN THE PUBLIC EYE:
ILLUSTRATING THE ROLE OF IMAGES IN
AQUATIC CONSERVATION**

The conservation of freshwater biodiversity has long been challenged by the obscurity of freshwater organisms and habitats among the general public. Beneath their reflective surfaces, freshwater ecosystems are out of sight, and remain largely out of the public consciousness. In contrast, species and ecosystems that have strong public conservation support are often those that are more conspicuous in the public eye. Images, both moving and still, are a powerful means of representing reality and conveying value through many educational, informational, and artistic mediums. Indeed, successful conservation efforts have long utilized the power of images, particularly those that convey the aesthetic, intrinsic, and ecological values of biological diversity. Yet, a survey of the images that collectively represent freshwater biodiversity reveals two important problems. First, most freshwater species are simply not seen in photographs, video, or film. Second, the majority of the images of freshwater life tend to exclusively convey the utilitarian value of aquatic species (e.g., angling photos). Ultimately, freshwater biodiversity is not only underrepresented in the public eye, but also misrepresented. We urge scientists and conservationists to recognize a need for 1) an increased visibility of freshwater biodiversity across educational and informational mediums, and 2) a greater emphasis on the aesthetic, intrinsic, and ecological values of freshwater life. Strategies to meet these needs include a more careful use of images in outreach and education, an increased proficiency with photographic and videographic mediums among scientists and naturalists, and a more collaborative interaction between freshwater conservationists and media specialists.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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USE OF TELMETRY, REMOTE SENSING, AND GIS TO IDENTIFY SPECIES DISTRIBUTIONS AND HABITAT CLASSIFICATION IN FRESHWATER AND ESTUARINE SYSTEMS

The formulation of effective conservation strategies requires information about habitat use and requirements, but assessing habitat use in large freshwater and marine habitats is logistically difficult. Remote sensing and GIS have been widely used to assess terrestrial species distributions and habitat quality, however many of these tools are not directly transferable to aquatic environments. For example, satellite and aerial imaging methods currently used with terrestrial systems are unable to penetrate all but the shallowest segments of aquatic systems. Nonetheless, the integration of emerging technologies can be used to identify habitat types for GIS classifications including side-scan sonar, and underwater videography, and additional instruments such as acoustic Doppler current profilers (ADCP) and multi-meters (temperature, depth, conductance, dissolved gasses, etc.) that characterize the strong temporal and spatial variation in physical parameters (e.g. discharge volume, velocities, flow vectors, water chemistry, turbidity). Biological data on species abundance and distributions can be collected using some of these techniques, especially for sedentary species, while acoustic and radio telemetry can document fine-scale habitat use and distribution information for more mobile species. We have recently integrated these technologies in the Columbia River and its estuary to 1) assess exposure to supersaturated dissolved gas produced by dams in returning adult Chinook salmon, 2) map and classify subtidal habitats in the estuary, while 3) quantitatively assessing adult salmon habitat use over the complex tidal cycles and flow regimes found in the estuary. This integrated suite of tools will have broad application in freshwater and marine systems where quantitative spatial data on the migration, refuge or spawning habitats of a focal taxon will assist in the prioritization of conservation action.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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AN ECOSYSTEM MANAGEMENT APPROACH TO WETLAND BIODIVERSITY CONSERVATION

Biodiversity conservation of freshwater resources, which is defined as the preservation of the important values of these resources as well as the sustaining of the productivity of the aquatic ecosystems, requires application of a specific management approach that is referred to in this research as “ecosystem management approach”.

One of the major concerns in wetland conservation is the issue of how to identify the demand of stakeholders for wetland resources, and to ensure the continuity of wetland ecosystem's goods and services. For the purpose of the study, the Freidoukenar wetland (Ramsar Site) and its adjacent local community settlements is selected as the study area.

The study aims to determine the main stakeholders contributing in biodiversity conservation of freidoukenar wetland and to analyse the demand of indigenous people for the freshwater resources and their role in preservation and conservation of the wetland ecosystem. The study emphasizes in particular on the role of local people, who, as the main stakeholders and landowners, have long been preserving their lands through a traditional method of community originated approach, parallel to the role of governmental institutions and their approach for wise use of natural resources being supplied by the wetland. A potential for a tourism market development is addressed as an opportunity to base the future conservation policies on.

In order to identify the main factors contributing to freshwater biodiversity conservation an evidence based status quo principal component analysis using the available limited data is applied. After the main values of the wetland are identified, the major contributing stakeholders are specified. A cost benefit analysis using the results of a previously conducted study is applied as the basic methodology to evaluate the demand for natural resources of the wetland by the local communities with respect to the capacity of wetland to supply resources needed for sustaining the security of the whole ecosystem including the adjacent settlement areas.

Based on the results, an integrative management approach comprising two components of tourism markets development and a community-driven conservation system is recommended as an opportunity for further consideration.

