MOBILISING IMPROVED FARM MANAGEMENT OF HEADWATERS LAND[1]

Davis, B., Harley, H.J., Lockyear, A., May, A., Thomasin-Foster, M., Uglow, J., Wibberley, E.J. & Williams, K.

Corresponding Presenting author: Professor E. John Wibberley, *REALM* & University of Reading & Royal Agricultural University Cirencester, UK
ejwibberley@btinternet.com Tel +44 (0)1626 873159

Abstract

Work linking good soil care with proper water conservation practice is of both tropical and temperate importance. This Paper draws heavily on the principles of ongoing collaborative research, development and practice in Headwaters of the River Exe, on Exmoor, SW England begun in 2015 and supported by the regional South-West Water Company. It refers to criteria for monitoring indicators of progress and outcomes. Farm management is being improved by many farmers in that catchment area. Such work is inherently long-term to achieve success, and to respond to changing weather and hydrological conditions. Voluntary consent and engagement of farmers and landowners is crucial, and the Paper's emphasis is on the means of mobilising, maintaining and spreading these responses. Data and farm case studies are reported with a view to inspiring emulation elsewhere. The co-existence of the Exmoor Hill Farming Network since its origins in 2009 is briefly explained as being of considerable significance in terms of effective extension of good farm management practice. Location of these Exe headwaters within Exmoor National Park chimes with established protected landscape care but invitation to cooperate with headwaters improvement must be voluntary and not perceived as policy interference.

KEYWORDS: headwaters, management, farmers, teamwork, ecosystem, mobilisation

Introduction and Purpose

Practitioners have long recognised that good soil management correlates with good water conservation, and protective or remedial measures should begin at the top of slopes, upstream (Joy & Wibberley, 1979). In seasonally wet tropical zones, sheet erosion was found on slopes as slight as 0.5º in Nigeria. Uncontrolled water movement can cause not only physical damage and biochemical pollution but also loses water infiltration that agro-ecosystems need for sustenance. Natural Flood Management (NFM) is a catchment-wide approach that involves working with natural processes to manage sources and pathways of flooding. It involves balancing and integrating the restoration of natural processes with existing land uses including restoration, enhancement and alteration of natural features and characteristics. As no strategy can completely eliminate flood risk, NFM measures are focussed on managing flooding within a catchment. A key component of this is allowing identified areas to flood in order to decrease

[1] Davis, B. (*Corylus Ecology*), Harley, H.J.(ENP = Exmoor National Park), Lockyear, A. (FWAG = Farming & Wildlife Advisory Group SW), May, A.(FWAG SW), Thomasin-Foster, M.(HoE = Headwaters of Exe Chairman), Uglow, J.(FWAG SW), Wibberley, E.J.(HoE and as above) & Williams, K. (EHFN = Exmoor Hill Farming Network).

flood risk elsewhere. This has been implemented in many cases, including on the *National Trust* Holnicote Estate in north-western Exmoor, SW England (Glendell, 2013; EA 2014; Hester *et al*, 2015). However, as well as mitigation of flood damage, huge concern exists to protect water quality and avoid pollution by sediments, chemicals such as phosphates, and all matter increasing BOD (Biological Oxygen Demand). This has spurred the Headwaters Science network in the USA both linked with the USDA (Caldwell, 2016) and with its Forest Service (Stringer *et al*, 2016), plus many worthy 'hands-on' field research efforts by postgraduate students there, since 'Headwaters' cover all catchment waters of a main river system.

