4.0 Land Use

As explored in **Section 2.0**, the importance of land use to the geomorphology and ecology of upland rivers cannot be overstated. By 2015, the Water Framework Directive will require an integrated approach to managing water quality and quantity across whole catchments. The importance of connectivity between river systems and their catchments is emphasized in this new legislation.

This section reviews the legislative control of land use and the incentives available for the adoption of sensitive land use practices. In addition it examines in detail the practical options available for land managers who wish to adopt the principles of catchment sensitive farming and forestry. For clarity, links to key websites are provided at the end of this section.

4.1 Key land use issues

Surface water run-off

Probably the biggest single issue affecting upland catchments, poorly attenuated surface water run-off can have hugely damaging impacts on upland rivers. Changes in agriculture since the Second World War, have generally increased stocking levels on grassland, whilst arable cultivation has been undertaken in ever increasing field sizes, using larger and heavier machinery. Ground compaction on both land types has thus become greater, leading to increased speed of run-off.

As climate change becomes a reality, the increased intensity of rainfall onto badly managed land results in increased 'flashiness' of river flows. These can cause tremendous physical changes to rivers, with damaging erosion of banks and bed. The obverse of these huge flood events can be the low flows experienced during dry weather. Observations, often backed up by empirical data, show a reduction in the storage of water in upland catchments, often as a result of drainage of moorland and forestry. As a consequence, spate flows continue for shorter periods than historically, with very low base flows remaining. These extremes of flow not only cause physical damage to instream habitat, but can result in direct losses of important flora and fauna.

Planted coniferous forestry is a very significant source of run-off. Trees can cover many hectares of land, often on the steep slopes of hilly areas. Conifers are planted in straight rows, often down the side of hills, with associated extensive drainage of the land. As a consequence, run-off from the acidic build up of pine needles pours from the plantations into larger drainage systems, and ultimately into rivers. Not only is this run-off

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potentially damaging due to its high acidity, it also plays a part in mobilising toxic metal salts from the underlying geology. The most damaging of these are aluminium salts, deriving chiefly from bauxite, which affects permeability across the gill membranes of fish, often leading to their death.

These impacts can become acute following clear felling of coniferous plantations, with large scale erosion and catastrophic damage to spawning tributaries.

Areas of hard standing, and buildings can also contribute to increased rates of surface water run-off. This is a particular concern where new development has taken place, often in more urban and suburban areas. The use of so-called Sustainable Urban Drainage Systems (SUDS) is promoted by the statutory authorities to reduce the impacts of new building on peak run-off. Typically, SUDS might include the installation of balancing ponds, with 'throttled' outfalls (hydrobrakes), grassy 'swales' (linear infiltration trenches), and the use of porous hard surfaces that increase infiltration rates.

Run-off from agricultural buildings and areas of hard standing is of particular concern, due to the risks of contamination of surface water by pollutants including silage effluent and cattle waste. Recent increases in the usage of plastic wrapped 'big bale' silage have helped reduce the risk from silage effluent. However, numbers of traditional silage 'clamps' remain as a potential risk of contamination of surface water run-off. An additional concern is the mixing of roof drainage with yard drainage, increasing the volume and mobility of contaminated run-off. All of these sources of pollution may result in eutrophication (elevated nutrient status) of rivers. This can lead to excessive growth of algae, which can cause damaging reductions in dissolved oxygen levels, particularly during hot weather and periods of low flow.

Whole farm conservation plans represent one of the best possible mechanisms of addressing these issues. Rivers Trusts, and the Farming and Wildlife Advisory Group (FWAG) are well placed to provide integrated advice on key issues affecting watercourses

RUN-OFF FROM AGRICULTURAL BUILDINGS AND ASSOCIATED HARD STANDING CAN BE A SOURCE OF SEDIMENT AND NUTRIENT

Road run-off is of very serious concern, increasing both peak flows and sediment loading. Many rural roads receive un-attenuated run-off from agricultural land. This is often heavily silt-laden, particularly in areas of arable farming. Large numbers of cattle, slurry spreading, silage production and maize production, are all known to increase the input of nutrients to rivers ('eutrophication'). This can lead to an increase in algal growth and oxygen deficits during hot weather.

Run-off can flow for miles along the road network, increasing in volume as it collects water from more fields or from other roads, before entering the river via discrete drainage outfalls. In this way, diffuse source run-off can both bypass riparian buffer strips, and can also become a point source of pollution.