■ **INNOVATIONS IN PLANNING FOR CONSERVATION**

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SETTING CONSERVATION PRIORITIES IN THE CONNECTICUT RIVER WATERSHED

Site specific conservation strategies within the Connecticut River Watershed were developed based on an ecoregional scale analysis of patterns of biodiversity and a local scale assessment of specific conservation targets and threats. An ecoregional assessment was used to identify areas in the northeast U.S. that collectively represent the variety of terrestrial, freshwater, and marine biodiversity at appropriate geographic and biotic scales within ecoregions. Ecoregionally significant examples of fine filter species targets and coarse filter community and ecosystem targets were identified within the Connecticut River Basin. Fine filter targets included over 35 rare, threatened, declining, and endemic plant, animal, and invertebrate species, and migratory species such as the Dwarf Wedgemussel, Brook Floater, Atlantic Sturgeon, Shortnose Sturgeon, and Cobblestone Tiger Beetle. Ecosystem targets included terrestrial communities and representatives of freshwater ecosystems as defined through a GIS based freshwater ecosystem classification. The development of this ecoregional freshwater classification and the process used to select most viable examples is presented. Once the ecoregional portfolio of biologically significant areas was identified, a more detailed Site Conservation Planning process was undertaken. This process employed a team of experts across four states tasked with selecting a smaller suite of conservation targets, evaluating key threats, and suggesting strategies to abate those threats within the basin. Hydrologically-mediated site conservation targets included the mainstem ecosystem, tributary ecosystems, tidal wetlands and estuary, floodplain ecosystems, migratory fish, and mussel assemblages. Six major conservation strategies emerged. These strategies focus on ecological flows, connectivity/barrier removal, invasive species, floodplain forest restoration, and land protection. We further present some site specific projects which illustrate implementation of several of these high leveraged strategies.

■ **INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS**

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SMITH RIVER TAILWATER: OPPORTUNITIES FOR ENHANCEMENT OF HABITAT FOR NATIVE AND INTRODUCED FISHES

Operations of Philpott dam for flood control and peak power generation since 1953 have substantially altered downstream ecosystem conditions in the Smith River from the dam to Martinsville. A diverse assemblage of native fishes were replaced by depauperate populations of natives fishes and wild brown trout (*Salmo trutta*) and stocked rainbow trout (*Oncorhynchus mykiss*). Average peak flow and duration of generating flows significantly depressed abundance of native fishes and recruitment of brown trout. Low productivity of insects, crayfish, and fish has resulted in slow growth and poor condition of brown trout and average angling success. Although there are no “silver bullet” solutions, the most successful path toward improving the tailwater will reflect tradeoffs to balance environmental, economic, and recreational goals. We recommend mitigating the effects of fluctuating releases from Philpott Dam through a combination of flow management (e.g. characteristics of dam operations during baseflow and peak flow periods) and habitat improvement (e.g. channel restoration, temperature management, enhanced biological productivity). In addition, removal or modification of Martinsville Dam to enhance flow, habitat, and fish and sediment passage would benefit fish populations and environmental conditions in the lower tailwater. Management actions for improving flow and habitat also should be assessed in light of the presence of the Federally Endangered Roanoke logperch *Percina rex* that also appear to be limited by degraded environmental conditions in the tailwater.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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FRESHWATER ECOREGIONS OF SOUTH AMERICA: UNDERSTANDING REGIONAL PATTERNS OF AQUATIC BIODIVERSITY, A FRAMEWORK FOR SETTING PRIORITIES

The Nature Conservancy and World Wildlife Fund are developing a system of freshwater planning units for Latin America that will provide a comprehensive and biologically meaningful framework for freshwater conservation planning. The system will identify two sets of planning units at different spatial scales. We are delineating a set of broad continental scale fresh-

water ecoregions and Ecological Drainage Units (EDUs) at the watershed scale. Ecoregional units are based on patterns in fish biogeography and distribution patterns, whereas EDUs will incorporate climate, and landforms in addition to the faunistic data. This regional designation of freshwater planning units in Latin America is part of a global effort to map and describe freshwater ecoregions and will serve as an important step toward building consensus with other organizations that have begun to identify freshwater conservation priorities. We will present the preliminary delineations of the aquatic ecoregions for South America and estimates of fish species richness and endemism for each ecoregion.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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ECOLOGICALLY SUSTAINABLE WATER MANAGEMENT: CASE STUDIES, TOOLS AND COLLABORATION

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Human demands for freshwater have more than doubled during the past half century and continue to increase as the human population swells globally. With the corresponding intensive management of rivers, hydrologic alteration – changes in the natural patterns of river flows – has become a leading cause of the precipitous decline in freshwater ecosystems. For example, in the United States – which is a global hotspot for freshwater biodiversity – 37% of freshwater fish and 69% of freshwater mussels are imperiled. However, rapid scientific advancements in river ecology during the past few decades have provided the understanding necessary to support river management that both sustains ecological integrity and meets human needs. Through its efforts to improve river flow conditions for the benefit of freshwater biodiversity, The Nature Conservancy has worked with river scientists, water managers, and conservationists around the world to develop a framework for ecologically sustainable water management. This poster summarizes the ecologically sustainable water management framework, presents an example tool – referred to as the Indicators of Hydrologic Alteration – that is used to help guide water management, and highlights a national collaboration between the Corps and TNC on ecologically sustainable water management.