In the tropics, headwaters management research and development has been relatively little so far (Luke *et al* 2018; Birkel *et al*, 2020). Headwaters are generally assumed to contribute the majority of water to downstream users, but how much water, of what quality and where it is generated are rarely known in the humid tropics. There is a weak evidence base supporting the effective management of riparian ecosystems within tropical agriculture. Policies to protect riparian buffers - strips of non-cultivated land alongside waterways - are vague and vary greatly between countries. Riparian functions are mediated by buffer width and habitat quality, but explicit threshold recommendations are rare. Most of the 107 studies reviewed by Luke *et al* (2018) were from Brazil (31%), then Malaysia (14%) and Costa Rica (11%). They note that riparian areas regulate rainfall and run-off into freshwaters, filter sediments and pollutants, stabilise riverbanks, maintain shading and low water temperatures, and provide inputs of terrestrial organic matter such as wood, leaves, seeds and insects. Protecting non-cultivated riparian buffers also mitigates flooding, sedimentation, and nutrient run-off in farmland. In general, buffers with greater vegetation quality provide better hydrological benefits. We reckon in African farm practice that uncultivated land adjacent to rivers and streams should be roughly as wide each side as the stream itself at its peak flow. However, it is likely that protecting relatively narrow buffers (*c.* 5–10 m) will help regulate hydrology in tropical farmland. Luke *et al* (2018) report that in Brazil, riparian buffers of >60 m included both annually flooded and dry forest types, maintaining higher tree species diversity. In pasture, widths >100–200 m are recommended for mammals, birds and dung beetles. In oil palm in Borneo, minimum riparian widths of 40–100 m (either side of the river) for birds and dung beetles are suggested, while in sugarcane in Queensland, widths >90 m are needed to support forest specialist birds. In short, positive associations exist between riparian buffer width and terrestrial tropical biodiversity. A buffer width of 100 m each side of the bank would help support multiple animal and tree taxa regardless of agricultural land use or geographic location. Riparian buffer habitat could improve agricultural yields and save production costs via pollination, pest control, decomposition, and water provision services; or agricultural productivity could fall due to increased exposure to pests and predators. Local technical support, including capacity to map

streams and land boundaries, expertise to help with monitoring and restoration, and schemes to increase policy awareness among land managers, are often lacking, meaning that riparian guidelines may fail to deliver benefits on the ground in the tropics. Only a few tropical studies have investigated the use of riparian buffers to increase landscape connectivity, with most focussing on single species. This is a key knowledge gap that is in critical need of further research to inform policy. In the temperate zone too, such landscape connectivity is sought and could well be further investigated and promoted. Riparian processes should be considered alongside catchment-level processes.

Anywhere, management efforts need to start in headwaters areas where catchment sensitive farming can help. Especially where rivers ultimately discharge into ecologically-rich and vulnerable coastal zones, such as the Great Barrier Reef in Australia, pasture management standards affect catchment lands (Bartley *et al*, 2014; Koci *et al*, 2020), and where adjacent to strategic waterways such as the Panama Canal (Ogden *et al*, 2016). Management of this requires a multidisciplinary approach to monitoring (Archer et al, 2016) - and tools for this are fast improving with use of drones, LiDAR and photogrammetry. Using this information, the key is then due mobilisation of farmers and land managers to implement beneficial changes (Marshall *et al*, 2013). It is this last point which is the key in the present review.

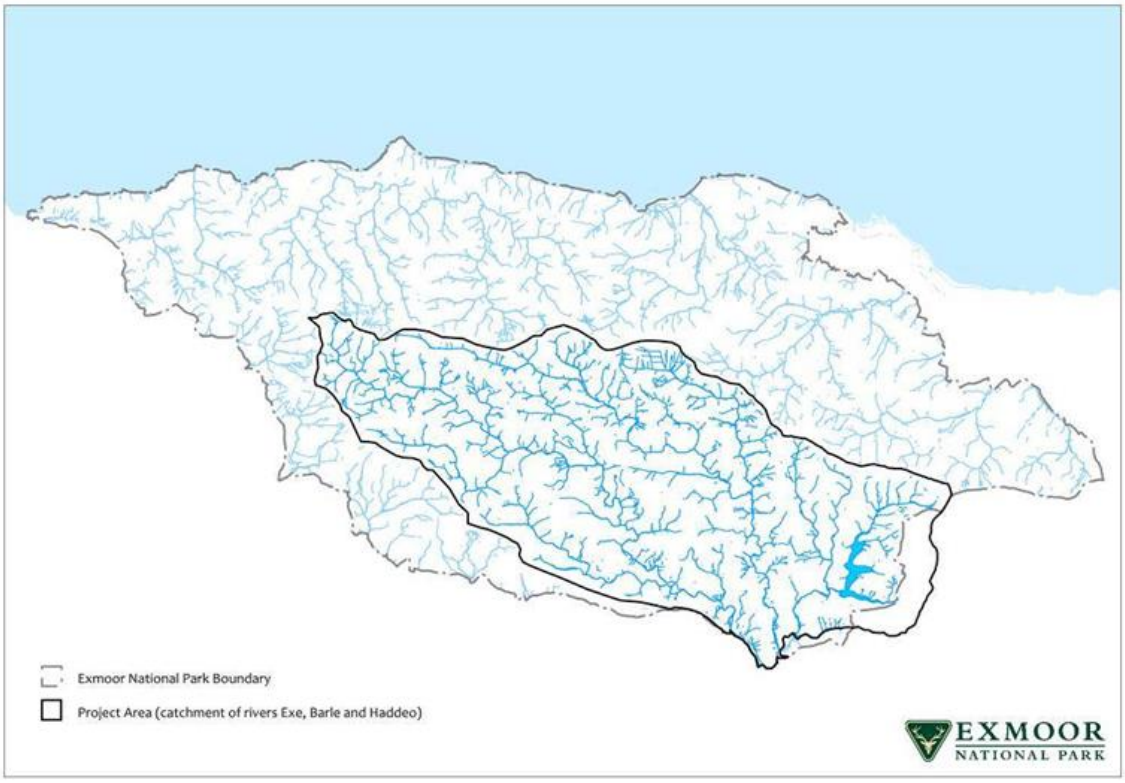
The Headwaters of the Exe (HoE) SW England – Background Overview

