

In Memoriam: Richard Norris (1951–2011)

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On September 19, 2011, freshwater science lost one of its finest researchers and mentors. We lost a close friend and colleague.

Richard Norris was born in Canberra on January 18, 1951 into a scientific family. His father Kenneth (Dick) Norris was a renowned Commonwealth Scientific and Industrial Research Organisation (CSIRO) entomologist, a dipteran systematist. His uncle Don Norris also worked with CSIRO and is a world

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authority on plant viruses. Richard's younger brother Murray is currently a cancer researcher at the University of Sydney.

Educated in Canberra schools through his teenage years, Richard completed his BSc (Honours) degree at Australia National University, a Graduate Diploma in Education at the Canberra College of Advanced Education (now the University of Canberra), and then moved to Hobart, Tasmania, to do his PhD at the University of Tasmania with aquatic ecologist Sam Lake. His PhD thesis dealt with the ecological effects of mine effluent on the South Esk River, a topic that presaged his future contributions to applied aquatic ecology. Following graduation in 1979, he worked as researcher in freshwater ecology for the Museum of Victoria in Melbourne. In 1981, he took a position at the University of Canberra. He, the late Peter Cullen, and a small group of energetic colleagues forged a niche in freshwater science for the Canberra College of Advanced Education as it morphed into the University of Canberra. This group ensured that freshwater science grew into a real research focus for the young institution, eventually giving rise to the Cooperative Research Centre (CRC) for Freshwater Ecology and its successor the eWater CRC. He became a Full Professor at the University of Canberra in 2004, and Director of the Institute for Applied Ecology in 2005. Under his leadership, the Institute became a major research venue in Australia. Richard retired from the University in 2011 because of ill health. His death soon after was the result of complications from liver cancer.

Richard's main, lifelong research interest was in the field of biological monitoring using benthic macroinvertebrates, the subject of his doctoral research. He played an important role in the development and adoption of multivariate predictive-modelling approaches to water-quality monitoring and water-management issues in Australia and around the world. Key to the approach was development of the 'reference condition', an aggregation of unimpacted or least-impacted sites against which sites suspected of being environmentally perturbed could be compared.

From 1986 to 1994, Richard led a team of researchers in developing the Australian River Assessment System (AUSRIVAS). AUSRIVAS was a modification of the River Invertebrate Prediction and Classification System (RIVPACS) model developed in the UK starting in 1977. He

played a central role in the establishment and development of river bioassessment under Australia's National River Health Program and First National Assessment of River Health. From 1994 to 2003, Richard and his team developed manuals, training and accreditation for Australian researchers in the use of AUSRIVAS for bioassessment, and continually refined and updated the software for AUSRIVAS. AUSRIVAS provides the robust and standardized approach to freshwater monitoring widely used in Australia today.

In 2001, Richard led the teams that undertook the influential Land and Water Resources Audit and the Snapshot of Murray–Darling Basin River Condition. These audits were the first time an integrated assessment of Australia's rivers had been attempted, and underpinned an informed discussion on matters affecting river health in the Basin. This work was critical to establishing credible estimates of environmental flows, the water required to maintain the riverine ecosystem, a matter of much debate in Australia's food basket. These large-scale assessments of the condition of Australia's rivers became the foundation for Richard to develop the Framework for the Assessment of River and Wetland Health for the Australian National Water Commission.

From 1992 to 1996, Richard was able to apply his predictive-model approach internationally. He participated in the planning of the use of the approach on the Canadian side of the Great Lakes and (after he had AUSRIVAS in place) on the Fraser River, British Columbia. The models for the Canadian bioassessment studies were developed by Trefor Reynoldson, then of Environment Canada, and were called Benthic Assessment of Sediment (BEAST). Richard also collaborated with C.P. Hawkins of Utah State University to apply RIVPACS-type models to US rivers. The two collaborators organized a symposium entitled 'Landscape Classifications and Aquatic Biota' held at the 1998 annual meeting of the North American Benthological Society (now the Society for Freshwater Science) in Charlottetown, Prince Edward Island. Reference condition and regional reference concepts were a central premise of the symposium, which was published as a special issue of the *Journal of the North American Benthological Society* (now *Freshwater Science*) in 2000 ('Landscape Classifications: Aquatic Biota and Bioassessments', 19/3, Guest Editors C.P. Hawkins and R.H. Norris).

Richard also took the reference condition approach to New Zealand, South Africa and Indonesia. Much of his perspective on, and development of, bioassessment were synthesized in his 2004 book 'Bioassessment of Freshwater Ecosystems: Using the Reference Condition Approach' co-authored with Robert Bailey and Trefor Reynoldson.

