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Drought and sheep — is there a link?

Anne Sansom's article a year ago on *Floods and sheep* provoked some discussion. Here she introduces the possible connection between drought and sheep.

Britain's climate is notoriously changeable. We are used to the weather breaking records with the "hottest July for twenty years", the "coldest winter for fifty years" or the "wettest February on record". Globally, the world's climate may be changing or it may not — we do not know for sure. Some experts argue that this is due to our own actions, others argue that the climate may be in a constant state of change entirely independent of ourselves. One thing is certain however, Britain has a maritime climate with prevailing westerly winds which collect warm, moist air, straight off the Atlantic.

Global opinion is more consistent when it comes to the process of desertification. This process has occurred in many parts of the world, often with devastating consequences, even the extinction of civilizations. Desertification is due to the denudation of the existing vegetation (through deforestation and/or overgrazing), followed by floods, soil erosion, drought and local climatic changes.

In Europe desertification and its implications has been recognised by the UN Convention to Combat Desertification, agreed in 1994 (Pearce, 1995). The UN Food and Agriculture Organisation (FAO) warned that "the sustainability of Mediterranean agriculture appears questionable unless urgent and drastic measures are taken". Mediterranean Europe has always lived on a climatic knife edge, with rainfall in Spain, for example, limited to between 20 and 60 cm a^{-1}. It is hardly surprising that desertification starts during periods of drought, such as Europe has experienced over the past ten years or more. In Spain the FAO is calling for the promotion of water-saving farming techniques, such as drip irrigation, and for other benign technologies to be developed and shared among countries, including an end to overgrazing and over-intensive agriculture (Pearce, 1995). However, it is not recognised that this process may be occurring a few hundred miles further north in Britain's own 'green and pleasant land' — a land with a temperate, maritime climate and a relatively high rainfall.

In many parts of the British Isles the existing vegetation is already becoming denuded, primarily through overgrazing, particularly in the west and in upland areas. The main cause has been an almost fourfold increase in the number of sheep since the 1940s. During the second world war there were about 12 million sheep in Britain: today there are 44 million. Even since 1982 the population of this grazing animal has increased by an average of 34% across the country as a whole, and in some areas increases of up to 79% have been suggested. The increase has been fuelled by Common Agricultural Policy payments from the European Union: these support the incomes of upland farmers, so that they can continue to look after these important areas of our national heritage. Headage



Looking northwards from Helvellyn, summer 1996

payments of £30-£40 per ewe, on top of the market value, ensure that there is no incentive for farmers to reduce the size of their flocks. The resulting severe overgrazing has led to the denudation of many of our uplands and to other problems, including soil erosion, riverbank erosion (National Rivers Authority, 1995), loss of habitat and diversity, damage to fisheries, possible changes in hydrology, and the socioeconomic costs of dealing with these and a chain of associated problems (Table 1; Sansom, 1996).

But how can this denudation process lead to desertification in the British Isles? Reduced rainfall does have serious implications for certain types of vegetation, particularly if it is already stressed through overgrazing. But can the loss of this vegetation itself trigger a local change in the climate (i.e. reduced rainfall), particularly over the summer months? There is increasing evidence to suggest that summers are becoming dryer and winters wetter, particularly in northern Britain. Over the uplands of the Yorkshire Dales the 40% increase in the number of sheep over the last fifteen years has led to a serious reduction in the biomass of vegetation. The heather cover has been seriously damaged and over large areas the combined root and shoot length of grasslands has been reduced to about three or four centimetres. Rabbits have exacerbated the tightness of this sward, apparently thriving in the droughted conditions. Reducing the average length of a grass sward leads to a corresponding reduction in rooting depth, the plants no longer dig deep for moisture and become even more vulnerable to drought. A reduction in the biomass of surface vegetation to this degree over large areas of Britain's uplands (and large areas of western Britain are uplands) must significantly reduce the evapotranspiration rate during the summer. A local reduction in moisture recycling may reduce the rainfall as the prevailing winds travel east. Figure 1 shows the trend for summer rainfall (the combined totals for May, June, July and August) over the last thirty years for a rainfall gauging station at York.

Drought also hits grasslands harder when they are constantly grazed. Many people with lawns will have recognised how regular cutting during a drought accelerates the drying out of the sward and quickly leads to browned off turf. The constant cutting or grazing not only keeps the grass short unnecessarily, but it also stresses the plants which lose water through the cut leaves while they are desperately trying to reduce water loss by closing their leaf pores or stomata. This additional stress means that with little or no rainfall swards rapidly become drought stricken. The

Table 1 A look at the effects of erosion

Flood defence	Increased capital and maintenance costs due to flood damage, repairs to riverbanks, floodbanks and flood defences, gravel extraction from the channel, flooding, excessive weed growth in lowland streams due to eutrophication.
Water quality	Eutrophication, siltation, turbidity and possible diffuse pollution with soil erosion, poor dilution due to low flows.
Water resources	Low flows, loss of reservoir capacity due to infilling with sediments, increased costs to treat potable water supplies.
Fisheries	Loss of good habitat: bankside and in-channel, problems with high and low flows, poor recruitment, increases in water temperature and light, reduced food supplies, changes from salmonid fisheries to coarse fisheries.
Conservation and recreation	Loss of bankside habitats, footpath loss and damage, riverbank repairs with unsuitable or inappropriate materials and methods, ponds and lakes filling with sediments, aesthetic considerations, loss of biodiversity in general.
Waste management	Increased fly-tipping, use of inappropriate material (rubble, hardcore, concrete etc.) to stabilise banks.
Other organisations	National Parks (footpath, dry stone walls and river bank repairs), Highway authorities (road and bridge repairs), local councils (footpath, road and bridge repairs), landslides.
Landowners	loss of soils, land, fences, walls, deposition of sediments (including toxic materials, e.g. lead)

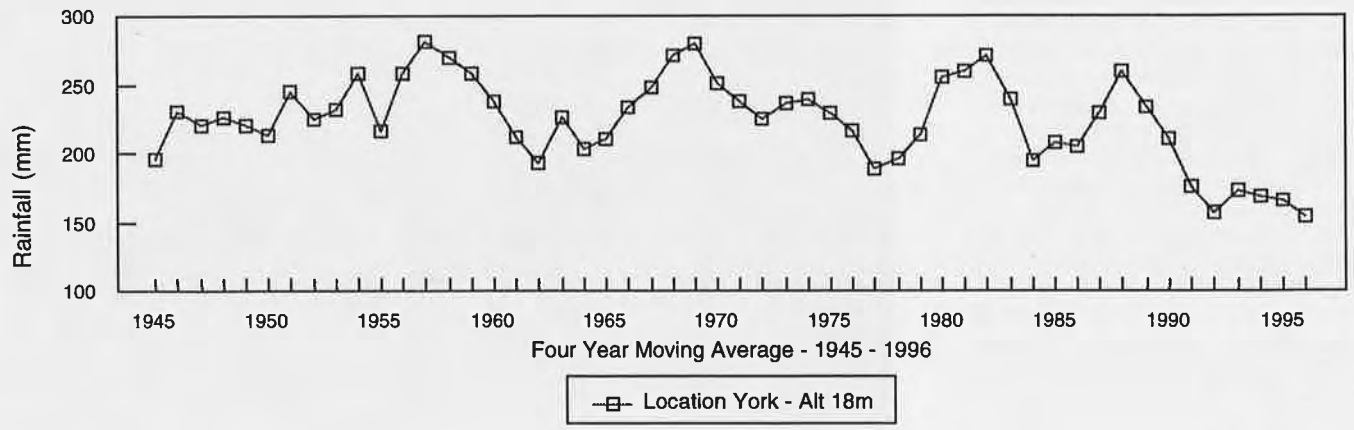


Figure 1 Rainfall totals, 1st May to 31st August, at York

result is large areas of parched landscape, no longer green, but brown. Dry, browned off land absorbs radiant heat from the sun more readily than lush green hillsides, stressing the plants still further and helping to accelerate weathering processes. The locally hot, dry climate that results from these drought conditions may also contribute to a reduction in moisture recycling.