'Upstream thinking' is the slogan of the partnership engaged in this programme since 2015.[2] South–West Water, the regional supply Company, has clear interest in improving water quality (Brooks *et al*, 2015; SWW, 2017), supported by Exmoor National Park Authority (ENPA) with match and in-kind funding. Biodiversity improvement aspirations were logged by UK Government (Defra, 2011). The River Exe rises at Exe Head near Simonsbath in the heart of Exmoor National Park (only 8 km south of the Bristol Channel coast) and runs due south some 100 km mainly through Devon via Exeter city to its ria towards Exmouth. Wimbleball Lake on Exmoor supplies drinking water to Exeter and parts of East Devon by releasing water into the River Exe. The water released from the dam is used to regulate flow and support abstractions downstream at

[2] Headwaters of the Exe catchment management programme owes thanks, particularly to South West Water & Exmoor National Park Authority, for their funding and endorsement of the work, and the programme's Steering Group, led by Mark Thomasin-Foster CBE, FRAgS, for expert guidance and encouragement. Special thanks to the farmers and land managers who have taken part in the programme and who are the true custodians of the National Park and its important river systems. Thanks also to the other partners involved in the programme, including the Farming and Wildlife Advisory Group South-West, Exmoor Hill Farming Network, the University of Exeter, *Exmoor Society*, River Exe and Tributaries Association, Greater Exmoor Shoots Association, Nicky Green Associates (crayfish), Riverfly Partnership (water quality indicator), Devon Biodiversity Records Centre, Somerset Environmental Records Centre, Natural England, Environment Agency & Westcountry Rivers Trust.

Allers Water Treatment Works (WTW) near Tiverton and Pynes WTW near Exeter. Water may also be pumped directly from the dam to Wessex Water's Maundown WTW serving Taunton and central Somerset. Fig.1 shows the catchment area. Farming in the catchment is mainly extensive cattle and sheep rearing. Sustainable management of farmland is crucial to maintenance of water quality, with main risk factors comprising soil erosion and run-off arising from compaction and poaching, nutrient management including poor management standards for storage and application of manure (causing both pollution and loss of valuable nutrients including phosphates), livestock, pesticide applications and handling of chemicals, particularly around Wimbleball Lake.

Fig.1. Headwaters of the Exe Catchment Area



Around two-thirds of the woodlands in the catchment, primarily found along deeply incised wooded valleys, are actively managed. The main risks to water quality from woodlands are from infrequent large-scale woodland management practices and forestry operations, such as the creation of tracks and clear-felling, which may lead to run-off of pollutants and sedimentation.

The catchment is also a premier game shoot location. There are possible risks associated with shoot management, primarily in terms of run-off and nutrient enrichment. For instance, the management of some of the shoots operating in the catchment includes pheasant rearing pens and access tracks in close proximity to watercourses.

In addition the catchment hosts an extensive network of public rights of way, permitted paths and open access areas. The HoE is of high ecological value and includes a number of Sites of Special Scientific Interest (SSSI) and other protected designations which may be negatively impacted by presence of non-native invasive species. These include plants such as Japanese knotweed *Fallopia japonica*, Himalayan balsam *Impatiens glandulifera,* and Montbretia *Crocosmia* x *crocosmiiflora,* and animals such as signal crayfish *Pacifastacus leniusculus*.

