New Forest Freshwater and Wetland restoration plan: Section 9 – Monitoring

1.1 Monitoring should follow the key principles set out in the box Key principles of freshwater and wetland restoration monitoring in the New Forest.

Key principles of freshwater and wetland restoration monitoring in the New Forest

- Monitoring should focus on measuring the impacts against desired outcomes as identified in the Evidence phase (case studies and measures of success).
- "Gamma diversity" should be considered in intepreting data – i.e. not a count of species associated with one feature, but the overall diversity of target assemblages within the system (n.b. invertebrates in particular can be very abundant in New Forest habitats, and a focus on rarer species is needed).
- Full monitoring is not necessary (or feasible) at every location. Use of selection criteria will ensure that only sites that are likely to benefit from restoration are selected (e.g. based on the level of modification and its consequences - channelization, lack of submerged and emergent vegetation in the channel, lack of transitional habitat).
- The monitoring should be focussed on the stretch or area where the restoration was carried out, but the impact on neighbouring reaches may also be considered (e.g. changes in deposition and flooding).
- Monitoring may need to continue over several years, as it can take a long time for wetland habitats to reach their full potential after restoration.
- The information should be in a form that can be used to create a narrative of change.
- Monitoring data should provide evidence of positive trophic cascades within the system e.g. improved conditions for plants, invertebrates and their predators.
- Monitoring will be used to assess whether further modifications are needed at restoration sites and to highlight any lesson learned about the techniques used.

Key components

1.2 The following techniques are likely to be required at most restoration sites where monitoring is carried out (see Figure 1). The approaches used will vary according to restoration site and type in addition to site-specific objectives. The particular circumstances (e.g. extent and type of restoration, resources available, species present) will dictate the specific monitoring plan for each site and not all sites will need comprehensive monitoring.

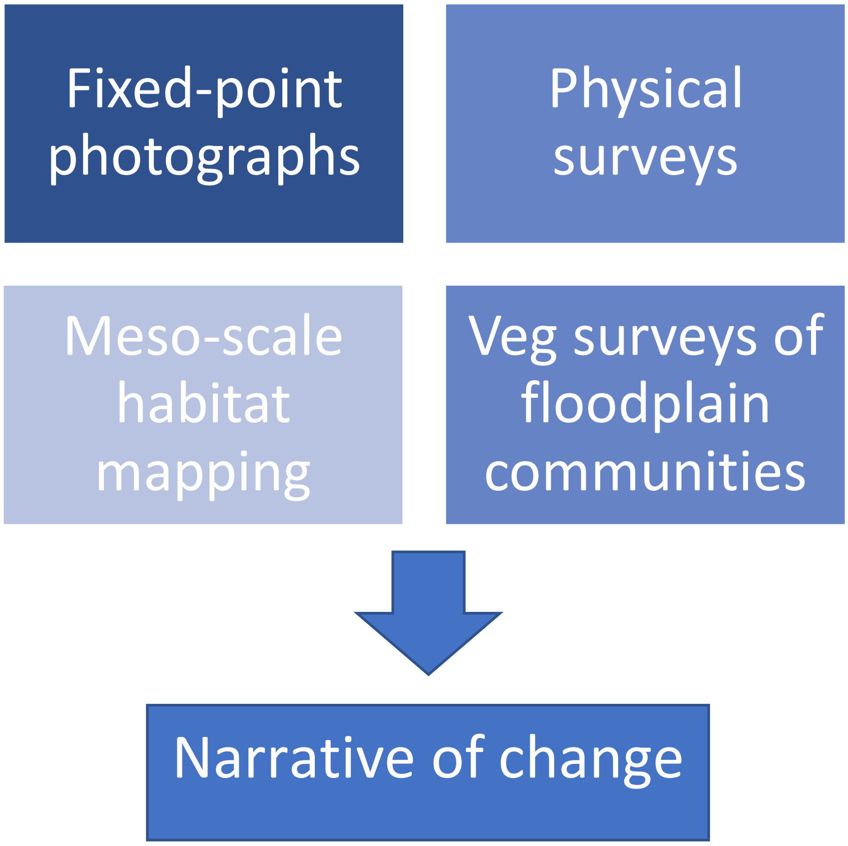


Figure 1: Suggested approaches to monitoring wetland restoration in the New Forest.

1.3 **Fixed point photography** is a powerful monitoring tool. It is relatively quick and cheap to carry out, requires no specific expertise and the results are very intuitive. However, it cannot readily be used to obtain quantitative data, rather it provides a qualitative interpretation of change over time. It can be a useful way to tell the restoration story in a non-technical way. 360° photos can be used to create a linear interactive photographic record along a watercourse in Google maps (similar to street view).

1.4 **Physical surveys** (including geomorphological features) e.g. Modular River Physical (MoRPh) surveys[1] or River Habitat Surveys (RHS)[2] may be useful to evaluate the success of the technique in creating diversity in the channel structure (rather than evaluating the restoration against the key outcomes). Bespoke monitoring using existing techniques may be needed to assess outcomes, for example, looking at erosions and deposition, movement of sediment, or riffle/pool patterns as indicators of natural processes.

1.5 **Meso-scale habitat mapping** should be used to establish the extent of in-channel vegetation and the transitional zone in addition to pools, etc. This will need to be seasonal for seasonal streams/shallow pools. The habitat descriptions developed in the description of quintessential New Forest habitats (see Figure 3) will be required.