As the local temperatures soar, the stressed plants try another survival technique. High summer temperatures and raised carbon dioxide CO_2 levels cause the stomata to narrow. Atmospheric carbon dioxide concentrations have increased from about 280 ppm in pre-industrial times to 358 ppm in 1994, an increase of slightly over a quarter. Both these processes reduce evaporation, which in turn disrupts the recycling of rainwater (Gribbin, 1995). A higher temperature increases evaporation from the leaves up to a threshold of about 25°C. Above this temperature, further increases have little effect on evaporation because the plants restrict their water loss by closing their stomata. The effects of increases in temperature and atmospheric concentrations of CO_2 have been calculated for the second half of this century by Lockwood (1995), who concludes that there has probably been a net reduction in evaporation from plants of between 2 and 4% for temperate zone grasses, which is already enough to influence the weather, and although Britain is probably too small for this effect to be pronounced, dry soils and suppressed evaporation in recent summers have probably helped to keep summer rainfall below normal.

Just as certain parts of the world exist on a climatic knife-edge, so ecological communities may be poised between survival and disaster. In the Dales the problems of general habitat degradation through overgrazing are severe, but not yet irreversible. However, travel further west (into higher rainfall areas) and the problem worsens significantly. In some areas of the Lake District the denudation process has reduced upland turf (formally heather and bilberry) to bare soil and scree, ripe for weathering and erosion. In parts of Ireland the situation is beyond repair, for the soil (formally protected by vegetation) has been washed away from whole hillsides and catchments, devastating the fragile upland ecosystem, and the fisheries in particular. The hillsides, after taking thousands of years to sustain vegetation and accumulate soils, have been reduced to bare rock, with its own implications for the local climate, water resources and sheep farming. Last year APEM Ltd (a fisheries consultancy) described to me the situation on the headwaters of the River Boyne (just West of Dublin) as "quite frankly devastated beyond recognition". Parts of the 'emerald isle' are being turned into a moonscape, and there is no doubt in this case that overgrazing by sheep is the problem. Not only is the EU paying for sheep subsidies, but it has also provided £14M to the Central Fisheries Board in Ireland towards river restoration schemes.

Regardless of whether overgrazing is linked to flooding or local climate change, the damage being caused to our environment is enormous. It will take only another few years for the extreme problems described in Ireland to begin to affect the uplands in Britain. Positive action is needed soon. The policy makers must change the CAP's Sheep Annual Premium Scheme into an environmental land-management subsidy instead. The main problem has already been identified, the remedy is simple and the restoration process would be rapid if nature were allowed to take its course. To delay while further scientific research is carried out would be like treating a starving man by investigating exactly how he is starving to death instead of feeding him as soon as possible and returning him to health. If we choose the former course of action, it is likely that we really will have deserts on our doorstep.

References

John Gribbin (1995) "Plants issue their own global warning" *New Scientist*, 30th September.

Lockwood (1995) *Weather* 50, 289

Fred Pearce (1995) "Deserts on our Doorstep" *New Scientist*, 6th July.

Anne Sansom (1996) "Floods and Sheep — is there a link?" *Circulation No. 49* & *The Bulletin*, (British Ecological Society newsletter), Vol. XXVII:1

National Rivers Authority (1995) "Understanding riverbank erosion — from a conservation perspective" 18th October 1996 Apem Ltd.

Anne Sansom
Land Use Project Officer
Environment Agency, North East Region

(This article does not necessarily represent the views of the Environment Agency)

President's Piece

Since writing my previous *President's Piece*, I have attended two excellent BHS national meetings. The first was organised by the Southern Section at Imperial College on 30th October. The topic "Climate Change —what do the data say" attracted over one hundred people and the two papers presented provoked a good discussion. Clearly hydrological data is not conclusive, and although I have moved marginally from being an atheist to being an agnostic in respect of global warming, I have still to be convinced. I remember clearly the presentation of evidence in the 1960s which purported to show we were entering a period of much colder weather. Sea level changes, which one might expect to be an integral of global warming, have risen by 10-15 cm over the past 100 years — surely within the range of random variation one might expect.

The second meeting was organised by the South West Section at Exeter on 9th October. The topic was "Flood Forecasting and Modelling" and it was attended by about sixty people: a very good attendance for an afternoon meeting in a relatively remote centre. Again the presentation of papers was followed by a lively discussion. The methodology presented by **Allan Lambert** (used quite extensively abroad but not in the UK) reminds us again about the problems of a prophet in his own country!

The Society relies very heavily on a rather small number of active members to organise events and it is therefore very gratifying when meetings are well attended.

The BHS raised two comments on the paper "Water Resources and Supply: agenda for action". These were both passed on to the Department of the Environment:

(i) The lack of a senior hydrologist in the Department to advise officials and Ministers on hydrological matters;
(ii) The gap in the legislation controlling trickle irrigation.

In response to the first point the Department noted that they relied on advice on hydrological matters from the Institute of Hydrology, the Environment Agency and BHS. The second point is still to be dealt with.

At the October committee meeting it was decided that a strategic review should take place of the future needs of hydrology and how these should be dealt with by BHS. The committee had a further brief discussion at its January meeting. The review is being undertaken by **Hilary Smithers**, who with other member of the committee is looking at issues of public policy, **Rob Drayton** and others are considering aspects of design and practice, while **Adrian Butler** and others are looking at research, education and training. Any member who wishes to forward views on any of these topics is invited to contact one of these people.

The appeal for help in funding the costs of young scientists from developing countries to attend the Exeter meeting is finally under way. We plan regular updates in *Circulation* of the contributions received between now and July 1998 towards the target of £5000. Could I commend this appeal to those members who have not yet responded?

M J Hamlin
President

Help young hydrologists

Have you contributed yet to the fund to help young scientists from developing countries attend the Exeter symposium in 1998? So far the cash received is £685, from only a small number of members, with some more promised.

Large or small contributions are welcome towards the target is £5000. If like me you intended to give something but cannot now find the form, please send a cheque, payable to "Brtish Hydrological Society – Exeter Symposium", to Richard Howard, Secretary BHS, at the address on the back page of *Circulation*.

Member on the move

An established chair in Hydrogeology was created last year in the School of Earth Sciences at Birmingham University following the early retirement of Professor John Lloyd.

I was offered the post in October last year and I take up the new Chair on 1st April 1997, when I will relinquish my current post of Director of the Centre for Land Use and Water Resources Research at Newcastle University.

The new Chair is being supported by the creation of an additional lectureship in hydrogeology, which has been advertised recently. This will bring the team at Birmingham to a complement of five (including Professor Lloyd, who continues to work in the school for two days a week).

As you can guess, I am looking forward to the move and to a successful future in Birmingham.

Rae Mackay

BOOKS

Stream hydrology for ecologists

Stream hydrology: an introduction for ecologists, by Nancy D. Gordon, Thomas A. McMahon and Brian L. Finlayson, John Wiley & Sons, Chichester (1992), 526pp. ISBN 0-471-93084-9 (Hardback, £75.00) 0-471-95505-1 (Paperback, £29.95)

This book is intended as an introductory text which summarises methods in engineering hydrology, fluvial geomorphology and hydraulics. The target audience, as the title suggests, is mainly ecologists and biologists interested in the biological implications of stream physical processes. However, the book has a much wider appeal and should be of value to many individuals interested in stream hydrology.

The contents are divided into nine main chapters, two appendices, references and an index. The chapter titles are deliberately quirky — e.g. Chapter three *Potential sources of data (how to avoid reinventing the weir)* — but this tongue-in-cheek approach belies a logical and clearly structured framework. Chapter one (*Introducing the medium*) describes the physical properties of water. The approach is standard and could be found in numerous other texts, but the material is essential in an introductory text of this nature and the short section on Dissolved Oxygen is useful, given the ecological bias.