■ INNOVATIONS IN PUTTING PLANS INTO PRACTICE

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USING MOLECULAR TOOLS TO AID IN THE CONSERVATION OF NORTH AMERICAN ATYID SHRIMPS: A CASE STUDY USING THE ENDANGERED ALABAMA CAVE SHRIMP (*PALAEMONIAS ALABAMAE*)

The family Atyidae is large and cosmopolitan in distribution, including both surface (epigeal) and cave dwelling (stygobitic) forms. Assessing biological diversity in cave dwelling forms is especially problematic, as populations may often go undetected due to their small size and restricted, fragmented habitat. In the southeastern U. S., two species are recognized, the endangered Kentucky Cave Shrimp (*Palaemonias ganteri*) and the endangered Alabama Cave Shrimp (*P. alabamiae*). Recently, two new populations (*Palaemonias* sp.) of cave shrimp were discovered from northwestern Alabama. The discovery of these new cave shrimp populations raises questions concerning the true diversity of cave dwelling atyids in the United States. We examined the morphological and genetic (COI and EF1_α) diversity of stygobitic and epigeal atyid shrimps in North America. The results indicate the recognition of a new species of atyid shrimp in Alabama is warranted. Only 80 km separate *P. alabamiae* from the newly discovered populations, yet we have found genetic divergence (over 4%) between these two species (COI). This compares to the relative low genetic diversity found within both the Alabama Cave Shrimp and the new species (0.5% and 0% respectively). Based on phylogenetic analyses, these two Alabama cave atyids are basal to other species within this shrimp family. Furthermore, atyid cave shrimp from Mexico are more closely related to epigeal atyid shrimp (*Syncaris pacifica*) found in freshwater streams on the Pacific slope of North America than to the Alabama cave shrimp species. Preliminary analysis of COI sequences of *S. pacifica* collected from Marin, Napa, and Sonoma counties in California reveals genetic structure that indicates that epigeal shrimp populations separated by a relatively short distances may also be shown to be distinctive as well.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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THE CONTINENTAL DECLINE OF SCAUP AND SCOTERS IN NORTH AMERICA: THE IMPORTANCE OF ARCTIC WETLANDS IN THE NORTH WEST TERRITORIES, CANADA

Continental populations of scaup (*Aythya* sp.) and scoters (*Aythya* sp.) have declined 41% and 58% respectively in the past 25 years. White-winged, surf and black scoters have decreased from 1.8 million to 700,000. Scaup populations continue to drop an average of 150,000 birds each year. Why these species are declining while other North American waterfowl populations remain steady or are increasing, is unknown. Cooperative studies are underway in North America examining their wintering, migration and breeding habitats. While scaup and scoters winter in different locations, retrospective analyses examining correlations between the two declining populations suggest that they share limiting factors in the North West Territories of Canada, where the majority breed. It is here, in the Lower Mackenzie Watershed (LMR), that close to 80% of the continental scoter decline can be attributed. It is also where the effects of global warming are expected to be intense and where gas and oil exploration continues at a high rate. Using radio telemetry, we studied the movements, body condition, and nest success of female white-winged scoters and lesser scaup in the LMR, along with the arctic wetlands these birds use. We examined the food availability, hydrology and geology of wetlands to see which variables were most important. Initial analysis in this multi-year study indicate that wetland invertebrates influence hen distribution and nesting preference. Water chemistries and upland features, such as natural burns, do not appear to be significant. Aquatic invertebrates in these systems are closely linked to water temperature, ice-free days, and photoperiod. Our concern is that climate change has the potential to strongly influence the natural hydrology of these wetlands and aquatic invertebrates. Continental conservation strategies for scaup and scoters will need to consider the importance of arctic wetlands and the impacts of global warming and resource extraction on this region.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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PARTICIPATORY AND ADAPTIVE MANAGEMENT FOR THE AMAZON FLOODPLAIN BIODIVERSITY

The Amazonian floodplains, or várzeas, are remarkably complex in their ecological, social, economic and institutional interactions. The distribution of freshwater biodiversity is poorly known with the exception of a few well studied areas near to urban centers or national reserves. Environmental degradation and social conflicts are high due to inefficient natural resources management, lack of protected areas and specific political policies.

