# Appendix C

PowerPoint slides for presentations on day one and two of the Monitoring Seminar *the River Restoration Centre*

# Monitoring Workshop
# $12^{th}$ – $13^{th}$ September

the River Restoration Centre
Working to restore and enhance our rivers

SCOTTISH NATURAL HERITAGE

ENVIRONMENT AGENCY

SEPA
Scottish Environment Protection Agency

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## River Restoration Centre

- Information and Advice centre
- Supporting project and linking to science
- Themed Workshops
  - RR and Sustainable Land Management (1999)
  - RR and Chalk Streams (2001)
  - RR and Geomorphology (2001)
  - RR and Post Project Appraisal (2002)
  - RR funding (2003 & 2004)

## This workshop

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- Monitoring – application to river restoration
  - Conceptual: what we aspire to
  - Practical: what is being undertaken
- What should be best-practice?

(at its simplest: can it be used by everyone?)

- Consensus – framework, detail, integration
- How to disseminate it?

## Questionnaires

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**Specific Techniques in terms of their applicability for River restoration monitoring**

| *Methodology by group* | *Number of 'hits'* | *Methodology by group* | *Number of 'hits'* |
|---|---|---|---|
| ***Macrophytes*** | | Fish survey | 1 |
| Macrophyte sampling | 1 | Kick sampling | 1 |
| Site condition monitoring | 1 | Electric fishing | 1 |
| RCS | 1 | HABSCORE | 1 |
| Holmes JNCC | 2 | | |
| Fixed photography | 2 | | |
| **MTR survey** | **3** | | |
| **RHS** | **3** | ***Geomorphology*** | |
| Visual inspection of vegetation/vegetation survey | 1 | Replicated before-after-control intervention design | 1 |
| | | **RHS** | **3** |
| | | MImAs | 1 |
| ***Hydrology-Sediment/Water Quality*** | | Airborne photography | 1 |
| Permanent gauging stations | 1 | Geomorphological mapping | 1 |
| Fixed water level | 1 | Physical biotope mapping | 1 |
| Visual inspection of vegetation/vegetation survey | 1 | Repeatable topographic survey | 2 |
| Cross-sections | 1 | Invertebrate sampling | 1 |
| Continuous water level monitoring | 1 | Fixed point photography | 3 |
| **Spot gauging station** | **3** | Fluvial audit/rapid assessment | 2 |
| Invertebrate sampling | 1 | Cross-sections | 1 |
| Water chemistry | 1 | River reconnaissance survey | 1 |

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| Methodology by group | Number of 'hits' | Methodology by group | Number of 'hits' |
|---|---|---|---|
| Ecology of channel riparian and flood plain zones | 1 | Fixed point photography | 1 |
| River Energy Audit Scheme | 1 | Subjective assessment | 1 |
| Geomorphological monitoring | 1 | Post river restoration assessment | 1 |
| HEC-RAS | 2 | GeoRHS | 1 |
| Water table | 1 | | |
| Vegetation survey | 1 | ***Fisheries*** | |
| ***Ecology/macroinvertebrates*** | | Hydro acoustic survey-3D tracking-tagging | 1 |
| Replicated before-after-control intervention design | 1 | Hydro acoustic survey – 2D radio tracking | 1 |
| Multivariate community analysis | 1 | Radio tracking | 1 |
| Assessment of conservation value | 1 | Species specific trapping | 1 |
| Long-term data collection | 1 | Electrofishing | 1 |
| Interdisciplinary approaches | 1 | Fish counts/pass | 1 |
| Quantitative macroinvertebrate | 1 | Spawing habitat assessment (visual or quantitative) | 1 |
| Semi-quantitative macroinvertebrates | 1 | Seine and stop netting | 1 |
| Qualitative macroinvertebrates | 1 | Tagging | 1 |
| Mesohabitat assessment | 1 | Scale analysis (age and growth) | 1 |
| BACI design | 1 | HABSCORE | 1 |
| Baseline Ecological Assessment | 1 | | |