How to study a stream (Chapter two) outlines the main physical factors governing the stream environment (streamflow, temperature, substrate, etc.) and considers methods of approaching stream investigations. This leads on to sampling and concludes with three examples of sampling designs. Data sources, covered in Chapter three, are broadly divided into physical data, maps and air photographs / remote sensing imagery. In fact Chapter three could have come before Chapter two, because a consideration of potential data sources often precedes sampling design.

Getting to know your stream (Chapter four) begins "'The process of getting to know a stream is not unlike that of a doctor learning about a patient and his or her health". This style will not be to everyone's liking but you do tend to get use to it. The content of this chapter assesses the general nature of the stream environment; describes measures of catchment characteristics (stream pattern, stream order, etc.); and examines streamflow hydrographs and hydrological statistics. Chapter five (*How to have a field day and still collect some useful information*) deals with field methods, such as stream channel topographic survey; flow measurement; substrate and sediment sampling; and analysis of the physical properties of the substrate. The chapter concludes with a very brief section on water quality: given the biological emphasis of the book, this seems too short. *Water at rest and in motion* (Chapter six) covers fluid mechanics of the stream environment and is broadly divided between hydrostatics and hydrodynamics.

Although there are clear attempts to include ecological references in these sections the treatment is very predictable, with much of the material covered in other fluid mechanics texts. *Patterns in shifting sands* (Chapter seven) — probably the most misleading of the chapter headings — deals with channel morphology and sediment transport. Here the treatment focuses on the introduction of basic principles interspersed with ecological examples. There is probably a slight overemphasis on sand-bed streams, which is partly acknowledged by the authors in section 7.4.2 *Deviations from* [the] *ideal*.

Chapter eight *(Dissecting data with a statistical scope*) outlines methods of streamflow analysis and numerical taxonomy. The bulk of this chapter is devoted to streamflow analysis and the section on numerical taxonomy is an uncomfortable addition, with several unnecessary diversions, e.g. classification of ice cream flavours!

The final chapter, *"Putting it all together": stream classification and management*, is an attempt at a synthesis of the methods covered in the early parts of the book. Three topics are discussed: stream and catchment classification; environmental instream flow requirements; and stream rehabilitation. A reasonable job is made of producing concise summaries of these large and diverse topics.

Appendix one gives an introduction to *Basic statistics*. It is hard to see why this is really needed, because this information is freely available in many existing statistical textbooks and the delivery is not particularly relevant to stream hydrology. Appendix two briefly describes *AQUAPAK*, a suite of 25 FORTRAN programs that allow readers to carry out computations of some of the procedures outlined in the text, e.g. Manning equation, Colwell's indices. The software is available separately. There is a useful collection of references and the index is comprehensive but not exhaustive.

In terms of presentation the book is generally well organised and errors are few. The text is well-illustrated throughout, but some of the line drawings and illustrations are not well produced because of the pixel-style quality of the line work: for example Figure 6.21 would be better as a photograph. The written style (as hinted at previously) is a little quirky

and, as you might expect from the authors, contains more than one passing reference to Australian indigenous wildlife: *How often will a platypus burrow be inundated?* — How often have you asked yourself that very same question?!

In summary the book largely fulfils its stated aims. It provides a sound introduction to stream hydrology and illustrates it with ecological examples. The book has a very wide scope, which means not everything will be covered in enough detail to satisfy the vagaries of some readers. Nevertheless, even at £30, the paperback version of *Stream hydrology* will provide a useful addition to many bookshelves.

Jeff Warburton
University of Durham

Climate change impacts on the UK

Review of the potential effects of climate change in the United Kingdom (1996) Department of the Environment, HMSO.

The Climate Change Impacts Review Group (CCIRG) is a body of independent experts set up by the Department of the Environment to consider the potential impacts of climate change on the UK. This is the CCIRG's second report, which updates the first report (1991) and evaluates possible adaptive responses at local and national level.

The review group's remit is to assess the impacts likely to affect the UK, to consider what might serve to reduce them, to assess the implications of climate change for policy and to make recommendations for future research. The report is mainly about potential impacts over the UK, but it also considers climate change elsewhere, where the effects may have an impact on the UK.

A concise conclusion and summary section is followed by 17 chapters, each beginning with a summary of findings, covering changing climate and sea level, soils, flora fauna and landscape, agriculture, horticulture and aquaculture, forestry, water resources, energy, minerals extraction, manufacturing, retailing and service industries, insurance, finance, health, recreation and tourism, and coastal regions The report ends with a useful glossary, list of acronyms, the membership of the CCIRG and the people who were consulted.

Chapter two concurs with the general view that the global climate is changing as a result of anthropogenic activities. It defines a scenario of changing climate and sea level rise, termed the 1996 CCIRG scenario, based on results from the Hadley Centre's global circulation model (GCM), which in turned was based on the IPCC IS92a scenario, for the decades 2020 and 2050. This scenario predicts a 1.6 °C increase in global mean surface air temperature by 2050. Although sulphate aerosols are not modelled in this GCM simulation, they are predicted to lower the global warming by 0.3 C. The atmospheric CO_2 concentration is predicted to be approximately 525 ppmv with the equivalent CO_2 concentration of all greenhouse gases at double the 1961-1990 baseline average. By 2050, mean sea level will rise by about 37 cm above the baseline period, although the effect of sulphate aerosols is predicted to reduce the rise by 14 cm. Chapter two then describes the effect of climate change on the UK climate, finishing with an estimate of the level of confidence the researchers have in the predicted changes.

The effects on UK water resources are covered in chapter seven. The 1996 CCIRG scenario predicts an increase in river flow in winter and a decrease in the summer, particularly in the south of the country. The frequency of riverine flooding is likely to increase with higher winter rainfall. How climate change affects groundwater recharge is not yet clear although it is possible that recharge would be reduced. It is also suggested that although water quality will be effected by reduced summer flows and higher temperatures these changes may be less important than the effects of land use and agricultural changes. Climate change is predicted to add a further 5% increase in public water supplies demand in southern England, with spray irrigation demands predicted to increase by 69%.

The book is clearly laid out, which assists quick access to sections of interest, and contains ample references for further reading. My only minor criticism is the lack of colour in some figures, which reduces clarity.

Overall this is a good introduction to the potential impacts of climate change in the UK, and it is essential reading for anyone working in the subject area.

Andrew Eatherall
Institute of Hydrology

New Members

We welcome the following members to the Society:

Alker, G.R. ..... Reading
Ashton, D.A. ..... Stirling
Baker, L.K. ..... Environment Agency, Winchester
Bamford, S. J. ..... Lincoln
Bonvoisin, N. J. ..... Tiverton, Devon
Cromack, M. ..... Dept of Geography, University of Dundee
Dils, R.M. ..... Sheffield
French, C.E. ..... Bedford
Gavin, H. ..... Dept of Geography, University College London
Kervell, A.N. ..... Birmingham
Leeson, M. J. ..... Brighton
Marshall, J.S. ..... School of Geography, Leeds University
Rosu, C.N. ..... Islington, London
Sharratt, G. ..... Vauxhall, London
Timmis, A.J.H. ..... Richmond, Surrey
Walker, G. ..... Dept of Geography & Geology, Cheltenham & Gloucester College of Higher Education
Wilson, D.A. ..... Horsham, West Sussex

AQUILA — an integrated library of engineering hydrological software

Like any artisan, the engineering hydrologist requires a toolbox. Ideally this would comprise a set of software tools that would permit the rapid and accurate completion of a wide range of analyses, it would use modern computational technology set in a contemporary software environment (WINDOWS) and it would produce report standard tables and graphics

