Ecosystem fertility and salmon smolt production in Wester Ross

Summary of meeting organised by Wester Ross Fisheries Trust at Gairloch Community Hall, 30th November 2007

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This report has been prepared as a non-technical summary for all participants at the meeting. Please contact Peter for contact details of any of the participants or for more information about the workshop.

1. Introduction

As a species, the Atlantic salmon has been around for a long time. Salmon evolved as part of an environment and ecosystem that is different from that which we see nowadays. Because adult salmon generally home back to where they came from, the number of adult fish that return to a river is proportional to the number of juvenile fish that go to sea (known as 'smolts').

Salmon are adaptable, able to colonise vacant habitat and to proliferate. It's only 10,000 years since salmon first recolonised the rivers of Wester Ross at the end of the last period of glaciations. Much has changed since then with the development then loss of forest cover and the loss of large predatory animals such as bears.

Overt the last few hundred years, human activities have done much to change river catchment areas. Until 200 years ago, cattle were grazed over much of the Highlands during the summer time. Then sheep were introduced, followed by the development of sporting estates[1].

Are the rivers of Wester Ross as productive as they once were? Should they be described as 'natural'? Should actions be taken to restore and enhance levels of fertility and the production of young salmon from our rivers (and thereby, the numbers of adult fish returning)?

The meeting was chaired by Johnie Parry (WRFT Chairman) who provided an introduction. The meeting focused on the production of Atlantic salmon (*Salmo salar*) in Wester Ross. The main aim was to learn more about production of *juvenile* salmon from the rivers of Wester Ross in relation to the fertility of the ecosystem of which they are a part.

The following sections summarise the presentations at the meeting.

[1] The grazing history of the N. Highlands is summarised in an article by Reay Clark (1995) 'The land of northern Scotland: 200 years of sheep – 1795 -1995' which appeared in the Heather Trust's Annual Report 1995. Thanks Reay!

2. Production of salmon smolts from oligotrophic [nutrient limited] streams

Dr John Armstrong, FRS Freshwater Laboratory,

John has researched the ecology and behaviour of juvenile salmon for over 15 years, progressing a series of lab and field based investigations, with many published papers. He currently leads the Freshwater Ecology group at FRS and also works closely with colleagues in other parts of Scotland and further a field to develop a clearer understanding of the factors which relate to fisheries production.

Atlantic salmon bring back nutrients to headwater streams, thereby linking river systems with ocean ecosystems. Many of the streams where salmon spawn are at a high altitude, have low nutrient concentrations and experience cold winters.

Juvenile salmon need to balance their need to grow with their need to avoid becoming prey for other animals. To become a smolt, they need to reach a length of about 9cm [by the end of summer before they go to sea?]. Where there is abundant food, juvenile salmon tend to be nocturnal, only coming out from hiding places in the streambed to feed at night. When food availability declines, rates of growth decline.

Until recently it was thought that the territorial behaviour of juvenile salmon determined the 'carrying capacity' of any given stream [the number of juvenile fish the stream is able to support]. However, it is now known from PIT [Passive Integrated Transponder] tagging studies that although some salmon may aggressively defend small territories of less than 1m, others may range over distances of 12m or more, and their territories or ranges may overlap with those of other fish. Some fish are very aggressive; others are more cautious and opportunistic. Like people, it seems there are lots of different 'personalities'. It has even been shown that juvenile salmon are able to recognise and act less aggressively towards kin than to non-related individuals.

From stock-recruitment curves produced from field data, it can be shown that above a given level of egg deposition within a stream, the level of production of juvenile salmon does not increase. The relationship between egg deposition and the production of smolts is a little more complex than this: the distribution of nests is important. As fish grow they require more space. If nests and eggs are concentrated in a small part of a stream, hatchlings and fry may be too crowded together in some areas when in other areas there is vacant habitat.

As juvenile salmon grow larger they require more space and the carrying capacity falls. Where fish grow quickly and evenly, there is little overlap in the size lengths of fish of different year classes (ages) and little inter year class competition. However, where juvenile salmon grow slowly, some of the younger fish may be as large as the older fish and there may be competition between year classes for shelter and food, reducing the production of smolts.

The timing of river entry and smolt departure of salmon belonging to different populations varies. Smolts tend to depart from upland areas earlier than those from lowland streams primarily for adaptive genetic reasons. Over 50% of smolts may be taken by predators on their way to the sea especially where they pass through lochs (e.g. Hydro lochs in the River Conon system).

