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In this Issue

Material for the September 2004 issue should be sent to the Editor for:

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Contributions on a PC formatted disk, in any standard word processor or DOS (ASCII) text, or as email attachments, will assist the Editor.

The International Association of Theoretical and Applied Limnology (Societas Internationalis Limnologiae Theoreticae et Applicatae, SIL) promotes and communicates new and emerging knowledge among limnologists to advance the understanding of inland aquatic ecosystems and their management.

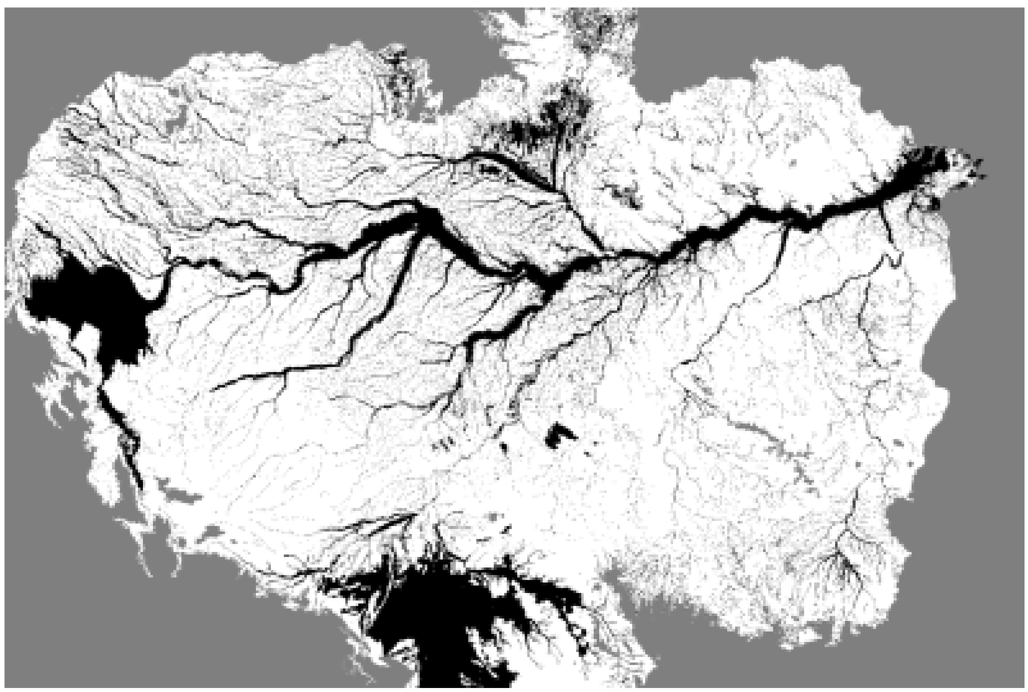

Fig. 1. Floodable area (black) for Amazon basin below 500 m contour derived from JERS synthetic aperture radar mosaic; floodable areas are not all inundated simultaneously and may include areas not floodable that do not appear on the scale of the figure (J.M. Melack, L.L. Hess and M. Gastil, unpublished).

Remote Sensing of Wetlands on a Global Scale

by
John M. Melack and Laura L. Hess

continued on next page

Wetlands cover extensive areas in tropical, temperate and boreal regions and are represented by a wide variety of plant communities (Gore 1983; Whigham *et al.* 1985). For example, estimates of the wetland area in the Amazon basin exceed 1 million square kilometers and include seasonally inundated forests and savannas, thousands of kilometers of waterlogged or frequently flooded riparian zones bordering streams and rivers, poorly drained backwater swamps, coastal mangrove and palm swamps, and high-elevation bogs (Fig. 1; Junk 1997). Wetlands, in general, have high rates of primary productivity and biogeochemical activity (Brinson *et al.* 1981; Mitsch and Gosselink 2000). In addition, wetlands play critical roles in maintaining and improving water quality, mitigating floods, recharging aquifers, and providing habitat for fish and wildlife.

Relative to their ecological importance, on a global basis, wetlands are not well characterized. A major factor contributing to the difficulty of inventorying and monitoring wetlands and their environmental functions has been the lack of means of determining their hydrological conditions and phenological changes of their vegetation. Fortunately, remote sensing instruments and analytical methods, developed in the past decade, make possible examination of wetland features on a scale not possible previously. Further, remote sensing can help provide critical information required by environmental agreements such as the Ramsar Convention and Kyoto Protocol.

Through a process of designation of individual sites by nations party to the Ramsar Convention on Wetlands, 1,280 sites constituting a total area of 107 million ha have been identified. However, as of 2002 only 29 of the 139 contracting parties had completed comprehensive national inventories and 40% of the areas were located in only 24 countries. Current Ramsar strategic plans call for completion of national inventories and assessment of wetland biodiversity and functions. Attaining these objectives will require a concerted effort that incorporates considerable application of remotely sensed data.