***Single hits*** 54

***Double hits*** Holmes JNCC, Fixed photography, HEC-RAS, Repeatable topographic survey, Fluvial audit/rapid assessment

***Triple hits*** MTR **survey** RHS (Macro) RHS (Geo)

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| **Limitations of the specific methodologies** | Macrophytes | Hydrology | Ecology macroinverts | Geomorph | Sediment/ water quality | Fisheries |
|---|---|---|---|---|---|---|
| The methodology is not easy to replicate | 1 | 1 | | 4 | | |
| The methodology is quantitative and the scale for the quantitative classification is limited | 1 | | | | | |
| Maps are required to apply the methodology | 1 | | | | | |
| There is a poor link between biological and physical data | 1 | | | | | |
| The data collected is of bad quality (e.g. poor photos) and lack of consistency locations | 1 | | | | | |
| The methodology is based in qualitative variables | 1 | | 1 | 1 | | |
| The methodology is subjective | 2 | 1 | | 3 | 2 | |
| The methodology is time consuming | 2 | 1 | 5 | | 4 | |
| The methodology is limited in detail/information collected | 4 | 1 | | 1 | 4 | |
| The methodology is costly | | 1 | 6 | 3 | 3 | |
| There might be errors in the measurements taken and in the associated calculations | | 1 | | | | |
| There are not enough resources available to apply the methodology | | 2 | 1 | | | |
| There is a poor cause-effect link | | | 2 | | | |
| Temporal variation is not captured | | | | 2 | | |
| High resolution required to obtain detailed information (DTM) | | | | 1 | | |
| Training is required before applying the methodology | | | | 1 | | |
| There is a lack of integration with other methodologies | | | | 1 | | |
| The methodology derives the information from data collected but it doesn't measure the variables | | | | 1 | | |
| Info required for the application of the methodology is only available for some/few species. | | | 1 | | | |
| No standard methodology/best practice guidance – relies on the commitment of the individual | | | | 1 | | |
| Results rely on experience | 1 | | 1 | 1 | | |
| New methodology with little scientific measurements | | | | 1 | | |
| The methodology is difficult to apply in large rivers | | | 2 | | | |
| *There are no limitations* | 1 | | 2 | 3 | | |

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# Costs for 100 m reach

| | Macrophytes | Hdrology | Ecology macroinvertebrates | Geomorphology | Sediment / water quality | Fisheries |
|---|---|---|---|---|---|---|
| <£100 | 7 | | | 6 | 2 | |
| £100-£199 | 3 | 2 | 1 | 2 | | |
| £200-£299 | | | | 2 | | |
| £300-£399 | | | | | | |
| £400-£499 | | | | 2 | | 1 |
| £500-£599 | 1 | | 2 | | | |
| £600-£699 | | | | | | |
| £700-£1000 | 1 | | | | | |
| >£1000 | | | 1 | 1 | 1 | |
| Not answered | 3 | 8 | 8 | 12 | 4 | 2 |

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# Aim and objectives

***Aim***

To bring together *key people from a range of natural science disciplines* (e.g. fisheries, ecologists, geomorphologists, hydrologists, water and sediment quality experts) *and backgrounds* (e.g. statutory authorities, academics, consultants, NGO) with a view to *agreeing a monitoring protocol* that is *underpinned by sound science* but critically *is feasible* to carry out in view of inevitable *cost constraints*.

***Objectives***

Agree a *monitoring/ appraisal framework* (matrix) which defines the most appropriate level of monitoring necessary on the basis of project size, sensitivity and cost.

Enhance understanding of each discipline's rationale for monitoring and through this agree *a trans-discipline monitoring protocol*.

Identify a range of sites (both completed and imminently proposed projects) that could be used as *case studies* to test the scientific rigour to the new framework/protocol.

***Assumptions***

Clear objectives and measurable targets have been set

# Outputs

- Results from the questionnaires (all)
- Notes from discussions
- Any agreed consensus
- Ways forward
- Others (as they emerge)

- RRC website, RRC conference, plus….

RRC Workshop Lyndhurst December 2006

# MONITORING CRITERIA, DURATION AND PREDICTING CONSEQUENCES

## Broad reasons for restoration

Ecological, societal, aesthetic, financial, political

(eg. bio-diversity, flood alleviation, flow restoration, fisheries, water supply, or multi-functional)

Evaluation concepts for rivers

ecosystem health, ecological integrity, ecological architecture, ecological function, geo-morphological processes, structural diversity, ecosystem services, the normative ecosystem, ecological status, stakeholder satisfaction, socio-economic satisfaction,…

SO MANY ALTERNATIVE CRITERIA THAT IT IS IMPOSSIBLE TO JUDGE WHETHER A PROJECT IS SUCCESSFUL OR NOT .

