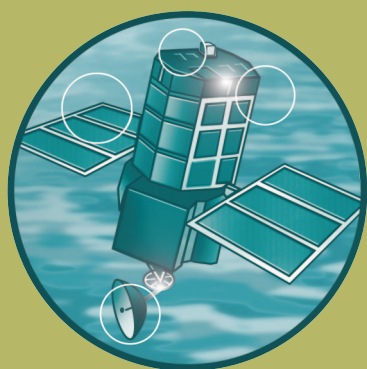


# Review of impacts of rural land use and management on flood generation

## Impact study report

### Appendix E: Ongoing monitoring, modelling and socio-economic studies

R&D Technical Report FD2114/TR



ENVIRONMENT  
AGENCY

Joint Defra/EA Flood and Coastal Erosion Risk  
Management R&D Programme

Review of impacts of rural land use and  
management on flood generation

Impact study report

Appendix E: ongoing monitoring,  
modelling and socio-economic studies

R&D Technical Report FD2114/TR

Authors: P.E. O'Connell, K. J. Beven, J. N. Carney,  
R. O. Clements, J. Ewen, H. Fowler, G. L.  
Harris, J. Hollis, J. Morris, G. M. O'Donnell,  
J. C. Packman, A. Parkin, P. F. Quinn, S.C.  
Rose, M. Shepherd, and S. Tellier

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## Authors:

P.E. O'Connell, J. Ewen, H. Fowler, G. M. O'Donnell, P. F. Quinn  
and S. Tellier

---

**University of Newcastle upon Tyne, Water Resource Systems  
Research Laboratory**

K. J. Beven

---

**Lancaster University, Institute of Environmental and Natural  
Sciences**

J. N. Carney

---

**NERC – BGS**

R. O. Clements

---

**IGER**

G. L. Harris, A. Parkin, S. C. Rose and M Shepherd

---

**ADAS**

J. Hollis and J. Morris

---

**NSRI**

J. C. Packman

---

**NERC - CEH Wallingford**

**Statement of use**

This report is aimed at those involved in land management. It provides the current position of knowledge and science with respect to land use management and its impact on flood generation. It will be of benefit to those seeking to reduce flood risk through specific land management practices, and those who wish to assess the impact of specific management practices on flood risk.

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**Research contractor:** University of Newcastle upon Tyne, NE1 7RU

**Defra Project Officer:** Mr. E. P. Evans, Halcrow Group Ltd., Burderop Park, Swindon, SN4 0QD

**Publishing organisation**

Defra - Flood Management Division

Ergon House

Horseferry Road

London SW1P 2AL

Tel: 020 7238 6178

Fax: 020 7238 6187

[www.defra.gov.uk/environ/fcd](http://www.defra.gov.uk/environ/fcd)

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## Executive summary

FD2114/TR, the 'Impact Study Report', introduces the FD2114 project and gives a comprehensive review of the impacts of rural land use and management on flood generation. Project FD2114 is part of the Broad Scale Hydrology Modelling Programme (Calver and Wheater, 2001).

This is Appendix E to FD2114/TR. One of the tasks (Task 2) specified for the project was: "*Carry out a comprehensive review of on-going initiatives not yet encapsulated in the literature*". This appendix lists and briefly describes relevant studies in hydrological and agricultural monitoring and modelling and socio-economics. Where possible, references for the world wide web (www) are given, so that up to date information can be obtained.

# Contents

1.	INTRODUCTION	1
2.	DEFRA	2
3.	ENVIRONMENT AGENCY	4
4.	OFFICE OF SCIENCE AND TECHNOLOGY: FORESIGHT	5
5.	FORESTRY COMMISSION	6
6.	NERC	7
7.	EPSRC	8
8.	BBSRC	9
9.	NEWCASTLE UNIVERSITY EARTH SYSTEMS LABORATORIES	10
10.	EU FRAMEWORK PROGRAMMES	11
11.	EU LIFE-ENVIRONMENT PROJECT	12
12.	EUROPEAN RURAL DEVELOPMENT FUND	13
13.	IAHS	15
14.	OTHER UK INITIATIVES	16
15.	OTHER INTERNATIONAL INITIATIVES	17
16.	REFERENCES	18