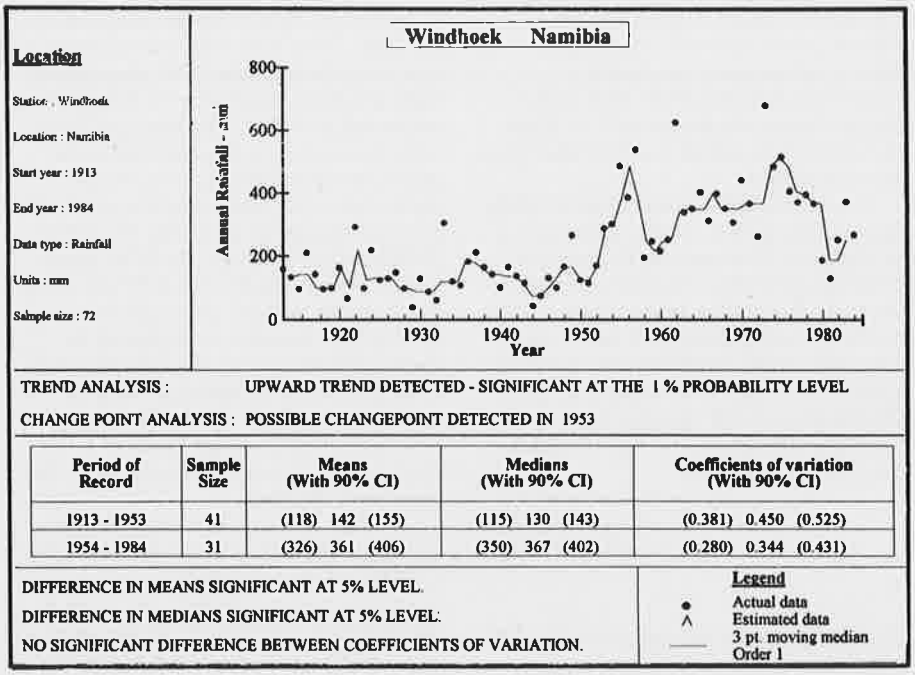
automatically. Any such organised collection of analytical software, supported by a full database facility would initially appeal to the consulting engineer and to educationalists as a powerful teaching aid.

The desirability of such a toolkit was recognised in 1993 when a joint research project was established between Halcrow and the Departments of Civil Engineering and Engineering Mathematics at Newcastle University. Funding was provided by the Teaching Company Directorate and by Halcrow for a two-year period to support a full-time research associate working at Halcrow's Swindon office.

After two years the result is **AQUILA**, the Phase 1 version of the toolkit. The emphasis has been to enable complex statistical analyses to be executed accurately and with confidence. This focus on data analysis recognises the central role of applied statistics in engineering hydrology, which by its very nature is data intensive. It also recognises the sad fact that within the fraternity of hydrologists only a very few come from a statistical background and few therefore are comfortable with anything but the most modest classical statistical methodology. There is a crucial anachronism here: most of the implicit assumptions in classical statistics are rarely, if ever, satisfied by hydrological data, and conclusions drawn from their application can be quite misleading. **AQUILA** sets out to reappoint applied statistics as a cornerstone of engineering hydrology.

Data, generally in the form of daily, monthly or annual time series can be entered into **AQUILA** from ASCII text files or manually. These are stored in a central database (FOXPRO) according to data type (daily rainfall, monthly flow, annual maxima, for example) and referenced within a user defined project catalogue.

The analytical and computational algorithms are collected into a family of discrete modules, arranged hierarchically in an integrated library of software tools to encourage the user to take a step by step approach to data analysis, statistical model selection, estimation and validation. The output of one step suggests the structure of the next. The initial module, through which all data must pass, is **Exploratory Data Analysis (EDA)**. The objective is to encourage structured examination of the data at the outset, to uncover the expected patterns and identify the unexpected features. Emphasis on meaningful visual display is central, using non-parametric procedures such as "box-plots". Powerful modern tests, taken from the recent statistical literature, detect non-stationarities such as trends and change points. Outliers and 'bad' data values are flagged, numerical and visual techniques are used to cross-validate samples and



Period of Record	Sample Size	Means (With 90% CI)	Medians (With 90% CI)	Coefficients of variation (With 90% CI)
1913 - 1953	41	(118) 142 (155)	(115) 130 (143)	(0.381) 0.450 (0.525)
1954 - 1984	31	(326) 361 (406)	(350) 367 (402)	(0.280) 0.344 (0.431)

Sample output from AQUILA — detection of a change point in annual rainfalls from 1913 to 1984, Windhoek, Namibia

indicate the structure of any inter-dependence. Where data treatment is required, for example the estimation of missing observations, the user is guided to the appropriate module.

Once the project database has been verified and any treatments completed, the user can proceed to any one of a number of analytical modules. Amongst these is **Univariate Model Selection**. For example, given a sample of annual rainfalls it may be necessary to fit a probability model in order to estimate various quantiles. But which model? Normal, log-normal, Gamma, Weibul, Exponential? The choice of the most appropriate approximating model is guided by a set of selection criteria that report measures of the discrepancy between sample and model, both overall and weighted to the upper and lower tail. If the user were particularly interested in deficient annual rainfalls then attention would be directed at selecting the model with the smallest lower tail criterion. These techniques, again taken from the recent statistical literature, offer a much more appropriate strategy of univariate model selection than the "naive" Chi-square statistic.

The **Extreme Value module** focuses upon analysis and graphical presentation of annual maxima and partial duration series. Extreme value models are estimated using probability weighted moments, selection criteria are again offered and confidence intervals are reported. Partial series are analysed using the Generalised Pareto Distribution. Facilities are offered for the analysis of flood data observed in arid zones, where zeroes may be present in a sample. Code has also been developed for the analysis of bi-variate extremes, applicable for example, to modelling the joint probability distribution of flood peak and volume.

Other modules in **AQUILA** include **Regression Analysis,** which refreshingly reflects recent advances in methods other than "least squares" — robust and non-parametric procedures are offered which overcome many of the weaknesses of the better known method. Residual analysis, data transforms and full diagnostics are emphasised so that models can be modified logically.

This is a very brief summary of the data analytical facility offered by **AQUILA** in its present stage of development. Future plans include the ultimate challenge of making **Stochastic Time Series Models** quick, easy and painless. Contemporary estimation procedures and selection criteria have been coded and validation methods developed for both single and multi-site models. Integrating these into the toolkit is one of the main objectives of the next stage of development.

A cynic might (not unreasonably) propose that hydrology as a science is now dominated by the concept of process, and is developing according to the aphorism: "Never let the facts confuse a good model — ignore the data!" Statistically the world is a log-normal place usually, with some obscure outposts inhabited by Gumbel populations. This may be an overstatement, but two decades of advances in applied statistics have been virtually ignored when it comes to routine hydrological practice. This is not surprising, since statistical work in the context of hydrology and water resource studies has all too often been esoteric , obscure and not generally

applicable. Most of the analytical and computational procedures selected for integration into **AQUILA**, and deemed relevant for routine application on the "shop floor" of hydrological endeavour, are taken from the statistical, not the hydrological, literature.

The development of **AQUILA** will continue as a joint undertaking between Halcrow and Newcastle University, under the technical direction of Professor Enda O'Connell, Dr Andrew Metcalfe and Dr Peter Adamson. David Cummins will continue to oversee the software engineering and Ian Rose will focus on management. QA standards are being met and accreditation sought in terms of ISO 9001 (the European software standard) and BSI tickIT procedures.

The release of Version I to a small group of accredited users is imminent. Their principal task will be to assess its present structure and content; after that a workshop will be held to consider comments and suggestions for immediate and long-term development. **AQUILA** is supported by a user manual, and by a technical guide that offers overview of the theory and statistical methods in addition to sample applications to hydrological data from many countries and environments. **AQUILA**, in short, represents a key development in engineering hydrology, both in terms of the application of modern methods of analysis and as an educational and training tool.