With regard to the Kyoto Protocol, natural wetlands and cultivated rice are a large source of methane (Aselmann and Crutzen 1989) and, therefore, are a key element in greenhouse gas accounting. Recently, Richey *et al.* (2002) have shown that outgassing of carbon dioxide from rivers and inundated floodplains is a significant component of the carbon budget of the Amazon basin, and likely to be so for other tropical river systems. Quantification of these greenhouse gas emissions on a global scale will require information derived from a variety of remote sensing systems (e.g., Sippel *et al.* 1998, Prigent *et al*. 2001, Hamilton *et al.* 2002, Hess *et al.* 2003, Melack *et al.* 2004).

For many years color infrared aerial photography and, more recently, multispectral visible and infrared digital imagery obtained from airborne or satellite-borne sensors, have been used to delineate wetlands (Butera 1983; Melack and Hess 1998, Hess *et al.* 2002). The last decade has seen development of a new suite of optical and microwave sensing systems and analysis algorithms that are dramatically advancing the understanding of wetlands (Melack 2004). An especially promising approach is synthetic aperture radar (SAR), which can image inundation and vegetation, unaffected by cloud cover, season, or time of day. When specular reflections from an underlying water surface interact with vegetation via double-bounce or multiple scattering, backscattering is enhanced, permitting detection of flooding beneath vegetation. Recent research has developed techniques for accurately classifying digital radar images into vegetative classes and inundation status based on airborne and Space Shuttle-borne imaging radar (Hess *et al.* 1995; Kasischke *et al.* 1997). With the advent of satellites with SAR sensors (Europe's Earth Resources Satellite (ERS) and Envisat, Canada's Radarsat and Japan's Earth Resources Satellite (JERS-1)), global monitoring of inundation and wetland vegetation has become feasible.

Optical and microwave sensors with capabilities for mapping the type and distribution of wetlands and the temporal and spatial distribution of inundation can be grouped into the following categories: coarse-, fine- and high-resolution multispectral optical systems; imaging spectrometers; light detection and range systems (LIDAR); passive and active microwave imaging systems; and microwave altimeters (reviewed in Melack 2004). A major challenge in the application of remote sensing to the study of wetlands is the very large temporal and spatial scales of variation typical of wetlands. Moreover, even extensive wetlands usually require fine-scale imagery to properly document their extent, seasonality and variety of vegetative covers. The incidence of inundation is often directly related to the size of the river adding the further need for high-frequency data.

The probable time periods for recording an image usable for wetland analysis with various remote sensing instruments varies from days to months (Fig. 2). Even though the repeat cycle for Landsat is biweekly, we expect that due to cloud

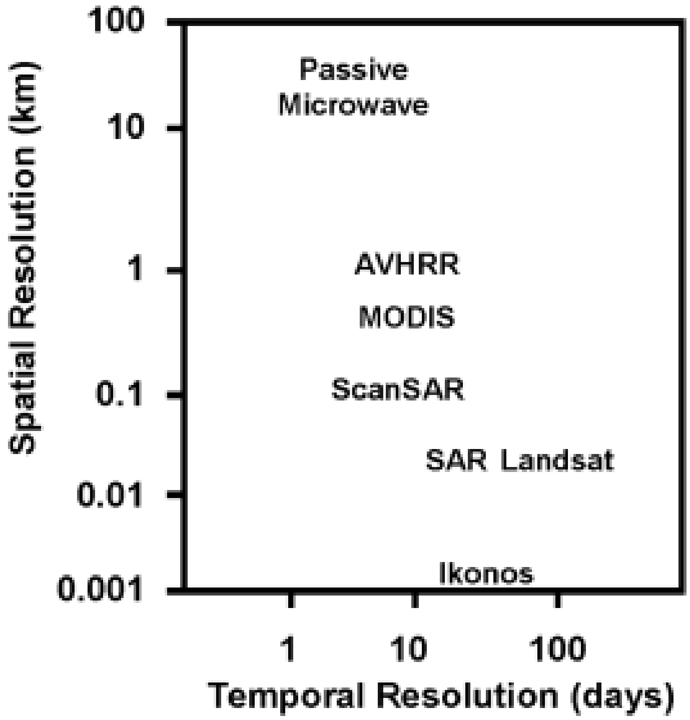

Fig. 2. Temporal and spatial resolution of various remote sensing systems applicable to wetlands and incorporating estimates of likelihood of data acquisition; AVHRR (Advanced Very High Resolution Radiometer), MODIS (Moderate-resolution Imaging Spectrometer), SAR (synthetic aperture radar). Landsat is one example of a fine-resolution optical system. Ikonos is one example of high resolution optical systems.