1.6 **Vegetation community surveys** of "wetted" habitat should be used to show the extent and character of recolonising wetland vegetation. Surveys will indicate whether restoration has successfully allowed typical plant communities to recolonise/expand. These may take the form of transects across the wetland system.

1.7 **Narrative of change**: the overall success of a restoration can be hard to evaluate from disparate monitoring reports. Therefore, an overall narrative of change should be compiled for every restoration. This should integrate data from each monitoring technique used to evaluate the restoration against the measures of success. It should highlight key developments and relate these to the pre-determined measures of success. This should take into account the time since restoration and should highlight any areas of concern where ongoing restoration work may be needed. It should highlight any lessons learned about the techniques used, both in relation to the monitoring results and in terms of practicalities (consultation with the restoration officer will be essential for this). The production of a narrative is a vital part of any monitoring and should not be overlooked.

---

[1] http://modularriversurvey.org/wp-content/uploads/morph-field-guide.pdf
[2] https://www.riverhabitatsurvey.org/rhs-doc/

1.8 **Other Ecological surveys:** In-channel fish and macro-invertebrate surveys have been carried out in the past but may not be required for new restorations. Ongoing monitoring is already providing useful information about fish populations and macro-invertebrates at selected sites after restoration[3]. These groups are not the best indicators of improving biodiversity in the New Forest wetlands, however, as the species assemblages are quite specific to the New Forest and restoration is not expected to result in notable changes in species richness. Approaches such as RIVPACS, which compares the observed fauna to the fauna expected in pristine conditions, may not be helpful for monitoring macro-invertebrates in the New Forest as the water quality is already good. Fish are not a notified feature of the New Forest SSSI but are nonetheless important and the New Forest should support self-sustaining populations. At a landscape level, restoration may result in both streams that support a diversity of species such as Bullhead, Stone Roach, Minnow, Trout, Brook Lamprey and other streams that support fewer fish.

Monitoring that may be desirable at some sites

- Measuring water levels to show whether restoration has resulted in appropriate levels for valley mire habitat and to provide an indication of water storage (dipwells)
- Modelling erosion rates (e.g. using sediment traps), measuring sediment movement.

Other tools that could be used/research ideas

- Use of Lidar data to assess the topography of the floodplain to see where mire vegetation should be able to develop
- Multiple species eDNA – e.g. analysis of flies coming out of streams
- Citizen science for higher taxa (engagement, information sharing)
- Measuring the magnitude and variability of water temperature (e.g. using temperature loggers) in restored streams to assess the impact of restoration and difference between areas shaded by trees and open areas shaded by in-channel vegetation (relevant for stream fauna)
- Satellite imagery to look at changes in vegetation over time
- Peat characteristics – degradation/depositions rate, soil organic content.

[3] Available at: https://www.hlsnewforest.org.uk/projects/surveys-and-monitoring/monitoring-wetland-restorations/fish-and-freshwater-invertebrate-surveys/.

1.9 More details on targets, techniques and potential timescales are provided in Table 1, followed by a hypothetical case study to show how monitoring techniques could be applied in a given situation. Protocols for key monitoring techniques are provided.

Table 1: Likely targets for monitoring in different habitats. Note that the timescales are suggested and will change according to individual situations and the type and extent of restoration work carried out. Year -1 refers to the summer before the restoration is carried out, year 0 is the summer when the restoration is carried out, year 1 the second summer etc. Site visits to check the stability of the restoration are not included in the monitoring programme but would be required to identify any follow up restoration work. Visits at 10 years would be for a selection of sites only.

Target	Mires	Headwater streams and tributaries	Higher order streams/ rivers	Essential	Desirable	Research element	Approach	Timescale (years from restoration year)
Geomorphology								
Channel morphology and in-stream features		✓	✓	✓			Geomorph surveys e.g. Modular River Physical (MoRPh) surveys or River Habitat Surveys where there is a defined watercourse. Surveys are already available for some sites.	-1, 1, 5, 10
Erosion rate and sediment loss/deposition	✓				✓	✓	Predictive modelling (requires specialist input) Expert judgement on status of nick points and any need for follow-up repairs	Custom
Flood events		✓	✓			✓	Predictive monitoring using Lidar (requires specialist input)	Custom
Habitats								
Habitat structure	✓	✓	✓	✓			Fixed-point photography (e.g. River Restoration Centre methods[4])	-1, 1, 5, 10

[4] https://www.therrc.co.uk/river-restoration-videos

Target	Mires	Headwater streams and tributaries	Higher order streams/ rivers	Essential	Desirable	Research element	Approach	Timescale (years from restoration year)
Habitat (extent)	✓	✓		✓			Meso-habitat mapping of the quintessential habitats and meso-habitats described in the FWRP to show the extent and distribution of habitat present (potentially compare with pre-restoration) Recent NVC/SAC feature survey of the New Forest mires could be used to provide a baseline (inclosures not included).	-1, 1, 5, 10
Wetland vegetation	✓			✓			Proposed Freshwater and Wetland Restoration methods. Pre-restoration surveys may not be required e.g. if no wetland vegetation is present. Can be combined with habitat mapping	(-1), 1, 5, 10
Aquatic vegetation		✓	✓	✓			Walkover survey to record presence and extent of in-channel vegetation along channel (e.g. mapped DAFOR see App I), where relevant.	-1, 1, 5, 10
Species								
Priority species	✓	✓	✓		✓		Surveys to record the presence and abundance of key species as appropriate e.g. Pillwort, New	-1, 1, 5, 10