These so-called 'black smokers' are a very significant source of poor quality run-off. Identifying and tackling inputs to a river system can be an effective and cost beneficial method of reducing sediment and nutrient loading. By systematically walking the catchment during rainfall events, noting the location of 'black smokers' and reporting them to the river authority, highways authority or catchment sensitive farming officer is the first step to addressing their impact.

Mobilisation of sediment

The sediment load carried overland, into rivers during peak flood events also has the potential to cause great damage to river systems. The removal of trees and hedges, both in the floodplain, and the wider catchment, has significantly reduced the rate of infiltration of precipitation into the soil, increasing the speed and volume of run-off.

Certain crops, particularly maize and potatoes, are associated with an increased rate of mobilisation of fine sediment, with the phenomenon most noticeable in areas with fine, friable soils, for instance in the River Wye catchment in Wales and England. This fine sediment drops out of suspension as flows decline rapidly, coating stony substrate and reducing its value for juvenile salmonids. Entrainment of sediment into spawning gravels reduces trout egg hatch rate, thus reducing recruitment. Sediment can also carry with it chemically and physically bound pesticide residues. For instance, until their widespread use was recently banned, the prevalence of the herbicides simazine and atrazine bound to sediment particles was of great concern in a number of rivers.

There is also increasing evidence of the impact of eutrophication on grayling recruitment, with nutrients stimulating the growth of algae on the river bed, leading to decreased oxygen levels and higher levels of toxic un-ionised ammonia.

DIFFUSE SOURCE RUN-OFF CAN BE CHANNELLED INTO THE DRAINAGE NETWORK, FORMING POINT SOURCE DISCHARGES OR 'BLACK SMOKERS'

4.2 Addressing land use issues

4.2.1 Influencing landowners

In most cases, fisheries interests will not have control of major land holdings within river catchments, and cannot therefore directly limit damage done to their river by poor land management practices. Despite this, there are a number of ways in which landowners can be influenced to undertake management that is less damaging to the ecology of rivers. Perhaps the most productive route for individual owners and angling clubs is to join one of the increasing number of rivers trusts. Generally, these address riverine conservation issues on a catchment or perhaps regional basis. Some are run by volunteers, although many of the larger trusts have paid professional staff. Through links with the rivers authorities, farming community, the Farming and Wildlife Advisory Group (FWAG) and other local and statutory bodies, they are able to influence land use on a catchment scale. They can also prepare whole farm plans for individual holdings. These cover a range of land use issues including pollution prevention, and land management to optimise conservation value.

In all dealings with landowners and farmers, building strong and lasting relationships based on trust is key. Continuity of contact is important, with a single point of contact often the best option for minimising misunderstanding. Similarly, it is vital to be straightforward about the aim and objectives of any plans, with landowners respecting clear descriptions of proposed work. The benefits of any works to the landowners should be highlighted. These could include increased stock control, better bio-security and increases in the value of their sporting assets.

The development of 'Angling Passport Schemes' promotes the value of small, previously difficult to let sections of upper-river and tributary fishing for the benefit of both angler and landowner. These schemes offer a great mechanism for not only convincing landowners of the benefits of stream protection and development, but also for highlighting the value of smaller channels to the wider catchment, particularly with respect to trout recruitment. Full details can be found at www.wildtroutfishing.co.uk and www.wild-fishing-scotland.co.uk

Financial incentives and legislative control measures available to influence land usage are examined in more detail in **Sections 4.2.2** and **4.2.3** below, whilst **Section 4.2.4** deals with practical management options that can be promoted.

4.2.2 Financial incentives and agri-environment schemes

The Common Agricultural Policy (CAP) has spawned a range of agri-environment schemes, with the aim of ameliorating the impacts of farming on nature conservation interests. Over time, the percentage of the CAP that is given to these schemes has increased, under the policy of 'modulation'. Delivery of these agri-environment schemes varies between EU members states. Of those countries covered by this manual, the chief mechanisms are as follows:

England: Countryside Stewardship (CS) and Environmentally Sensitive Area (ESA) payments. These are old schemes, superseded by the Entry Level Scheme and Higher Level Schemes (see below). However, a number of pre-existing CS and ESA have a few years left to run and can thus still deliver environmental benefit.