Work focused on implementing beneficial changes for water quality across the upper River Exe catchment, most of which lies within Exmoor National Park. The Headwaters of the Exe programme includes working with land managers, restoring rights of way and supporting non-native invasive species control. Land management work focusses on farms, woodlands and game shoots in high priority areas targeted by a catchment survey, which comprised desk-based mapping and wet weather survey, in 2015 (to ascertain performance under water pressure). Principal farming type here involves upland livestock grazing of sheep and cattle. The programme's land management team consists of ENPA, the Farming and Wildlife Advisory Group South-West (FWAGSW) and Exmoor Hill Farming Network (EHFN) working with local land managers by carrying out a series of 60 advisory visits, followed up by Water and Environment Plans for each holding and access to a £4,000 capital grant fund, as well as delivering a programme of 22 events and demonstrations.

HoE is guided by a steering group made up of representatives of partner organisations and local land managers, together with Exmoor Rivers and Streams Group, *Exmoor Society*, the Environment Agency and Natural England. Monitoring for the programme was overseen by the University of Exeter working closely with the partner organisations, with Riverfly monitoring (fish food-chain water quality indicator) undertaken in partnership with the River Exe and Tributaries Association.

Headwaters of the Exe (HoE) Objectives and Methodologies

The HoE has three main objectives:

- improving water quality through addressing diffuse pollution, by identifying potential sources, pathways and receptors of pollutants that can adversely affect water quality in the catchment;
- maintaining good water quality through sustainable land management; and
- delivering synergies with other stakeholders in the catchment through wider ecosystem services.

Key Performance Indicators (KPIs) are:-

a) the number of hectares of farmland under revised management to deliver environmental outcomes; and
b) the number of farms where a plan has been agreed to benefit the environment.

For HoE from 2015-2020, these targets were attained: 60 holdings (50 farms and 10 woodlands or game shoots). No area target was set.

Methodologies used to attain the above goals included:-

- advice to farmers, foresters and game shoot managers;
- a capital grant fund to support implementation of necessary works and management;
- training events, site visits and demonstrations to promote good practice;
- rights of way maintenance to reduce erosion and run-off in high risk areas;
- support for invasive species control projects;
- monitoring of water quality, and
- some use of 'citizen science' to engage with landscapes and encourage awareness.

Farm Advisory work focussed on pathways from farmyards and connection to rivers;

 Clean and dirty water separation;

 Manure management

 Out-wintering and late feeding of cattle;

 Management of farm tracks and highways;

 Forestry timber extraction;

 Management of game shoots.

Results 2015-2020

During the five year programme a total of 28 capital grants were agreed for works to improve water quality, with a total value of £125,667 which included significant match funding provided by beneficiaries. In addition, a pesticide amnesty secured the removal from the catchment of 192 litres and 5.5 kg of pesticides, as well as 2,500 litres of sulphuric acid silage additive. This pesticide amnesty carried out in the catchment resulted in the safe removal of enough pesticides to have been detected in 12,800,000 km of river, a figure which is 64 times greater than the total network of watercourses in the UK. Although River Exe pollution is very low, removing such pollutants at source will reduce costs for treating raw water at the two River Exe water treatment works.

Rights of way across the catchment were assessed by ENPA in 2015 and priorities for restoration established. By 2020, 6 km of restoration was carried out by ENPA and local contractors, with other improvements to an overall distance of 17 km of paths which posed a high risk to water quality. Support was provided for existing partnership projects operating across the catchment which focussed on the control of invasive non-native species. These included the Exmoor Knotweed Control Partnership and the River Barle Invasive Signal Crayfish Project. Work included a trial for controlling invasive plant species on organic land using electrocides.

Aspects of these results include:-

1. HoE from 2015 to 2020 implemented beneficial changes for water quality across the upper River Exe catchment, most within Exmoor National Park. The programme was funded primarily by South West Water through Price Review mechanism PR14, and Asset Management Plan 2015-2020 (AMP6) capital investments, with significant match funding and in-kind contributions provided by ENPA.
2. Alongside work of the Exmoor Mires Partnership, HoE provided an opportunity to promote sustainable land management which has many associated benefits, including helping to build resilience to extreme conditions and climate change, improving the conservation status of important habitats and raising awareness of the value of the Upstream Thinking (UST) approach. The work was prioritised through a detailed mapping exercise and wet weather survey carried out during the first year. The subsequent programme of work undertaken was broad and included working with land managers, restoring rights of way and supporting non-native invasive species control.
3. Exmoor National Park Authority (ENPA) and the Farming and Wildlife Advisory Group SouthWest (FWAGSW) worked with local land managers and the Exmoor Hill Farming