Target	Mires	Headwater streams and tributaries	Higher order streams/ rivers	Essential	Desirable	Research element	Approach	Timescale (years from restoration year)
							Forest Water Crowfoot etc. using/adapting existing protocols[5]	
Fish nurseries		✓				✓	Citizen science project to assess importance of habitat for fish nurseries (methods to be developed)	
Higher taxa monitoring	✓				✓	✓	Citizen science monitoring e.g. using existing projects and resources (e.g. the Riverfly Monitoring Initiative[6] and FHT methods[7]	
Water								
Water levels	✓				✓		Dip wells (see Natural England Commissioned Report NECR086)[8] , ideally with automatic loggers (pressure transducers), to measure soil water table	Custom
Water chemistry		✓	✓			✓	Citizen science project to test water chemistry to establish whether this could be an	Custom

[5] https://freshwaterhabitats.org.uk/projects/pondnet/survey-options/
[6] https://www.riverflies.org/
[7] https://freshwaterhabitats.org.uk/projects/pondnet/survey-options/
[8] http://publications.naturalengland.org.uk/publication/46013

Target	Mires	Headwater streams and tributaries	Higher order streams/ rivers	Essential	Desirable	Research element	Approach	Timescale (years from restoration year)
							exacerbating factor (see FWH Clean Water for Wildlife[9] for methods & resources for nutrient pollution; pH and Redox potential are also informative but straightforward to measure)	
Water temperature		✓	✓			✓	Temperature loggers in exposed, shaded and vegetated channels (desirable) (methods will depend on extent and resources available e.g. see guidance[10])	1, 5
Function								
Trophic cascades-insect emergence	✓	✓			✓	✓	Aquatic emergence traps to estimate abundance per m^2 and species richness. Methods will depend on extent of area and resources available	3
Erosion related to recreation							Citizen science – erosion as exacerbating feature (methods to be developed)	

[9] https://freshwaterhabitats.org.uk/projects/clean-water/
[10] https://pubs.usgs.gov/tm/03/a25/tm3a25.pdf

Target	Mires	Headwater streams and tributaries	Higher order streams/ rivers	Essential	Desirable	Research element	Approach	Timescale (years from restoration year)
Ecosystem service provision	✓	✓	✓		✓	✓	NCAT[11]	

[11] Environment Agency's National Natural Capital Assessment Tool

Hypothetical monitoring case study

1.10 The diagram below sets up the hypothetical monitoring carried out (post impact assessment) for a hypothetical restoration involving reinstating a headwater stream along its original meandering route to reduce erosion, recreate transitional edge habitats and improve in-stream habitats. This site was identified as a demonstration site, therefore more full monitoring was required than at some other sites.

1.11 The monitoring plan for this site was a key part of the planning of the restoration. It was designed to relate directly to the measures of success identified as being relevant for the particular site, with the addition of the work on trophic cascades, which was an addition following discussions with a university looking for opportunities for related research projects. This hypothetical case study is provided for illustrative purposes and is not intended to be a blueprint for other sites but to show how different elements from Table 1 can be used, depending on the character and specific aims of each restoration.

Habitat structure

20 fixed point photography points set up along the restoration reach including adjacent floodplain. Locations informed by restoration plan to include key features. Points recorded with hand held GPS, initial digital photos taken and stored with ID no. cross referenced to map of locations and accompaning spatial data set containing 10 figure grid reference. Repeated at year 5 and a visual comparison and brief report made.

Habitat mapping and wetland vegetation (combined)

Pre-restoration surveys identified that the adjacent floodplain was initially rather dry Purple Moor-grass rush pasture with no marginal habitat. Lidar data suggested that areas were sufficiently low-lying for mire vegetation to develop where embankments were removed and drains filled. Therefore when the monitoring was planned, it was decided that post restoration surveys would be needed to assess the species compostion of the vegetation that developed against the New Forest habitat descriptions. Areas of habitats were mapped in year 5, and 5 transects carried out across the breadth of the wetland system (% cover of plant groups plus litter, bare ground etc. was examined and an ordination used to explore transitional vegetation).

Priority species survey & aquatic survey

Priority species surveys were carried out at the same time as the habitat mapping New locations for Pillwort were recorded using a handheld GPS and the extent of patches mapped (e.g. using FHT methods)

Coral Necklace was recorded during the impact survey on a nearby track. This population was checked and found to have expanded due to localised bare ground creation during restoration works, and was recorded as above

A small patch of Chamomile recorded during the pre-restoration survey was not relocated, and a negative record made. Extensive patches of Chamomile were noted outside of the restoration area and noted for context.

At the same time, all aquatic, in-channel vegetation was recorded as above and mapped

Water characteristics

Examination of Lidar data during the planning phase indicated that changes in water levels in the floodplain could be a key feature at this site. Three dipwells were set up and levels monitoring once a month during year 1 and year 5 by volunteers. Water chemistry measurements were taken by the volunteers while on site. With the development on in-channel vegetation, this site was identified as suitable for an investigation into water temperature, therefore funding was secured for the installation of four temperature loggers, two in tree-shaded and two in open locations. These were installed in year 3 and retained for a year.

Trophic cascade

Liaison with a nearby university resulted in an MSc project looking at invertebrate emergence. A student therefore developed a methodology using emergence traps to look at insect emergence within the restored head water stream. As part of the project, this was compared with a non-restored stream elsewhere.