Questions

John Corbyn asked whether it was proposed that nutrient levels be increased in streams. **Dana Warren** ?indicated that experimental trials were being considered. **JA** answered that any proposal would need to be discussed with SNH and SEPA.

Nigel Pearson asked whether nutrient levels might affect run timing. The River Ling was noted for ‘spring’ salmon (salmon entering the river during the spring months). Is there a risk that higher nutrient levels might affect run timing? **JA** there was insufficient information about what causes a salmon population to have ‘spring’ running tendencies.

Derek Roxburgh asked about impacts of higher nutrients on Freshwater pearl mussels. **JA** acknowledged the risk and replied that the entire ecosystem would need to be considered.

Richard Munday asked about systems with lochs. How do lochs affect juvenile salmon production? **JA** replied that recently there had been more work on main river production but still little was known about production from lochs. Kelts that die settle in lochs. Care needs to be taken to avoid introductions of alien fish species.

Mark Pattinson asked about rates of egg to smolt survival. **JA** replied that it varies according to a wide range of factors.

Johnie Parry asked about stocked fish – how do they behave? **JA** replied that if they have been stocked before first feeding, they tend to behave like wild fish. If they have been fed, it takes them a while to readjust to the natural environment. If too many are stocked, shelters become ‘clogged’; there is insufficient shelter for all fish so some are displaced.

3. Salmon carcasses and stream fertility

Dr Keith Williams

Ness and Beauly Fisheries Trust

Following completion of PhD research studies on the River Bran (Conon River system) described bellow, Keith was appointed fisheries biologist for the newly formed Ness and Beauly Fisheries Trust.

A salmon carcass represents about 15g of phosphorus, enough fertiliser to produce 5kg to 7.5kg of plant material. There are many ways a salmon carcass can contribute nutrients of marine origin to a river. Eggs may be eaten by other fish (including salmon parr) and metabolic products including nitrates can enhance primary production. In North America, pacific salmon are ‘keystone species’ in the ecosystems of the Pacific Northwest. Bears remove salmon from the streams, eat them, then go into the woods to do what bears do, thereby fertilising large areas. Studies using stable isotopes have investigated levels of salmon derived marine nutrients in tree cores and bear hairs.

Does addition of salmon carcasses increase the abundance of juvenile salmon?

To investigate how Atlantic salmon carcasses might affect production of juvenile salmon in Scottish rivers, an experiment took place on the River Bran, a tributary of the River Conon. Six burns, each between 6m and 8m wide were selected. Into each burn, salmon fry had been stocked annually, and burns supported populations of both salmon fry and salmon parr.

Experimental treatments were as follows. Salmon carcasses (male salmon kelts from Conon hatchery) were added to each treatment section (100m long) at different concentrations from zero (controls) up to a maximum of one carcass per 15m^2 of stream. Upstream of each treatment section, a 100m control section was also identified. A stretch of both sections were electro-fished in July and August.

Fish were measures and weighed, and regression analyses were used to investigate relationships between treatment levels and differences in salmon biomass. No relationship could be detected between levels of carcass addition and salmon fry. A positive relationship between overall salmon biomass and treatment level was detected, however, and there was also a positive relationship between carcass addition and salmon parr biomass. In terms of overall salmon biomass, at the higher levels of carcass addition (over 60% of the maximum carcass input) the regression model predicts an approximate doubling of biomass. The relative contribution of density and weight to increased biomass was calculated with 73% being ascribed to the former and 27% to the latter. Above one site where salmon biomass was particularly high, a dead deer was found and the stretch was excluded from the statistical analysis.

What happens to salmon carcasses in streams?

This experiment demonstrated that salmon carcasses can increase salmon biomass in streams. However, in the experiment salmon carcasses were manually set into the stream bed in wire cages with rocks holding them in position to prevent them from being removed by scavengers (otter, mink) or from being washed downstream.

What happens to salmon after they spawn? To investigate, 38 salmon were radio tagged in the River Bran in 2003 and 2004 and tracked until June the year after spawning. Of these, 4 left the study area shortly after being tagged, 12 (35%) successfully vacated the study area after spawning, 12 (35%) died in the river where their carcasses decomposed, and 10 (30%) died or were washed into lochs after the spawning period.