# 1. Introduction

Project FD2114 is part of the Broad Scale Hydrology Modelling Programme (Calver and Wheater, 2001), and is concerned with the impacts of rural land use and management on flood generation. The project is introduced in FD2114/TR 'Impact Study Report', which contains a comprehensive review of the impacts of rural land use and management on flood generation. The review takes into account what is known about relevant on-going initiatives, to satisfy one of the tasks (Task 2) specified for the FD2114 project: *"Carry out a comprehensive review of on-going initiatives not yet encapsulated in the literature"*. In this appendix to FD2114/TR brief details are given for recently completed and ongoing initiatives involving studies in hydrological and agricultural monitoring and modelling and socio-economics which have some bearing on the understanding, modelling, or management of impacts of rural land use and management on flood generation.

The main bodies that are currently funding or managing initiatives are:

- Defra
- The Environment Agency
- UK Research Councils
- European Union, through the Framework Programmes, LIFE-Environment Programme and Rural Development Fund



## 2. Defra

Defra and the Environment Agency have a joint programme for flood and coastal defence which includes a large number of projects in categories such as engineering, flood forecasting and warning, risk and uncertainty, broad scale modelling, soil protection, policy development and programme management.

Defra supports a wide range of environmental research and development work which is directly or indirectly relevant to the impacts of rural land use and management on flood generation. Project lists and details are available at [http://www2.defra.gov.uk/research/project\\_data/](http://www2.defra.gov.uk/research/project_data/). The following Defra projects are of particular interest:

**ES0111 Development of a database of agricultural drainage (2002).**

Derived a spatial database of the agricultural drainage that has taken place in England and Wales since 1950.

**ES0112 Environmental benchmarks - arable (2002-04).** The main aim is to quantify the current and possible future environmental burdens of arable crop production systems, as well as the crop outputs, in the different farming systems and regions throughout England and Wales.

**FD2321 Risks to people phase II (Start-End Year: 2003-05).** The aim is to develop a method suitable for assessing and mapping the risk of death or serious harm to people as a result of flooding.

**IS0209 Agricultural futures and their implications for the environment (2003-04).** The overall aim is to provide information on possible agricultural futures in England and Wales in order to support decision making on environmental policy.

**IS0210 Yields of UK crops and livestock: physiological and technological constraints, and expectations of progress to 2050 (2003-05).** The aim is to estimate the physiological potentials for yield improvement in eight major crop and livestock species farmed in the UK, to specify physiological and technological constraints on yield improvement, and provide estimates on how agriculture yields may change in the future.

**SP0519 Critical levels of soil organic carbon in surface soils in relation to soil stability, function and infiltration (2001-04).** This project seeks to investigate more thoroughly the relationships between surface layer properties of soil and their ability to allow infiltration of rainfall and resist erosion.

**WC01007 Countryside Survey 2000 (1998-2003).** Recorded changes in the land cover, ecological characteristics, and landscape features of the wider countryside in Great Britain. This project forms part of a series of surveys. Previous surveys were undertaken in 1978, 1984 and 1990.

**WC01021 Multi-Agency Geographical Information for the Countryside (MAGIC) (2000-2003).** Brings together existing data on designations and

schemes (e.g. Countryside Stewardship Agreements and Woodland Grant Scheme) in England into a single, accessible Geographical Information System (GIS).

**WC02009 Electronic Capture of 1930s Land Use Maps** (2004). This project computerised the 1930s Land Utilisation Survey maps for England and Wales.

### 3. Environment Agency

ADAS are undertaking a review led by JBA for the Environment Agency (Richard Shires) on aspects of land management change in two Pennine sub-catchments. In brief, the objective is to produce a project plan for a comparative study to investigate the linkages between land management and runoff responses since the 1950s in two similar catchments, Croasdale Beck and Bottom Beck. The study, although investigating historical data, will seek to identify a programme of land management measures for sustainable mitigation of flood risk. The project plan will identify specific objectives that will meet this overall aim, propose appropriate analytical methodologies and, through a process of consultation, collect and analyse the data and information that are available to support the study.