Network (EHFN) to carry out advisory visits, followed by the production of Water and Environment Plans and access to a capital grant fund, as well as delivering a programme of events and demonstrations. Following prioritisation, those rights of way which posed the greatest risk to water quality were restored by ENPA and local contractors. Support was provided for existing partnership projects operating across the catchment which focussed on the control of non-native invasive species, including the Exmoor Knotweed Control Partnership and the River Barle Invasive Crayfish Project. The programme also enabled the commencement of a trial for controlling invasive plant species on organic land using electrocides which has since been taken over by the Exmoor Non-Native Invasive Species Project.

4. A water quality monitoring strategy was developed, overseen and co-ordinated by the University of Exeter, working closely with the partner organisations, and Riverfly monitoring was undertaken in partnership with the River Exe and Tributaries Association (RETA). Headwaters of the Exe (HoE) was guided by a steering group made up of representatives of the partner organisations and local land managers, together with Exmoor Rivers and Streams Group, Exmoor Society, the Environment Agency and Natural England.

5. Given the breadth of work undertaken and the large area of the catchment it has been difficult to prove conclusively that any beneficial changes in water quality are a direct result of the work carried out. However, the monitoring undertaken by the University of Exeter, South West Water, Exmoor National Park Authority and numerous volunteers has indicated that this approach to improving water quality can be successful.

6. The recorded results of the five-year HoE catchment management programme are positive for water quality and for the many other benefits associated with this approach. It is hoped that, by providing an innovative approach to improving raw water quality, HoE will have a lasting legacy. For example, through developing strong links with the farming community and working together to engender the sustainable management of the farmed landscape – such as through improving soil and animal health, habitats and rights of way – leading to benefits for the farm business, water quality, nature and other public benefits.

7. It was strongly recommended by Davis (2020) that work should continue into AMP7, from 2020 to 2025, ideally with a similar programme to that already undertaken, including additional elements, such as looking at issues arising from highways or from plant health.

Development of work from 2020

Along with 15 other '*Upstream thinking*' (UST) projects across SW England, HoE from 2020 secured further funding under AMP7, and aspires to contribute to:-

- Improved raw water quality and supply with long-term business resilience
- The new Biodiversity Improvement ODI 'Hectares of new catchment management' which involves penalty/reward
- The Pennon Sustainability (Pennon, 2019) and Natural Capital commitments (Helm, 2015) of year-on-year 3% improvement from a 2020 baseline
- Water UK carbon mitigation commitments made to the Secretary of State for the Environment (peatland restoration and tree planting).

In the Exe area, the last quarter of 2021 included the following achievements:-

- 8,330 trees delivered to 14 farms across the Exe catchment. Over 200 people attended an online Devon Wildlife Trust (DWT) talk to *More Meadows* which included grazing links and meadow creation activity carried out by the team.
- DWT hosted a full episode of BBC *Farming Today* on grazing and culm grassland. Little Burne Farm implemented 20 ha of aeration and numerous capital grant agreements are programmed. Water quality sampling was carried out across the catchment.
- The team carried out a ground truthing exercise with DWT's new UST Project Manager. This involved surveying water and land management issues across the catchment, and reviewing effectiveness of past and future recommendations.
- A farming family, after working with DWT's UST Farm Advisors, have now given up their entire hectarage of maize and have replaced it with a crop mixture, specifically to encourage winter birds and insects, alongside wide buffers for woodland, rivers, and hedges, totalling over 20 hectares. These options, supported by Mid-Tier *Countryside Stewardship* provide great gain for water, wildlife, and farming.
- WRT (Westcountry Rivers Trust) farm visits have included farms looking to enter UK Government-supported *Countryside Stewardship* agreements with interventions ranging from covering open feed yards to buffer strips, ponds, watercourse fencing and tree planting potential. Soil tests were completed on two farms in the Tiverton area of the catchment. An infrastructure audit was written for a farm in Chevithorne, to be used in a *Countryside Stewardship* application, highlighting the need to divert water away from entering their extremely limited slurry storage capacity.

- The Exe Farm Advisor presented to 25 members of the National Farmers Union on *Farming Rules for Water* which will inevitably affect proper voluntary action by farmers across all UST catchments.
- Exmoor Farming in Protected Landscapes (FiPL) funding has now been allocated. One farm is using FiPL as match funding. Detailed plans and schedules of works have been put forward for stream restoration and habitat enhancement at another farm. The scheme at a further farm, which was developed through HoE, will be put forward for FiPL funding without UST funding. ENPA is meeting with landowners to discuss further implementation of proposals.