Loch Ness Mystery

Sediment cores in Loch Ness demonstrate how nutrient levels have varied greatly since the ice age. Nutrient levels were high after the ice age due to the amount of glacial material left behind. They fell thereafter probably as the forests developed and locked the nutrients in. Old forests tend to leak nutrients. In response to the development of a rich forest ecosystem within the catchment area, nutrient levels rose gradually, then sharply during a brief period of deforestation. Thereafter nutrient levels fell to a lower level than before the forests were cleared until more recent anthropogenic inputs have once again gently raised nutrient levels. Levels of fertility in river catchments have changed over time. Highland streams should not be considered to be in a pristine state (as SEPA and SNH sometimes assume).

In conclusion: The contribution from salmon themselves to juvenile production is likely to be small but significant at local levels. However, nutrients are very important in salmon production and should be the focus of more attention in the future. Rather than assuming that less nutrient is always the more desirable, ‘more natural’ state, we (& environment agencies) should ask ‘what is the appropriate level of nutrient?’ for any particular stream.

Questions

Terry Doe asked about deer carcasses in river. **KW** Indigenous people in N America return skeletons of salmon to rivers. Deer and sheep accumulate nutrients from the vegetation. If they are removed from a catchment area, the nutrient is lost.

John Webb asked if carcass retention would be higher with more woody debris? **KW** riparian buffer strips would help, and also provide terrestrial insects for fish. The trees have gone. . .

Keith Nislow salmon eggs and newly emerged fry in the spring provide food for juvenile salmon – all from maternal origin. In the river Imsa, salmon eggs and fry ?can contribute up to 20% of nutrient flux

4. Predators: what do they mean to you?

Peter Cairns, 'Tooth and Claw'

Peter is an acclaimed wildlife photographer who lives on Speyside. He has contributed pictures and articles to various media including the BBC Wildlife magazine. Over the past few years he has been working together with Mark Hamblin on the 'Tooth and Claw' project to promote awareness and debate about the value of predators to people. Further details can be found at www.toothandclaw.org.uk . Peter's presentation was the most dramatic contribution to the meeting.

Predators [wolves were shown initially] are usually misunderstood and subject to prejudice. Different people value predators in different ways. Some see predators as indiscriminate killers or vermin, to be destroyed. Others see predators for their beauty and contribution to culture and society. It is important that people value predators one way or other; for in order to understand them they must first be interested. Many young people are simply disinterested in predators and other wildlife. Their lives are disconnected from the natural world.

Predators play an important role in ecosystems [pictures of wolves, bears, pine marten, eagles, seals were shown; pictures were shown of eagles ripping apart lambs, eagles feeding on foxes]. Can we learn to understand and learn to live with predators? Have we underestimated their importance to people, to natural ecosystems, and the role they have played in our own existence? Should there be a place for them in the future?

Questions and comments?

Nick Benge Predators may be valued by society, but the costs of having predators are felt by a minority of people who look after the land. Why should small numbers of people have to pay? **PC** From surveys carried out in areas where reintroductions (of wolves?) were proposed, typically 60% - 70% of respondents were in favour of reintroduction.

Peter Cunningham asked **Keith Nislow** and **Sigurd Einum** to comment on predators from their perspective. **KN** described how following European settlement in North America, wolves were eliminated from NW USA, and bears became very rare. In eastern USA there are Black bears but they behave differently to Brown (Grizzly) bears in their predatory tendencies. Over the past 100 years there has been a major ecosystem restoration effort in USA. People became tired of 'farming rocks' and there have been major increases in wildlife species. **SE** said that wolves and bears were absent from Norway for 50 - 60 years. There is much sheep farming and farmers do not want wolves, some of which have spread to inland parts of Norway. The proposed Norwegian solution is to designate areas where bears and wolves can exist and to issue permits to shoot them if they stray into other areas. **Dana Warren** reminded delegates that predators influence prey species, herbivore populations influence wildflowers through grazing [see research following wolf reintroduction to Yellowstone NP].