COVER STRIP PLANTED AS PART OF THE ELS SCHEME. THIS TYPE OF HABITAT IS OF GREAT VALUE FOR BIRDS AND INSECTS, WHILST ALSO HELPING TO DETAIN SEDIMENT AND ATTENUATE SURFACE WATER RUN-OFF.

Entry Level Stewardship (ELS): This pays a flat rate of £30/ha/year (with the exception of parcels of land >15ha within the moorland line for which a payment of £8/ha/year is made) on achievement of adequate 'points' for the retention and development of environmentally favourable land use over the whole farm. The scheme is open to all farmers and is non-competitive (i.e. all those who reach the target level of points will receive the payment). Agreement is generally for 5 years. Features that qualify for points include the planting of wild bird cover and nectar rich seed mixes, creation and maintenance of buffer strips, and the development of beetle banks. An Organic Entry Level Stewardship (OELS) scheme is also available.

Higher Level Stewardship (HLS): Higher Level Stewardship (HLS) aims to deliver significant environmental benefits in high priority situations and areas. It involves more complex environmental management, so land managers will need advice and support. HLS is usually combined with ELS or OELS options, but unlike these, entry into the scheme is discretionary. A wide range of management options are offered, which are targeted to support key features of the different areas of the English countryside. HLS agreements are for ten years and can include payments for capital items such as hedgerow restoration.

SPAWNING STREAM WITH A WELL DEVELOPED BUFFER STRIP

Natural England has produced a set of targeting maps to increase the environmental benefits delivered through HLS. The targeting maps are the first systematic joining together of information on biodiversity, landscape, natural resource protection, public access and historic interests. Natural England is actively seeking applications in target areas, and for key interest features outside these areas.

Wales: Tir Cynnal is the agri-environment entry level scheme for Wales. Farmers who join this scheme must protect the important environmental areas and features on their land. Although participation is voluntary, once farmers enter the scheme agreements must run for a minimum of 5 years. After this they will have the option of continuing for the full 10 years. Tir Cynnal is a whole farm scheme and farmers must agree to enter all of the land for which they have full management control. Farmers cannot be paid under Tir Cynnal for activities that are also being paid for under another scheme on the same land.

Tir Gofal is the Welsh Assembly Government's higher level agri-environment scheme. It is available on farmed land throughout Wales, and rewards farmers for caring for the environmental, historical and cultural features on their land.

From 2012, all agri-environment schemes in Wales will be consolidated into a single initiative known as Glastir. As a consequence of these changes, no new applications for Tir Cynnal or Tir Gofal are being accepted.

Scotland: Scottish agri-environment schemes are delivered through a series of Rural Priorities administered under the Rural Development Contracts scheme. Options that can attract funding include amongst others, soil and water management, nutrient management schemes, management of wetlands and the treatment of pollutants via bio-beds.

Northern Ireland: The Northern Ireland Conservation Management Scheme (NICMS) aims to:

- improve biodiversity
- improve water quality
- mitigate climate change
- improve soil quality
- avoid marginalisation and land abandonment

There is a target of having 50% of agricultural land in NICMS by 2013. This equates to around 18,000 farm businesses.

Republic of Ireland: The Rural Environment Protection Scheme (REPS) is a scheme designed to reward farmers for carrying out their activities in an environmentally friendly manner and to bring about environmental improvements.

The objectives of the Scheme are to:

- Establish farming practices and production methods which reflect the increasing concern for conservation, landscape protection and wider environmental problems;
- Protect wildlife habitats and endangered species of flora and fauna;
- Produce quality food in an extensive and environmentally friendly manner.

Farmers are expected to have prepared by an approved Planning Agency an agri-environment plan for their farm for a period of 5 years. This should comply with 11 basic measures including a farm nutrient plan, maintaining wild life habitats, reducing herbicide, pesticide and fertiliser usage, and protecting all watercourse and wells.

REPS annual payment is €200 per hectare for the first 20 hectares, €175 per hectare for the next and €10 per hectare for the remaining hectares. Additional payments are made for commonage land, Natural Heritage Areas, Special Areas of Conservation (SAC) and Special Protection Areas (SPA).