Reporting

Data from the 5 monitoring strands were combined into a single succint report to describe the site 5 years after restoration in the context of the habitats present (with reference to the typology) and the relevant measures of success. Any lessons learned were highlighted. This was made available as part of the restoration hub.

Figure 2: Hypothetical case study of monitoring of a New Forest restoration project.

Monitoring methods

1. Fixed point photography

1.12 Fixed-point photography is a powerful, intuitive, quick and cheap method of documenting the change brought about by restoration. It provides visual evidence that can easily be understood by most audiences and can show geomorphological changes, change in the extent of habitats and changes in habitat quality (e.g. vegetation structure, wetness and broad change in vegetation composition). It does not require particular expertise or training, and can be a useful engagement tool if carried out by volunteers.

Methods

- Use a digital camera (good quality smartphone cameras are convenient), ideally with a built in GPS.
- Choose locations based on the proposed works to ensure that key features will be covered. Take the long view – will it be possible to return to the same spot once restoration has been carried out, is vegetation growth likely to obscure the view?
- Record 10 figure grid references with a GPS as phone or camera GPSes can be inaccurate
- Record the direction of the photo, either as a compass bearing or using a directional arrow on a map, and the date.
- Multiple photos (i.e. upstream and downstream) can be taken from fixed points, but should only be taken if this is useful in the given location
- Avoid using a zoom, as this makes replicating photos harder
- Ideally, use the same camera (or camera with the same focal length) on return visits.
- Ideally take photographs on an overcast but bright day, as both strong sunlight and murky conditions can result in loss of detail.
- Repeat photos should be taken at the same time of year
- Baseline photos in different seasons may be useful (e.g to show seaonal flooding)
- 360° photos can be used to create a more or less continuous record along the watercourse.

Storage and viewing

- Storage systems should be as future-proofed as possible and should be updated in line with technological change so that images remain accessible
- Original individual image files should be retained even if the photos are compiled into a document, and storage should be backed up

- The “contact print” option in file explorer (Windows) is a quick and efficient way of displaying multiple labelled images
- Using a GIS plugin (e.g. in ImportPhotos in QGIS) is a very effective way of viewing photos in the context of their locations.
- 360° photos can be effectively stored and viewed in Google maps.

Tips

- Photos should be download and labelled at the earliest opportunity
- Take more photos than you need and discard extras. The final selection should not be overly large as this can present storage problems and also makes it less likely that the images will be used effectively in the future
- When revisiting, take a copy of the previous photos and a map of locations in addition to location data and a GPS.
- Plotting points within a mapping app on a digital devise can help re-find locations
- Where possible, frame the photo with markers that can be refound (e.g. trees, fenceposts, a distinctive skyline etc.
- Taking fixed-point photos is relatively quick. However, organising and storing them is quite time consuming and if not done efficiently can mean useful photos are not retrieved. Presenting photos taken from the same point a t different times is the most effective way of interpreting any change shown.

2. Physical surveys

1.13 Two existing methodologies are available for undertaking physical surveys, the River Habitat Survey and the Modular River Physical Survey. The two approaches use similar terminology and both have previously been used in the New Forest. They are described briefly here and a summary table provided to highlight key features, followed by a brief assessment of the suitability of each in particular circumstances.

River Habitat Survey

1.14 The River Habitat Survey (RHS) was designed by the Environment Agency in 1994 to gather baseline data to inform an overview of the physical condition of UK streams and rivers. It has been reviewed and improved on multiple occasions, firstly in 1997 and again in 2003. Since then, surveys have been used to determine the catchment characteristics of several UK rivers, identifying the attributes of high-quality sites, investigating species-habitat relationships and providing input to Environmental Impact Assessments. The

RHS is a relatively rapid approach based on sampling at 10 stops over a 500m reach. It relies on consistent and accurate recording and entering of data into the database, with the primary objective being context-setting.

The Modular River Physical Survey (MoRPh)

1.15 The Modular River Physical Survey was initially developed for citizen scientists and is an adaptation of standard methodology used in industry. It was designed to aid the Catchment Based Approach and river stewardship for Catchment Partnerships but is now being used for river assessment (including Biodiversity Net Gain) and monitoring.

1.16 The MoRPh survey is the foundation level survey within the Modular River Survey, which combines information gathered from three river units of different size (module, sub-reach and reach). MoRPh surveys are aimed at providing detailed data on physical habitat for short lengths of a river and can be built into a MultiMorph survey to encompass longer lengths. The data can be combined with biological monitoring, such as macroinvertebrate sampling. Due to this, MoRPh surveys can be used alongside other repeat sampling to monitor changes in the river habitat.

Table 2: Summary of the key attributes of RHS and MoRPh.