The study has identified data sets which can be used to indicate change over time periods or which can give useful information at one point in time. The areas included are:

- Climate
- Runoff
- Land management e.g. stocking rates (summer and winter), drainage/gripping, burning practices, forestry practices
- Land cover and soils e.g. dwarf shrub cover, forest age, soil structure and soil compaction, bare ground, gullyng, banksides
- Water storage
- Water compositional qualities e.g. silt, colour, other drinking water qualities

## **4. Office of science and technology: foresight**

The Foresight “Flood and Coastal Defence Project”, commissioned by the Office of Science and Technology, produced a long-term (30-100 years) vision for the future of flood and coastal defence in the whole of the UK. The future risks of flooding and coastal erosion were analysed for four different future scenarios (the Foresight Futures) embodying different approaches to governance (centralised versus localised) and different values held by society (consumerist versus community). Each of the socioeconomic futures was also associated with a different climate-change scenario. The findings are independent of Government and do not constitute Government policy, but are intended to inform long-term policy. The project has recently been completed (2004), and the findings are available at <http://www.foresight.gov.uk>.

## 5. Forestry Commission

Forestry Research, an agency of the Forestry Commission, is the principal organisation in the UK engaged in forestry and tree related research. In particular, the purpose of Forestry Research is to provide research, development, surveys and related services to the forest industry and provide authoritative advice in support of the development and implementation of the government's forestry policies.

Relevant projects include:

**Forest Hydrology.** This project assessed the impact of forestry on the freshwater environment, including the effect of lowland forestry on the quality and quantity of groundwater recharge, the impact of forests and silvicultural practices on winter flood and summer low flows, and the role of floodplain forests in flood defence and sediment control. A major output from this programme was the 4th edition of "Forests and Water Guidelines" (2003).

**Glen Urquhart Flood Management Plan.** The River Enrick in Glen Urquhart, Inverness-shire, has had six catastrophic flood events since 1989, resulting in massive damage to property, farmland and forestry. The aim of this project is to use sustainable techniques, which will work with nature as much as possible, to manage floods within the catchment. The project forms part of the SAFER initiative (Strategies and Actions/Implementations for Flood Emergency Risk Management), which includes partners in Ireland, Germany and Switzerland.

## 6. NERC

Under the NERC-JIF initiative the infrastructure money was awarded to two projects, CHASM and LOCAR, which have instrumented 7 catchments across the UK. These projects comprise the National Infrastructure For Catchment Hydrological Research (NICHE).

**CHASM** Catchment Hydrology And Sustainable Management (<http://www.ncl.ac.uk/chasm>). An ongoing study, coordinated by the University of Newcastle, to gain new understanding of how catchment response changes with scale, and to establish new protocols for linking field experimentation, landscape classification, modelling and prediction. Multiscale catchments are being carried out in four predominantly upland mesoscale catchments (~100 km<sup>2</sup>), and a key issue is how, what and where to sample so as to reduce predictive uncertainty. One of the main research themes is flooding, and the aim is to gain a better understanding of the natural controls on the flood frequency curve, and to build this into new physically-based approaches to flood risk estimation.

**LOCAR** Lowland Catchment Research (<http://www.nerc.ac.uk/funding/thematics/locar>). This is an ongoing (NERC) thematic programme to improve understanding of the hydrological functioning of lowland catchments, particularly stream-aquifer interactions, and to study linkages with aquatic ecology. Intensive monitoring is being performed in two Chalk catchments in southern England and a sandstone catchment in the Midlands.

## 7. EPSRC

### **Flood Risk Management Research Consortium**

(<http://www.floodrisknet.org.uk>). This has the following goals:

- To establish an integrated programme of high quality, underpinning science that will enhance our understanding of and ability to reduce flood risk and will support the development of longer-term flood prevention, management and mitigation strategies;
- The short-term delivery of tools and techniques for more accurate flood forecasting and warning, improving the flood management infrastructure and reduction of flood risk to people, property and the environment

As part of this project, research is to be undertaken at Pontbren, mid-Wales, to quantify local scale impacts of upland land management (including grazing, woodland and riparian buffer strips) on soil structure, flood runoff generation and geomorphology.