Conclusions

- Improved farm management for combined better soil and water conservation is internationally vital.
- The focal case of Exmoor's Headwaters of the Exe in SW England illustrates the timeliness of this work not only in its practical importance but also to integrate agricultural and environmental management for better overall Ecosystem Security, taking account of major policy signals and changes currently mirrored internationally and being developed in British Agriculture and Land Care (Helm, 2015; Deane & Walker, 2018; Wibberley, 2020).
- Given the multidisciplinary character of the endeavour, it is important that teamwork has been required to deliver the results so far reported and the cheerful coordination of this highly applied work has brought tangible, visible benefits and promises more.
- Crucial at the heart of it has been the Exmoor Hill Farming Network (EHFN; Knight & Wibberley, 2017). Begun as Exmoor Hill Farm Project in 2009, it became EHFN in 2014 and finally registered in 2020 as a Community Interest Company (CIC). Being farmer run and owned means that credible influence flows from enlightened and satisfied farmer clients of the HoE opportunities who advocate into the farming community. Farmers prefer to learn from other practical farmers worldwide, respecting proven adopters and those more experienced – but 'wearing similar boots' in similarly challenging conditions. Training and events provide not only information but fun and rural social interaction – which has been limited by coronavirus pandemic worldwide since the start of 2020.

- Mobilising further engagement by farmers and landowners is greatly helped by the number of visible land-use and livestock management improvements already done and appreciated by farmers (Fig.2), and in the training offered so far towards better understanding of our upland grazing livestock and their habitats.

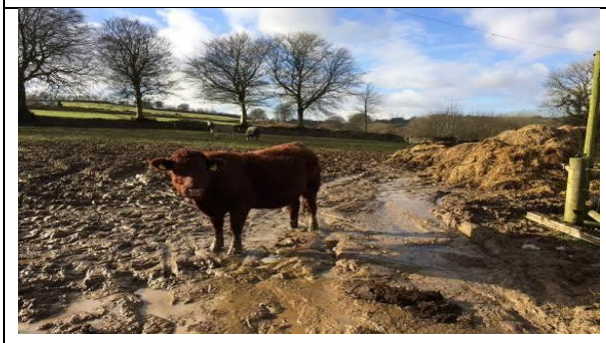
Outside Manure Heap *versus*	Proper covered storage
	

Fig.2 Tangible improvements appreciated by farmers.

It is hoped that sharing these results with international audiences will encourage others to adopt a teamwork approach strongly led by practical farmers and landowners whose field management is absolutely crucial for success. An enabling funding, clear monitoring, and informed policy context provides a sound basis for that farmer collaboration to work effectively for the public good.

References & Further Reading

Archer, D., Bathurst, J., and Newson, M. (2016). Piecing together the flood management mosaic. *The Environment*. Vol. **21**, pp 37-39. CIWEM publication. Syon Publishing, Brentford, UK.

Bartley, R., Corfield, J. P., Hawdon, A. A., Kinsey-Henderson, A. E., Abbott, B. N., Wilkinson, S. N., & Keen, R. J. (2014). Can changes to pasture management reduce runoff and sediment loss to the Great Barrier Reef? The results of a 10-year study in the Burdekin catchment, Australia. *The Rangeland Journal*, **36** (1), 67-84. doi:http://dx.doi.org/10.1071/RJ13013

Birkel,C., Correa-Barahona,A., Martinez-Martinez,M., Granados-Bolaños,S., Venegas-Cordero,N., Gutiérrez-García, K. & Blanco-Ramírez, S. *et al* (2020). Headwaters drive streamflow and lowland tracer export in a large-scale humid tropical catchment. *Hydrological Processes* **34** (18) 3824-3841. https://doi.org/10.1002/hyp.13841

Brooks, E. *et al* (2015) Tracing dissolved organic carbon and trihalomethane formation potential between source water and finished drinking water at a lowland and an upland UK catchment. pp. 203–212 In *Science of the Total Environment*. Elsevier, 537 pp.

