Case study 1. New Forest LIFE III Project

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Main driver: River and floodplain habitat restoration

Project stage: Completed over 2002 to 2006

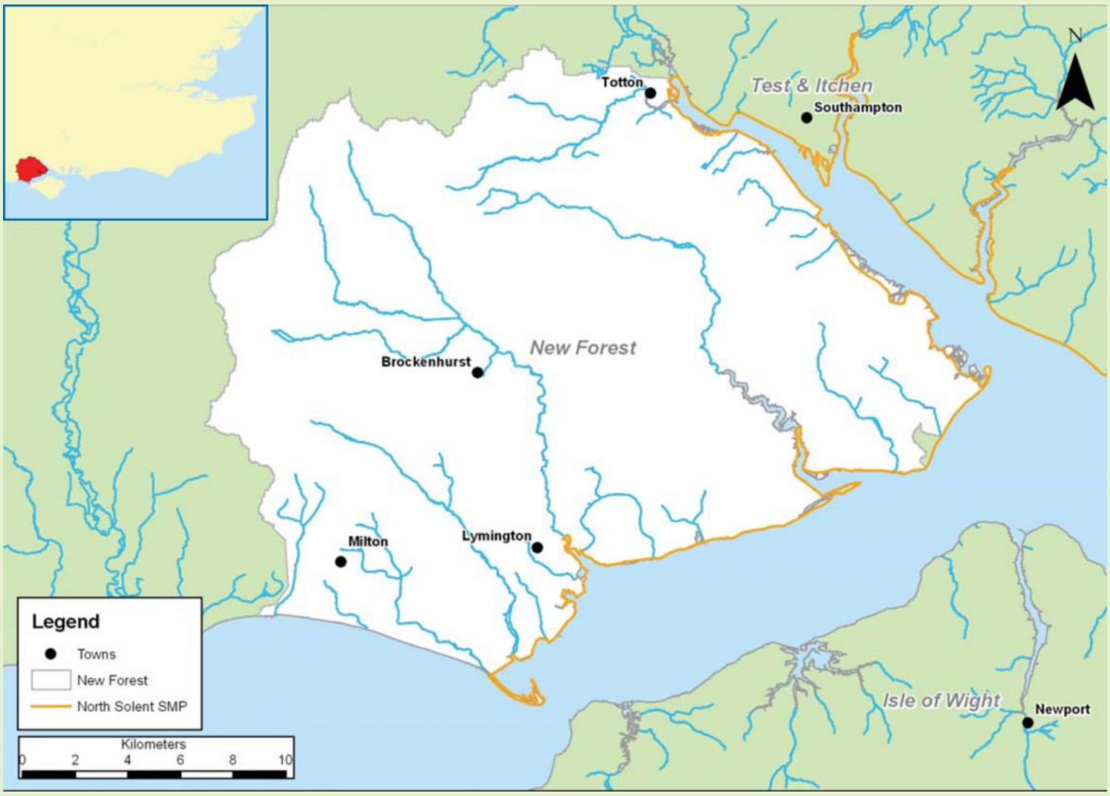
Photo 1: A section of the Black Water after its characteristic meandering stream morphology was restored (source: River Management Blog, Simon Dixon)

Project summary:

The New Forest in Hampshire (Map 1) is one of the largest remaining areas in western Europe supporting a mosaic of heathland, wetlands and semi-natural forest. It has been designated as a Special Area of Conservation (SAC) under the Habitats Directive in 2004 and has been a National Park since 2005. In 2003, with 40% EU LIFE 3 funding, a 4-year project began to restore the streams and wetlands within the Lymington River, Avon Water and Hampshire Avon catchments. This involved reinstating the characteristic sinuous course of the streams, adding large wood to channels, reconnecting floodplains and old meanders and restoring the characteristic wetlands and riparian forest.

Key facts:

A total of 10 km of degraded, straightened rivers were restored through floodplain reconnection, reinstating or reconnecting old meanders, and adding wood to the channel (upper tributaries of the Lymington River only). These restoration measures together resulted in a 21% reduction of flood peak magnitude and a 33% increase in flood peak travel time for flows that were less than $1m^3s^{-1}$ (equal to a 2-year recurrence interval). The project also resulted in the restoration of 261ha of riparian woodland, 18ha of bog woodland, 184ha of valley mires and 141ha of wetland habitats.