## Evaluation

Simple in principle:- Has the project reached its set target whether it be flood alleviation, conservation, fishery improvement, stakeholder satisfaction or multiple targets

Problem is that targets are often not clearly defined, quantitative or fully transparent….

<u>Therefore evaluation using whatever criteria may be impossible.</u>

## <u>EVALUATION CRITERIA</u>

Clearly must be related to the target (s)

<u>ECOLOGICAL CRITERIA</u>

Diversity, richness, abundance (of a species), ontogenic enhancement, distribution of a target species, stable functioning ecosystem,

NATURALNESS???? (SERCON)

<u>Don't forget unintended consequences:- disturbing a habitat for the "benefit" of one species/community, may cause disadvantages to another. (Even reducing pollution has adverse consequences on the "pollution fauna").</u>

## SCALE (Spatial and temporal)

River restoration is usually implemented at the reach scale for "results" (benefits?) at the larger scale.

Ecological monitoring/evaluation usually at same scale as restoration activity…. Should it be larger????

Ecological evaluation at larger scales is expensive unless monitoring is automated and /or selective

Temporal scale is more dictated by funding than actual requirement of knowledge

FROM THE "ORGANISMS EYE-VIEW "( Hidrew & Giller 1994)

**Restoration is a disturbance that alters the effects of a previous disturbance**

(Langford, 2007)

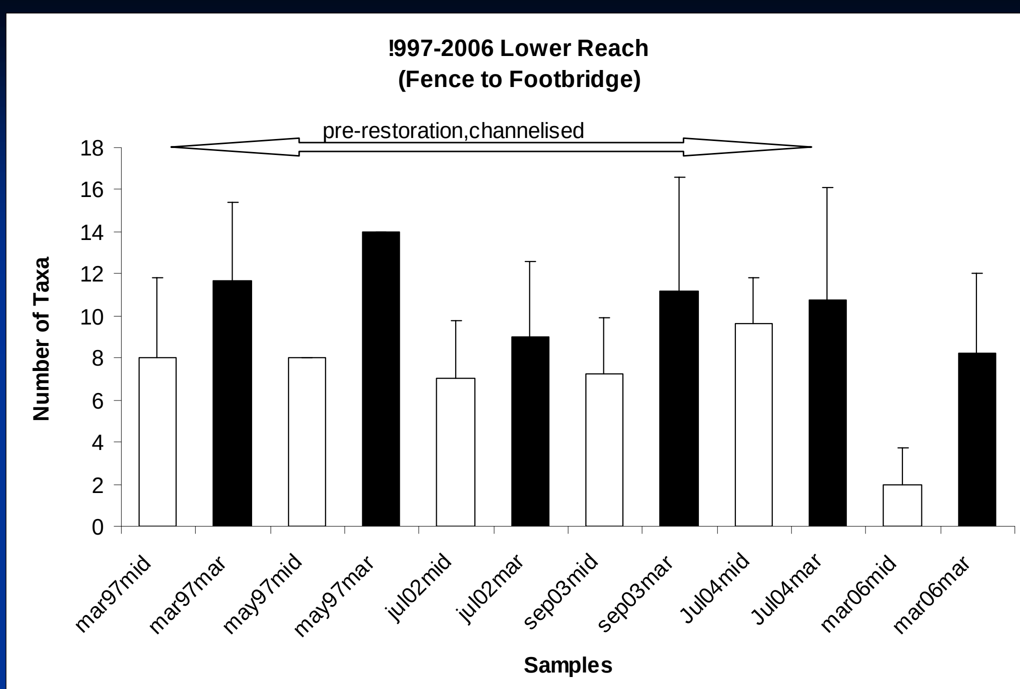
From the human eye-view restoration implies some kind of correction or return to a previous state often undefined.

## Factors affecting recovery from disturbance:-

Magnitude of disturbance, resistance and resilience of the flora and fauna.