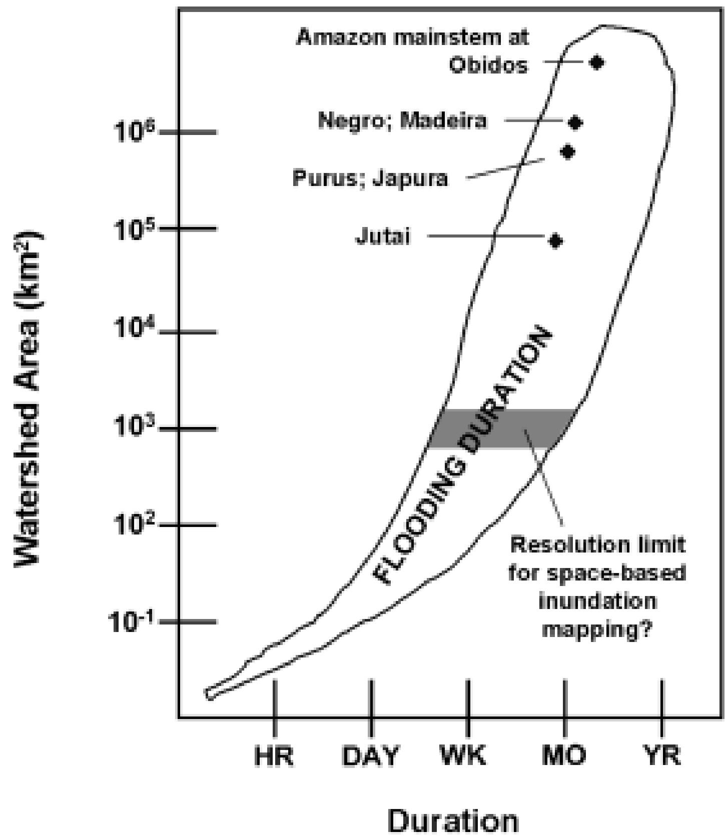

Fig. 3. Relationship between watershed area and likely flooding duration as a guide to resolution limit for space-based inundation mapping as applied to rivers in the Amazon basin.

cover a good image may be available at best three times per year in many tropical locations. Fig. 3 depicts the space/time domain for inundation for a sample of river systems in the Amazon basin. The rivers are plotted with respect to the scale of the contributing watershed and estimated average duration of annual inundation. Although the mesoscale tributaries to the Madeira River (i.e., the Ji-Paraná and Jamari rivers) probably have sufficiently long periods of flooding for multi-temporal image acquisition, it may be that the floodplains of these rivers are so narrow that there will be an insufficient number of pixels across the floodplain for discriminating flooded versus unflooded conditions without high-resolution sensors. There is probably an inundation mapping limit for typical rivers with contributing drainage basins on the order of 1,000 to 10,000 km^2 when the flood conditions occur only for a week to a month.

As part of a joint Brazilian-United States investigation of the Amazon basin (*http://lba-ecology.gsfc.nasa.gov/lbaeco/*), Hess *et al.* (2003) have developed methods for large-scale mapping of wetland vegetation and inundation at 100 m resolution using mosaics of JERS-1 synthetic aperture radar imagery. The JERS-1 data are well suited for this purpose because the L-band (~23 cm wavelength) horizontally transmitted and received SAR signals penetrate both clouds and vegetation and produce a strong backscatter from flooded vegetation. The dual season, continental-scale mosaic (Chapman *et al.* 2002) made it possible to create a wetland mask for the whole lowland Amazon basin (Fig. 1; J.M. Melack, L.L. Hess and M. Gastil, unpublished). Moreover, similar JERS-1 mosaics have been produced by Japan's Earth Observation Research Center for central Africa, southeast Asia, northern Australia, Central America, most of South America (Rosenqvist *et al.* 2000) and the pan-boreal region. These data provide the basis for a significant improvement in a global wetland inventory that incorporates information about inundation and vegetation structure.

Existing estimates of the distribution of the world's wetlands are based on spatially coarse information derived from maps or from optical data not well suited to delineate wetlands (e.g., Matthews and Fung 1987). Not surprisingly, when examined on a sub-continental scale for the Amazon basin, their estimates of the extent and distribution of potentially flooded areas differ substantially from analyses derived from the JERS-1 data (Hess *et al.* 2003). Two global 1 km land cover data sets derived from the 1992-1993 Advanced Very High Resolution Radiometer data are available, the DISCover (Loveland *et al.* 2000) and the University of Maryland (Hansen *et al.* 2000) maps. The University of Maryland product does not include wetlands. The DISCover approach was not suited to detection of wetlands; hence wetlands are under-represented in the database. Based on a comparison among three global wetland inventories and Ramsar data, (Darras *et al.* 1999) noted large differences in total wetland areas and little spatial fidelity among the inventories, and concluded that all are underestimates. The critical need for improved assessments of wetland extent worldwide is well recognized by organizations such as Wetlands International (Finlayson and Davidson 1999; *www.wetlands.org*).

The combination of multi-temporal SAR imagery with multi-temporal optical data derived from sensors, such as those on the Terra and Landsat satellites, will offer wetland scientists and managers powerful new methods for the generation of global analyses of wetlands needed for the International Geosphere Biosphere Program (Sahagian and Melack 1998), the Ramsar Convention and Kyoto Protocol. C-band (~6 cm) SARs, such as Radarsat and Envisat, provide imagery well suited for studies of herbaceous vegetation, woodlands and some forests (Ribbes and LeToan 1999; Townsend 2001), but reliable detection of inundation in densely forested wetlands requires L-band SAR. The launch planned in 2004 of the Advanced Land Observation Satellite (ALOS) by Japan promises to provide dual polarization L-band data, which improves detection of vegetation structure, and to include a ScanSAR mode capable of regular monitoring of large areas.