Map 1: Location of the New Forest in Hampshire (source: Environment Agency 2009)

1. Contact details

Contact details	
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Partners:	Natural England, Environment Agency, Forestry Commission, Hampshire County Council, The National Trust, RSPB and University of Southampton
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2. Location and catchment description

Catchment summary	
National Grid Reference:	SU 29619 03813
Town, County, Country:	Hampshire, UK
Regional Flood and Coastal Committee (RFCC) region:	Southern
Catchment name(s) and size (km^2):	Lymington River (49km), Avon Water (45km) and Hampshire Avon (1,750km)
River name(s) and typology:	Lymington River, Avon Water and Hampshire Avon

	Low gradient rivers
Water Framework Directive water body reference:	Lymington River: 429619 (Black Water: 425261 Highland Water: 425284) Avon Water: 426889 Hampshire Avon: GB108043015770
Land use, soil type, geology, mean annual rainfall:	Common grazing land and forestry Mesotrophic soils; clay and gleyed soils in floodplain areas; mixed heathland and forest; Barton clays and sands, mean annual rainfall 750mm

3. Background summary of the catchment

Socioeconomic/historic context

Some 150 years ago, meandering streams were straightened as part of a programme of land drainage works to improve growing conditions for commercial timber plantations. This resulted in a degradation of the natural character of stream and riparian habitats, and attendant problems of increased flood risk downstream and channel incision.

Flood risk problem(s)

Flooding is mainly related to overbank flows from rivers that flow through the New Forest. Following heavy rain, floods can be rapidly generated due to the impermeable nature of the geology and soils. The rivers draining the New Forest are also significantly tidally influenced, which can in turn influence flood inundation depth and extent towards the coast (Environment Agency 2009).

There is a history of flooding in towns within the New Forest. In January 2016, the towns of Brockenhurst, Sway and Sopley were flooded. Local observers commented that this event was possibly the greatest flood in the area in 15 years.

Other environmental problems

Riverbed erosion and sedimentation are caused by the channelised nature of the watercourses. Further problems have included the spread of invasive non-native vegetation species and lack of awareness by the public and landowners of the pressures facing the special habitats in the New Forest.

4. Defining the problem(s) and developing the solution

What evidence is there to define the flood risk problem(s) and solution(s)

Using modelling approaches, the Environment Agency has assessed the degree of flood risk in towns within the New Forest (Environment Agency 2009). It was estimated that ~760 properties are at risk from a 1% annual probability river flood in the towns of Milton/Milford, Brockenhurst, Lymington and Totton. In addition, key infrastructure is at risk from flooding (one emergency service centre, 11 electricity substations and one water treatment plant).

Before the restoration work was carried out, it was also perceived that peak flows and associated flood risk in downstream communities – including the towns of Lymington and Brockenhurst – were higher due to the alteration of the catchment upstream.

What was the design rationale?

The project aimed to improve habitat, restore river morphology and reduce flood risk through alternative means that were more sympathetic to the natural character of the New Forest.

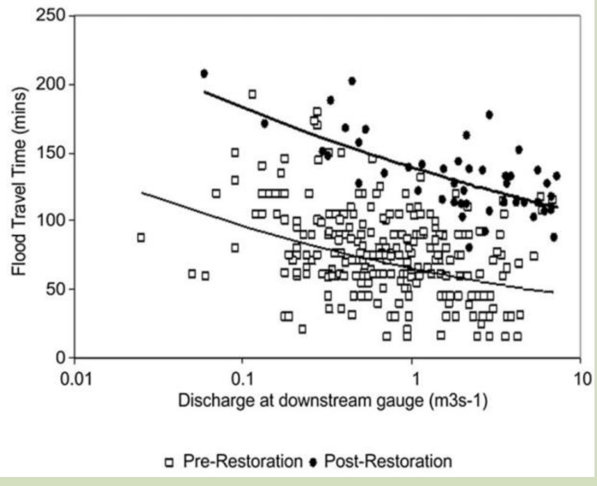
The design work incorporated existing knowledge of the ecology and geomorphology, which helped in planning the best types and locations of restoration measures. All design proposals drafted by the design team were sent to English Nature, the Forestry Commission, river restoration and ecology experts and the River Restoration Centre, as well as a local consultation forum. The input of these different stakeholders helped to refine the restoration designs to satisfy the habitat restoration objectives.