Resistance can depend on:- the part of habitat disturbed (restored) eg. River margins or midstream habitats or both. Avoidance by species/mobility

Resilience can depend on:- mobility of species, (dispersal mechansims), availability of inocula (eg. from upstream, downstream or adjacent habitat)




Resistance. Midstream and marginal taxon richness in restored reach of a low resistance stream

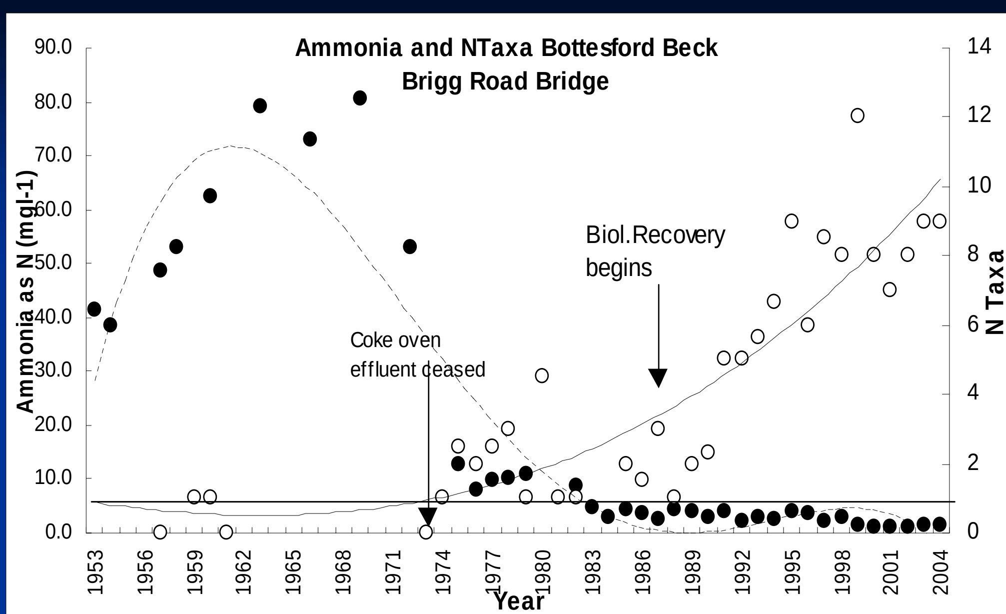
# Duration of evaluation programme:-

## Resilience

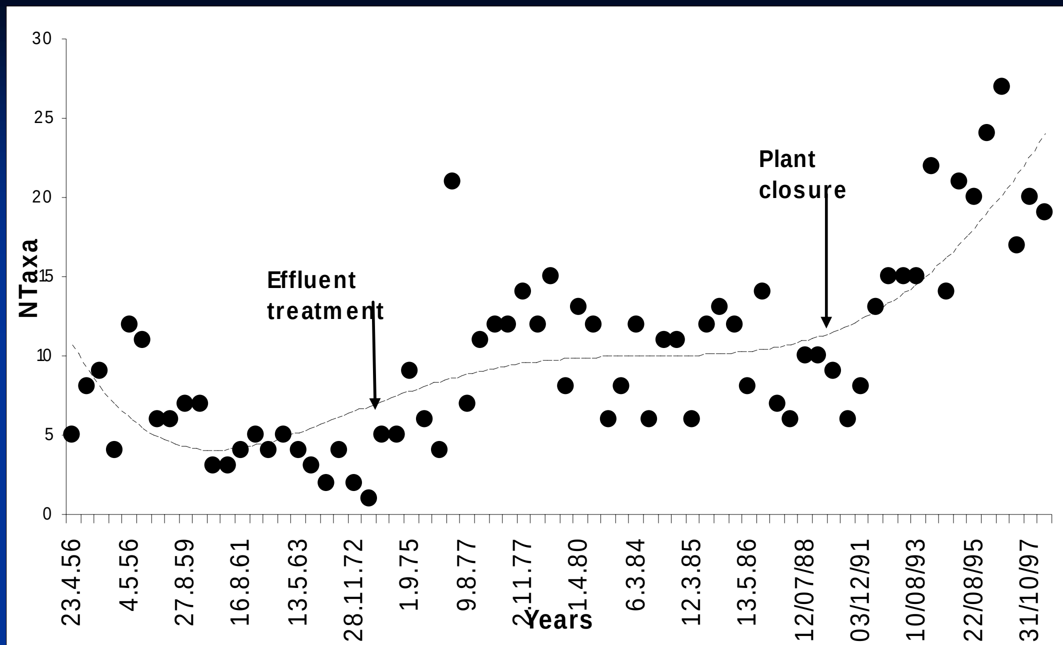
Main stages of recovery:- Colonisation, succession, stabilisation. Probably optimal monitoring should provide some information on the attainment of the last…but this might be hugely variable depending on ecosystem and the extent of the disturbance.