Feature	River Habitat Survey	The Modular River Physical Survey (MoRPh)	Notes
Aim	Characterise and assess, in broad terms, the physical structure of a river/stream. Provides a framework in which macro-invertebrate, macrophyte, fish and geomorphological surveys can be set.	A scalable citizen science programme used to summarise and monitor changing physical habitat conditions along and between rivers and to assess the links between organisms and habitat.	RHS can provide comparison with benchmark sites
Application	Initially used to collect baseline data to assess the physical condition of all UK streams and rivers. Has since been used to determine the catchment characteristics of several rivers in the UK, identify the attributes of known top quality 'benchmark' sites for habitat quality, investigate possible species–habitat relationships and provide input to environmental impact assessment.	MoRPh survey data can be combined with biological monitoring or other repeat sampling to investigate relationships between channel characteristics and other biological and physio-chemical variables. Surveys can be built into a MultiMoRPh survey which provides precise information of the hydromorphology of rivers. Now used in Biodiversity Net Gain.	RHS covers a longer length of the river, whereas MoRPh surveys deliver more localised data and may be more compatible with invertebrate survey data e.g. RIverfly
Output	Scores for 10 indices including river habitat quality, habitat modification, channel substrate, flow regimes, channel vegetation, geomorphic activity, riparian quality (bankface and bank top vegetation, bank material and modification and riparian vegetation complexity), channel re-sectioning (reprofiling/dredging). A Hydromorphological Impact Ratio (HIR) is also calculated to describe departure from "natural" conditions.	Scores from 14 indicators covering flow types, bed material (including siltation), channel physical habitat complexity, aquatic vegetation morphotypes, riparian physical habitat complexity, riparian vegetation morphotypes, channel reinforcements, non-invasive plants and human pressures and impacts.	HIR can be useful in describing the departure from natural conditions.
Data collection methods	Sampling - spot-checks produce detailed survey data for 10 equally-spaced 1m wide transects; 'sweep-up' surveys produce cumulative estimates for the entire 500m length.	Assessment within a rectangular area (transect width depends on width of channel). 14 indicators are automatically generated from each survey to summarise physical habitat conditions at the time of the survey.	Modular approach - MoRPH is the foundation level survey and when combined with sub-reach (MultiMoRPh, e.g. 10

Feature	River Habitat Survey	The Modular River Physical Survey (MoRPh)	Notes
		These can be aligned with biological survey points.	MoRPH) and reach (HydroMoRPh) survey data, makes up the Modular River Survey.
Parameters recorded	General Information: Land-use, bank profiles, vegetation. Physical features: Predominant channel substrate and flow-type; habitat features; modifications to the channel and banks; Vegetation features: channel vegetation types, vegetation structure of the banks and banktop; and land-use.	General Information: River channel dimensions. Bank top: ground cover, vegetation, water related features. Bank face/channel margin: profile, materials, reinforcement, features, vegetation. Channel Bed: Materials, water surface, physical/artificial features, vegetation.	
Survey area	500m length of channel	10-40m length of channel (scaled according to the width of the channel). MultiMoRPh is 100-400m (e.g. 10 MoRPh surveys and HydroMoRPh may be several km.	RHS unsuitable for monitoring interventions over a short reach, as it spans 500m (i.e. results from the restoration area would be diluted”)
No. of survey points	10 equally spaced spot-checks (approximately every 50m).	One MoRPh survey covers 10-40m of river length (depending on width of river).	
Equipment	Laminated Spot-check Key, survey forms, GPS, mobile phone, camera, ranging pole, rangefinder, waterproof document holder.	Field survey sheet, code sheets, GPS mobile phone, camera, ranging pole, tape measure, waterproof document holder.	
Timings	All year round	All year round but best completed between May and September to include period when aquatic vegetation is apparent.	Repeat surveys should be carried out at the same

Feature	River Habitat Survey	The Modular River Physical Survey (MoRPh)	Notes
			time of year, ideally when the water levels are similar
Time taken	Approx 2 hours	Approx 2 stops per day – 5 days for one MultiMoRPh	
Extent of usage	Used "extensively" since 1994.	Used since 2017	
Degree of skill required	Requires ability to recognise vegetation types plus understanding of basic geomorphological process. 3-day training programme.	Can be conducted by volunteers and river managers following 1 day of training.	Consistency between surveyors is essential – depends on training.
Number of surveyors required	One surveyor in low-risk areas, two surveyors in areas of high risk.	One surveyor from the bank top.	
Support available	App available, online manual, Citizen page including free training, accredited 3-day training course.	App available, also field guide/website	
Data Entry	Data entered on the RHS database using a reference number that is unique to each site and each surveyor.	The raw field data are entered into the MoRPh web tool, which stores, analyses and maps physical habitat information and generates values of 14 indicators.	
Additional info collected	Observational info on valley form, land-use in river corridor, photographs (360 recommended) every 10 m	Photographs	360 photos can be used to create photo trail (e.g. similar to street view in Google Maps)
Data download	Two headline indicators available. Contact scheme for remainder of data	Indicators + full data available for download	

RHS, MoRPH and bespoke approaches

1.17 Neither RHS nor MoRPH were specifically designed to show the outcomes of freshwater restoration. However, they provide an established, replicable method that could be adapted for use for larger restorations in the New Forest. Necessary adaptations would depend on the specific situation, but might include, for example, the exclusion of the MoRPH score for wooded features (which would not necessarily be positive for a New Forest headwater stream, for example). Similarly, the inclusion of poaching (often a desirably feature along New Forest streams) within the RHS modification score would require careful consideration and the index for human pressure (transport infrastructure, arable etc.) and channel reinforcement (MoRPH) are unlikely to be relevant.

1.18 RHS likely to be effective in describing the baseline condition of a restoration site and the level of modification. The approach is not suited to small restorations, as it is based on sampling a 500m reach, therefore restoration work over a short reach could be concealed by the remaining sampling stops. For restorations larger than 500m where changes are likely to be substantial, it will show change and could also be used to provide a comparison with benchmark sites.