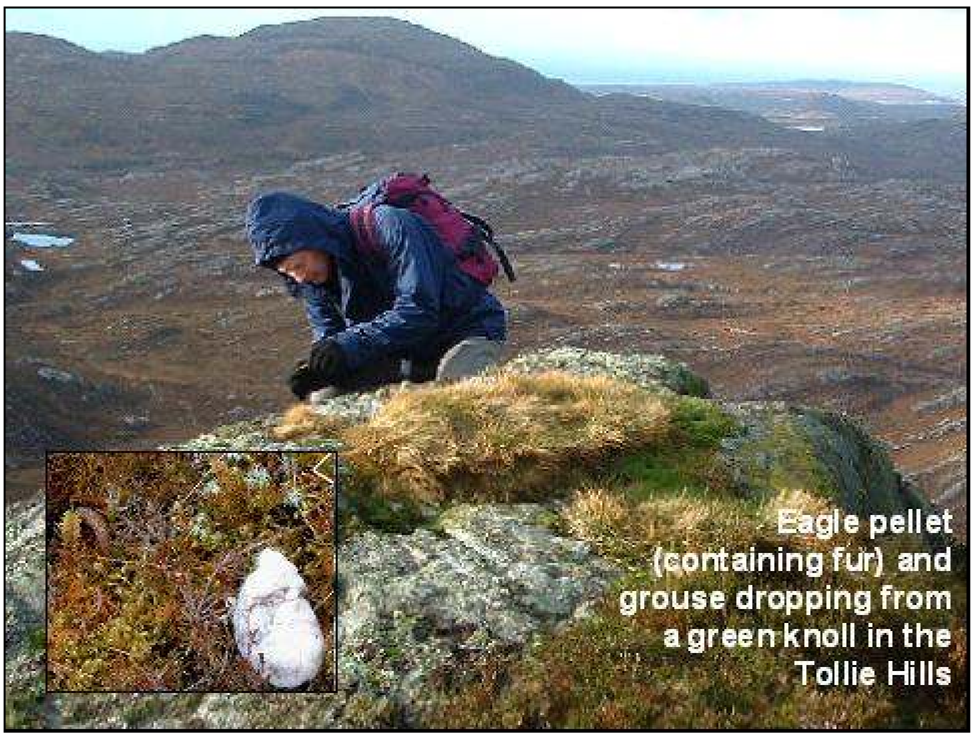
PCairns commented that a reintroduction can sometimes be judged as successful when the first animal is hunted as a game animal by a paying hunter (e.g. Sweden).

There were also a few comments on beaver reintroduction – **KN** in NE USA beavers have no natural predators and come into conflict with infrastructure so need to be culled. **SG** said that if a beaver builds a dam [which blocks a road culvert] in Germany, the first time the dam is removed. The second time the beaver is shot.

Open forum

SEPA [Scottish Environment Protection Agency] would normally object to proposals to introduce nutrients to burns. However, because salmon carcasses were naturally present in spawning streams, they could not object to the experimental studies described by **KW.**

Comments were made about SEPA's implementation of the Water Framework Directive legislation. Government agencies have traditionally been cautious about nutrient levels in streams, but their approach to dealing with nutrient enrichment / eutrophication problems was described as sometimes being '*akin to dealing with problems of people becoming overweight by putting everyone on a diet'*. Area Advisory Groups were becoming more realistic in their approach, recognising that landscapes were not pristine, that they had changed through time.



4. Land use and smolt production: some observations and challenges for fisheries management in Wester Ross

Peter Cunningham, Wester Ross Fisheries Trust

Peter has worked as biologist for WRFT since 2001 following a field study to investigate what happens to spawned salmon in Scotland. He has worked on fish farms, taught fisheries in Thailand and learnt about the fisheries of the Mekong River whilst working for a 'fisheries co-management' project based in an artisan fishing village in Laos.

Salmon have probably been of importance to the people and to the ecology of Wester Ross since they first arrived. In 2003, salmon spawned in the little Tournaig River system following an absence of several years. In late summer 2004, large salmon fry were found to be present at sites throughout most of the accessible part of the river system. In spring 2005, 11 S1 salmon smolts were caught in the downstream trap as they headed out of the system. In late summer 2005 (following further spawning of a larger number of stray adult salmon in autumn 2004) salmon fry were found throughout the system, together with 1+ year old salmon parr from the 2003 spawning. The salmon fry in 2005 were smaller than in 2004. Competition with parr for food and shelter may have reduced fry growth rates in 2005.

Elsewhere in Wester Ross observed variation in rates of growth of juvenile salmon are consistent with food availability being a primary limiting factor. Where densities of fry are very high (e.g. middle parts of the Little Gruinard River) fry tend to be small. Where densities are low relative to the available food supply (e.g. near the outflow of the Fionn Loch, top of the Little Gruinard River) fry and parr are larger.

Streams in Wester Ross are naturally oligotrophic with relatively little food for juvenile fish. A few have been enriched as a result of nutrients discharged from houses and fish farms. Most streams drain catchment areas of low fertility that provide little food or nutrients for in-stream production. Have these catchments always been as infertile as they are at present?