Careful validation of the wetland products developed from remote sensing is of critical importance. Validation strategies that work well for local studies, such as ground surveys, interpretation of aerial photographs or use of existing high-resolution maps, become impractical or impossible at continental or global scales. Instead, a statistically valid verification can be based on high-resolution satellite imagery of a set of randomly selected sample pixels (Scepan 1999). Validation sets can also be developed using intensively studied sites representative of biome types, building libraries of multi-sensor, multi-scale data (Justice *et al.* 2000). Another solution to sub-continental-scale validation based on aerial videography is described by Hess *et al.* (2002). They demonstrate that geocoded digital videography can provide a cost-effective means of compiling high-resolution validation datasets for wetland mapping in remote, cloud-covered regions.

To fully exploit the potential offered by advanced remote sensing systems will require an internationally coordinated and funded effort that incorporates the expertise of wetland ecologists, remote sensing specialists and resource managers. Collaborative programs among government agencies, non-government organizations, private ventures and universities will be essential. The worldwide network of aquatic scientists associated with SIL are well poised to play a key role in such an endeavor.

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Environmental Issues

Mountain Lakes of the Great Caucasus

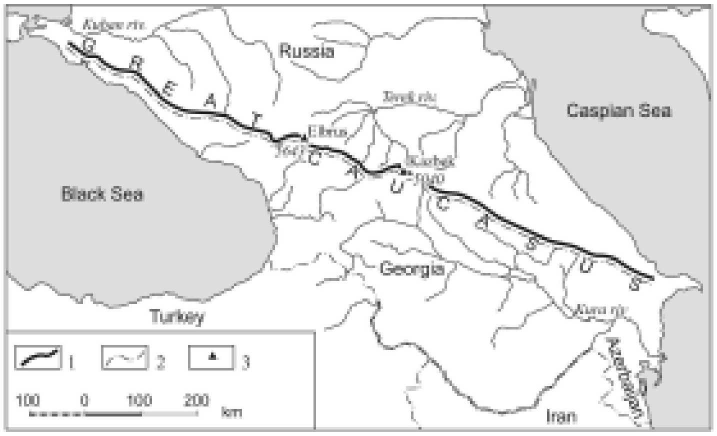

Fig. 1. Sketch of the Great Caucasus. (1-The main divide of the Great Caucasus; 2-Boundaries of the states; 3-Highest peaks).

The Great Caucasus Mountains stretch for 1,100 km from northwest to southeast (Fig. 1). The mountains are asymmetric in composition, formed by sedimentary rocks of the Jurassic, Cretaceous, Paleogenic, and Neogenic periods. Paleozoic rocks are exposed west of the axis of the mountain range (Zhulidov *et al*. 1997).

Numerous mountain lakes are widespread over the Great Caucasus territory (Fig. 1). Lakes vary in their origins and their water regimes. At present there are 1,852 lakes with a total area of 95.8 km^2. The largest lakes are Kazenoyam, Abrau, Big Ritsa, Kelistba, Bazaleti (Table 1). Most of the mountain lakes (60%) have an area <5,000 m^2. These smaller lakes account for 11.5% of the total lake water surface (Efremov 1993).

Table 1. Major lakes of the Caucasus.

Lake	Area (km^2)	ASL (m)	Max. depth (m)
Kazenoyam	1.70	1,870	72
Abrau	1.60	837	10
Big Ritsa	1.49	884	102
Kelistba	1.28	2,914	63
Bazaleti	1.22	878	7

Most of the Caucasus lakes have a glacial (78.5%) or karst (10%) genesis. Narrow (shallow gully) tarns, depression tarns and moraine tarns amongst larger glacial lakes were identified for the first time by Efremov (1984). These tarns are different from each other by the type of dam that retains the water (Efremov 1984) and have variable morphometric characteristics that may change depending on natural factors (geomorphologic, climatic etc.). The physical, chemical and biological properties of both large and small lakes are also depend upon natural forces (Efremov 1993).

Most of the lakes (78%) are situated on the north slope of the Great Caucasus in high-mountain areas near modern glaciation areas. A clear and regular pattern of lake distribution at high-altitudes is observed here. This fact allows us to identify "lake belts" at altitudes of 2,500-3,000 m on the north slope and 2,000-2,500 m on the south slope. River run-off begins at 2,500-3,000 m.

Mountain lakes are very sensitive to changes occurring in their watersheds. Changes connected with climate, glaciation and river run-off are particularly important. Periglacial lakes are more sensitive to these changes than other lakes. According to existing ideas the formation and development of glacial lakes in high-mountain areas is a consequence of climatic variability, expressed in the process of glacier degradation. The area and quantity of glaciers are decreasing. Periglacial lakes are formed in favorable geomorphologic conditions where glaciers have vanished. Studies have shown that most of the periglacial lakes appeared during retrogressive phases of glaciation 2,500 - 3,000 years ago and in the 19th century. Analysis of literature sources, topographic maps from 1881-1910 and topographic interpretation of aerial photos from different years, have shown that glaciers existed to the end of the 19th century in many places now occupied by modern glacial lakes.