Catchment Sensitive Farming:

England: The Catchment Sensitive Farming (CSF) programme aims to develop measures to tackle diffuse water pollution from agriculture (DWPA) to meet Water Framework Directive requirements. CSF promotes land management that keeps diffuse emissions of pollutants to levels that are consistent with the ecological sensitivity and uses of rivers, groundwaters and other aquatic habitats, both in the immediate catchment and further downstream. Farmers are encouraged to adopt best practice over a range of issues, including the use of fertilisers, manures and pesticides; to promote good soil structure to maximise infiltration of rainfall and minimise run-off and erosion; to protect watercourses from faecal contamination (e.g. with fencing and livestock crossings), and from sedimentation and pesticides (e.g. with buffer strips) and to reduce stocking density or grazing intensity.

The CSF programme takes forward the Government's strategic review of DWPA in England, by promoting voluntary action by farmers in 50 priority catchments to tackle the problem of DWPA.

A list of these catchments can be found at:
http://www.defra.gov.uk

CSF officers have been appointed for each catchment. They are imbedded with Defra, the Environment Agency or Natural England, and can be contacted for advice at the relevant local office.

The recently launched Campaign for the Farmed Environment is a voluntary agreement with the aim of replacing ecologically valuable land that was lost as a result of the abolition of set-aside. Farmers are encouraged to farm parcels of land so as to optimize their ecological value. Management options include the creation of wide buffer strips, game cover, and over-wintered stubbles. If this voluntary approach proves not to be successful, legislation to enforce these changes is expected in 2012.

FLOWER RICH GAME COVER CAN PROVIDE BENEFITS TO A RANGE OF SPECIES

Wales: The Welsh Assembly has adopted a different approach to CSF, with the focus on two demonstration projects aimed at promoting CSF. The projects are based in an intensive lowland dairy catchment in South West Wales, and two neighbouring upland livestock farming catchments in North Wales.

Within these areas the project partners will work with the farming community to raise awareness of how farming practices affect the health of water bodies. They will encourage the adoption of CSF practices to reduce diffuse pollution. Water quality monitoring will be used to demonstrate key issues to the farming community and highlight progress.

Scotland: No specific CSF scheme is at present in place in Scotland. However, a series of agricultural management best practice guidelines are available.

Northern Ireland: CSF issues are dealt with by the Department of Agriculture and Rural Development under their Rural Development Strategy for the period 2007-13.

SPAWNING TRIBUTARY BADLY DEGRADED BY OVER-GRAZING AND TRAMPLING

4.2.3 Legislative control

Consensus in land management is clearly desirable. Where possible, fishery interests should endeavour to work with farmers and other land managers, possibly using the agri-environment options detailed above.

Where consensus fails however, there are a number of potential legislative mechanisms whereby good land management can be enforced. These include:

Cross compliance measures under the Single Farm Payment. Farm payments provided by the EU under the CAP are now made as a Single Farm Payment. This payment is independent of production levels, but is dependent on adherence to a number of 'cross compliance' conditions. These place obligations on claimants, including the management of farmland soil, pesticide usage, protection of watercourses, maintenance of landscape and the protection of habitats. Failure to adhere to these conditions by farmers may result in the loss of a percentage of their Single Farm Payment. Cross compliance is thus a potentially powerful tool that can be used against landowners whose management practices are damaging rivers systems. The relevant statutory authority controlling agricultural payments in each country will enforce this legislation if required.

Code of Good Agricultural Practice: This is non-statutory guidance available to farmers on how to manage their farms so as to minimise risks of environmental damage, and to optimise benefits to biodiversity. Some sections of the code provide advice on how to avoid breaching current legislation, particularly with reference to the use of pesticides and the protection of water. By 2015, the Water Framework Directive will require an integrated approach to managing water quality and quantity across whole catchments. Following the legal requirements and good practices in the Code will help farmers achieve the standards which will be set.

CLEAR FELLING CONIFER PLANTATIONS CAN LEAD TO SERIOUS WATER QUALITY ISSUES

Forestry practice: Detailed policies covering all aspects of forestry work have been prepared by the forestry authorities. Reference to these policies may prove helpful in addressing poor forestry practice that affects the ecology of upland rivers.

Specific guidelines covering 'Forests and Water' have been published by the Forestry Commission. Revised in 2003, these guidelines cover forestry operations that could affect watercourses, with protection and mitigation measures highlighted. They are a good source of information regarding the workings of the forestry trade, and its possible impact on river systems. A useful summary of current water regulation legislation is also provided in the publication.