Peter Adamson
Halcrow

Travel grants

The BHS subcommittee set up to administer the interest from the Exeter Fund and other travel grants has four members: the President, the Hon. Treasurer, Dr David Collins (IAHS rep. on the BHS committee) and Dr Jim McCulloch.

Grants of up to £150 are available to help members with the cost of attending meetings (see *Circulation 38* to *47*). Please provide details of the meeting, why you want to attend, the costs of attending and other sources of finance. Successful applicants are expected to produce a short report of their experiences in attending the meeting.

Any enquiries should be made to the Hon. Treasurer, Dr Richard Harpin *(tel/fax 01793 812479).*

Ted Hollis Scholarship in Wetland Hydrology and Conservation

As BHS members will know from the last issue of *Circulation*, **Dr G.E. (Ted) Hollis** died of heart failure on 28th September 1996, at the end of the Fifth INTECOL International Wetlands Conference in Perth, West Australia.

Ted was Director of the Wetland Research Unit in the Department of Geography at University College London. He was only 49 and his sudden death cut short a brilliant academic career (most notably in the field of wetland hydrology and conservation), which had been characterised by his profound commitment to field teaching and his genuine concern for broadening the skills of both undergraduate and postgraduate students.

Ted was responsible for pioneering work at an international scale, which has had a beneficial influence on the sustainable use of wetlands, from the North Kent marshes to northern Nigeria, Tunisia, Senegal and Kakadu in Northern Australia.

In recognition of this work, and of Ted's firm commitment to his students, members of the UCL Geography Department, in conjunction with his wetland research and conservation colleagues around the world, are joining together to establish a scholarship in Wetland Hydrology and Conservation that will bear his name. This scholarship will support a postgraduate student at UCL with a specific interest in wetland hydrology and conservation. It will be aimed at overseas students, preferably from developing countries, who are both academically exceptional and truly needy.



Dr Ted Hollis

The Geography Department is seeking donations, of any size, to endow the permanent scholarship in Ted's memory. If you would like to offer support please contact Dr Julian Thompson, Department of Geography, University College London, 26 Bedford Way, London, WC1H OAP, Tel: 0171 387 7050 Ext 5405, Fax: 0171 380 7565, E-Mail: jthompso@geog.ucl.ac.uk

Report on IHP-related activities in the UK

The UNESCO International Hydrology Programme (IHP) is represented in the UK by the UK IHP Committee, whose membership is the same as that of the Interdepartmental Committee for Hydrology. These two committees provide the main formal communication between governmental and non-governmental organisations with hydrological responsibilities in the UK.

Government is represented by the Department of the Environment, DoE Northern Ireland (represented by its Environment and Heritage Service), the Meteorological Office, the Environmental Affairs Group of the Scottish Office Agricultural, Environmental and Fisheries Department, the Overseas Development Administration (represented by their Water Resources Adviser), the Welsh Office, the Office of Science & Technology (represented by the Natural Environment Research Council), the Ministry of Agriculture, Fisheries and Food.

Other organisations are the Royal Society, the University of Oxford (represented by the Department of Geography), the Scottish Environment Protection Agency, the Environment Agency (represented by the Water Resources Department), the British Hydrological Society, and the Institute of Hydrology, which provides the chairperson and secretariat.

The United Kingdom is not a

member of UNESCO at present, but because of its significant hydrological interests internationally, it negotiated observer status with IHP in 1991.

During IHP-IV the main project supported by government and the Natural Environment Research Council funds was Project H-5-5. The FRIEND Project in it original form successfully coordinated regional hydrology studies using a common pool of data from smaller catchments across Northern Europe. This is summarised in the Proceedings of the conference at Braunschweig, Germany (IAHS Red Book No. 221, 1994). A brochure is available that describes the database and related research themes. The success of this team approach to research across a relevant continental area has led to its replication in other parts of the world, including Africa.

The UK IHP Committee normally meets once a year to consider requests from the IHP Secretariat and to stimulate interest and understanding of IHP activities throughout the UK. The Committee does not control any funding, but encourages its members to consider the value of IHP themes in the context of their own responsibilities. This is seen to occur at two levels. Firstly, through UK technical assistance activities internationally through the Overseas Development Administration and secondly within Europe assisted by the Department of the Environment and the Environment Agency.

The UK, through Professor Des Walling at the University of Exeter, has played a significant part in extensive work under IHP auspices in sedimentation and erosion. The highlight was the Exeter 1996 Conference on "Erosion and Sediment Yield — Global Regional Perspectives". This arose from Project H-1-2 and formed an approved contribution to Theme 2.1 of IHP-V. Over 130 delegates attended from about 35 different countries, very satisfactory for a specialist conference. The papers were prepublished as IAHS Red Book No. 236, which contains the most recent international review papers on this topic.

The British Hydrological Society, with its membership of around 700, has a strong series of national and regional meetings, many of them covering themes that are also present in IHP, but not normally designated in that way.

The City University, through its Civil Engineering Department, organised a conference on "Aspects of Conflicts in Reservoir Development Management" in September 1996, with a strong list of papers from a broad range of countries. IHP, both from Paris and the UK Committee, lent its support. Details of the conference publication, a contribution to IHP-V, Theme 4, can be obtained from Professor V Rao, Director of Water Resources Engineering, City University (e-mail: k.v.rao@city.ac.uk).

Invitations were extended by the IHP Secretariat to UK representatives to participate in Working Groups, including Project 1.3 "... Global Change Predictions" (Dr Nigel Arnell), Project 2.1 "Vegetation, Land Use and Erosion Processes" (Professor Des Walling — coordinator), Project 3.2 "Monitoring ... Groundwater Quality Problems" (Brian Adams), Project 5.3 "WRM ... Semi-arid Zones" (M Gavino), Project 5.4 "Coping with Water Scarcity" (Sir Charles Pereira), Project 6.1 "Hydrological Processes ... Humid Regions" (Dr John Gash).

The IHP Bureau has also nominated members of International Steering Committees: Theme 1.1 "FRIEND" (Dr Alan Gustard) and Theme 6.4 "Information Exchange ... Water Management" (Sir Charles Pereira).

The IHP Bureau has nominated Dr Andy Bullock to be sole rapporteur of Theme 6.3: "Integrated Water Management for Sustainable Development in the Humid Tropics".

The only funds available with formal support of any IHP project in the UK are for UK participation in the FRIEND project. This corresponds to a level of support given before the UK withdrew from formal membership.

The United Kingdom has collaborated with other national and international organisations/programmes; it has been active in GEWEX planning and has a committee that supports its input. A document outlining its strategy has been published, and details are available from Professor W B Wilkinson, Director, Centre for Ecology and Hydrology, Wallingford OX10 8BB.

British scientists are also strongly committed to BAHC activity and further details are available from Dr J S Wallace, Director, Institute of Hydrology, Wallingford OX10 8BB.

As a result of the streamlining of the Royal Society's network of committees, the UK IAHS Committee is now part of BHS: the Chairman is Dr David Collins of Oxford University's Department of Geography.

The UK has active postgraduate courses in hydrology, in university departments as diverse as civil engineering, environmental science and geography. However, no course has a formal link to IHP, nor is it known that any UK participant has gone overseas for IHP course training.

Exeter University has experience in producing course materials, and a presentation was made to the UK IHP Committee about a possible "portable" short course in "Applied Environmental Earth Science". This would focus on groundwater issues at a graduate level and would be particularly appropriate to newly industrialised countries of Asia and the Pacific. The comprehensive training course package would be presented in three-week modules. The UK IHP Committee concluded that the course concept deserved support as a link initiative, and only sought, in commending the course, to have the title changed to include the word "groundwater". The outcome of discussions between the University and UNESCO for final support are not yet known.