Lake formation in the Great Caucasus is continuing today as glaciers recede. As a result, over the last 50 years about 100 new periglacial lakes have appeared in the West Caucasus (Table 2). The biggest of them are situated near the South Dalar, West Okril and Amanauzsky glaciers.

Lake shorelines increase by 1.5-15 m per year as glaciers recede (Efremov and Ilyichev 1998). The glacial recession and the appearance of new periglacial lakes have a cyclical character. Periods of very intensive lake formation over the last 100 years correspond to periods of rapid glacier melting from 1890-1908, 1915-1929, 1935-1938, 1940-1955, 1960-1965 and 1975-1977 (Table 3). Similar regularities are observed in other mountain systems. Lateral tributaries separate from a main glacier during recession and new lakes appear between them. These lakes can periodically empty. Good examples of such lakes are the Talsekva in Alaska (Stone 1963) and the Mertsbakhera in Tien Shan.

Table 2. Information on glacial lake formation in the Caucasus high-mountain area as a result of glacier loses.

Name and (or) number of glacier/lake	Altitude above sea level, m	Lake Area (approx. for 1998), m^2	Year when the lake appeared
Mikelchiran, N 5	3,251	15,600	1960
Birdzhalychiran, N 6	3,300	35,500	1976
Bashil, N 10	3,078	25,000	1950
Bodorku, N 21	3,000	5,700	1970
Small Azau, N 28	3,270	232,000	1950
Bashkara, N 59	2,568	53,000	1940
Ulluazna, N 64	2,500	20,600	1964
N 77	2,270	500	1975
Marukhsky, N 107	2,750	2,500	1960
East-Klukhorsky, N177	2,980	30,310	1945
Chaulluchat, N 215	2,930	30,000	1960
N 216	2,700	6,000	1950
N 220	2,770	4,800	1960
Chingurdzhar, N 287	2,670	20,000	1960

Periglacial lakes can be reduced in size or completely disappear as a result of glacier activation. A few such events are known in the Great Caucasus when glaciers approached a lake area. An example is the lake situated near the edge of the East-Klukhorsky glacier (Lake N 177). The lake appeared in 1880 and increased in size up to 1929 but it almost vanished in 1935 as a result of the glacier's approach. N 177 appeared again in 1945-1946 and has continued to become larger up to the present day. In some years (1977-1979, 1980-1982, 1986-1987) the area of N 177 decreased, coinciding with the glacier's approach. Therefore, the presence of periglacial lakes always points to the gradual degradation of glaciers.

Table 3. Surface area changes of periglacial lakes in the Great Caucasus.

Lake	Observation Period	Area Changes, m^2	Notes
Amanauzskoe	1978-1985	+5, 910	
East-Klukhorskoe	1935-1958	+10,820	
	1958-1963	+3,560	
	1963-1977	+6,380	
	1977-1979	-1,470	
	1979-1986	+9,170	
	1986-1987	-1,060	
	1987-1988	+2,910	
Perevalnoe	1929-1988	+2,500	The glacier melted in 1977
Birdzhalychiran-1	1958-1981	+3,900	The lake broke out in 1983
Birdzhalychiran-4	1981-1987	+4,200	
Birdzhalychiran-5	1958-1987	+32,000	
Birdzhalychiran-8	1958-1987	+8,800	
Mikelchiran	1981-1988	+8,590	
Small Azau	1981-1988	+6,250	
Bashkara	1984-1988	+4,000	
Ulluazna	1984-1986	+2,428	Situated near the end of the glacier

Observations conducted on several lakes in the West Caucasus (Karakel, Tumanlykel, Klukhorskoe, Zerkalnoe) have shown that a direct dependency between atmospheric precipitation and water level of the lakes exists. A dependency between air temperature and lake levels also exists. The levels of the periglacial lakes increase with increasing temperature. The levels of lakes situated outside of glacial areas increase at the beginning of summer, as a result of snow cover melting. After the snow has melted, changes in air temperature are basically reflected in the temperature of the water, but changes in lake levels are not observed in high-mountain areas. Levels of lakes situated in middle- and low-mountain areas may sometimes decrease in summer time during stable hot weather. Morphometric indexes of lakes also depend upon climatic conditions, as do water regime indexes. For instance, lake levels are raised when rainfall increases but so, in consequence, are depth, area, width, length of shoreline and other characteristics.

We conclude that mountain lakes are indicators of environmental changes. However, specific relationships between indicators and climate and glaciation changes for individual lakes have not been studied in enough detail to make more than this generalized conclusion. We propose that this available information can form the basis for further studies.

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Book Reviews

A Field Guide to Bacteria

by Betsy Dexter Dyer
368 pp., 2003
Cornell University Press
Cloth ISBN 0-8014-3902-7, Price US $49.95 £31.50
Paper ISBN 0-8014-8854-0, Price US $26.00 £16.50

Here is a book to remind us that we really live in the age of bacteria and that we should pay attention to them. After all they account for 50% of all diversity, biomass and drive all biogeochemical cycles, degradation and transformations on the planet.