1.19 MoRPH is more detailed (and more time consuming). For example, it records the abundance, not just the presence, of bankside features. It records everything within the survey area, rather than sampling it. It can be used to compare a given site over time or between restored and unrestored reaches. MoRPH has been adapted for headwater streams with fields for terrestrial vegetation in the channel bed. Another useful feature is the inclusion of invasive non-native species. Surveyor variability may be more of an issue for MoRPH than RHS, due to the shorter training requirement and more detailed approach. The precise relocation of survey areas will be important.

1.20 For smaller restorations and mire restorations, it is unlikely that either RHS or MoRPH will be worthwhile, and a bespoke method should be developed if geomorphological information is required. This may be as simple as before and after fixed point photos (e.g. using a ranging pole to indicate the level of incision), or undertaking geomorphological mapping. For intermediate projects, it could involve measuring one or more indicators such as sediment movement or erosion/deposition using established protocols such as those published on the PRAGMO wiki site[12]. This is likely to require expert input, for example, from the River Restoration Centre[13].

1.21 Any follow up monitoring should be done within 6 months and then again in 3-4 years to show recovery after the interventions. It should be carried out at the same time of year and with similar water levels (e.g. measured from a fixed feature such as a bridge of culvert) - if water levels are too high, key features may be obscured.

[12] PRACTICAL RIVER RESTORATION APPRAISAL GUIDANCE FOR MONITORING OPTIONS (PRAGMO) - PRAGMO (therrc.co.uk)
[13] https://www.therrc.co.uk/

3. Habitat mapping and vegetation sampling

1.22 Figure 3 outlines the process of monitoring habitats and vegetation for New Forest freshwater and wetlands restorations.

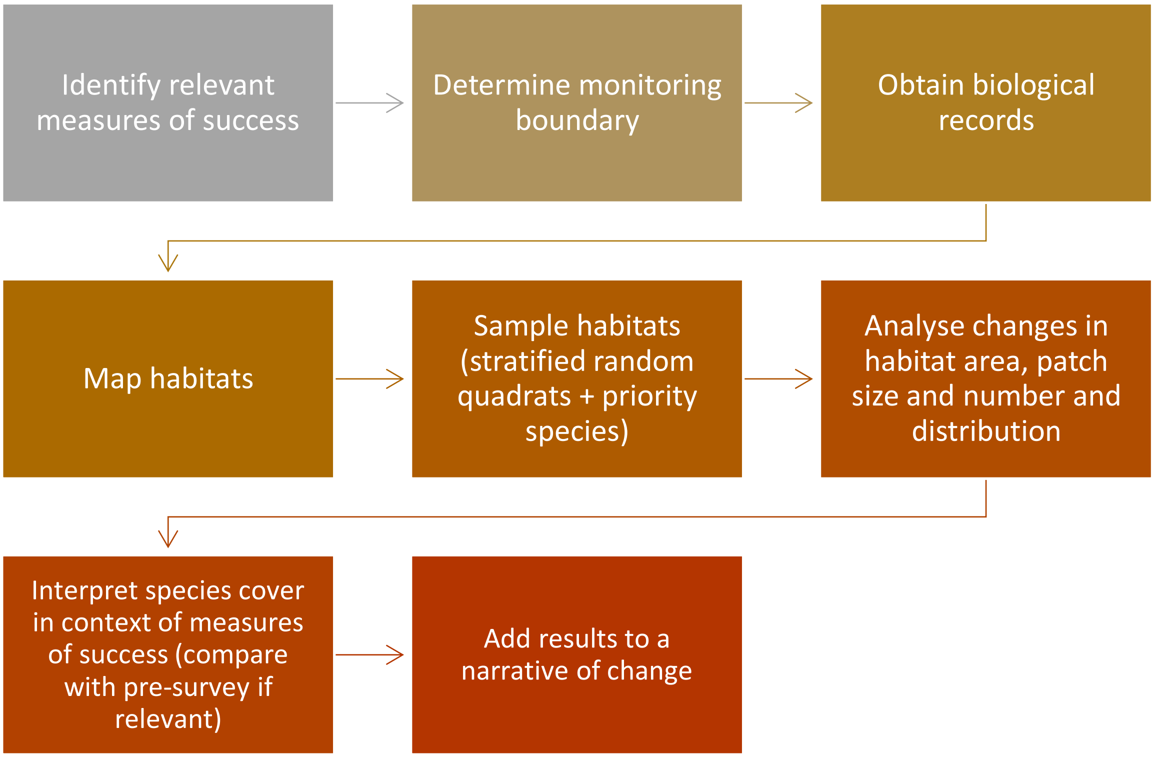


Figure 3: The steps required for habitat mapping and vegetation sampling.

Outputs and measures of success

1.23 The overall aim of new restorations will be to remove modifications and restore natural processes to allow the characteristic abiotic features and habitats to support the full range of natural species assemblages. The role of vegetation monitoring will be to evaluate restorations by identifying changes in habitat area and quality seen in the vegetation communities representative of characteristic New Forest freshwater and wetland habitats. Specific measures of success will be derived from descriptions of quintessential New Forest habitats. Measures of success are unlikely to be defined strictly quantitively[14], but may include, for example, an increase in the area of Valley Bog with a concomitant increase in the abundance and variety of Sphagnum mosses, or an increase in the extent of marginal

[14] Quantitatively defined targets would difficult to apply where the objective is to restore natural functionality, as the exact outputs may be hard to predict.

disturbed habitat characterised by species such as Pillwort. Depending on the level of evidence required, it will also be possible to compare post restoration monitoring data with baseline data to provide a more quantitative assessment of change in terms of habitat extent, distribution and quality (again using the measures of success to help define good quality).