In the International Hydrology series, preparation is well advanced for the publication of "Environmental hydrology of humid tropics islands with emphasis on Caribbean karst terrains". Two of the editors, John Chilton and Nick Robins are from the British Geological Survey, Wallingford.

The IAHS Press Ltd, based at Wallingford, has a strong programme of conference publications and publishes several documents each year with UNESCO co-sponsorship. (The full publications list is available on request to e-mail penny@iahs.demon.co.uk).

Books recently published by John Wiley for the Institute of Hydrology include *Wetlands, ABRACOS, Remote Sensing* and *Global warming, river flows and water resources.*

From 21-27 September 1997 the International Association of Hydrogeologists will hold its 27th Congress in Nottingham with the title "Groundwater in the Urban Environment". UNESCO's Division of Water Sciences is one of the sponsors.

The European Environment Agency has formed an Inland Waters Topic Centre, involving a large consortium of hydrometric and research organisations of different types from eight lead countries and further collaborating ones. Management of the consortium rests with the Water Research Centre; the Institute of Hydrology has a role in network design for surface water quantity and quality.

Besides the Institute of Hydrology, there are over fifty universities with some interest in hydrological research and training. An overall view of future hydrological research can be found in the BHS research review "Sustainability in a changing world: the key role of hydrology" (1994).

The UK IHP Committee has encouraged BHS to organise the international conference in Exeter on "Hydrology in a Changing Environment". Already over 200 potential papers have been offered around the six themes. The Chairman of the Organising Committee is Professor Des Walling of Exeter University and the Chairman of the Scientific Programme Committee is Professor Howard Wheater, Imperial College, London. It is hoped that more than 400 delegates will convene for this event which has been targeted at combining key ideas from IHP-V with important elements of the Operational Hydrology Programme of WMO. The conference will be accompanied by an exhibition of the best of hydrological software and hydrometric instrumentation. Details

were sent out with the last *Circulation* and are on the BHS internet pages.

The UK hydrological community is very keen to see IHP Working Groups come to Exeter and hold their own meetings in conjunction with associated conference themes that they find relevant.

Among activities envisaged for 2000-2001, British hydrology had hoped to launch a CD covering 1000 years of proxy flow records to mark the new millennium. Unfortunately the bid to the Millennium Commission for substantial funding support was unsuccessful, but other ways are being sought to finance part or all of this initiative. The planning for this project has brought together the palaeohydrological community within the UK and it may be that the recent approval of a research programme in environmental history will enable some aims to be made over the next four years.

Some initial work has been done on a National Floodmark Survey. One aspect of this might be the position of new flood marks for any outstanding floods that occur in the UK during the years 1999 and 2000.

Frank Law
UK IHP Committee

Gardening under global warming

BHS Southern Section Meeting
Imperial College
18 December 1996

In its previous meeting, the Southern Section considered the subject of climate change, and its implications for water resources in the UK. For its Christmas meeting, the general theme continued, focusing on water use in agriculture and horticulture.

Water sharing in agriculture

The first of two papers was given by **Simon Bamford** (Southern Water). Until a few years ago, there has been little need for farmers in the UK to have formal schemes for water sharing (although this is common practice overseas, with well established management systems). However, against a background of increasing demand for irrigation water by agriculture, especially in the drier eastern side of the UK, several schemes have been developed to share water resources.

A group of farmers in Lincolnshire wanted licences to abstract from Internal Drainage Board (IDB) drains, but there was insufficient resource available. The National Farmers Union and Witham 4th IDB together put a proposal to the NRA, involving transfer of water from the River Witham near Coningsby through the West Fen Drain and the fen drainage system and pumped into the Hobhole Drain for abstraction for irrigation. The River Witham has a good supply of summer water, augmented by transfer from the River Trent at Torksey, via the Fossdyke, for further transfer to the River Ancholme. There was therefore adequate resource for the West Fen Drain scheme to be feasible. The NRA agreed and the company Water Transfer Ltd was created in 1990 with 70 shareholders.

The set-up cost was £60,000 and shareholders' charges were set per cubic metre abstracted. The capital loan was to be repaid in a one-off payment of £467 per 4500 m^3 abstracted, and then administration and running costs paid at a higher annual rate. The initial capital cost compares very favourably with a simple reservoir (costing about £3000 per 4500 m^3). The scheme has been so successful that new members join every year. It is important to appreciate that a scheme of this size is only feasible on the lower reaches of a river where there is plenty of water. However, the technical, managerial and licensing issues provide a model that could be implemented elsewhere, albeit on a smaller scale.

Lark Abstractors, a group of 27 farmers, got together because of a total ban on borehole abstraction late in 1990. Abstraction had been stopped because of low flow and poor quality in the River Lark (which is groundwater fed). The consequences of the ban were severe, because most farmers had not planned for restrictions, and orchards that had not yet used any water could not be irrigated. Rather than litigate, the group decided to negotiate with the NRA to limit abstraction for 1991 to 50% of licensed quantity, provided they could continue to abstract until the end of the season, and so plan the best use of a limited resource. The NRA agreed, although they could not guarantee that there would be no ban. In the event, abstraction was able to continue to the end of the season. The group still exists and is meeting soon to plan for the coming year. Without any direct sharing, the cooperation of a group of farmers has enabled a limited resource to be managed to the benefit of all.

Reservoirs are the most reliable way of ensuring a supply of water for irrigation during the summer months, regardless of river and groundwater conditions. The most common obstacle to the construction of a winter storage reservoir is geology (and consequently cost) rather than the availability of water. However, often one farmer has part of the farm on clay subsoil (where a reservoir could be constructed cheaply), whilst the bulk of his land, and his neighbours', might require a geomembrane-lined reservoir costing up to four times as much. Here a group of farmers could join together to construct a large reservoir on the clay site and distribute water via pipes, ditches, streams or rivers. The proposed Feltwell Reservoir near Ely in Cambridgeshire is a large-scale example: the areas with the greatest potential to benefit from summer water from this reservoir are the South Level Fens and the Rivers Stour, Colne and Blackwater, and perhaps around 600 spray irrigation licences could be supported.

If the reservoir design is to allow for irrigation water as well as public supply, the promoter has several choices. He could increase design capacity and hope to sell irrigation water in due course (considered unlikely), or the Environment Agency could 'buy in' water on behalf of irrigators and 'sell it on' via the licensing system (financial pressures and government policy make this unlikely), or the agricultural industry could puts up the money as a partner in the reservoir (the most practical option). The Environment Agency (EA) has commissioned a market research study of farmers' irrigation requirements to assess potential demand from the proposed Feltwell reservoir.

Water sharing enterprises can be managed through a limited company, a partnership or a cooperative with legally binding agreements. The main issues which need to be considered when forming a water sharing enterprise include the type of agreement, financial arrangements, ownership and

operation/management. It was noted that persuading a farmer to have a facility on his land may not be a problem if the benefits of improved land value are explained.

Abstraction licensing that has developed on a first-come-first-served basis is recognised as an inefficient way to allocate resources. Farmers in the Arreton Valley on the Isle of Wight have spray irrigation licences for relatively small areas of land, and water cannot be abstracted except for on those areas. This causes problems where one farmer grows irrigable crops on another's land and cannot use his own water on it. Possible ways to overcome the difficulties and make the licensing system more efficient have been considered in a report by Richard Buxton, an environmental lawyer, on 'Efficient use of spray irrigation licences' commissioned by the EA.

Simon concluded by emphasising that it was usually the management, organisation and abstraction issues that caused major difficulties in water sharing schemes, rather than the technical issues.

Water stress & plants — adaptations, responses, and uses

Trevor Sims (Royal Horticultural Society) turned from agriculture to horticulture in his paper. He asked the question, "What is water stress?" From the point of view of a plant, it is an interruption of water flow from the roots to the foliage, so that water loss becomes greater than water gain.