The author uses macroscopic field marks, a concept borrowed from birders and mammal watchers and applies this with useful effect to allow observations on microorganisms without the aid of a microscope. Dr. Dexter Dyer provides a variety of cues using all the senses to identify bacteria in the field. Indeed, her use of field marks is reasonably effective for determining the identity of bacteria with certain colour and smell in a particular habitat etc. The presence of 100 colour illustrations is also very useful. These could be significantly improved, particularly when the author refers to several objects, by the addition of arrows and/or other indicators.

It is also good to consider that bacteria can be appreciated and studied without the requirement for expensive equipment, laboratory space or even an extensive professional background. A primer is also provided on microbiology and essentials of microbial ecology to orient the user, although it may be used like many field guides by simply finding the right chapter when a question arises. That said, the field guide also provides relatively straightforward instructions on using light microscopy, sterile technique and culturing methods to further examine bacteria. The question remains, how useful is this approach for the aquatic ecologist or limnologist? As the author notes, the sections on particular bacteria are not intended to be exhaustive but rather provide useful “tricks of the trade” or “rules of thumb” used by professionals to identify bacteria and bacterial processes in the field. This approach can be very useful particularly in the context of teaching, field trips and field courses were there should be a desire to integrate these organisms into the course and the students consciousness. This approach may allow less bacteriocentric aquatic ecologists and limnologists to address the whole ecosystem and consider the significance of bacteria in a variety of natural and engineered systems.

This book compiles a large amount of interesting and valuable information and would be of interest to those in natural history, keen secondary level educators and both microbiologists and non-microbiologists alike.

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Application of Geographic Information Systems and Remote Sensing in River Studies

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This book is a collection of papers that describe emerging geospatial approaches in river studies. The focus is clearly on the application of remote sensing and geographic information systems (GIS) in assessing the ecosystem function of river systems. This includes assessments of flooding in riparian regions, the effects of landscape changes, vegetation dynamics and integrated effects monitoring; all using geospatial data sources in conjunction with traditional ground-based observations. The authors present a perhaps overly optimistic view on the utility of geo-spatial data in tackling the complex interactions of the riparian ecosystem. Nonetheless, we are encouraged by, and see the value, in the importance of using the geospatial approaches in river studies. Effective ways of doing this are clearly spelled out in a number of chapters throughout the text. The fact that geospatial approaches are seen as an important part of the overall solution to river management is very encouraging.

This collection of papers is arranged in four major sections, introduction, applications of remote sensing, applications of GIS, and finally discussions. The most interesting section of this text comes in the introduction, where the geospatial approach is defined and elaborated upon from the perspective of the river ecologist. The ecological framework is presented as a general strategy to assess and monitor biodiversity in a changing landscape. A paper by Alard and Poudevigne presents a compelling strategy for further understanding of ecosystem function by examining habitat structure spatially through patch analysis. The presumption that biodiversity is positively correlated with landscape heterogeneity provides a direct application of geomatics in river ecology. The authors note that landscape changes influence ecological communities at the landscape "patch scale" and by monitoring and describing the distribution of these patches it is possible to describe and understand the importance of changes to the ecology of a particular river system.

The first paper by Geerling *et al*. assesses the feasibility of using aerial photographs to understand the extent and severity of peatland degradation of a river basin in Ireland. This is of tremendous ecological importance because of the influence this has on the sediment regime in western Irish streams. The authors note that although peatland degradation has been observed in many locations, there is no systematic accounting of the extent of this degradation in Ireland. Black and white aerial photography, combined with ground-truth data was used successfully to map upland areas that suffered from peatland degradation, while low-lying regions were not as successfully mapped. There is no biophysical explanation given for why the aerial photography was not as successful in low-lying regions. One would speculate that low-lying regions are water saturated and that the visible reflectance is dominated by the presence of water. Perhaps a multi-spectral or multi-sensor (considering microwave active radar sensors to examine surface structure) would have proved more useful. Given the current availability of high-resolution multi-spectral satellite sensors such as the IKONOS or SPOT satellites, it would seem prudent to investigate the use of these satellites to further explore this problem. Regardless, this initial and rather crude approach demonstrates the extent of the problem. The authors speculate that 70% of the total study area has been degraded. Clearly more investigations are needed.

Mount *et al*. discuss using aerial photography and photogrammetric techniques to assess river stability in an upland river in Wales, UK. Again photo-interpretation is used to assess temporal changes in a lower reach of the Afon Trannon catchment. As a first attempt, no orthorectification of the digitized imagery was used to assess the temporal changes in the imagery and very simple imaging software was used. The purpose of such an exercise was to assess the utility of non-georeferenced imagery for change detection. Given the relative ease and low cost of basic image analysis systems, there are arguably no valid reasons to pursue such an approach. However, the authors quickly redeem themselves by using proper geomatics software-tools to ortho-rectify the imagery to standard map-projections using a simple affine transformation. There is no mention of map-coordinates geometry, datums or the resolution of the digitized photographs that were used. The results were encouraging in that basic geo-morphological changes in the channel characteristics within the basin of study were readily and accurately identified using the historic air-photo time series.