Project summary	
Area of catchment (km^2) or length of river benefitting from the project:	10km of river 604ha of forest and wetland habitats restored
Types of measures/interventions used (Working with Natural Processes and traditional):	All working with natural processes
Numbers of measures/interventions used (Working with Natural Processes and traditional):	6 types of measure used
Standard of protection for project as a whole:	Not available
Estimated number of properties protected:	Not available

How effective has the project been?

Kitts (2010) found that the river and riparian restoration measures together resulted in a 21% reduction of flood peak magnitude and a 33% increase in flood peak travel time for flows that were less than $1m^3s^{-1}$ (equal to a 2-year recurrence interval; Figure 1). Dixon et al. (2016) hypothesised that flows over 2-year recurrence interval 'drown out' the influence of roughness features resulting in flood wave travel times similar to the pre-restoration conditions.

Using pre- and post-restoration monitoring over 3 years at 3 restoration sites in the same catchment, Sear et al. (2006) showed that floodplain inundation frequency and duration were increased. Although, isolating and quantifying the catchment scale effects of the individual restoration measures was not possible, all measures are likely to have been influential in affecting attenuation (Sear et al. 2006).



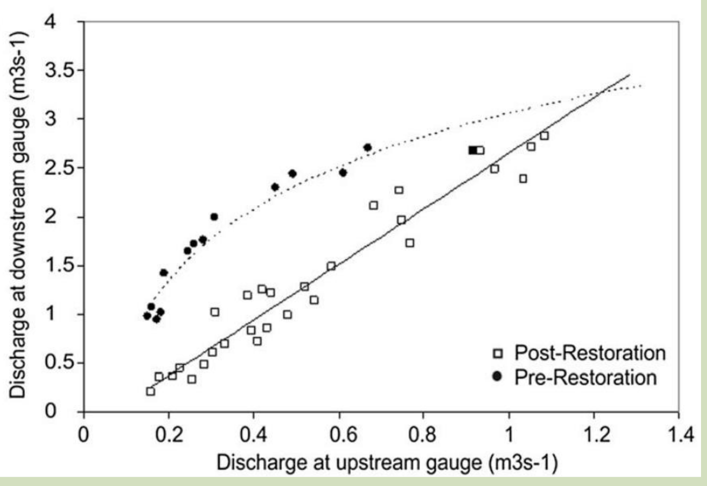


Figure 1: (Left) Empirical evidence of the increase in flood wave travel time (left) and discharge attenuation as a result of channel restoration and adding in-channel wood on the Highland Water (right) (after Kitts 2010; adapted from Figure 1 in Dixon et al. 2016).

Using a catchment model, Dixon et al. (2016) predicted the individual hydrological effects of restoring floodplain forest and adding log jams at the catchment scale (Highland Water catchment). Adding log jams was found to have a variable effect; there was an up to 6% increase or decrease in peak flow magnitude for log jam restoration over 0–100% of the catchment network. Restoring riparian forest cover had a greater and more consistent effect on peak flows; restoring riparian forest cover over 10–15% or 20–40% of the catchment area reduced flood peak magnitude by 6% and up to 19%, respectively.

The increased channel hydraulic roughness created by the restoration work in the Highland Water also resulted in the formation of a finer bed substrate relative to the control reaches. In contrast, the wooden dams added to the channelised streams did not result in a fining response because the dams encouraged stream bed scour which allowed the free passage of sediments downstream (Sear et al. 2006).

The restoration work also resulted in the following benefits (Sear et al. 2006):

- an increased retention capacity for wood material and organic matter
- the re-establishment of geomorphic processes characteristic of natural channels including the reactivation of floodplain channels and erosion and deposition processes on the floodplain and the reduced movement of gravel

At the reach scale, restoration also resulted in an improvement of habitat with riffles, pools and coarse woody material accumulations occurring more frequently than prior to restoration, though not at a level observed in the near natural reference reaches.

5. Project construction

How were individual measures constructed?

River beds were raised by adding material previously removed from the channel and subsequently placed on the river bank. Where extra material was needed, hoggin (unwashed gravel) was used to restore natural riverbed levels and reduce erosion. Combined with adding clay plugs to hold the infill material in place and block of previous channelised courses, this helped to reconnect the floodplain and old remnant channels.