Water stress can take various forms: too little water (as in a drought); intermittent water supply (which can slow down growth); too much water (waterlogging can kill the roots); frozen soil (water unavailable); or pests & disease (killing the root system, or toxins upsetting water transport). Plants have developed defences against water stress, and can reduce their water loss by different adaptations: waxy surface to the leaves (e.g. cauliflower); plant architecture where leaves assist the movement of water to the centre (e.g. yucca); hairy leaves to insulate, absorb water and protect stomata — the small openings in the leaf surface through which water vapour escapes (e.g. Lavender); leaves that roll up, sometimes with a hairy undersurface to close up and provide a furry coat to the plant; leaves as spines (e.g. cactus), and water storage organs such as a bulbous root.

There are varying degrees of water stress. Under mild stress, the leaf margins die, mineral deficiencies can be induced by root damage (for example Blossom End Rot in tomatoes), and there may be early autumn colour, early leaf drop, or an abundance of fruit (often followed by no fruit at all). As the water shortage becomes more acute, foliage wilts, the plant tissue dries, root hairs die, and eventually the whole plant dies.

Plants can survive in very hostile environments, such as the Namib desert in south-western Africa, where the average annual rainfall is only 20 mm, against an average annual evapotranspiration of 4000 mm. Moisture from fog rolling in off the sea can add another 50 mm, but 1996 was the 20th year without any rain at all. The air temperature reaches 40°C, the ground temperature 70°C. In this environment grows the *Welwitschia*: the oldest specimens may be over 2000 years old. It is something of a horticultural puzzle, as it does not have waxy leaves, it has more stomata than any temperate or tropical plant, the leaves do not roll up, and the root system is relatively shallow (a 3 m tap root with spongy side roots). It has a single pair of leaves, which grow at up to 100 mm per year.

Water stress can be reduced by careful planting (ensuring good root/soil contact and spreading out the roots), adding organic matter to the soil (increasing moisture retention), planting at the correct depth, supporting the plant with stakes, good drainage, no weeds or grass around the plant (which represent competition for the available water), mulching the soil surface (to reduce evaporation), and adding water (surprisingly enough!).

No doubt motivated by market forces, horticulturists have developed many techniques to use water stress to their advantage, with some examples being:

Increasing the number of fruit buds by partial or complete ring-barking, which temporarily restricts or interrupts the flow of water from the roots to the branches. Fruiting can even be increased by bending the branches so that they are sub-horizontal.

Improving and controlling plant size and shape by changing the root stocks, to achieve 'designer plants' for specific purposes.

Shoot encouragement by 'nicking and notching' (cutting the bark below a bud and above a bud respectively), to get branches growing in the desired places, and even at chosen angles.

Better flavour fruit by making the plant struggle for water, achieved by 'slacking' (withholding water, or even temporarily digging the plant up) or using high-conductivity water. Cherry tomatoes are a prime example, especially when grown under nutrient film techniques, when salt can be added to the water, imparting a pleasant salty taste to the tomatoes.

Trevor Sims' paper was accompanied by high-quality slides and gave a fascinating insight into the technical aspects of water use in horticulture, and the detailed responses of plants to water shortage. The lively discussion covered the increasing use of trickle irrigation, both to save water and to exploit a licensing loophole. As it was close to Christmas, the meeting was followed by wine and mince pies, and the only disappointing aspect of a most enjoyable and instructive evening was the low turnout.

Richard Boak,
Southern Water

Using constructed wetlands to treat coal mine drainage

Scottish Hydrological Group Meeting
Edinburgh
15 October, 1996

***Dr Kate Heal* (University of Stirling) addressed an audience of over fifty people on the treatment of coal mine drainage using constructed wetlands, and in particular a Scottish case-study from Fife. She outlined the scale of the acid mine drainage problem in the UK and in the USA, the processes that cause the problem, and the factors influencing drainage composition.**

The impacts of mine drainage and the need for treatment were clear. Physical, chemical and biological approaches offered alternative means of treating acid mine drainage. The biological treatment using constructed wetlands is

relatively cheap, involving low running costs and low technology, and is also flexible.

Kate outlined the processes through which treatment is achieved in a wetland, drawing distinctions between surface and subsurface flow wetlands. She then went on to consider the practicalities of construction, the components and their functions, and the parameters used in design. Treatment efficiencies of up to 90% for iron and 80% for manganese are possible.

Potential design problems included long-term effectiveness, sizing and variability in performance. Variability can be seasonal, and it was interesting that in a survey of 146 wetlands in the USA, no correlation could be found between performance and design.

The Mains of Blairingone site in Fife, eastern Scotland, which was used as a case-study, has a ferruginous discharge attributed to an opencast coal mine. The drainage had a high iron content (mean total iron concentration 47.6 mg l^{-1}), and since 1994 had been staining a 2.5 km stretch of the River Devon. In May 1995, an existing wetland close to the site was bunded to form the constructed wetland. Despite the wetland being only 78% vegetated, very good performance was achieved. Treatment efficiency in the removal of iron was over 88%, which significantly improved the water quality in the River Devon. Problems of flow channelisation were identified, and further work is considering the effects of storm events, and storage of iron and manganese.

Kate Heal's talk stimulated a wide-ranging discussion. **Emma Edwards-Jones** (Heriot-Watt University) asked about vegetation types: Kate thought that a mix of vegetation was generally most favourable. **Neil Stuart** (University of Edinburgh) described a wetland study recently carried out at Lamb Hill opencast coal mine, where results similar to Kate's had been obtained. Neil thought that long-term alkalinity was critical to performance. **Bayo Adeloye** (Heriot-Watt University) asked questions about the design approach, the depths of sediment and the role of vegetation. The role of vegetation was considered to be more physical than biological. In discussing sediment, and in reply to a question from **Peter Smart** (University of Glasgow), Kate said that most of the iron in wetlands is usually held in the top 10 mm of sediment. **Richard Hannah** (Scottish Office) wondered if de-sludging and treating the material as a controlled waste would be required, but this was not known. **Professor Paul Jowitt** was interested in the influence of transient events: this could be a reason for the high variability in the USA observations.

Robin Wardlaw
University of Edinburgh

FORTHCOMING EVENTS

Meetings

IAHS'97 at Rabat

The International Association of Hydrological Sciences (IAHS) 5th Scientific Assembly, comprising six symposia and five workshops, is to be held in Rabat, Morocco, from 23 *April* to 3 *May 1997*. Most of the symposium papers will be pre-published by the IAHS Press in their Red Book series.

Registration is through the IAHS'97 organising committee, Direction Générale de l'Hydraulique, Casier Rabat - Chellah - Maroc, *Tel +212 7 77 90 08 / 77 87 42, Fax +212 7 77 8696.*

The IAHS newsletter may be found on the World Wide Web at http://www.wlu.ca/~wwwiahs/index.html

Conference on DIFFUSE POLLUTION AND AGRICULTURE II 9-11 April 1997 Edinburgh, Scotland

As pollution from point sources becomes more efectively controlled, the effect of diffuse sources is becoming more evident. This conference, sponsored by SEPA and the Scottish Agriculture College, will consider water quality, pollutant transport, nutrient losses and agricultural pesticides, and will look for practical affordable solutions. The programme has been finalised, but posters are still invited for display at lunchtime on *Wednesday 9th* and *Thursday 10th April.*

There is an optional field trip in the Scottish borders on *Friday 11th April.*

To register, or for more details, please contact Fiona Grant, SAC Building Design Unit, Craibstone, Bucksburn, Aberdeen AB21 9YA, *Tel. 01224 711221, fax 01224 716433.*

International Seminar on MONSOON METEOROLOGY AND WATER RESOURCES HYDROLOGY 15-17 August 1997 Visakhapatnam, India

This seminar is being organised by the Association of Hydrologists of India, with which BHS maintains close links (and former President **Mike Mansell-Moullin** is serving on the organising committee). It is in honour of Professor Koteswaram, president of the AHI since 1983 and Vice President of WMO.