The following paper Bourcier *et al*. shows an excellent example of using SPOT multi-spectral data in monitoring ecological phenomenon in a riverine environment at large scales. They highlight the need for systematic time-series information and analysis in order to track ecological changes, and point out quite rightly that remote sensing techniques are the only viable option for this type of monitoring. In a somewhat related case-study by Farthing and Teeuw, a comprehensive overview of the UK environmental agency strategy for using GIS and remote sensing for river management is presented. This paper is of particular interest to practioners who are looking for a conceptual model for incorporating geo-spatial information into their respective river management programs.

The second half of the book focused more on traditional GIS applications to river management. As an example, issues arising from the use of various interpolation techniques are presented. Although this topic, particularly with respect to digital elevation model (DEM) generation has been studied for many years, the assessment approach outlined in this text is interesting in that the robustness of the techniques is looked at from the ecologist's perspective. Other GIS functionality, such as looking at spatial variability of pollutants for ecological risk assessment, are well described and provide compelling arguments for adopting the geo-spatial approach in ecological monitoring and modelling. Similar examples of risk assessment techniques within the context of GIS analysis are presented in the remainder of this section. The book's editors provide an interesting and comprehensive conclusion at the end of the book, highlighting both the advantages and limitations of GIS and remote sensing in river studies.

This is an excellent book for the uninitiated in the field of study who want a synopsis of what is feasible from a river management perspective using geo-spatial analysis. This also provides interesting details on specific applications that will be of interest to river managers who have, or don't have, experience in dealing with remote sensing and GIS techniques.

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News and Views

FOG

W lay dormant in the mud on the lake bottom, her sleep guaranteed by the darkness of the freezing, motionless water above her. Higher up, all was silent and still as far as the thick covering of ice on the lake, its surface sullied by a deposit of grey-pink acidulous dust. Higher still, in the dark moonless night, Orion had risen, bearing starry witness to the depth of winter. Sirius almost dazzled.

It took just a week for the ice to melt, first with the foehn, then the blustery March winds. The free, oxygenated water was pushed down to the bottom to touch the muddy sediment. The acidity was mitigated by bicarbonate, and the turbulence lifted clouds of W cysts to where the water was full of light, and here they hatched and began to eat photons and litho-nutrients. They grew and multiplied, supported by the continuing storms.

As the sun grew warmer and the days longer, there was anticipation of the arrival of the tasty morsels of "r" flagellates, tiny, green and nourishing. But everything, water and algae, was still being driven towards the bottom by the continuing winds and storms. Dark, light, dark, light, so it went on. The W microalgae in their stylish glass outfits invaded the whole of the lake like a thick brownish-green fog. And no-one ate them, except for the odd reckless individual. The previous year's lesson had been learned, and now everyone knew.

Eudia and the others were desperate. Pelagic in their habits, they could not go on living on the FPOM near the shore. By now they had used up all their reserves; they had to give in to their hunger. And so they began to eat the W algae. And they were delicious! When they took them into their mouths and chewed them with their tiny jaws, there was a delightful crunching sound, as when you chew a sweet with liqueur or syrup in the centre. But, and now it was common knowledge, those delicious algae damaged the embryo, and when the young were born, they were almost all deformed. Poor little nauplii, with their tiny feet missing or twisted! It was so sad to watch them swimming about like flies without feet.

But that wasn't all. Eudia and the others were attacked by myriads of small fish that the fishermen weren't trying to catch. And they were not fry, either, they were adults, their small size due to the overcrowded conditions.

And so the green fog grew denser with every day that passed. And the water stank. Eudia and the few others that were left had a hard time holding out in the world that was rotting around them. Their only hope was that those minute "r", a good, safe food supply, would appear. But the storms did not let up and the "r" could not appear.

Then, for a couple of days boats ploughed through the thick green water, and the surface was noisy with the sounds of men. Eudia and the others noticed that suddenly the small fish had disappeared, and there were large fish in the lake they had never seen before. In a few weeks, helped by the arrival of fine weather, the fog had gone.

"I must say I was not at all confident," said George. "In fact, I would not have bet a wooden nickel. But the manipulation worked". They returned to the shore and went off to a restaurant to eat steaks and sausages.

(translated from Italian by Sandra Spence)

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From Science to Adoption: the 'Living Murray' Experience

A commissioned, complex, scientific evaluation of ecological benefits that could be expected from potential environmental flows in the River Murray system in eastern Australia has provided some insights about the human face of the scientific advisory process.

The River Murray is heavily used for irrigated agriculture, towns, industry and recreation, and supports a number of Ramsar-listed wetlands. As a result, the Murray-Darling Basin Commission that manages the river-system faces an array of environmental, economic and social issues. While the scientific evaluation was in progress, there was considerable concern among the river's irrigation communities. With the river already very committed, and their water allocations restricted (by drought), they felt that environmental flows could threaten their livelihoods.

Looking back on the hectic months of scientific evaluation, several behavioural and cultural lessons emerge. They may interest others who are broadening their conversation with *community stakeholders* about the ecology of heavily-used rivers.