Disturbance and post-disturbance literature extensive, methods, frequencies of sampling, duration of programmes, data analysis. Lots of background. Firm scientific basis.

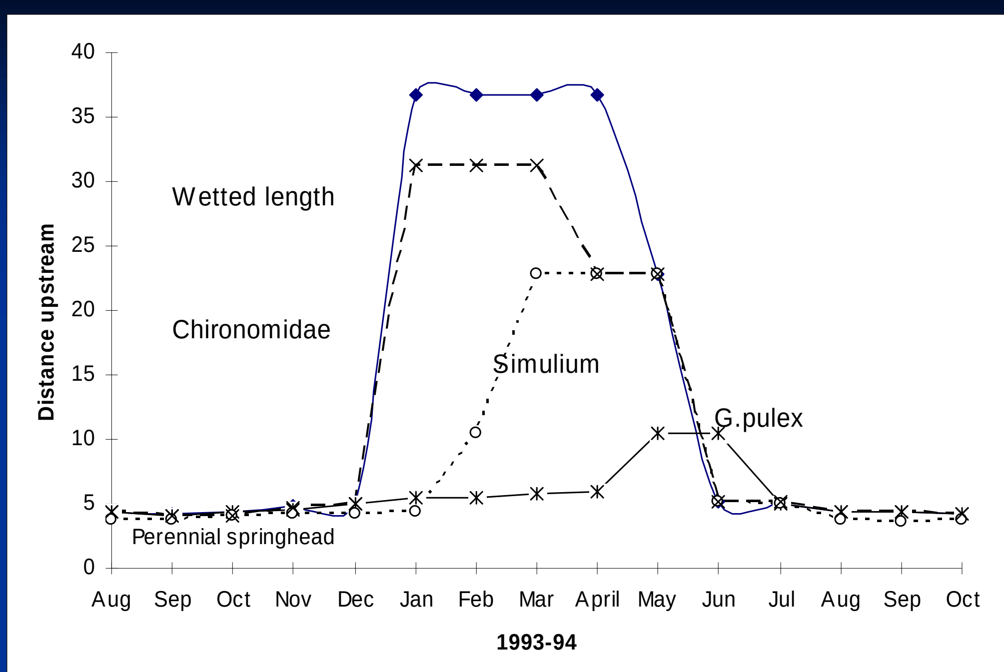
Programme duration can be estimated from published data and "before" surveys.