### **Network on Conveyance in River/Floodplain Systems**

(<http://ncrfs.civil.gla.ac.uk>). The Network is composed of forty practitioners and academics from the UK engaged in the field of modelling flood conveyance in rivers and floodplains. It aims to translate academic research into enhanced computer models and design manuals and also to enable practitioners to have more influence on future directions in fluvial research.

### **Strategic Management of Non-point Source Pollution from Sewage Sludge**

**(SEAL)** (<http://www.sheff.ac.uk>, <http://www.ncl.ac.uk/wrgi/TOPCAT>). This is an ongoing project, coordinated by the University of Sheffield, to assess the effects on water resources of applying sewerage sludge to agricultural land. The aim of the project is to advance understanding of the form and fate of nutrients through the use of multiscale monitoring and modelling.

## 8. BBSRC

BBSRC (2002) sets out BBSRC's priorities for research. There are three main priority areas – innovative agricultural practices, new crops and systems and the ecology of managed landscapes. The report discusses ways of fostering these objectives, all three of which have relevance to runoff/flooding issues, and quotes the Sustainable Agricultural Systems Agri-Food Committee as having an interest in “agricultural and associated natural habitats in the rural landscape that may affect or be affected by agricultural practices”.

The **Environmental Change Network** (ECN) may have some relevance to runoff and flooding in the long-term. The ECN is essentially a monitoring exercise, partly funded by BBSRC, in which changes to the flora and fauna are being assessed at a large number of terrestrial and aquatic sites in the UK (Projects 3112 and 3020).

The effect of forage grasses and legumes on soil processes (Project 3108) may also have some relevance in the long-term.

Project 013479 at Rothamsted Research Station is entitled “Measurement of runoff and soil losses and associated losses of phosphate, other nutrients and pollutants on land liable to erosion”.



## 9. Newcastle University earth systems laboratories

Newcastle University has invested £750K of infrastructure funds in two rural initiatives:

- Creating a **sustainable farm** that includes flood ponds, overland flow filters and bioreactors, wetlands and within-ditch ponds. The goal is to allow the farmers to continue their normal farming practice but sacrificing small sections of land for flood storage and pollution stripping;
- **Rural Energy Initiative**. This is looking at technologies to create hydrologically based energy sources to supply farm holdings. This includes the establishment of telemetered, nested flow sites. These will be added to the hydrological rainfall –runoff network already in existence for the CHASM project in the river Eden. One of the spin-off benefits from this work will be the unrivalled density of multi-scale monitoring points in the test catchment, which could prove useful in future studies. Another benefit is that zones of coppice woodland will be established as part of a riparian area/ buffer zone initiative, and this may be useful in future flood-control studies.

## 10. EU framework programmes

There is substantial European funding for environmental research and development work in Framework Programme 5 (FP5; 1998-2002) and Framework Programme 6 (FP6; 2002-2006) which is directly or indirectly relevant to the impacts of rural land use and management on flood generation. Details on FP5 and FP6 can be found at <http://www.cordis.lu/en/home.htm>.

Relevant projects in FP5 which have just finished or are still ongoing include:

**SPHERE** Systematic, Palaeoflood and Historical data for the improvEment of flood Risk Estimation ([www.ccma.csic.es/dpts/suelos/hidro/sphere](http://www.ccma.csic.es/dpts/suelos/hidro/sphere)). Completed May 2003. Developed new methods for reconstructing paleofloods, providing indirect information on hydrologic variability and extreme floods over long-time intervals (100 to 10,000 years).

**MUSIC** Multi-sensor precipitation measurements integration, calibration and flood forecasting (<http://www.geomin.unibo.it/orgv/hydro/music>). Completed January 2004. The aim was to improve the reliability of rainfall estimation techniques based on radar and satellite data, by combining them with traditional raingauge observations.

**FLOBAR2** Floodplain biodiversity and restoration 2: integrated natural science and socio-economic approaches to catchment flow management (<http://www-flobar.geog.cam.ac.uk>). Completed July 2003. Provided guidance for policy makers and river managers in Europe on the restoration of floodplain forests.