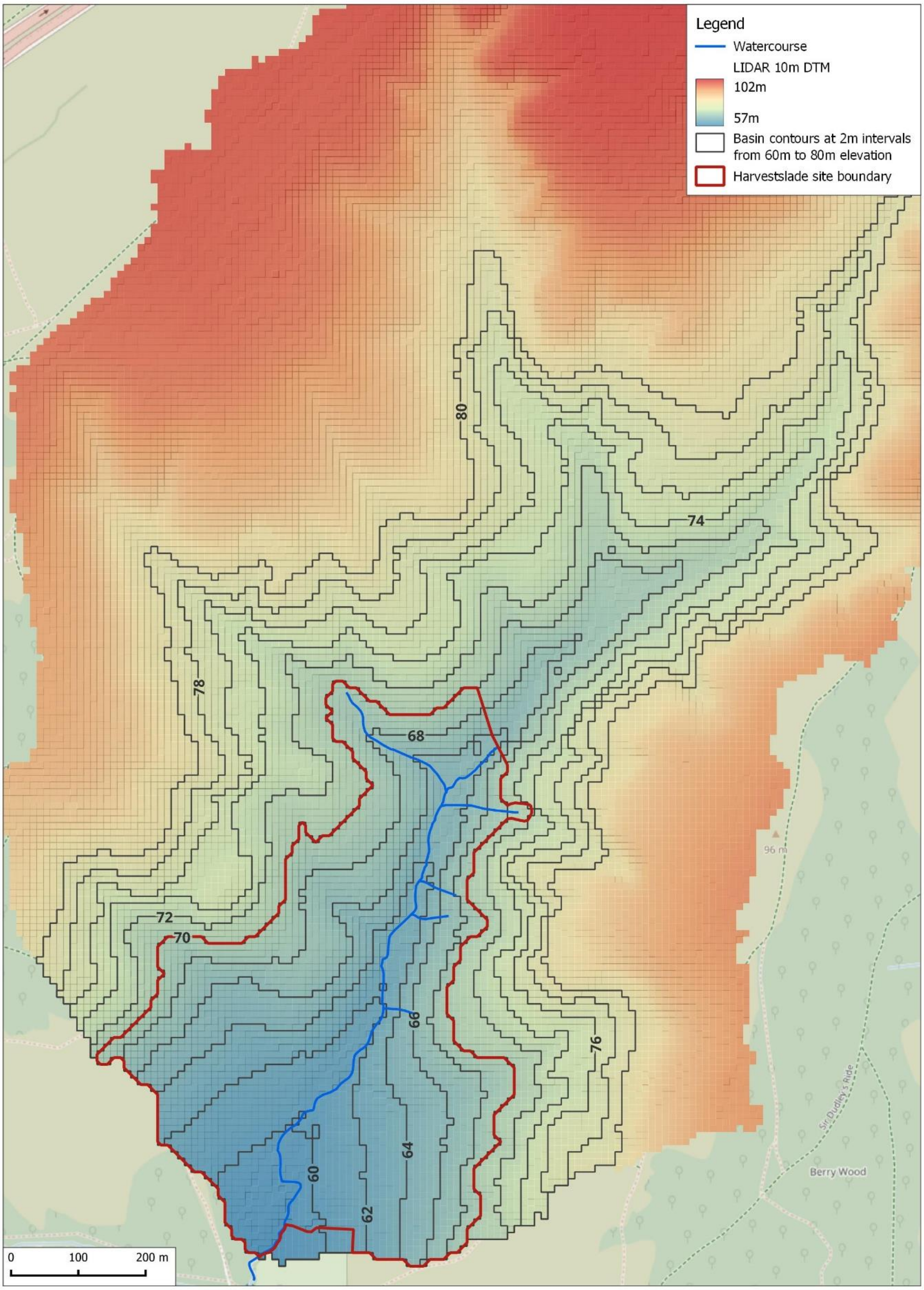
1.24 For previous restorations, for which measures of success have not necessarily been defined, it will be necessary to deduce intended outputs from the original project plans. Example outputs relevant to vegetation monitoring could include, among others, increasing the area of valley mire, improving the quality of streamside lawns, increasing the amount of poached and disturbed stream margins, increasing the cover of aquatic vegetation etc.

1.25 The success of other outputs, such as restoring meanders or increasing the diversity of in-channel features such as riffles, snags etc. will be addressed separately through geomorphological monitoring, as appropriate.

Monitoring boundary

1.26 A site boundary is set for the purposes of the restoration, including planning applications. However, this is not necessarily relevant for the monitoring, as it may include, for example, areas of dry heath that are not part of the restoration but were part of the area used during the restoration for access. A monitoring boundary should be established for pre-restoration surveys that will be relevant after the restoration. This is likely to require a combination of lidar data and aerial imagery plus information from project planning - Lidar data may be used to help inform the boundary by using a maximum contour height. and taking into account the planned restoration work (see Map 1).

Map 1: Example showing height data used to identify a monitoring boundary for Harvestlade.