- For communities to see science as reasonable and acceptable, we should strive for trust as well as credibility. Without trust, even sage advice from a Nobel Prize winner may be dismissed by wary stakeholders. Hence, scientists engaged in the science advisory process should be people that the community trusts, and must behave accordingly.

- We should use independent decision systems and predictive models when providing scientific advice to government and the community. The scientific evaluation used an ecological decision support system that is transparent, repeatable and fully documented. It has quelled much of the concern in the community, which distrusts 'expert opinion'.

- Scientists should recognize that their advice (necessarily independent and robust) has a social and political context. They should avoid terminology, such as 'degraded river', that has a different meaning to members of the community and can hinder cooperation.

- It is important to separate scientific advice from environmental advocacy. If scientists, even unintentionally, embed their views about desirable ecological outcomes in their advice to government and communities, there is a significant risk of alienating key stakeholder groups.

This article is based on an article in 'Watershed', December 2003, available at: *http://freshwater.canberra.edu.au > Publications > Watershed > 2003.*

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Purely descriptive work, whether limnological, ecological or taxonomic, can only be considered if it is firmly embedded in a larger biological framework.

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Christel Keurentjes
Christel.keurentjes@wkap.nl

Calendar of Events

XII Conference of the Spanish Limnology Association and the IV Iberian Conference of Limnology.
5 - 9 July 2004
Porto, Portugal
Contact: CIMAR
Rua dos Bragas, 177
P 4050-123 Porto
Portugal
limnol2004@cimar.org
Phone +351 223 401 837
Fax +351 223 390 608
www.cimar.org/limnol2004

Sixth International Chrysophyte Symposium.
2 - 7 August 2004
Lammi Biological Station, Central Finland
Organizers:
Johanna Ikävalko, Finland
johanna.ikavalko@alih.masa-yards.fi **OR**
ikavalko@mappi.helsinki.fi
Gertrud Cronberg, Sweden
gertrud.cronberg@limnol.lu.se
Joergen Kristiansen, Denmark
joergenk@bot.ku.dk
http://www.helsinki.fi/ml/ekol/chrys2004/

SIL XXIX Congress.
8 - 14 August 2004
Lahti, Finland
Contact: Congress Management Office
University of Helsinki
Palmenia Centre
for Research and Continuing Education
Kirkkokatu 16
15140 Lahti
Finland
sil-2004@helsinki.fi
Phone: + 358 3 892 11
Fax: + 358 3 892 20219
www.palmenia.helsinki.fi/congress/SIL2004

Fifth International Symposium on Large Branchiopods (ILBS5 for short).
16 - 20 August 2004
Toodyay, near Perth, Australia
ILBS5@cyllene.uwa.edu.au
www.zoology.uwa.edu.au/ILBS5

2004 Joint Meetings
XI International Conference on Ephemeroptera and XV International Symposium on Plecoptera.
22 - 29 August 2004
Flathead Lake Biological Station
The University of Montana
Polson, Montana (USA)
flbs@flbs.umt.edu
www.umt.edu/flbs

5th International Symposium on Ecohydraulics.
12 - 17 September 2004
Madrid, Spain
Contact: TILESA, OPC, S.L.
Londres, 17
28028 Madrid, Spain
Phone: +34 91 361 2600
Fax: +34 91 355 9208
ecohydraulics@tilesa.es
http://www.tilesa.es/ecohydraulics

9th International Conference on Wetland Systems for Water Pollution Control.
27 - 30 September 2004
Avignon, France
Contact: Wetlands Systems Conference Secretariat
CEMAGREF - 3, bis quai Chauveau
69336 Lyon Cedex 09
France
wetlands@lyon.cemagref.fr
Fax: +33 4 7847 7875
www.iwahq.org.uk/template.cfm?name=wetland_systems

International Symposium on World Subterranean Biodiversity.
8 - 10 December 2004
Claude Bernard University - Lyon 1
In Villeurbanne, France
Contact: Janine Gibert/Annick Papin
PASCALIS
Université Claude Bernard Lyon I
HBES
Bât. FOREL/403
43 Bd du 11 Novembre 1918
F-69622 VILLEURBANNE CEDEX
France
Fax: 33 (0) 472 43 15 23
pascalis@univ-lyon1.fr
http://www.pascalis-project.com/

2005

53rd Annual Meeting
North American Benthological Society.
23 - 27 May 2005
http://www.benthos.org/

5th conference on the Ecology and Management of Shallow Lakes (Shallow Lakes 2005).
“Shallow lakes in a changing world”
5 - 9 June 2005
Dalfsen, the Netherlands
Contact: Conference secretariat Shallow Lakes 2005
C/o NecoV (Netherlands-Flemish Ecology Society)
Mozartstraat 53A
6661 BH Elst
The Netherlands
administratie@necov.org
www.shallowlakes.nl

2006

The Tenth International Symposium on Aquatic Oligochaete Biology. Tentatively scheduled to convene at:
The Institute of Hydrobiology
Chinese Academy of Sciences, Wuhan, China
Contact:
Dr. Hongzhu Wang, D.Sc., Associate Professor
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