Monsoons account for 80% of India's rainfall, but their variation in time and space are often catastrophic and are still only poorly understood. Scientists working in the field of monsoon meteorology and hydrology will be presenting papers.

For further details please contact Mike Mansell-Moullin, Old Hatch, Lower Farm Road, Egffingham, Surrey, KT24 5JL, *Tel. 01372 452672* or Prof. P. Rajendra Prasad, Association of Hydrologists of India, Department of Geophysics, Andhra University, Visakhapatnam - 530 003, India, *Fax 0891 555547.*

International Symposium on MODELLING SOIL EROSION, SEDIMENT TRANSPORT & CLOSELY-RELATED HYDROLOGICAL PROCESSES 13-17 July 1998 Vienna, Austria

Soil erosion and the related sediment transport are integral components of hydrological processes and their description and prediction is an important environmental issue.

This symposium, organised by IAHS and UNESCO, will focus on the

understanding and description of these processes, including recent modelling techniques: empirical grey-box, stochastic and physically-based. There will be a poster session and a limited number of PCs will be provided for software demonstrations.

A mid-symposium tour will look at soil erosion and the phosphorus problem in eastern Austria, and a four-day excursion from *18th to 21st July* will visit the River Danube, the Alpine regions and other relevant sites.

Abstracts of 200-500 words are invited by ***15th May 1997***; full papers will be required by *1st October* and the proceedings will be published as an IAHS "Red Book". A separate volume will contain extended abstracts of poster presentations and the software workshop.

For further information, please contact one of the coordinators: Dr Wolfgang Summer, UCD Hydraulics Laboratory, Davis, CA 95616, USA *Tel. & fax +1 916 752 2385, e-mail wsummer@ucdavis.edu* or Prof. Eduard Klaghofer, Institute for Land Management Research, A-3252 Petzenkirchen, Austria, *Fax +43 7416 521083, email baw.ikt@art.at* or see the IAHS web site: *http://www.wlu.ca/~wwwiahs/index.html*

International Conference on WATER RESOURCES VARIABILITY IN AFRICA IN THE XXTHCENTURY
16-19 November 1998
Abidjan, Côte d'Ivoire

Africa presents enormous contrasts of water resources from arid regions to rain forests, and significant fluctuations with time. This conference will review water resources variability in Africa and discuss its consequences. It is supported by IAHS, WMO, UNESCO, ORSTOM and the African Hydrologists Association.

Themes will include variability of rainfall and flow regimes, connections with human activity and ecohydrology.

Abstracts in English or French are invited by ***30th June 1997***; full papers or posters will be required by *31st January 1998*. Conference proceedings will be published in an IAHS "Red Book".

To register, or for further details, please contact the secretariat: ABIDJAN '98, ORSTOM Antenne Hydrologique, 06 BP 1203 Cidex 1, Abidjan 06, Côte d'Ivoire, *Tel. +225 45 00 74 / 45 41 70, fax +225 45 00 76 / 24 65 04, e-mail servat@orstom.rio.net* or *101727.2773@compuserve.com* or talk first to Dr Andy Bullock at the Institute of Hydrology, Tel. 01491 838800, Fax: 01491 692424, Email anb@ua.nwl.ac.uk.

Copy deadline for *Circulation* No. 54 11th April 1997

Diary

26th February 1997
BHS Southern Section meeting
"Estuary management for the Thames"
Time: 5.30 p.m., tea from 5.00 p.m.
Venue: Dept of Civil Engineering, Imperial College, London SW7
Contact: Dr A P Butler, Dept of Civil Engineering, Imperial College, London SW7 2BU *(Tel: 0171 594 6122)*

5th March 1997
BHS Midlands Section meeting
"Movements of sediments from hillslope to estuary"
Venue: University of Birmingham
Time: 13.40 - 17.25 p.m.
Contact: Prof. Angela Gurnell, School of Geography, University of Birmingham B15 2TT *(Tel: 0121 414 5526)*

19th March 1997
Scottish Hydrological Group & BHS National Meeting
"The snow resources of Scotland"
Venue: Royal Hotel, Bridge of Allan
Time: 10.00 - 16.30 *(Lunch provided)*
Cost: £40 (£22 student/unwaged)
Booking/information: Dr A R Black, Dept of Geography, University of Dundee, Dundee, DD1 4HN *(Tel: 01382 344433, Fax: 01382 344434, email: A.Z.Black@ dundee.ac.uk)* — make cheques out to the *Institution of Civil Engineers* — see also Scottish Hydrol. Group Internet pages: http://www.dundee.ac.uk/~azblack/SHG.htm

21st March 1997
Scottish Hydraulics Study Group 1-day seminar (also sponsored by CIWEM)
"Water supply: sustainability, quantity and quality"
Venue: UnivEd Training & Conference Centre, Edinburgh
Time: 9.30 a.m. to 5.00 p.m.
Contact: Dr S G Wallis, Dept of Civil & Offshore Eng, Heriot-Watt University, Edinburgh EH14 4AS *(Tel 0131 449 5111 x 4430, Fax 0131 451 5078, e-mail stevew@civ.hw.ac.uk)*

15th-17th April 1997
BHS Postgraduate Symposium
Venue: Imperial College, London
Contact: Prof. H S Wheater, Dept of Civil Engineering, Imperial College, London SW7 2BU *(Tel: 0171 594 6066)*

9th-11th April 1997
SEPA/SAC conference
"Diffuse pollution and agriculture II"
Venue: Edinburgh (see Meetings)

10th April 1997
BHS Midlands Section / Welsh Hydrological Group joint meeting
"The Shropshire Groundwater Scheme"
Field visit: 2.00 - 4.00 p.m.
Presentation: 4.15 - 4.45 p.m.
Venue: Shrewsbury
Contact: Simon Griffiths, 14 Cathedral Road, Cardiff, CF1 9LJ
(Tel 01222 388777, Fax: 01222 384888)

23rd April – 3rd May 1997
IAHS 5th Scientific Assembly
Venue: Rabat, Morocco
Contact: IAHS Organising committee, *Fax +212 7 77 8696*; IAHS Web site: http://www.wlu.ca/~wwwiahs/index.html

30th April 1997
BHS Southern Section meeting
"GIS Applications in Hydrology"
Time: 5.30 p.m., tea from 5.00 p.m.
Venue: Dept of Civil Engineering, Imperial College, London SW7
Contact: Dr A P Butler *(address above)*

21st May 1997
BHS Pennines Group AGM
"Flood defence modelling"
Venue: University of Salford
Contact: Dr K A Tilford, Dept. of Civil Eng., University of Salford, M5 4WT
(Tel: 0161 7455000, Fax: 0161 7455060, E-mail k.a.tilford@civils.salford.ac.uk)

28th May 1997
BHS National meeting — jointly with the British Soil Water Physics Group
"Soil physics and macropore flow"
Time: 2.00 p.m. - 5.00 p.m.
Venue: Dept of Civil Engineering, Imperial College, London SW7
Contact: Dr A P Butler *(address above)*

15th - 18th September 1997
Sixth National Hydrology Symposium
Venue: University of Salford
Contact: Dr K A Tilford *(address above)*

Circulation is the quarterly newsletter of the British Hydrological Society. It is issued free to members, but is also available on an annual subscription of £20. Enquiries about membership should be made to Richard Howard, Institution of Civil Engineers, 1-7 Great George Street, London SW1P 3AA. Tel 0171 665 2234, Email howard_r@ice.org.uk. Please address all other correspondence to the Editor, John Griffin, Institute of Hydrology, Wallingford, OX10 8BB. Tel 01491 692395. Fax: 01491 692424. Email b.h.s@ua.nwl.ac.uk.

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