The natural meandering courses of streams that existed prior to straightening were reinstated through excavation (Photo 1). Together with the addition of wooden structures using locally sourced wood (Photo 2), these measures aimed to increase floodwater storage and slow the flow to aid attenuation through increasing roughness and improving floodplain connectivity. This also aimed to benefit the regeneration of riverine and bog woodland, which are priority European habitats. In addition, woodland management actions through removing invasive non-native species and conifers, and the coppicing of riparian trees was also carried out. Drains were also blocked by using heather bails to:

- further reconnect floodplains
- reduce flows and the excess scour in the main channel
- restore associated wetlands

How long were measures designed to last?

By restoring natural river processes, morphology and riparian woodland, it was expected that the measures would be self-sustaining and evolve naturally over time. No finite lifespan for the measures was set.

Were there any landowner or legal requirements which needed consideration?

The New Forest has several nature conservation designations: Site of Special Scientific Interest (SSSI), Special Protection Area (SPA) and SAC. The SSSI site is also a Ramsar site due to the importance of invertebrate species within the wetland areas. Given these designations, care had to be taken to ensure that there was no degradation as a result of the restoration actions undertaken. It was anticipated that the measures would help to safeguard and even improve the natural character of the New Forest river corridors that underpin the designations with the bog and riverine woodland habitats being priorities.

The restoration planning also had to consider the rights and requirements of the different land ownerships (New Forest Life Partnership). Within the forested areas ('inclosures'), large areas of conifers were removed to aid regeneration of natural tree species in these areas.

The plan also considered the area of common grazing land managed by the Forestry Commission in close partnership with the Verderers and Commoners Defence Association. By shifting fences, floodplain areas have been opened up to livestock which also helps to control scrub development and break bracken down.

Photo 2: A naturally occurring log jam in the New Forest (source: River Management Blog, Simon Dixon)

6. Funding

Funding summary for Working with Natural Processes (WWNP)/Natural Flood Management (NFM) measures	
Year project was undertaken/completed :	Started in 2002 Finished in 2006
How was the project funded:	40% of the money came from EU LIFE 3 and 60% from the project partners
Total cash cost of project (£):	£2.9 million
Overall cost and cost breakdown for WWNP/NFM measures (£):	Not available

WWNP/NFM costs as a % of overall project costs:	Not available
Unit breakdown of costs for WWNP/NFM measures:	Not available
Cost–benefit ratio (and timescale in years over which it has been estimated):	Not available

7. Wider benefits

What wider benefits has the project achieved?

The project helped to safeguard an internationally important range of habitats that comprise the New Forest SAC. The removal of dense conifer tree plantations, which were uncharacteristic of the natural forest communities, has improved light and temperature conditions in the streams as well as restoring a more natural hydrological regime. Characteristic biodiversity has also benefitted from the removal of invasive plants and conifers.

Initial results of the ecological monitoring (New Forest Life Partnership 2006b) showed an encouraging response at one site of the Blackwater where macroinvertebrates had been monitored. Some 16 months after restoration, the reference reach and restored reach communities were very similar and productivity was higher in the restored reach partly due to an increase in habitat area. However, the difference was not statistically significant, perhaps because the restoration of processes and habitat was incomplete. For fish populations, no significant difference in species diversity was detected between 2003 and 2006 or between control and restored sites (New Forest Life Partnership 2006b).

How much habitat has been created, improved or restored?

The project resulted in the restoration of 261ha of riparian woodland, 18ha of bog woodland, 184ha of valley mires and 141ha of wetland habitats. In addition, 10 km of river were restored which helped to keep the rivers at good ecological status as defined under the Water Framework Directive.

8. Maintenance, monitoring and adaptive management

Are maintenance activities planned?

The majority of the sites forming part of this project were very successful, however the Forestry Commission needed to carry out some maintenance work and remedial repairs at some of the sites. Holmsley bog the project cleared willow scrub, because this area is not part of the open forest livestock were unable to graze and so the re-growth has periodically had to be cut. Slufters the restoration work was very good. The point at which the LIFE project finished the drop off point was unstable and so picked back. The Forestry Commission went back to complete the rest of restoration upstream and because LIFE had finished part way along the reach they had to redo 100m. The lesson from this is to complete all sections of the restoration and work at a catchment scale. At Dames Slough the new channel was causing erosion of the cycle track, so the Forestry Commission carried out some repairs to reduce the impact. Blackwater/Rhinefield Drive the restoration has left the channel too deep and this has meant that it still didn’t interact with floodplain. The old drain was just blocked by using clay plugs and over time the water has eroded the plugs meaning they have started to nick through. The Forestry Commission had to go back to infill the redundant bits of old drain. The lesson learnt is that you have to restore the full floodplain. At Blackensford/North Oakley the new meander was too deep and has created incision of the new channel, which then continued to destablise the mire. The Forestry Commission had to restore the headwater and have temporarily protected the mire. This site does still need further bed level raising. The lesson learnt here was not to be over cautious of size of channel needed. The Broomy bottom site had heather bales that washed out and left stakes showing. The