ProVárzea, a multi-donor project implemented through the Brazilian Environment Agency (Ibama) since 2000, is challenging those problems through (i) strategic studies on biodiversity distribution, land tenure, socioeconomics and the agricultural, fishery and forestry sectors; (ii) innovative local development projects with community organizations, NGOs and different branches of government, (iii) Pilot areas which test local participatory management and governance models. These components contribute to the formulation of political policies with key stakeholders. This poster presents some of the results obtained in the last three years. The biodiversity study was conducted along the main channel of the Amazon collecting 573,103 individuals, including spiders, plants, birds, fish and rays, from which 2,092 species have already been identified. From this data four distinct biogeographical zones were delimited which will form the basis for future conservation planning. In *Silves*, a locally-supported project involving 19 communities (548 families and 2,700 people) implemented local fishery agreements which helped to increase productivity and fish stocks. In *Santarém*, a pilot area, fishing accords, fishing councils and community-based environmental volunteers have shown that the sustainable use of fisheries resources require: 1) local support 2) decentralized management; 3) influence on the formulation of coherent public policies; 4) diversifying the economic base. If these requirements are met, integrated management and habitat protection can be achieved. Thus, *ProVárzea* is demonstrating that it is possible to integrate scientific knowledge with local management initiatives and participation to manage and conserve the *várzeas'* biodiversity.

■ INNOVATIONS IN PUTTING PLANS INTO PRACTICE

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TAXONOMIC ACCURACY: DISTRIBUTION OF CATFISHES OF THE GENUS CHAETOSTOMA IN THE TROPICAL ANDES IN PERU

The accuracy of using museum records for determining actual and potential distribution areas for the catfish genus *Chaetostoma* is evaluated using GIS analysis tools. Museum collections represent a vast source of information for conservation purposes. Accurate identification of the species collected and geographical reference of the collection sites, together with GIS analysis tools can be used to determine landscape factors that define target species distributions. Knowing the factors that define preferred habitat for the target species could be the basis of proposing potential distribution areas. Tropical Andes have been pointed out as one conservation hotspot in the world. Not many fish species are distributed in the Tropical Andes but *Chaetostoma* species are distributed in fast flowing rivers on the

eastern slope of the Andes. The genus *Chaetostoma* is distinctive and considered to be easily distinguished from other genera. These criteria were evaluated comparing the actual and potential distribution pattern of the genus *Chaetostoma* in relation to elevation, slope and land use, considering identifications before and after an ongoing revisionary work. The extent of the distribution of the genus *Chaetostoma* is restricted geographically and by elevation. Because species are easily recognized they may be valuable indicators of the distribution of aquatic communities in need of protection in the Tropical Andes.

■ INNOVATIONS IN EVALUATING AND MONITORING OUTCOMES

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INTERMITTENT STREAMS: A UNIQUE BUT FORGOTTEN HABITAT

Although watersheds are composed largely of intermittent streams they are the least studied of freshwater habitats. Intermittent streams harbor a unique community of lotic species specifically adapted to seasonal flow behaviorally or physiologically through burrowing into the hyporheic zone, egg-diapause or spring emergence. One striking example is the large, semi-voltine dragonfly *Cordulegaster obliqua* (Odonata: Cordulegasteridae), a Massachusetts NHESP watch-list species. While vernal pools are protected in Massachusetts, intermittent streams are overlooked in land use planning despite their contribution to stream biodiversity. To demonstrate this diversity we conducted a study of ten streams in eastern Massachusetts using EPA standardized sampling methods. Stream discharge was measured monthly for one year and streams were classified as perennial (constant flow), intermittent (dry for 3 months or less), or episodic (dry for more than 3 months). Our results showed that intermittent streams displayed similar or higher macroinvertebrate richness and diversity than perennial streams, while episodic streams displayed low levels of richness and diversity in comparison. Flow regime appears to play a major role in maintaining stream community structure; it is likely that extended periods of drought (more than 3 months) will substantially reduce stream diversity. We propose that intermittent streams be certified for protection based on biological diversity, including indicator species such as *C. obliqua*, in accordance with flow permanence. This is a means to prioritize the protection of highly diverse streams while maintaining the economic liberties of developers in the rapidly developing state of Massachusetts, where freshwater resources and the biodiversity they contain are critically threatened.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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ASSESSING THE GEOGRAPHIC DISTRIBUTION AND INVERTEBRATE BIODIVERSITY OF NATURALLY FISHLESS LAKES IN MAINE, USA