Caldwell, P. (2016) Managing Headwaters in the High Country**.** *Agricultural Outlook Forum* 236851 United States Department of Agriculture, *RePEc:ags:usao16:236851* DOI: 10.22004/ag.econ.236851

Davis, B. – compiler (2020) The Headwaters of the Exe Catchment Management Programme 2015-2020 – Evaluation Report, *Corylus Ecology* 81 pp.

Deane, R. & Walker, A, (2018) Towards a Register of Exmoor's Natural Capital, 28 pp (Rural Focus/Exmoor Society).

Defra (2011) Biodiversity 2020: A strategy for England's wildlife and ecosystem services. Report PB13583 Department for Environment, Food and Rural Affairs, UK.

Environment Agency UK (2014) Evaluating the benefits of catchment management for multiple ecosystem services. (Report: SC120042/R)
Glendell, M. (2013) *Evaluating an Ecosystem Management Approach for Improving Water Quality on the Holnicote Estate, Exmoor*, PhD Thesis, University of Exeter.
Helm, D. (2015*) Natural Capital* **:***Valuing the Planet* (Yale Univ. Press, USA) www.dieterhelm.co.uk
Hester, N., Rose, S., Hammond, G. & Worrall, P. (2015) Case Study 20. From Source to Sea: the Holnicote Experience. (Report for National Trust & Defra/EA, UK, 7 pp.)
Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (2019) The Global Assessment Report on Biodiversity and Ecosystem Services. IPBES, ISBN No: 978-3-947851-13-3.
Joy, D.C. & Wibberley, E.J. (1979) *A Tropical Agriculture Handbook*. Cassell, London, 219 pp.
Knight, D. & Wibberley, E.J. (2017) Managing Progress through Farmer Networks: Exmoor Hill Farming Network, UK. International Farm Management Association (IFMA21), Edinburgh, July 2017.
Koci, J., Sidle, R.C., Jarihani, B., & Cashman, M.J. (2020) Linking hydrological connectivity to gully erosion in savanna rangelands tributary to the Great Barrier Reef using structure-from-motion photogrammetry. *Land Degradation and Development*, **31** (1) pp. 20-36. (James Cook University https://doi.org/10.1002/ldr.3421)
Luke, S.H., Slade, E.M., Gray, C.L., Annammala, K.V., Drewer, J., Williamson, J., Agama, A.L., Ationg,M., Mitchell, S.L., Vairappan, C.S. & Struebig, M.J. (2018) Riparian buffers in tropical agriculture: scientific support, effectiveness and directions for policy. *Journal of Applied Ecology* **56** (1) 85-92.
Marshall, M., Ballard, C., Frogbrook, Z., Solloway, I., McIntyre, N., Reynolds, B. and Wheater, H. (2013) The impact of rural land management changes on soil hydraulic properties and runoff processes: results from experimental plots in upland UK.. *Hydrological Processes*, **28** (4) pp. 2617-2629.
Ogden, F., Hall, J.S., Barnard, H., Stallard, R.F., Fenichel, E., Adamowicz, V., Ewers, B., Kempema, E. & Zhu, J. (2016) Hydrological effects of tropical land use management incentives: Panama Canal Watershed. PR-P In Stringer *et al* (*loc.cit.*)
Pennon Group (2019) Our Sustainability Strategy 2019 – 2030, a clear ESG (Environment, Social & Governance) framework for performance management (sustainability@pennon-group.co.uk)
Stringer , C.E., Krauss, K.W. & Latimer, J.S. – eds (2016). Headwaters to estuaries: advances in watershed science and management -Proceedings of the Fifth Interagency Conference on Research in the Watersheds. March 2-5, 2015, North Charleston, S. Carolina. e-General Tchnical Report SRS-211. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research St'n.302 pp.
South West Water (2017) *Water Future Our Vision 2020-2050*.
South West Water (2022) SWW's Catchment Management Programme UST3, AMP7, Quarterly Report to end December 2021.
Wibberley, E.J. (2016) Overview of Issues of Soil Management in the UN Year of Soils 2015. *Agriculture for Development* **27,** 58-59.
Wibberley, E.J. (2020) Integrating Agricultural & Environmental Management Policy: a UK perspective. *International Journal of Agricultural Management* **9**, 149-153.
https://www.dartmoor.gov.uk/.../dartmoor-headwaters-project
https://leaf.eco/farming | LEAF (Linking Environment and Farming)
https://www.fwagsw.org.uk/headwaters-of-the-exe
https://pooleharbournitrates.org.uk/ NFU led Poole Harbour Nutrient Management Scheme.