4.2.4 Practical measures at a local scale

Influencing land use, by agreement or if necessary, by law, will require a considerable expenditure of time and effort meeting and talking with landowners. Much of this work will involve written correspondence, emails, telephone calls and face to face meetings. The outcomes of this effort can have hugely beneficial impacts on a catchment-wide scale particularly if anglers' efforts are combined, perhaps through the local river's trust.

Just as important however, is the implementation of control measures on a local scale. Influencing farmers, foresters, landowners and statutory authorities to adopt policies that positively favour the ecology of river systems may not be easy. Working with them on small-scale projects may provide evidence of the efficacy of such polices, leading to their wider adoption over larger areas. A selection of useful management strategies are discussed below.

It is imperative that any measures to control the impact of land use are conducted as close to the source of the problem as possible. For instance, run-off from agricultural fields is best tackled at the individual field level. This philosophy should underpin all catchment based management. Although this may seem a small, localised approach to tackling catchment-wide management, their cumulative impact will be hugely significant.

Angling groups can highlight key areas of concern to river authorities. A strategic review of run-off hotspots, including 'black smokers' should be carried out, with detailed locations noted, ideally using an OS grid reference or GPS co-ordinate. Photos should be taken showing run-off pathways and entry points of pollution plumes into the river. Data should be recorded in a standard format on a form, which can then be submitted to the river authority. Working with the authority in partnership, key sources of sediment can be prioritised and remedial action taken.

POORLY LOCATED FEEDING AREAS CAN EXACERBATE SOIL EROSION INTO RIVERS

Agriculture: The rate of surface run-off from areas of upland grassland is increased by grazing with cattle and sheep. Even relatively low densities of stock have been shown to cause soil compaction and thus reduce rates of infiltration, with higher densities of livestock exacerbating the problem.

Removing stock and allowing species of rough grass to re-grow considerably increases infiltration rates and reduces the volumes of run-off. An even greater benefit can be obtained by planting shelter belts of hardwood trees in strategic locations, generally across the contours of fields. Research undertaken in mid-Wales as part of the Pont Bren project, has shown that these narrow belts of trees can increase infiltration of overland flow by as much as six-fold. Overall, this can reduce flood peaks by upwards of 29% for frequent events. From an agricultural perspective, shelter belts offer wide-ranging advantages. They provide wind protection for stock, particularly lambing ewes and their offspring. The width of the zone of wind protection is greater than for similarly sized conifer belts, with the result that sheep spread out, and poach the ground adjacent to the belts far less. This helps with hygiene and welfare, in particular reducing rates of foot rot. There are direct benefits to conservation from the shelter belts, which also provide a valuable timber and firewood resource as they grow.

The other major upland agricultural practice that significantly affects rivers, is the so-called 'gripping' of moorland areas. Large areas of moor have historically been drained in the mistaken belief that this would benefit both grouse *Lagopus lagopus* and livestock. This practice reduces the ability of the soil to retain water, with 'flashy' flows in receiving watercourses occurring as a result. In addition, the drier soils are more prone to wind erosion during the summer, whilst the loss of waterlogging increases the mobilisation of peat and metal salts from the soil. This can be a particular problem with metal salts and fine peat damaging fish spawning habitat in small streams.

A number of large-scale projects have sought to reverse the worst impacts of gripping. Work undertaken in Wharfedale, North Yorkshire, used a combination of straw bales, heather bales and peat dams to block some of the existing grips over an area of some 17 km^2, to slow down run-off and thus increase infiltration rates. Monitoring of the effects of this work have shown that grip blocking reduces run-off volume by up to 24%.

DEGRADED MOORLAND ON BLEAKLOW
(*Photo © Moors for the Future: www.moorsforthefuture.org.uk*)

Surface run-off from arable fields can also be hugely damaging to upland river systems, increasing peak flows and adding excessive amounts of fine sediment. Maize and potatoes are particularly damaging crops, especially on friable sandstone soil, as found in much of Devon and the River Wye catchment. Ideally, cultivation of this type is stopped. However, where this is not possible, mechanisms should be put in place to control excessive run-off. Sediment pathways should be identified. This is easily undertaken by visual observation of key fields during heavy rainfall. Often, sediment can be retained within the field by the use of well-vegetated field margins. These can be promoted to farming interests under the various agri-environment schemes discussed earlier in the section. Rough grass allowed to grow in these strips detains fine sediment and increases infiltration of water. It is also important to identify sediment pathways that bypass these strips. Typically, these include farm tracks and gateways. A little careful thought and planning can reduce their impact. For instance, the installation of a cattle grid at a field entrance prevents run-off from leaving the field. Provided that the fall of the land is suitable, a large, piped outlet from the base of the cattle grid can then be used to direct flow to a suitable attenuation zone, perhaps a rough grass field, wetland area, or grassy swale. Once again, it should prove possible to get funding for some of this work.