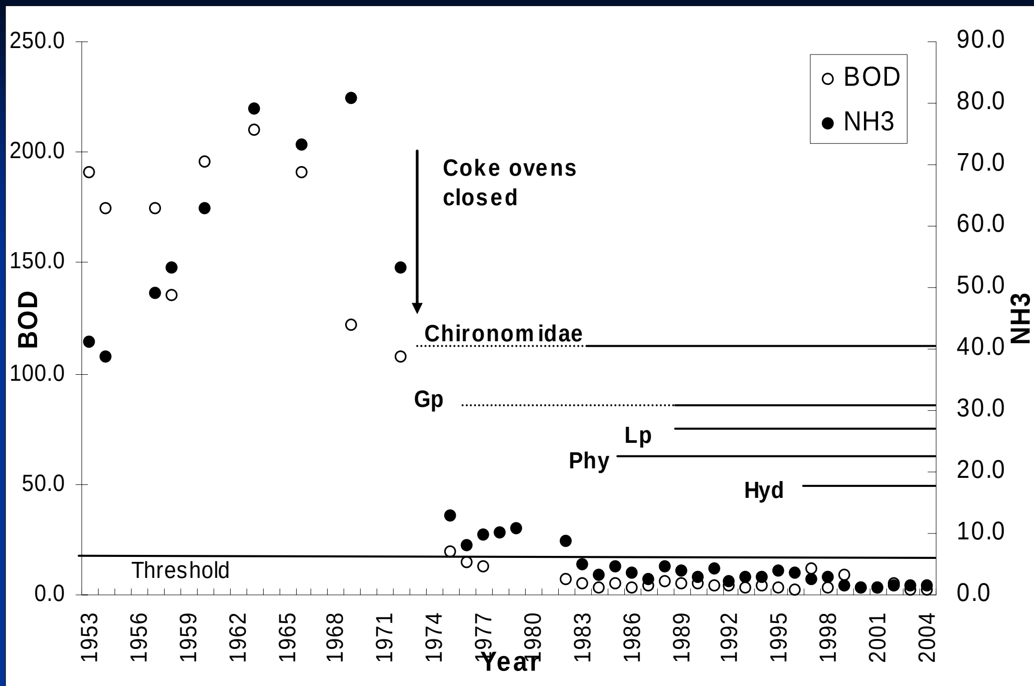

Poor resilience. Delayed recovery after steelworks closure. No clean-water fauna upstream




**Good resilience.** Recovery of macro-invertebrate richness following closure of a paper mill. Clean river fauna upstream




**Mobility of species.** Rates of colonisation of various taxa as flows varied seasonally in a winterbourne. The River Bourne. Wiltshire. Until December the stream was dry upstream of the SH



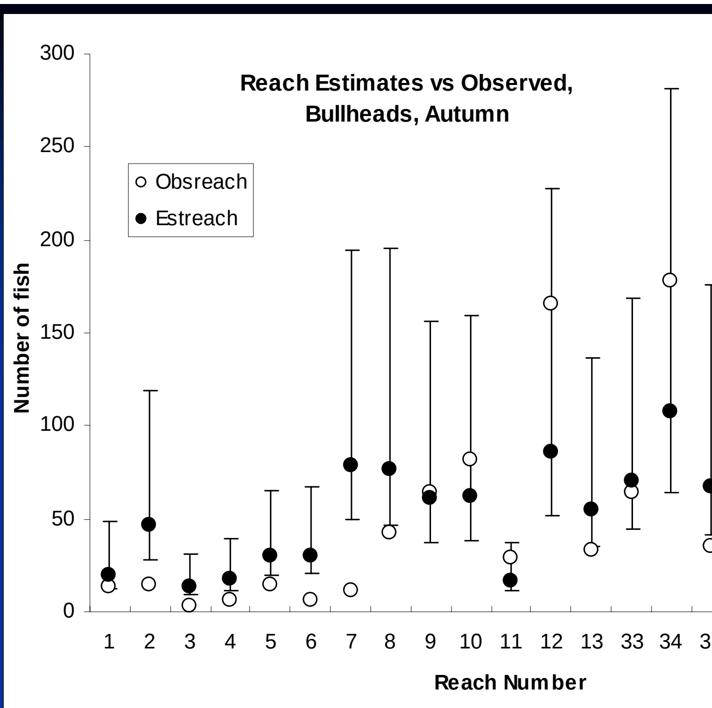

Relative colonisation rates from downstream or non-stream sources. (Total pollution)No instream fauna upstream

# FEASIBILITY OF ECOLOCICAL TARGETS, (PREDICTING CONSEQUENCES)

Although each restoration project may be regarded as a new "experiment" in terms of disturbance ecology the basic theory is well documented.

<u>From "before" studies and published literature</u> it should be possible to make reasonable predictions of target feasibility either qualitatively or quantitatively. This is rarely (if ever) done.

Use habitat preference data for prediction (models????)




Median and quartiles/Estimates of bullhead pops.in reaches. Est from seasonal median. Densities in riffles,pools and CWD

Predicting consequences (models):- Estimated numbers of bullheads in reaches in relation to observed numbers. Data used were areas of riffle, pool and cwd matrices in each reach and median densities of fish from all habitat unit samples.

## General principles for predicting consequences

In-channel/riparian structural changes unlikely to increase diversity other than at the reach scale…redistribution of species.