During the 20th century it was common practice for government agencies throughout North America to stock fishless lakes with sportfish. Recent research, mainly in western North America, has revealed that fishless lakes provide critical habitat for a wide range of taxa, and introduced fish have detrimental effects on native biota. Little is known, however, about the distribution and biological communities of fishless lakes in the Northeast. Due to its glacial history and resulting topography, as well as a relatively low human population density, Maine may host the greatest number of unaltered fishless lakes in the northeastern United States. This project was developed with four primary goals: 1) estimate the number and distribution of fishless lakes in Maine using a geographic information system (GIS); 2) characterize invertebrate communities associated with fishless lakes; 3) assess the effects on resident invertebrate fauna of introducing fish into fishless lakes; and, 4) identify invertebrate species useful as indicators of current and historic fish absence. Based on landscape attributes (e.g., surrounding slope, connectivity) of known fishless ponds in Maine, a GIS model was created to identify other potentially fishless lakes in the state. Eighteen of these lakes were surveyed for fish presence in 2004. Additionally, during the summers of 2002-2004, invertebrates were sampled in 51 lakes (22 fishless, 7 historically fishless and now stocked, and 22 with fish) using a combination of plankton tows, submerged light traps, littoral dipnet sweeps, and aerial netting of adult Zygoptera. Initial results suggest that significant differences exist in the invertebrate community composition between fishless and fish-containing lakes (e.g., Odonata, Diptera). The phantom midge, *Chaoborus americanus*, may be useful as an indicator of current and historical fish absence. Our preliminary results suggest that fishless lakes host a potentially unique aquatic fauna of scientific and conservation interest.

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MOLECULAR TECHNIQUES AND CONSERVATION IN THE AMAZONIAN RIVERS: TWO NEW SPECIES OF *HYPOPYGUS* HOEDEMAN, 1962 (GYMNOTIFORMES: RHAMPHICTHYIDAE)

Over the last few years, we have been dedicated to understand how the biodiversity of the Amazon rivers might be generated and sustained, using the electric-fish genus *Hypopygus* as a model. In this regard, we are conciling morphological, molecular and physiological (Electric Organ Discharges, EODs) parameters from populations sampled at right and left margins tributaries of the Rio Negro. Although just two species are currently recognized in the literature, our results indicate new, still undescribed, taxa. Analyzing the genetic parameters of specimens collected in 8 sampling points, we present two putative new species of *Hypopygus* from Rio Negro, based upon analyses of mitochondrial (mt) and nuclear (n) DNA fragments. Our study included two individuals of each species of the *Steatogenini* tribe. Several other gymnotiform taxa were sequenced and used as outgroups. Fragments of the 12S and 16S mtDNA genes and RAG-1 nDNA gene were sequenced and analyzed. The phylogenetic relationships between the taxa were estimated through the maximum-parsimony and maximum-likelihood methods and the resulting topologies were concordant, support the following: (1) according to genetic distances and character-based analysis, there are two other new *Hypopygus* species in the Rio Negro basin, which are closely related to *H. lepturus*; (2) the topology found: (((*Stegostenopos criptogenes*, *Hypopygus neblinae*) (*Hypopygus lepturus*, (*H. sp1*, *H. sp2*))), makes the genus *Hypopygus* paraphyletic; (3) the tribe *Steatogenini* sensu Albert & Campos-da-Paz (1998) is monophyletic; and (4) corroborating Alves-Gomes et al (1995) the family *Hypopomidae* sensu Mago-Lacia 1984 is an unnatural group, since *Steatogenini* is closer related to the rhamphichthyids than to the hypopomids. Our results indicate a necessity for a taxonomic review of the group and its systematic and that the current number of species associated to the aquatic biodiversity in the Amazon have been underestimated. This is critical for management and conservation policies in the Amazon.

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ECOLOGIC AND ECONOMIC VALUATION OF WULLAR LAKE FOR SUSTAINABLE DEVELOPMENT

Today, most planning and development decisions are made on economic grounds and, more and more, on the basis of the forces at play in the free-market system. While this new paradigm has its own limitations and dangers, it would be unrealistic to ignore it and to base our quest for the conservation and wise use of wetlands on a completely different set of values. Hence, wetland goods and services must be given a quantitative value if their conservation is to be chosen over alternative uses of the land itself or the water which feeds the wetlands.

Wullar Lake – known as Asia's largest freshwater lake has become an environmental mess due to growing anthropogenic pressure, human greed, and unwise practices followed by the people in the catchment. The Lake was given the Ramsar status in 1990, but still no visible measures to restore its lost legacy are seen on ground. To justify its conservation, valuation study of Lake is carried out which identifies the important structures, processes and functions of the Lake and tries to explore the ecologic-economic interface besides employing total economic value (TEV) framework to quantify all the use and non-use values of the Lake.

The study found the lake worth Rs 219 crore per annum in terms of the benefits which are transacted in market or have a market value. These direct benefits accrue to surrounding population. Other important benefits from the lake which cannot be quantified in monetary value such as flood absorption basin, water quality improvement, natural reservoir for power plants, etc may be far higher than the marketed product benefits. In addition, the lake forms an important site for both resident and migratory birds (waterfowl).

Looking to the importance of the lake, the government should take measures for its conservation on priority basis. TEV and other important functions provided by the lake justify the budget allocation for the management of the lake.