No major area of science is without its controversy, and bioassessment was no exception. State water-quality-monitoring agencies in the US had committed to the multimetric approach (e.g. James Karr's Index of Biotic Integrity), whereas Richard advocated a predictive-modelling approach (e.g. RIVPACS, AUS-RIVAS, BEAST). The debate over the most effective approach continued for several years in the mid- to late 1990s, and began to diminish in 1997 with the convening of an international workshop in Oxford, England, where RIVPACS and other water-quality-monitoring techniques were discussed. This workshop was the beginning of a more collaborative atmosphere between the multimetric and predictive-modelling camps, and Richard played a key role in this collaboration.

Richard was a much-sought-after invited speaker, and his participation in a conference session guaranteed a full room. However, he was also instrumental in organizing highly technical conferences, symposia and workshops (as described above). Several international conferences in Canberra were noteworthy: Biomonitoring and the State of the Environment (1988), Use of Biota to Assess Water Quality (1993), Managing Collaboration for Scientific Excellence (1996) and What is River Health? (1997). Key papers from these conferences resulted: W. Maher and R. Norris. 1990. Water-quality assessment programs in Australia. Deciding what to measure and how and where to use bioindicators. *Environmental Monitoring and Assessment* 14:115–130; R.H. Norris and K.R. Norris. 1995. The need for biological assessment of water quality: Australian perspective. *Australian Journal of Ecology* 20:1–6; P.W. Cullen, R.H. Norris, V.H. Resh, T.B. Reynoldson, D.M. Rosenberg and M.T. Barbour. 1999. Collaboration in scientific research: a critical need for freshwater ecology. *Freshwater Biology* 42:131–142; and R.H. Norris and M. Thoms. 1999. What is river health? *Freshwater Biology* 41:197–210. These publications were solid contributions to evaluation of aquatic resources and

the strengths and benefits of international collaboration.

Richard helped organize/participated in two other special workshops (in addition to 'Landscape Classifications and Aquatic Biota') at annual meetings of the North American Benthological Society (NABS). These workshops came at crucial times in the development of robust bioassessment approaches, and catered to an international audience of bioassessment practitioners. 'Study Design and Data Analysis in Benthic Macroinvertebrate Assessments of Freshwater Ecosystems Using a Reference Site Approach' was held in 1996 in Kalispell, Montana. 'Performance Characteristics and Accuracy of Statistical Approaches in Benthic Biology' was held in 2002 in Pittsburgh. All three of Richard's NABS workshops brought together students and international colleagues to learn state-of-the-art technical approaches in bioassessment, and to discuss future developments and strategies. Richard's energy in assembling and participating in these kinds of technical and learning sessions will be sorely missed.

The interface between science and management was another focus of Richard's career. The translation of science into action was a recurring theme for him, and gained increasing prominence in his later years. He could see that, as critical as science was to good decision making, it would come to nought if that science could not be understood or championed by those in charge of creating change. The prescience of this view can be seen, in large measure, in the problems of the Murray–Darling Basin. We have already alluded to Richard's role in the first environmental audits of the Basin.

A good example of Richard's research/management ties was construction of the enlarged Cotter Dam. The enlargement was meant to secure Canberra's water supply, but it threatened a remnant population of the endangered Macquarie Perch. Richard's team engaged with the water-supply authority (ACTEW Corporation) and the construction groups to develop a novel solution to providing habitat for the fish in the enlarged reservoir. This research included both basic research (fish ecological and behavioural studies) and applied research (design and placement of artificial habitat structure) to provide the ACTEW Corporation with a practical way of protecting biodiversity in the enlarged reservoir.

Richard's recognition that Australian waterways were in urgent need of coordinated and systematic management led him to conclude that the translation of science into action was essential to avoid catastrophe in Australia's fresh waters. Through his role as program leader with the eWater CRC and then as Director of the Institute for Applied Ecology at the University of Canberra, he focused much effort in his latter years to forging strong collaborations among researchers and the agencies involved in water management. His goal was to focus scientific knowledge through integration into management action on the basis of mutual respect between scientists and managers. These engagement activities resulted in strong relationships and joint ventures between the University of Canberra and community groups, state agencies and federal agencies such as the National Water Commission and the Murray–Darling Basin Authority.

Richard saw the need to make better use of the vast pool of underused scientific research to inform management decisions. He led a team to harness the growing interest in applying the principles of epidemiology to assemble evidence and build convincing arguments regarding ecological questions of cause and effect. His 'Perspectives' article in the first issue of the newly named journal '*Freshwater Science*' is dedicated to this work (R.H. Norris, J.A. Webb, S.J. Nichols, M.J. Stewardson and E.T. Harrison. 2012. Analyzing cause and effect in environmental assessments: using weighted evidence from the literature. *Freshwater Science* 31:5–21).