SEVERE EROSION IN A CORNISH CATCHMENT

Similar mechanisms can be used to help catch flow passing along field ditches, that would again potentially bypass grass margins. It may be possible to block ditch systems at key locations, creating a wetland area outside the arable field. Careful excavation of the selected area can create wader scrapes, duck flighting ponds or areas of wet grassland. A network of these features can help to control run-off and sediment mobilisation, whilst providing sporting and ecological benefit.

MONITORING OF NEWLY PLANTED DECIDUOUS TREE STRIPS AT PONT BREN

SEDIMENT ACCUMULATING IN A SMALL UPLAND STREAM AS A RESULT OF EXCESSIVE EROSION

Forestry:
Coniferous forestry often involves a densely planted mono-culture or very simplified species mix. Prior to planting, gripping and ditching of the site is undertaken. Research has clearly shown that this leads to erosion of the site, excessive sediment mobilisation and increases in run-off rate.

Recent guidelines (see 4.2.2) suggest mechanisms to minimise these damaging impacts. A watching brief should be kept on any forestry operations in the catchment to ensure that they follow the advice contained in these.

Excessive supply of sediment has been identified as a key issue for many rivers. In many cases, fine sediment enters rivers as a result of soil erosion from agricultural fields or areas of extensive forestry. These issues are covered elsewhere in this section.

In some upland rivers however, over-supply of coarse sediment (gravel and cobbles) has been a problem. Typically, this has been addressed by the construction of in-river gravel traps. These are sections of over-widened and over-deepened channel, often delineated by upstream and down-stream concrete sills. Excess gravel collects in these engineered river sections. Regular emptying is required in order to maintain the systems efficiency. Gravel traps are expensive, labour intensive and do not address the source of the problem. They are also potentially very disruptive to river processes and trout habitat.

A gravel trap similar to this had been installed near Buckden in the upper River Wharfe, Yorkshire, in the 1980's. In addition to construction of the trap, the work had involved significant hard bank revetment and the re-alignment of a tributary stream, the River Cray. Over time, dissatisfaction with the works grew, with particular concerns being the resources required to maintain the traps efficacy, and the changing legislation covering gravel removal from rivers. Research was implemented in an effort to identify the source of the excess gravel entering the Wharfe and travelling down the river. The study showed that the rate of accumulation of sediment in the Wharfe was un-naturally high largely due to erosion from key tributary 'gills' (small, steep sided streams) which had been historically de-forested. By carefully targeted planting of deciduous trees along the gill sides, sediment erosion and transport into the Wharfe was reduced by 85%, removing the need for the gravel trap and hard bank engineering. Subsequent to the success of this approach, the gravel trap was removed and the reach restored to a more natural form.

Acidification:
Many upland catchments are naturally acidic in nature, a direct consequence of their solid geology. Man made changes to both land-use, particularly extensive coniferous forestry, and to acid precipitation as a result of nitrous and sulphurous emissions from industrial processes, have increased this acidity in many catchments.

It is believed that up to 80% of Scotland's acidification is in Galloway. Water quality monitoring by Galloway Fisheries Trust (GFT) has attributed much of the acidification to inappropriate coniferous forestry planting in key watersheds. Electrofishing surveys have confirmed that fish populations in afforested streams are severely depleted or in some cases, extinct, even in areas known historically to be important salmonid spawning areas. In addition to juvenile fish surveys and direct water quality monitoring, eyed ova planted into the gravel in egg boxes are used to show impacts on salmonid eggs. These data have been used by GFT to direct change to forestry plantations in sensitive streams, largely through the use of the Forest and Water Guidelines (4th Edition). These rely heavily on the concept of Critical Load Analysis (CLA) to identify areas at risk of acidification, and prevent damage to them from future planting. However, GFT and many other organisations have limited faith in the current system, and are working to improve the sensitivity of CLA, in order to ensure recovery of all Galloway's streams from the impacts of acidification.