**TransCat** Integrated water management of transboundary catchments (<http://transcat.isq.pt>). Completion date, January 2006. The main objective is to create of a Decision Support System (DSS) for optimal water management of transboundary catchments (state or regional). The DSS to be developed will focus mainly on pollution, flooding and water use issues.

The relevant ongoing FP6 project is:

**FLOODsite** Integrated flood risk analysis and management methodologies (<http://www.floodsite.net>). Will develop methodologies and tools for inland, estuarine and coastal flood risk analysis and management by integrating hazard, vulnerability and risk assessments. The overall aim is that of sustainable flood mitigation and defence, recognising the complex interaction between natural bio-physical and socio-economic systems, to support spatial and policy planning in the context of global change and societal advance.

## 11. EU LIFE-Environment project

The European Union LIFE-Environment programme (<http://www.europa.eu.int/comm/environment/life/home.htm>) was launched in 1992 to provide funding to European Union countries to encourage sustainable development and assist in the implementation of the European Commission's environmental policies.

Relevant projects funded under the EU Life programme include:

**WUF** Wise Use of Floodplains (<http://www.floodplains.org.uk>) (1999-2002). Studied the restoration and management of floodplains across 5 EU catchments. The project's overall objective was to demonstrate how floodplain wetlands could contribute to the sustainable management of water resources within river basins.

**Wet Woods Restoration Project** (<http://www.wetwoods.org>) (1998-2002). Restored areas of bog woodland and floodplain woodland at five sites in Scotland, reinstating more natural hydrological systems.

## 12. European rural development fund

The European Rural development Fund is actively funding large scale structural project that include flooding ([http://www.europa.eu.int/index\\_en.htm](http://www.europa.eu.int/index_en.htm)). Each region has an administrative office (e.g. <http://www.go-nw.gov.uk/> for the North West of the UK). The following projects have been approved for funding. Most regions of the UK now have substantial development budgets.

**Joint approach for managing flooding** (Led by JAF, Netherlands; work in the UK on the River Parret). The aims are (1) better spatial planning to promote multifunctional land use; (2) restoration of rivers, in particular to extend the retention capacity and improve the water capacity; (3) implement new technologies and policies to improve flood management; and (4) increase public awareness and support for new measures and policies through communication.

**Creative flood management** (UK-led: Environment Agency). The aims are: (1) change public perception from flood prevention to flood risk management; and (2) develop a master plan in a Thames Gateway 'zone of change' - potentially buildings designed to allow for flooding, opportunities for controlled inundation of land, public information, emergency evacuation procedures.

**AMEWAM** (Morley Research Centre). The aims are: (1) integration of agricultural measures for water management into spatial planning; (2) develop and evaluate a set of transferable measures for water management; (3) develop and evaluate regional guidelines for site and field specific evaluation of water management measures; (4) develop and evaluate a coherent land use management system based on GIS-related info; and (5) transfer best practice and experience.

**ERDF INTERREG Programme.** Is concerned with international co-operative projects. The **IRMA Project**, initiated under INTERREG phase II-C (1997-2003), looked at the whole of the Rhine and the Meuse, with over 153 projects in over 6 countries, creating a number of Best Practise documents (<http://www.irma-programme.org>). The more recent INTERREG phase III programme (2000-2006) aims to stimulate cooperation between North Sea regions (<http://www.interregnorthsea.org>). Under this programme, the "Water Management" priority addresses the danger of flooding, water shortages and the deterioration of water quality. Projects of particular interest are:

**FLAWS** Flood Plain Land Use Optimising Workable Sustainability (<http://www.flows.nu>). Aims to provide a 'tool box' of techniques that planners, water managers and decision makers can use in decision support systems for areas facing increased flood risk from climate change.

**PURE** Planning for Urban-rural River Environments, North Sea Region (<http://www.purenorthsea.com>). Aims to develop and implement sustainable solutions for the problems of flooding, dehydration and poor water quality in the rural-urban fringe zones of medium-sized cities.