Land management practices have altered the productivity of large parts of Wester Ross. Historically forests were cleared, large predators were removed. Until 200 years ago many people (without modern sanitation) lived during the summer months in the upper catchments and tended cattle. Anecdotes indicate that pastures were relatively fertile. Subsequently grazing pressures increased with sheep production on a large scale (latterly encouraged by state subsidy). Management of sporting estates contributed to further defoliation and further loss of fertility as deer numbers rose. Moor burning and export of animal carcasses out with catchment areas further diminished levels of fertility.

Trials on Beinn Eighe NNR have demonstrated that in the long term, fertilisation (of formerly burnt areas) can restore soil and vegetation cover, and enhance biodiversity in addition to increasing productivity. Animals such as bears and wolves that in the past would have facilitated nutrient recycling and higher biological productivity are no longer present to perform this vital role. Additional consequences of a dysfunctional ecosystem and degraded landscape include excessively rapid run off following heavy rainfall, exacerbating damage to streams, streamside habitats and manmade structures (e.g. Strathcarron railway).

The potential for restoring fertility and more productive ecosystems can also be seen around the Sheneval Bothy in the upper River Gruinard catchment. Where soils have been enriched, oak trees grow, earthworm populations are healthy enough to support a mole population; the nearby stream supports fatter, faster growing juvenile salmon than in the nutrient-deficient mainstem nearby. There is a need to restore catchment fertility elsewhere in Wester Ross.

5. Soils, vegetation and catchment fertility

Dr James Merryweather
Highland Soil Biodiversity Group

*In addition to researching mycorrhiza and their importance for sustaining plants (based at York University), James edits the Pteridologist (*a colourful magazine about ferns*) and has recently produced the third edition of 'The Fern Guide' (published by Field Studies Council), and performs a series of lectures about fern, the sea shore and bagpipes with two chanters. James now lives at Auchtertyre and is actively involved with the South West Ross Field Club and Scottish Wildlife Trust. The following summary is based on James's handout circulated before and during the meeting*

MYCORRHIZA is a symbiosis: two or more different organisms living together. It is probably one of the most important life processes on land, but being subterranean, microscopic, invisible and virtually unknown to us, it is not an easy concept to comprehend … or share with others. To invisibility we must add the perplexingly complicated and obscure ecology of mycorrhiza, which is just too much hassle for many of the scientists in whose studies it ought to be relevant, even ecologists. Some are simply unable to include it in their simplistic picture of the world, so they just leave it out. That is a shame, because it matters a great deal (gross understatement).

This tongue twister combines two Greek words (*mikas-riza*), literally 'fungus-root'. In a mycorrhiza, specialised fungi invade plant roots where they form an interface for the exchange of nutrients. Its most usual function is to facilitate the supply of phosphate to plants. This essential nutrient generally occurs at extremely low concentrations in natural soils and is mostly held tightly by soil particles, unavailable.

When they first embarked upon their land-based lifestyle together around 500 million years ago, plants and mycorrhizal fungi collaborated to form a novel symbiosis which enabled them both to live on land and diversify. From the start, mycorrhiza was the normal way of life for land plants, and it still is for an estimated 90-95% of plants in all ecosystems on every continent. Mycorrhiza was, always has been and still is ubiquitous.

Ice sheets sweep away everything living, but when they retreat, soils and ecosystems rebuild rapidly. Thus, after the last ice ages, it took northern lands less than 10,000 years to recover reasonable biodiversity, which is feeble compared with that of tropical rain forests, the sort that support up to an amazing 200 tree species per hectare. Their fabulous biodiversity took a lot longer to develop, though ice probably once affected their continents as they drifted about the globe millions, rather than thousands, of years ago. Today, we can see how rapidly soils and communities form when quarries, exposures of bare rock, a clean canvas, are abandoned and left to nature.

From the outset, man's intervention set in motion a series of disasters for naturally sustaining, symbiotic communities. Yes, worms, rabbits, tree wind-throw and earthquakes all disturb the soil, but only in isolated patches that all the constituent species can rapidly recolonise. This sort of disturbance is built into soil ecological processes for it releases localised bursts of nutrients promoting soil heterogeneity and ecosystem biodiversity.

Agricultural tillage often affects vast areas, repeatedly exterminating soil organisms by exposure and, in the case of the fungi which form wide-ranging networks, also fragmentation. Destroy mycorrhizal fungi, and plants that are dependent upon them die, whilst populations and communities of adaptable plant species will be compromised. The fungi themselves are not so adaptable. They are entirely dependent upon their plant partners, for they are unable to produce a basic foodstuff, carbohydrate, themselves but they do obtain it through the symbiosis. If separated from their plants, they cannot adapt; cannot survive. Therefore, if you remove the fungi, plant populations disintegrate and if you remove the plants you kill the fungi. Whether you take the viewpoint of the plants or the fungi, it is symbiosis that keeps them alive and symbiosis that is disrupted by man who must share the consequences.