With his retirement in sight and keen to see a collaborative, multi-disciplinary and applied approach to the severe problems of the Murray–Darling Basin, Richard piloted a successful bid to establish a major Collaborative Research Network linking biological scientists, economists and social scientists at several Australian universities and CSIRO with government agencies such as the Murray–Darling Basin Authority, the National Water Commission and the Department of Sustainability, Environment, Water, Population and Communities. Sadly, Richard passed away just as the Network was finding its feet.

Richard also left his mark on education. As part of his formal training, he completed a Graduate Diploma in Education, flagging a lifelong interest in the principles and practice of education. That interest manifested itself through a strong commitment to

undergraduate teaching and postgraduate training (Richard supervised 28 BSc Honours students, 10 MSc students and 13 PhD students, with three in progress), but also to the development of non-credit courses with innovative online content that allowed self-paced learning and flexibility for students juggling the competing demands of a job and learning opportunities.

In 2006, Richard and Michael Barbour collaborated on developing an e-learning module for bioassessment that was intended to help agencies evaluate the rigour of their bioassessment program regardless of which index or biological indicator was used. Although this work was never published, it is an example of how two researchers with different bioassessment approaches found common ground.

In testimony to Richard's influence in freshwater science and education, many of his former students are key members of Australia's state, territory and federal water-management agencies.

Richard was active in a variety of scientific societies (e.g. Australian Society of Limnology, NABS). He served in editorial positions with *the Australian Journal of Ecology*, *Journal of the North American Benthological Society* and *Hydrobiologia*. He also served on a number of national and international committees dealing with water-quality issues (e.g. ACT Flora and Fauna Committee, Interim Board of Management of the Jerrabomberra Wetlands, Freshwater Biodiversity Section of the National Climate Change Adaptation Research Facility and Capital WATER).

In preparing this memorial statement, numerous anecdotes and events that we shared with Richard came to mind. These memories involved his wonderful sense of humour, his love of physical pursuits, his competitive nature, his passion for anything new and technological (including his desire to convert those not interested in the latest devices), and his loyalty to friends.

Richard's passion for science was matched by his passion for physical pursuits. He was an Olympic-class sailor, dabbled in karate, and in 2009 represented Australia in his age class at the World Triathlon Championships. He was particularly fond of competing, and loved nothing better than pitting himself against his students and much younger colleagues in feats of endurance on a bicycle. On one long training run on his bicycle, he collided with a large kangaroo.

When he hit the pavement, his helmet split in two and he sustained multiple abrasions. Yet, when colleagues asked about the accident, they most often wanted to know what happened to the kangaroo (it survived). On the bright side, Richard bought a new and better bicycle after the accident. The relative merits of handicapping were a subject of considerable contention between Richard and his competitors, with Richard often beating those half his age.

Huge technological advances over the past two decades have not only changed the way we do our work but also have permeated our everyday lives. Richard always prided himself on being the one who leapt over the watersheds of innovation, and a friendly technological arms race existed between Richard and his close colleagues over the years. Richard had the first good laptop computer, complete with colour screen, and was the first to use Powerpoint presentations effectively. He was the first to develop decent web tools for bioassessment and education. He was admiring but faintly disappointed when Trefor Reynoldson appeared with the first digital camera used regularly (complete with a 3.5-inch floppy drive in the back).

Richard was at his professional best when making a presentation, no matter what the level. He was always self-assured in these situations, almost appearing arrogant. However, for those of us lucky enough to know him well as a colleague and lifelong friend, he had the wonderful trait of approaching his life's work seriously, with passion and drive, but at the same time not taking himself too seriously. Numerous tongue-in-cheek awards for various faux pas and amusing incidents adorned his desk for all to see.

Richard was a devoted husband to his wife Ursula, and a caring and involved father to his three daughters, Nicole, Emily and Alexandra. He would often describe his daughters' accomplishments in glowing detail. He was also strongly attached to his extended family; parents, in-laws, cousins and siblings typically had Friday-night dinners together. Many friends lucky enough to be in Canberra for one of those nights became instantly part of his extended family and saw what was truly important to Richard.

During his lifetime, Richard received national and international recognition for his research and advisory contributions. He was the recipient of the 2010 Australian Society of Limnology Medal for Outstanding Contribution to Australian limnology, and the University of Canberra and CRCs of Australia honoured him and his lasting achievements at a retirement dinner in 2011. He also received an award from the US Environmental Protection Agency (along with a group of US colleagues, the 2009 Scientific and Technical Achievement Award for 'Outstanding Contributions to the Field of Ecological Assessment, through Refining the Concept of Reference Condition') and a 2011 Presidential Letter of Recognition from the North American Benthological Society.

A memorial plaque honouring the great benthic invertebrate researcher Edward Percival stands at the University of Canterbury's Field Station in Cass, New Zealand. Inscribed on the plaque is the proverb that teachers never really know the lives they touch. To us, this proverb applies equally well to Richard. His contributions as a scientist, teacher, mentor and friend will influence others in Canberra and beyond long after his untimely, too early death.