**FRaME** Flood Risk Management in Estuaries: Sustainable New Land Use in Flood Control Areas (<http://www.frameproject.org>). Seeks to reduce flood risk in North Sea estuaries by combining Flood Control Areas, where water can be stored when water levels are high, with alternative sustainable land use.

## 13. IAHS

The decade 2003-2012 has been designated the International Association of Hydrological Sciences (IAHS) decade on Predictions in Ungauged Basins (PUB; Sivapalan et al., 2003), with the aim of *"formulating and implementing appropriate science programmes to engage and energize the scientific community, in a coordinated manner, towards achieving major advances in the capacity to make predictions in ungauged basins"*. This is relevant to the problem of predicting the flood impacts of changes in land use and management, because the main problem with such predictions is that they have to be made without direct calibration against measurements. Any progress made in PUBs is therefore likely to be useful in predicting flood impacts.

## 14. Other UK initiatives

Ongoing work at **Leeds University** (Prof S. Lane) was reported in the Daily Telegraph (2/4/03, page 14) with the headline “Flooding is blamed on sheep and cows”. He is quoted as saying that large increases in sheep and cattle stocking densities have trampled upland pasture to such an extent that the ground now absorbs less water. Rainfall was more likely to runoff into watercourses and increase flooding risk downstream. There was nothing to suggest that recent increases in flooding were due to the weather. He said that there is still no major change in rainfall pattern since 1900 that can adequately explain the dramatic increase in floods.

The work was also reported in a contemporary article in Farmers Weekly in which an NFU spokesman disputed the conclusions reached by Lane and commented that he disagreed with Lane’s conclusions and that overgrazing could not be blamed for the increase in floods. The literature reviewed above however lends considerable weight to the argument that changes in agricultural practice are implicated in changes in water runoff patterns from land, at least at the plot scale. There is perhaps not much evidence to link the connectivity between what happens at the plot scale to what happens at the catchment scale, but an absence of evidence cannot be taken as evidence of absence of the effect seen in plots being promulgated downstream.

In agroforestry research at **IGER, North Wyke**, Devon, the introduction of trees at wide spacings into grassland has had a dramatic and easily perceptible impact on the hydrology of the area (R.O. Clements, pers. comm.). An implication of this observation is that planting trees at wide spacings (5 x 5m) could help increase infiltration into pastures.

Clements (**IGER, N. Wyke**) and Donaldson (**Univ. Bristol, Long Aston**) have recently acquired substantial funding to continue their work measuring runoff and the impact of a range of amelioration measures (principally simple changes in crop husbandry) in maize and other crops in the Parrett Catchment area of Somerset. No data are yet available. Dewar (**IACR, Brooms Barn**) and Donaldson (**Univ. Bristol, Long Ashton**) are investigating the impact of a range of understories in maize on wildlife, but the work may also lead to some conclusions about the effect of the understories on runoff.

The **Maize Growers Association** (MGA) considered importing a “Swiss drill” to test in the UK, but in the end a pioneering maize farmer (C. Moore) who is chairman of the MGA’s environment panel has done this and has it on test in this country. No results are yet available.

## 15. Other international initiatives

**International Flood Network** (<http://www.internationalfloodnetwork.org>). The objective is to facilitate international cooperation in flood management, with the aims of reducing the loss of life and damage caused by floods, and to promote policies and practices for a safe and sustainable future.

**The U.S. Climate Change Science Program (CCSP)**

(<http://www.climatechange.gov>). CCSP-supported research on land-use/land-cover change focuses on processes that determine changes in land cover and land use at local, regional, and global scales, and on how land cover and use will change over timescales of 10-50 years. One of the aims is to identify areas of rapid land-use and land-cover change and the extent and impact of major disturbances including flooding on land use and land cover.

**USGS Evaluation of Watershed Response to Land Use Changes**

(<http://www.werc.usgs.gov/redwood/watershed.htm>). The objective is to evaluate future damage to aquatic and riparian resources in north coastal California under different timber harvesting and road building scenarios, coupled with a probability analysis of floods of various magnitudes.



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**Nobel House  
17 Smith Square  
London SW1P 3JR  
[www.defra.gov.uk](http://www.defra.gov.uk)**