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INDICATORS FOR MONITORING FRESHWATER BIODIVERSITY: NO SILVER BULLETS

Conservation of freshwater biodiversity is a priority for both government agencies and national and international conservation organizations. A number of large-scale conservation plans specifically targeting freshwater biodiversity have been, or will soon be, implemented across the globe. Although numerous potential biodiversity indicators have been proposed for monitoring the status of freshwater ecosystems, few of these indicators have been evaluated. Choice of indicator is especially problematic in many parts of the developing world, where biodiversity data are sparse in general and budgets are limited. In contrast, many developed countries have created freshwater biological assessment programs, which are generally based on measuring aspects of macroinvertebrate assemblages. Many aspects of these assessment methods have been rigorously evaluated. However, macroinvertebrate-based assessments have not been generally applied to biodiversity conservation, and the extent to which macroinvertebrate-based measures of biological integrity reflect trends or responses in other taxa is unclear. We reviewed the extensive biodiversity and bioassessment literature to identify a practical set of biodiversity indicators for monitoring the success of freshwater conservation plans. After defining the properties that such indicators should possess, we concluded that no extant indicator can adequately assess the biodiversity status of freshwater fauna. We highlight areas for further research and suggest combinatorial approaches that may prove adequate in the interim.

■ INNOVATIONS IN EVALUATING AND MONITORING OUTCOMES

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MOVEMENT PATTERNS OF AN INVASIVE FRESHWATER SNAIL: AN EFFICIENT MODELING APPROACH

Invasive species are currently considered one of the major threats to freshwater biodiversity. Predicting the spread of invasive species across environments in a timely manner requires an

efficient modeling approach that can be applied to many species across many environments. Furthermore, modeling invasive spread must take into consideration the influence of environmental and phenotypic heterogeneity. An aquatic snail, *Tarebia granifera*, apparently invaded streams in the Northern Range Mountains of Trinidad in the last 10-20 years, but has never been studied. To address how local movement patterns of this species are affected by environmental heterogeneity, in terms of resource level, and phenotypic heterogeneity, in terms of body size, we measured individual snail movement in an experimental stream facility at high and low resource treatments. We postulated variations on the simple advection-diffusion equation as a priori working hypotheses. Using experimental movement data, we examined the dependency of model selection on resource level and body size. We assessed the ability of these models to predict population level movement behaviors using Akaike's Information Criterion (AIC). At low resources, large individuals moved faster than small individuals and a model that includes size dependency is important for good model fit. At high resources, individuals moved upstream together as a wave and size differences largely disappeared. These findings show empirically how 1) environmental heterogeneity, or resource level, restructures animal movement patterns for this species and 2) the importance of population heterogeneity for accurately characterizing animal movement is context dependent. Finally, we illustrate how this approach may be used to efficiently model the movement behaviors of invasive species and other organisms. Modeling invasive spread efficiently will contribute to our understanding of invasion dynamics, and may provide more timely, yet still scientifically robust, predictions regarding biological invasions.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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THE GLOBAL DRAGONFLY ASSESSMENT

While freshwater ecosystems cover only 0.8% of the Earth's surface, they are the habitat of virtually 100% of the world's 5,600 species of dragonflies and damselflies. Rapid degradation or loss of wetlands and freshwaters are resulting in the imperilment of large numbers of dragonfly and damselfly species. Regional analyses have suggested that greater than 20% of dragonfly/damselfly species may be endangered or threatened, and there is a growing number of presumed extinct taxa.

In order to develop a strategic plan to effectively conserve dragonfly diversity and, more broadly, freshwater biodiversity, the American Museum of Natural History and Conservation International

have initiated a global assessment of the conservation status of the world's dragonfly and damselfly species. This effort represents the first effort to comprehensively document the distribution, population status, and conservation needs of any invertebrate taxon at the species level.

Conservation status of the world's dragonfly/damselfly species are being assessed within the IUCN SSC Red List Program framework, on the basis of: a) documented range sizes/trends; b) known population sizes/trends. Data on the distribution of species is being derived from museum collection specimen records, regional or private databases of collection records, and locality information contained within the historical literature. Where possible, population trends are being assessed from modern monitoring data and/or the historical patterns of collection records. These distribution and population trend data will be coupled with additional expert information on threats, population trends, etc. for each species to produce final assessments.

The GDA will identify the most threatened species and critical habitats for this group of invertebrates, as well as lead to the inclusion of dragonflies and damselflies in other global initiatives such as CI's Hotspot analyses and the Alliance for Zero Extinction's map of priority conservation sites.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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USING A DECISION SUPPORT SYSTEM TO DEVELOP CONSERVATION PLANS FOR PNW SALMON