Remove a diverse forest community and collateral extinctions below ground mean that thereafter the soil can support no more than a few adaptable weed species - until the soil community has been rebuilt, which requires the presence of reserves of all the original organisms beyond the margins of the devastated area. If the area to be recolonised is large and potential recolonisers locally extinct, restoration is likely to take a long time or fail. Hence, it will take centuries for a landscape to reassemble itself. Eventually, after a very long period of recovery, it might begin to resemble something we humans would accept as natural, but it probably won't be, particularly if some extinctions were widespread rather than local. *We* can't reassemble complex ecosystems properly ourselves because we don't know what they were originally. Planting countless millions of trees of the sorts we are able to grow does not make real forests. It's what I call Naïve Conservation.

Agricultural land, particularly in the 'developed' world, is probably a worse starting point for ecosystem restoration than bare rock thanks to contamination, not just by pesticide residues. At low concentrations, soil phosphate is a nutrient in biological communities that can recycle it efficiently. In agricultural circumstances, where populations of mycorrhizal fungi are impoverished, we find we have to keep adding phosphate to soils so that crops will grow. Therefore, when it is added in large quantities as an artificial fertiliser and not utilised or recycled, phosphate becomes a pollutant. Only phosphate in soil solution is available to roots unaided, and even then it does not flow in soil in they way that, say, nitrate solution does. Excess becomes attached to soil particles - stuck so that only specialist fungi can gather it - or is out of reach to the root system. Phosphate-rich soils (fertilised, enriched, disturbed, abused soils) favour non-mycorrhizal plants and, therefore, ecosystems become permanently changed, usually not for the better.

When we add phosphate to crops, even the few, tough, generalist mycorrhizal fungi that have survived mechanical assault are physiologically excluded from roots by their plant hosts, cutting off the last remains of the phosphate acquisition service they would receive free of charge in an intact natural community. Thereafter, plants must gather their own phosphate. The majority cannot, but some can: WEEDS.

Questions

Time was limited; none were noted.

6. Can woodlands benefit fisheries?

John Parrott,
Scottish Native Woods

John Parrott is the local area manager for Scottish Native Woods and has been closely involved with the promotion and development of a wide range of native woodland projects, including Woodland Grant Schemes, in the north and west of Scotland over the past 14 years. John has also worked on forest projects in Africa . . .

Many of the rivers which adult salmon return to spawn have wooded banks. Trees bind river banks together, and their roots provide cover for adult fish as they migrate upstream to spawn. Woody debris retains other organic matter and gravels in which salmon and trout may spawn. Juvenile salmon may feed on insects and their larvae which fall into the river from overhanging trees. In the autumn, leaf fall feeds the stream. There are two sorts of energy sources for streams: 1. **autochthonous** instream production (e.g. algae) 2. **allochthonous** inputs from outside the stream, including leaf litter and terrestrial invertebrates.

Riparian woodlands provide: invertebrates, leaf litter (which provides a food supply for freshwater invertebrates), bank protection, shelter and shade, coarse woody debris and visual isolation for young fish. They are also important habitats in their own right, providing wildlife corridors and adding to the landscape.

In most of Highland, ancient native woodlands are reduced to small remnants. Over much of the uplands only riparian woodlands remain. Where riparian trees have been lost, stream banks are more vulnerable to collapse and erosion.

This decline in woodland cover has gone hand in hand with a loss of nutrients. Soils are exposed to erosion and leaching. Timber has been extracted for a variety of purposes, so removing more nutrients from the uplands. Ongoing harvesting of timber from upland plantations perpetuates this one-way traffic of nutrients, as does the removal of deer carcases.

This loss of fertility may be reversed if the vegetation is allowed to recover. Scrub may improve soils and pave the way for the development of woodland cover. Some shrub species such as broom and whin may help with nutrient cycling by fixing nitrogen. Many scrub species (whin, hawthorn, blackthorn, juniper) are thorny and help to protect to regenerating trees.

Unfortunately relatively few woodland schemes have incorporated riparian habitats. This is partly because water gates can be difficult to site and maintain.