Forestry Commission repaired it in 2016, but there was further extreme weather event afterwards, so it still requires some further minor repairs. Holly hatch/Anses wood the project installed wooden dams but this has just made a series of steps that are eroding underneath. The lesson here is that solid structures don't have the give for high flows. The site is planned for repair in 2017, with bed level raising with hoggin.

Is the project being monitored?

The project was monitored by the Environment Agency and the University of Southampton using a before–after–control–impact (BACI) approach. This included several years of geomorphic, hydrological and habitat pre-restoration monitoring in addition to the main period of monitoring between 2002 and 2006; the results are presented in Sear et al. (2006). The monitoring network included replicated groups of semi-natural control reaches, as well as the restored reaches, to enable reliable detection of river channel changes created by the restoration actions as opposed to natural variability.

Prior to the restoration work being undertaken, gauging stations upstream and downstream of the restoration areas were already in place on the Highland Water. This allowed a robust before and after restoration comparison of the river flow regime and detection of potential flood risk management benefits (flood wave travel time delay and attenuation of peak discharge). The hydrometric network was expanded to assess in more detail the local hydrological effects of the restoration work (Davies 2006).

Macroinvertebrate and fish populations within the streams were monitored to determine ecological response of the river channel restoration work. Wading birds were surveyed by the RSPB in 2004 giving an indication of ecological value of wetland areas.

Has adaptive management been needed?

No information provided

9. Lessons learnt

What was learnt and how could it be applied elsewhere?

The project has promoted the importance of habitat restoration in the area and improved the skills and knowledge base necessary for maintaining the area at a good status for nature conservation. The habitat restoration techniques used could also be applied to other similar settings (New Forest Life Partnership 2006a).

The monitoring showed a number of positive outcomes that may be transferable to similar settings elsewhere. The field-based evidence of peak flow attenuation for moderate flows suggests that, in low gradient streams with forest covered floodplains, flood risk management benefits for moderate floods are possible through restoring natural river processes and features. Further empirical evidence is needed to assess if the current measures result in attenuation of higher recurrence interval floods and whether restoration of a greater extent of riparian forest – as predicted by Dixon et al. (2016) – can lead to measurable peak flow reduction. Adding log jams to channelised streams did not lead to a positive floodplain reconnection response (Sear et al. 2006), suggesting that these stream sections required greater intervention (for example, restoration of meanders) to create an effect.

The restoration work led to elevated suspended sediment concentrations in the Highland Water due to disturbance in the channel (Sear et al. 2006), emphasising the importance of incorporating sediment control measures during restoration if possible. It also highlighted the unstable nature of sediments after restoration which should be anticipated in any river restoration project involving direct intervention.

The project has also been a valuable learning experience in devising and implementing monitoring of hydrological, geomorphic and ecological responses. The monitoring framework is noteworthy for its extensive area and long-term nature, the integrated measurement of a number of variables and the clear statement of objectives (New Forest Life Partnership 2006b). These principles should be adhered to in other flood risk management and river restoration monitoring projects to reliably capture all the responses.

A number of specific monitoring lessons have been learnt.

- Monitoring should begin as soon as possible once the project has started to maximise the value of before and after restoration comparisons (Davies 2006).
- Location selection for flow monitoring stations should be undertaken with care to take into account where the restoration will occur and the type of restoration (Davies 2006).
- Multiple measures mean it is difficult to separate the individual flood risk management effect of each measure (Sear et al. 2006).
- More discerning monitoring methods if possible that examine local scale and catchment scale effects are needed. This would help to promote and predict the effects of individual measures in other projects.

The whole catchment needs to be considered when carrying out stream restoration so that impacts from unrestored reaches are assessed to prevent their impacting negatively on restored sections.

10. Bibliography

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Project background

This case study relates to project SC150005 'Working with Natural Flood Management: Evidence Directory'. It was commissioned by Defra and the Environment Agency's Joint Flood and Coastal Erosion Risk Management Research and Development Programme.