Biological records

1.27 Once the boundary is determined, existing biological records (e.g. from HBIC) should be obtained to provide information on specific notable/protected species. It is not intended that the presence of each species should be reinvestigated after the restoration as part of the monitoring, but such data will provide useful context, particularly for those species that are indicative of particular meso-habitats (see below).

1.28 Data should also be obtained for the post-restoration period if possible, although surveys and ad hoc records from the intervening period may be limited.

Habitat extent - mapping

1.29 Within the monitoring site boundary, the distribution and extent of habitat types should be mapped. This may be informed by aerial imagery, but should be ground-truthed, using a GPS where necessary. Mapped habitats should include the "meso-habitats" typical of the New Forest. These "meso-habitats" should be identified with reference to the New Forest quintessential habitat descriptions (see Section 3 of the Freshwater and Wetlands Restoration Plan). However, note that only a subset of these are likely to be present at any one site. The habitat types are:

- Dry Heath (not included in habitat quality monitoring, see below)
- Wet Heath
- Humid Heath
- Valley Bogs (including seepage step mires)
- Bog pools (may be included within Valley Bog)
- Soakways
- Poor Fen
- Moorgrass Mires
- Transition Mires
- Tussock Sedge Fen
- Marl Flushes
- Poached and Disturbed Habitats
- Bog Woodland
- Alder Moor
- Wet lawns
- Temporary and permanent pools
- Temporary Headwater Streams
- Fast and slow flowing Oligotrophic Streams
- Fast and slow flowing Mesotrophic Streams
- Incised Woodland Streams

1.30 Baseline mapping should also include non-wetland habitats (dry heath, humid heath and semi-natural broadleaved woodland as described in Wright and Westerhoff (2001)) for context, also non-priority habitats such as coniferous woodland if relevant to the restoration. Mapping should be fine scale, for example at the level of $25m^2$ for most habitats, but it may be necessary to map mosaics (e.g. Wet Lawn and Wet Heath). More fine-grained habitat (Soakway, Ephemeral Pool etc) may need to be target-noted rather than mapped.

1.31 The National Vegetation Classification can be useful to inform the survey, but should not be used for mapping. It does not adequately describe some of the characteristic habitats of the New Forest, but conversely includes more detail about other habitats (such as heathland) than is required here.

1.32 The length of time needed for fieldwork is very dependent on the terrain and complexity of the habitat mosaic. As a rough estimate, about 250 ha may be achieved within a day, but this is very dependent on the variability and complexity of the habitat present. In general, the time needed for digitizing the data and providing field maps for the next steps is likely to take a similar amount of time as the survey.

Analysis

1.33 Habitats should be mapped in GIS to allow analysis and the creation of field maps for habitat quality monitoring. Extraction of key data from the GIS including overall areas of habitat and patch size and number will allow a comparison of pre and post restoration habitat area and distribution and would facilitate the identification of the type of habitat that expanding/new habitats have replaced, if required.

Vegetation sampling – quadrats

1.34 Habitat quality should be investigated through stratified random sampling, using quadrats to record the percentage cover of different species (also bare ground and plant litter) within each habitat type. This approach is proposed due to the difficulty of establishing permanent plots in a restoration landscape, and the possibility of missing patchily distributed key mesohabitats if a transect-based approach (at right angles to the flow of water) is taken.

1.35 A minimum of 15-20 quadrats per habitat type is recommended, but this should be decreased for habitats that are very limited in extent (e.g. bog pools, soakways, flushes etc.). Quadrats within wet heath, valley bog, transition mire, lawns and woodland groundflora should be 2m x 2m. A smaller 1m x 1m quadrat may be needed for habitats likely to occur in small patches such as bog pools, soakways, flushes etc. A measure of vegetation volume[15] should also be recorded (this provides an indication of the density of vegetation rather than simply the height of the tallest plant). Any notable species within the habitat should also be noted and a grid reference recorded. Where quadrats fall within transitional vegetation (e.g. between Valley Bog and Wet Heath), this should be noted and taken into consideration in the analysis – transitional habitat should not be excluded, as it may be where change is taking place. A single photograph should be taken from a predefined point (e.g. south west corner of each quadrat) to help with interpretation and record the context of the quadrat in the surrounding habitat (multiple photos create a large dataset that becomes unmanageable).

1.36 A description of each habitat should also be made in the field, as this will help with interpretation and can include elements (species or vegetation structure) that may have fallen outside of the samples.

1.37 For each quadrat, the following information should be recorded:

- % cover of each species present (using 0.5% for anything under 1% cover)
- % cover of bare ground, water, plant litter and dung
- Vegetation volume using a drop disc (weight 200g)
- Grid reference (SW corner)
- Size of quadrat
- Photograph (from S edge showing some habitat beyond, rather than straight down)

Analysis

1.38 Quadrat data should be used to compare the restoration against the "measures of success", for example particular species or suites of species present and their relative abundance. Factors such as grazing pressure or recreational disturbance should be taken into account in the interpretation. Useful statistics are likely to be the average cover of different plant groups (e.g. dwarf shrubs, graminoids, herbs, bryophytes), the average species richness, the presence of rare or priority species, and the average cover of bare ground and litter and sward height.

[15] E.g. using a drop disk which entails dropping a disk of known weight down a central pole and measure the height from the ground at which it settles.

1.39 Where pre-restoration surveys exist, any changes in the variables recorded can be identified and interpreted in the context of the measures of success. Ordination techniques may be useful to investigate the significance of changes in vegetation composition, but are definitely not a necessity.