**Primary factors determining species occurrence at stream scale:-**

Biogeography, water chemistry

Largest changes in diversity from improvements in water quality

Cost benefit for ecological improvement alone by channel alteration…….disastrous

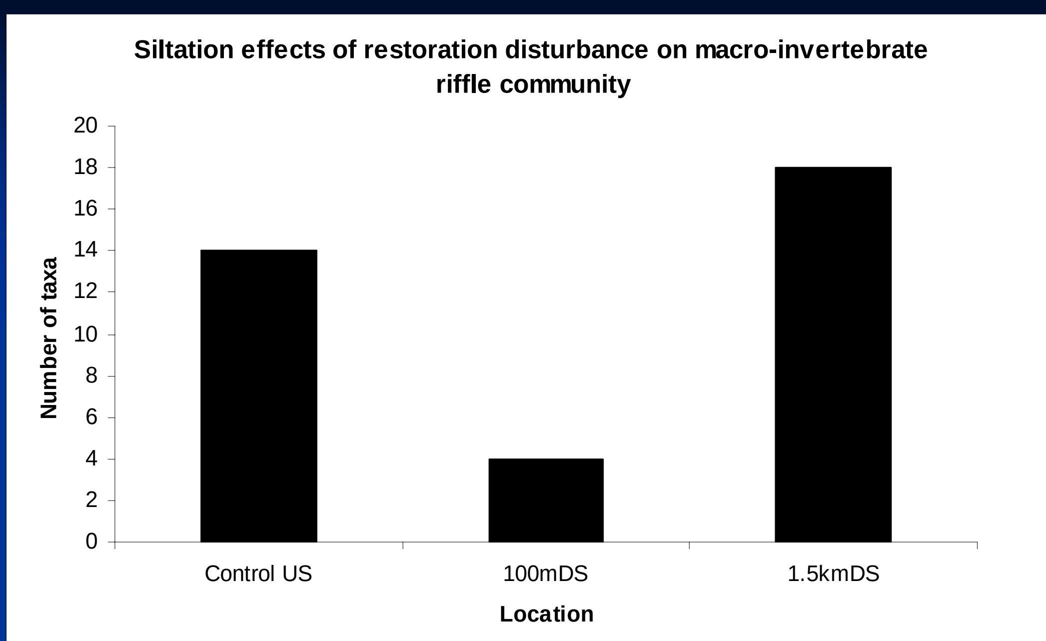
DEVILS BROOK.DORSET

Unrestored

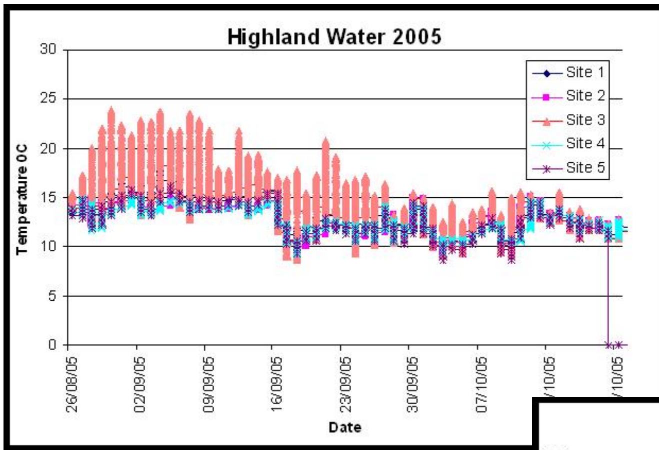
Restored

Unintended consequences

Eight species of riparian plants were missing from the restored reaches

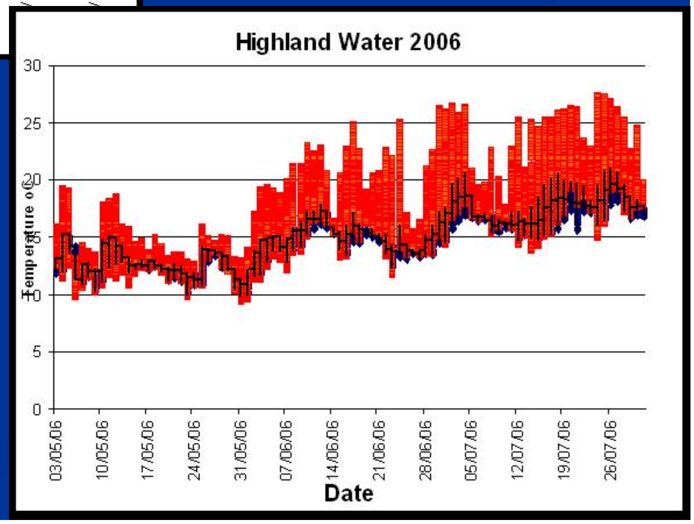



Unintended circumstances. Displaced silt (fine sediments) “stifle” the invertebrate community in a riffle downstream of the restored reaches.