Alder trees are commonly found in riparian areas: their roots are happy in flowing water. They are important for nitrogen input. In the N & W of Scotland they are often found on flushed ground including hill sides.

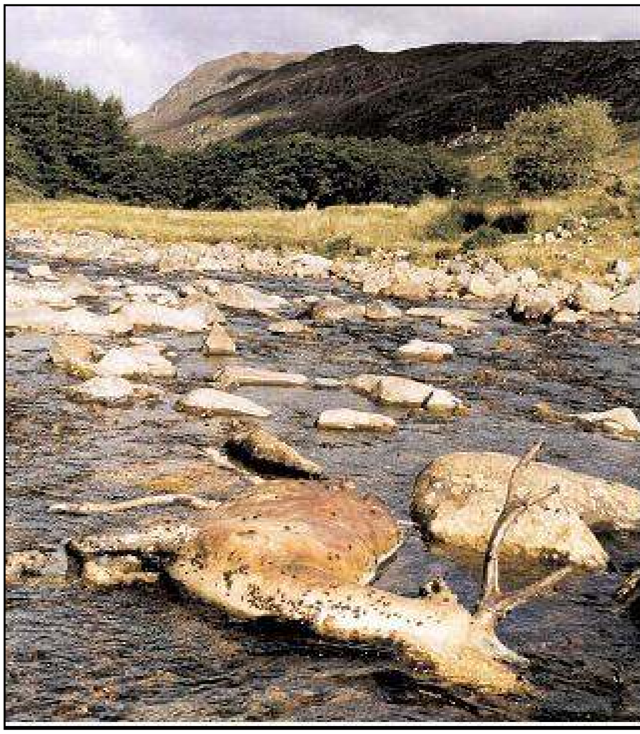
In 1957 and 1967, Donald McVean carried out a series of trials on Beinn Eighe NNR to establish trress by direct seeding. Scots pine, birch, alder, rowan, whin, broom, bog myrtle and juniper were sown directly on moorland. Results varied, but some of the alder trees grew to 3m in 8 years. Flushed sites were best; on poorer sites GRP (Ground Rock Phosphate) was essential.

The importance of phosphorus for vegetation is brought home by witnessing tree growth on more fertile sites. At Alladale, rowan trees were noted growing particularly well on an old estate midden where bones had been dumped.

The Highlands once supported thriving communities. These folk depended on a diverse and productive environment for their livelihoods and well-being. This environment has been steadily parcelled up into sheep-farms, grouse moors, forestry plantations and deer forests.
If we want to restore the land to its former diversity and productivity, we need to find a way to improve the integration of these different land-uses.

Questions

Time was limited; none were noted.



A deer carcass contains ~3 kg of phosphate: mainly in bones.

The removal of deer, sheep or cattle from upland catchment areas represents an unnatural loss of nutrient from the ecosystem.

7. Using hydromorphology to increase nutrient levels in streams

Eric McVicar,
Lochaber College

Eric is a retired farmer, fisherman and engineer with a wide range of knowledge and practical experience. He has recently come out of retirement to develop a fisheries training course at Lochaber College. Eric's presentation was based on work carried out at Fortesk on the River South Esk and Kinnaber on the River North Esk.

One of the factors that limits the productivity of rivers is that there are often few places where organic debris can settle to provide food for invertebrates. Much gets flushed away. Sections of the North Esk at Kinnaber were wide and shallow, providing little cover for adult fish and few places where organic debris such as leaves and woody debris could collect. The same problem had previously been addressed at Fortesk on the South Esk in the early 90's.

To address these problems, an engineering approach was adopted. The aims were the three R's: **restrain** the river channel; to **reclaim** unstable riparian habitat for growth of trees and other riparian plants; to **retain** organic matter including leaves, woody debris and dead kelts.

Large boulders were placed at the sides of the river channel to make the channel narrower and create backwaters where organic sediment could settle out. These boulders which were placed in an upstream configuration stabilised mobile gravel and cobble which deposited upstream of the boulders during spates. These depositions have good flow characteristics through them and hence make ideal redd sites.

A second action was the placement of large logs set across the side of the channel to retain sediment and to concentrate the flows. These also create ideal habitat for invertebrates which require woody debris.

Over a period of years these modifications have become established features of the river bank with riparian vegetation growing over the top of them. Benefits to fish include the creation of holding water for adult fish, retention of organic matter as a food supply for invertebrate larvae (particularly the caddisfly larvae *Sericostoma* and *Anabolia*]. Fish (salmon and sea trout) now spawn within the sections that have been modified. Parr and fry also have sanctuary areas during heavy spates and from predation.