Salmon conservation in the Pacific Northwest, USA, requires the development and assessment of scientific tools that provide insights into the relationships between multiple salmon species and their habitats; these tools must be immediately useful in developing recovery plans for listed species. Specific challenges include the design and evaluation of methods for (1) assessing current and historic habitat value for multiple species over the entire watershed, (2) predicting in-stream responses to restoration and preservation actions at multiple locations within the watershed, and (3) estimating species-specific population responses to changes in in-stream habitat across the watershed. Estimates and predictions must be made over vast areas for which collecting field data and developing detailed models is impossible. Often competing

models and scientific uncertainties cloud the selection of the best and most efficient habitat management plans. We present details on the Lewis River case study in SW Washington in which we use a decision support system as an innovative way to meet these technical and scientific challenges. The Lewis River case study combines coarse assessments of watershed processes (hydrology, sediment production, and riparian condition), detailed models of those same processes, a customized habitat evaluation tool, and 4 methods of linking habitat to fish response. Potential restored landscapes can be generated based on varied restoration strategies. The potential landscapes are then evaluated using the embedded habitat and fish response models. Output metrics provide both technical support for conserving salmon abundance and diversity in the Lewis River watershed as well as regional advice on which models support consistently similar conclusions and which restoration strategies are most likely to increase salmon population performance. The decision support system provides detailed information over large areas, balancing the trade-offs between local accuracy and large-scale coverage or synthesis and uniquely managing uncertainty in modeled data and predictions.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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SHARING DIGITAL IMAGERY AS A TOOL FOR AQUATIC MACROINVERTEBRATE CONSERVATION: IMAGE DATABASES, COLOR LAMINATES AND ELECTRONIC FIELD GUIDES

Digital cameras, open source software, and the internet are rapidly increasing the speed and ease with which biodiversity information can be shared. We illustrate the usefulness of these digital technologies to support freshwater invertebrate conservation using three examples. As part of the Nantucket Biodiversity Initiative we surveyed several ponds on Nantucket Island in June of 2004. Traditional collecting techniques were complemented by taking digital photographs of species at the site or back in the laboratory. The images are now stored on a publicly accessible website at UMass Boston (see <http://gallery.cs.umb.edu/gallery>) with appropriate metadata that will help people find the images and identify species. A second example is the use of laminated

color guides for the Massachusetts Biodiversity Days. Novices and children were given laminated sheets with 9 images per side to help them identify aquatic organisms. Finally an Electronic Field Guide to aquatic macroinvertebrates of small streams in eastern Massachusetts (<http://efg.cs.umb.edu/keys>) has been made that uses pictures to identify species from this limited habitat and geographic location. Digital images are particularly useful to excite and teach people about an unfamiliar world and to help people identify and document species and habitats. Rapid advancements in technology have made it possible for skilled amateurs to take quality digital images. Obstacles to wider use of digital images include 1) social issues concerning the sharing of images, 2) the design, maintenance and operation of cyberinfrastructure and 3) the adoption by scientific societies of standards to certify images and associated metadata and support broader community involvement. We discuss steps to overcome these impediments. (Research supported by the National Science Foundation and the Massachusetts Environmental Trust.)

■ INNOVATIONS IN PUTTING PLANS INTO PRACTICE

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EFFECTS OF ZEBRA MUSSELS ON NATIVE BIVALVES: THE BEGINNING OF THE END OR THE END OF THE BEGINNING?

Conservationists fear that the invasion of the zebra mussel from Europe in 1985 may lead to the extinction of many populations and species of native North American bivalves. The invasion of the Hudson River estuary by zebra mussels was followed by steep declines (77 to >99.7%) in populations of all species of native bivalves between 1992 and 1999. Body condition of all unionids, and growth and recruitment of young unionids also declined significantly. Declines in population size and body condition were correlated primarily with the filtration rate of the zebra mussel population, not with fouling of native bivalves by zebra mussels. Samples taken since 2000, however, have shown that populations of all 4 common native bivalves have stabilized or even recovered, although the zebra mussel population has not declined. The mechanisms underlying this apparent reversal of fortune are not clear: recruitment and growth of young mussels have showed limited recovery, but body condition of adults has not. We found no evidence that spatial refuges contributed to this reversal of population declines. Simple statistical models project now that native bivalves may persist at population densities about an order of magnitude below their pre-invasion densities. These results offer a slender hope that long-term coexistence of

zebra mussels and native bivalves may be possible at some sites.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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INCORPORATING COMMUNITY CLASSIFICATION INTO FRESHWATER CONSERVATION AREA PLANNING

Developing conservation targets at multiple scales (ecological systems, communities, species) is an important concept in conservation planning. While freshwater conservation planners have embraced the use of ecological systems and rare species as targets, little effort has been spent developing freshwater community targets. Community classification techniques can be useful in describing and delineating distributions of community targets for conservation planning efforts. Using an extensive fish dataset from the Ohio Environmental Protection Agency and a suite of multivariate statistics, I developed eight fish community targets for the Lower Scioto Basin Conservation Area. These fish communities were incorporated into a framework that addresses conservation targets at multiple scales and multiple sites across a large conservation area. This framework will provide an efficient yet comprehensive base for identifying stresses and developing strategies for a multitude of complex targets within the Lower Scioto Basin. This framework has utility in other freshwater conservation planning projects for large watersheds.