APPLYING LIMESTONE SAND TO A HEADWATER STREAM IN THE TOWY CATCHMENT

Acidification of other catchments has been addressed by liming. The Towy in South West Wales is one of Britain's best sea trout rivers. However, runs of both sea trout and salmon declined in the 1970s and 1980s, as a result of acidification to both the main river and its tributaries.

Liming was considered as a technique to reverse this acidification. Three techniques were considered:

- **Whole catchment liming**. Probably the most effective technique in terms of water quality improvement. However, it would have been very expensive and would have been likely to have significant detrimental impacts on terrestrial ecology adapted to acidic conditions. A more targeted liming of water sources proved more cost effective and less ecologically damaging, but had less beneficial impact on the river's pH over time.
- **Lake Liming of Llyn Brianne**, a large reservoir situated towards the top of the Towy. This involved introducing lime directly to Brianne on an annual basis. Positive aspects of this approach were that it was relatively cost effective and there were no impacts on the surrounding land. However, the benefits to water quality waned after six months, allowing re-acidification to occur.
- **Direct dosing of the Towy** and tributaries upstream of Llyn Brianne, using mechanical dosers dispensing carefully measured volumes of powdered limestone in response to water quality in the streams measured by automatic monitors. This system produced good results, with an improvement in the aquatic ecosystem downstream of the reservoir. It was flexible, being able to respond rapidly to changes in water quality due to increased flows. Dosing upstream of Brianne increased the buffering capacity of the reservoir, allowing beneficial impacts to continue even when the dosing plant failed for short periods. Of equal importance was the cost effectiveness of the methodology.

4.3 Case Study: Pont Bren

A number of research projects have been undertaken examining the role of land use on run-off of rain water from uplands. One of the most recent and indeed, most interesting is the Pont Bren project. Started by a group of local farmers who formed a limited company in order to manage their land in a more sustainable, yet still profitable manner, Pont Bren spawned a number of innovative studies, examining the benefits of some of the agricultural changes undertaken.

One of the most important discoveries of the study was that using the simple mechanism of planting shelter belts of native deciduous trees at strategic locations on grazed land, the rate of overland flow during high rainfall events was dramatically reduced. Similar effects were observed when grazing of comparable parcels of land was stopped. The reduction in overland flow associated with both types of management change were ascribed to increases in the infiltration rate of surface water, due to a more open soil structure. Measured infiltration rates increased 600% within the shelter belts, with the peak overland flows from frequently observed rainfall events reduced by up to 29%, and flows from extreme events by 5% within the small headwater catchments of the Severn in which Pont Bren lies.

One clear advantage for farmers of the shelter belt approach is that it allowed them to continue sheep grazing; clearly, the option of removing stock to allow ungrazed pasture does not. The shelter belts had additional agricultural benefits including:

- An increase in the width of shelter created on the downwind side of the trees in comparison to more traditional dense conifer belts. The latter produce a very narrow area of shelter, into which sheep crowd, increasing poaching and contamination (by faeces and urine) of the ground. This led to high rates of foot rot. Deciduous shelter belts provide a more open structure, with a wider area of wind shelter, allowing sheep to spread out more and hence reducing disease problems.
- The deciduous trees provide a productive source of both firewood by rotational coppice/hedge laying. Smaller branches are chipped and used initially as bedding for sheep in the winter, and subsequently as growing medium in a tree nursery run on one of the farms at Pont Bren,
- A direct biodiversity gain, increasing the area of woodland on the farms, benefitting a range of birds, and invertebrates.

PONT BREN STUDY SITE SHOWING RECENTLY PLANTED DECIDUOUS TREES

Further information on the benefits of tree planting for controlling run-off can be obtained from:

http://www.floodrisk.org.uk/images/stories/Phase1/ur16_impacts_upland_land_management_wp2_2_v1_0.pdf

http://www.therrc.co.uk/case_studies/upper%20wharfedale%20information%20series%20-%20no%202.pdf

http://www.therrc.co.uk/case_studies/upper%20wharfedale%20information%20series%20-%20no%206.pdf

http://www.therrc.co.uk/pdf/References/Lane_2006.pdf

4.4 Useful Links

Surface Water Run-off:

Further details regarding the use of SUDS can be obtained at

http://www.ciria.org.uk/suds/

http://www.environment-agency.gov.uk/business/sectors/36998.aspx

Rivers Trusts:

Details of river trusts can be found at

http://www.associationofriverstrusts.org.uk/ (England),

http://www.rafts.org.uk/home/home.asp (Scotland)

http://www.afonyddcymru.org (Wales)

Use and control of grazing animals for conservation:

http://www.grazinganimalsproject.org.uk/gap_publications.html

The impact of simazine and atrazine:

http://www.cdpr.ca.gov/docs/emon/pubs/fatememo/simazine.pdf

http://www3.interscience.wiley.com/journal/62004564/abstract?CRETRY=1&SRETRY=0

Financial Incentives and agri-environment Schemes:

England:

Entry Level Stewardship:
http://www.naturalengland.org.uk/ourwork/farming/funding/es/els/default.aspx

Higher Level Stewardship:
http://www.naturalengland.org.uk/ourwork/farming/funding/es/hls/default.aspx

Wales:

http://new.wales.gov.uk/topics/environmentcountryside/farmingandcountryside/farming/agrienvironmentschemes/?lang=en

Details of the new Glastir scheme
http://wales.gov.uk/docs/drah/publications/090813axis2pressnoticeen.pdf

Scotland:

http://www.scotland.gov.uk/Topics/Rural/SRDP/RuralPriorities

Northern Ireland:

http://www.ruralni.gov.uk/environment/countryside/schemes

Republic of Ireland:

http://www.agriculture.gov.ie/farmerschemespayments/ruralenvironmentprotectionschemereps/overviewofreps/

Catchment Sensitive Farming:

England:
http://www.defra.gov.uk/foodfarm/landmanage/water/csf/index.htm

Wales:
http://new.wales.gov.uk/topics/environmentcountryside/consmanagement/csfarming/?lang=en

Scotland:
http://apps.sepa.org.uk/bmp/Default.aspx

Northern Ireland:
http://www.dardni.gov.uk/index/strategies-reports-accounts/strat-reports-accounts-dard-rural-strategy-2007-2013.htm

Cross compliance measures under the Single Farm Payment.

England:
http://www.crosscompliance.org.uk

Wales:
http://www.adlib.ac.uk/adlib/browse.aspx?group=4005101&id=174890

Scotland:
http://www.scotland.gov.uk/Publications/2005/12/0990918/09199

Northern Ireland:
http://www.dardni.gov.uk/index/grants-and-funding/cross-compliance.htm

Republic of Ireland:
http://www.agriculture.gov.ie/ruralenvironment/environmentalobligations/crosscompliance/

Code of Good Agricultural Practice:

England:
http://www.defra.gov.uk/foodfarm/landmanage/cogap/index.htm

Scotland:
http://www.scotland.gov.uk/Topics/farmingrural/Agriculture

Wales:
http://new.wales.gov.uk/topics/environmentcountryside/farmingandcountryside/farming/codesofgoodagripractice/?lang=en

Northern Ireland:
http://www.ruralni.gov.uk/index/environment/countrysidemanagement/cogap.htm

Forestry practice:

Forest and Water Guidelines:
http://www.forestry.gov.uk/pdf/FCGL002.pdf/$FILE/FCGL002.pdf

England, Scotland and Wales:
http://www.forestry.gov.uk/

Northern Ireland:
http://www.forestserviceni.gov.uk/

Republic of Ireland:
http://www.coillte.ie/

http://www.agriculture.gov.ie/forestservice/publications/codeofbestforestpractice/

Grip Blocking on Moorland:

http://www.therrc.co.uk/case_studies/upper%20wharfedale%20information%20series%20-%20no%203.pdf

Acidification:

http://www.gallowayfisheriestrust.org/research-projects.asp

http://www.associatedcontent.com/article/112899/the_effects_of_acidification_and_lime.html?cat=58

References cited

1. *The hyporheic zone of running waters: ecological patterns, processes and bottleneck functions* Dietrich Borchardt and Martin Pusch [Eds.] Authors´ addresses: 1 Philipps University Marburg, Department of Biology, Working Group Animal Ecology, Karl-von-Frisch-Str., D-35032 Marburg, Germany.

2. *Cascading effects of eutrophication on intragravel life stages of European Grayling (Thymallus thymallus L.)* Hübner D, Borchardt D, Fischer J. Manuscript to be published in Arch. Hydrobiol. (Advances in Limnology): *The hyporheic zone of running waters: ecological patterns, processes and bottleneck functions* Dietrich Borchardt and Martin Pusch [Eds.]