In 1990 there were 2 pools in at Fortesk and the catch was less than 20 salmon per year. In 2007, there were 18 pools and the catch had risen to over 100 salmon per year. In summary the works described produced better habitat for the fish and its food chain. When purchased in 2000 the Kinnaber 5 year average was stated as 200 salmon in 2006 this had risen to 497 salmon and work is ongoing to enhance smolt production on this beat of less than 1 mile.

Questions

Dana Warren how have fish numbers changed? EV shoals of fry and parr can now be seen in the modified section which was previously devoid of juveniles. Adult fish are resident in the pools from the spring through to the autumn. After spawning dead kelts get washed into the backwaters where they are retained. Big brown trout are also present at Fortesk, a thing that had never before been noted on the South Esk.

8. Factors influencing the success of collaborative catchment management

Dr Keith Marshall,
McCauley Land Use Research Institute

Keith is an integrated catchment management specialist and has studied some of the conflicts between the different objectives of natural resources management, biodiversity conservation, river basin planning. Keith has worked on a range of catchment management projects around the country, including the West Country Rivers Trust. The following summary is based on overheads presented.

Integrated-catchment management requires the involvement of all those who are or will be affected to work together. There are many examples from around Scotland (e.g. Tweed Forum, Solway Forum, Dee Catchment Management Plan) and elsewhere in the world where a collaborative approach has been adopted. Good communication between different interest groups is essential. Roles and responsibilities need to be clearly defined.

Sometimes collaborative management is required to address a single issue (e.g. pollution) or a range of issues (e.g. wildlife conservation, access, and farming). The process needs to be able to adapt to new information. Success can sometimes be defined by measurable increases in something (e.g. fish populations or the condition of deer). Additional benefits may include more frequent dialogue and communication between different interest groups. Good dialogue also helps to minimise conflicts. Where successes and achievements are acknowledged, the collaborative approach is strengthened.

In the context of fisheries management or river catchment management in Wester Ross, suggested actions need to be compatible with the SEPA-led River Basin Management Plan. Fisheries interests on the local Area Advisory Group [AAG] are represented by the Wester Ross Area Salmon Fisheries Board. The AAG forum is open to everyone and meets periodically within the Wester Ross area.

Actions may include demonstration projects to promote new practices, research and monitoring, and education.

In summary, collaborative management is about people: engagement, consultation, inclusive representation, a working system where there is good communication between different interest groups; working together to achieve objectives.

Questions and Comments:

Kenneth Knott The Forestry Commission now prepares Forest Plans which are much more ecology focussed and not just about ensuring a supply of timber for the future. Wildlife conservation, amenity and other issues are of high priority. There are now 50 different pieces of legislation dealing with water that affect forestry practices. We invite all to visit Achnashellach Forest (River Carron catchment) at a future meeting to find out more!

Open Forum

Graeme Wilson During low flows in the summer, the Little Gruinard already becomes very warm and an algal matt develops. Surely additional nutrients in the water would make algal growth even worse?

Ben Rushbrooke Growth of algae may be tied more to nitrate than phosphate in the summer.

John Parrott It would be best if nutrients were put on the land rather than in the water to let plants take them up.

Roger Macdonald Most of the trees planted in the Balle mor (Gairloch Estate) Woodland Grant Scheme were fertilised with 125g of GRP. In the River Kerry catchment less fertilkiser was permitted because of concerns for Freshwater pearl mussels.

John Webb [Firstly] Are we overstating the importance of nutrient levels in headwater streams? Surely the major bottleneck for salmon populations is in the marine environment?
[Secondly] is there not a risk that if rates of growth rates of juvenile salmon are increased in freshwater, there will be less of a natural buffer to a bad winter or spring (with an entire year's smolt production affected)?

JA increased food availability through nutrient enhancement may increase densities as well as growth rates of juvenile salmon. There may be opportunities for a group of owners to get together to carry out an experimental trial. Such a trial should be closely monitored.

Brian Fraser described how the size of brown trout in a loch had been increased though application of lime and nutrients. **PCu** cautioned that it was accepted that nutrients could increase production; for government agencies to permit fertilisation in the future, any fertilisation would probably need to be based on what could be justified as restoring a natural level of nutrient availability.

KW said he would not advocate keepers throwing bags of phosphate around. The restoration of fertility requires a more careful approach. Carefully designed trials, with appropriate controls are required to answer specific questions.

[end of meeting]