■ INNOVATIONS IN PLANNING FOR CONSERVATION

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ECOSYSTEM INDICATORS FOR ASSESSING RESTORATION PROJECTS

During the past decades river restoration activities have increased rapidly. Although a huge amount of detailed environmental knowledge has been compiled, up to 60% of all restoration projects are still ineffective. The main reasons for project failure include (i) the “missing-link” between natural and social science and (ii) the lack of reference data from near-pristine ecosystems, which constrains our understanding and mimicking of ecosystem processes. Additionally, restoration projects are rarely evaluated. If evaluated, the selection of inappropriate indicators may have a major effect on the output of the evaluation process. Our intent is to present guidelines on how to select and to apply indicators for assessing river restoration projects. We propose a

hierarchical framework for choosing indicators for individual projects. The main elements of this hierarchical framework include hydrogeomorphic (physical), ecological (biological), and socio-economic indicators. Much emphasize is on the development of novel indicators to assess ecosystem functions such as functioning organic cycles (e.g., decomposition of leaf litter), ecosystem resilience (e.g., density and spatial arrangement of refugia) and lateral connectivity (aquatic-terrestrial interaction). In particular river shores are very sensitive areas for a variety of aquatic and terrestrial organisms, many of which are listed as threatened or endangered. We have developed new indicators that not only provide sensitive information on aquatic and terrestrial habitats but also on cross-boundary trophic linkages.

■ INNOVATIONS IN UNDERSTANDING FRESHWATER SYSTEMS

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THE KALA OYA RIVER BASIN, SRI LANKA: WHERE SMALL IRRIGATION TANKS ARE NOT REALLY SMALL

Today’s map of Sri Lanka, especially the Dry Zone, is dotted with thousands of ancient fresh water tanks. These ancient tank systems have both ecological and biological importance. A key issue is seasonality and duration of water retention, which has a significant influence on their biodiversity and ecology. This case study describes an exercise that was undertaken in the Kala Oya Basin of Sri Lanka to assess the livelihood and biodiversity values of traditional tank systems. The Kala Oya Basin contains a largely rural population of some 400,000 people, most of whom are engaged in farming as their main form of livelihood. Cultivation of rice and other crops is combined with fishing and the harvesting of wild plants and animals. Tanks yield a range of direct livelihood values for surrounding villagers. Some of the most important benefits are associated with the provision of water for crops, livestock and domestic uses such as bathing, washing clothes and household water supplies. Additionally, the wild plants and animals associated with tanks are important for local subsistence and cash income. These resources include fish, reeds and edible plants, and the flowers. The results of the valuation study showed that tanks of the Kala Oya Basin yield an average value of US\$ 425 per household per year in terms of water and aquatic resource use, or almost \$3,000 per hectare of inundated area. The valuation study also showed that these benefits were particularly important for poorer households, who lacked access to their own wells and for whom alternative sources of income and subsistence were scarce.

■ INNOVATIONS IN EVALUATING AND MONITORING OUTCOMES

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**THE VEGETATION, PALEOECOLOGY AND
GEOMORPHOLOGY OF A NEW JERSEY PINE
BARREN RIVERSIDE SAVANNA**

*The Outer Coastal Plain of southern New Jersey contains a unique ecosystem called the Pine Barrens, a million-acre mosaic of sandy, acidic soils supporting fire-dependent pitch pine dominated uplands, and a voluminous aquifer feeding numerous streams and associated wetlands. Pine barren riverside savannas are groundwater seepage fens dominated by sedges and grasses with scattered trees and shrubs, found on the floodplains of rivers and streams in the Pine Barrens. These ecological communities are imperiled globally and provide habitat for thirty-three rare plant species, including the federal candidate species bog asphodel (*Narthecium americanum*). The origin of savannas has been debated. Some scientists believe that land use history (bog iron mining, Atlantic white cedar logging, turf cutting for cranberry bog berms) played a significant role in the formation of savannas. Others suggest that natural processes (hydrology, oligotrophic conditions, deer browsing, fire) formed these open, graminoid communities. Paleoeological and geomorphological studies were conducted at one savanna, "Above Buck Run" in the Oswego River Natural Area of Wharton State Forest, in an attempt to answer this question. Geomorphological transects indicate no surface disturbance to the riverside savanna. The thickest peats define a buried channel with dimensions similar to the modern main stream channels, and likely represent channel networks etched during the latest stage of floodplain incision, prior to sea-level and water-table rise, and organic accretion. Results of pollen and charcoal analyses of a peat core suggest that savanna vegetation has been present in the landscape for approximately 8000 years, and that fire played an important role in regional floristic dynamics. The findings of this study have contributed to an understanding of how Pine Barren riverside savannas function in the landscape, and have informed protection and management strategies for these globally imperiled ecological communities and associated rare plants in the Pine Barrens of New Jersey.*

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