## UNINTENDED CONSEQUENCES

WATER TEMPERATURES LOGGED OVER 2 SUMMERS IN CLEARFELLED AND SHADED REACHES




Maximum daily temperatures could be 8-10°C higher in unshaded than shaded reaches, at times exceeding "comfort zones" for trout and bullheads.

## PREDICTING CONSEQUENCES OF RESTORATION DISTURBANCE

For each proposed project can we:-

Devise a <u>"recovery index"</u> for streams and rivers based on categories of disturbance intensity and colonisation strategies and rates of flora and fauna.

Devise a <u>recovery index</u> for substrates, channel morphology and physical diversity

and combine the two.

<u>Based on both spatial and temporal data</u>

"When you can measure what you are talking about and express it in numbers, you know something about it. When you cannot express it in numbers your knowledge is of a meagre and unsatisfactory kind"

Lord Kelvin (died 1907)

# Can models which predict sediment *dynamics* be used to aid prediction of physical habitat status?

## Questions

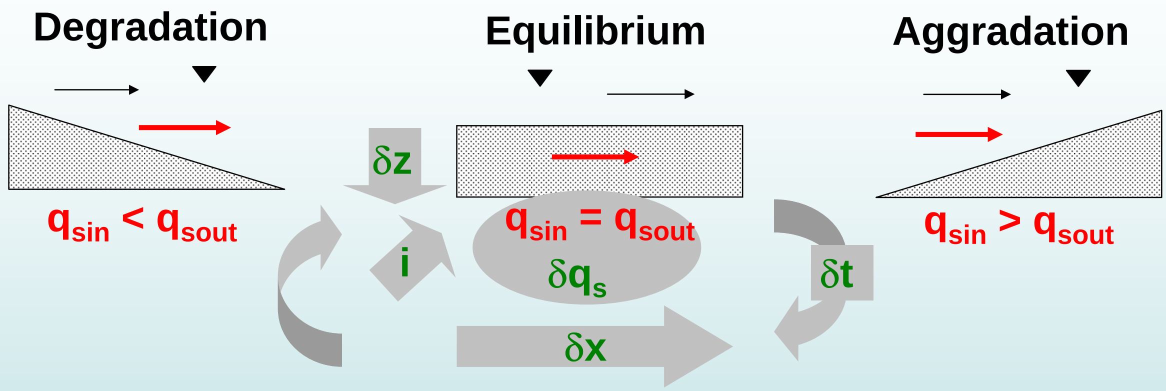
Can channel stability models be used to help predict habitat status?

Can the data required for such models be used in pre-existing habitat models?

Can channel stability models be used to direct post project monitoring efforts?

# Channel Stability

In essence channel vertical stability involves a continuum of ….




and in essence sediment dynamics models solve ……

$$\frac{\delta z}{\delta t} = -\frac{\delta q_s}{\delta x} + i$$

The University of Nottingham jba flood risk management research consortium FRMRC

# What assumptions are being made when considering channel dynamics and habitat?

- Dis-equilibrium in sediment transport is **bad**

## Why ?

# DEGRADATION

- Loss of substrate vital for feeding / spawning / habitat
- Loss of diverse bed morphology
- Flashier flows due to confinement
- Loss of aquatic plants

# Aggradation

- Smothering of substrate vital for feeding / spawning / habitat
- Loss of morphological diversity
- Loss of flow depth
- Fines choke fauna
- Increase in water temperature

# What assumptions are being made when considering channel dynamics and habitat?

- *DYNAMIC* equilibrium is **good**

## Why ?

# *Dynamic* Equilibrium

- Ordered but variable bed morphology – Species diversity
- Channel is *dynamic* – There is change but this enables diversity of habitat
- Adjustment of morphology (vertically *and* laterally) is gradual enabling sustainable flora & fauna migration with the physical system and habitat succession
- Varied range of flows within limited extremes and thus limited extreme sediment transport

# Sample of Channel Stability Models

### Stream Power Screening Tool

(A. Brookes)

### River Energy Auditing Scheme (REAS)

(N. Wallersetin & P. Soar)

### HEC RAS Sediment Impact Assessment Model (SIAM)

USACE HEC

### ISIS Sediments

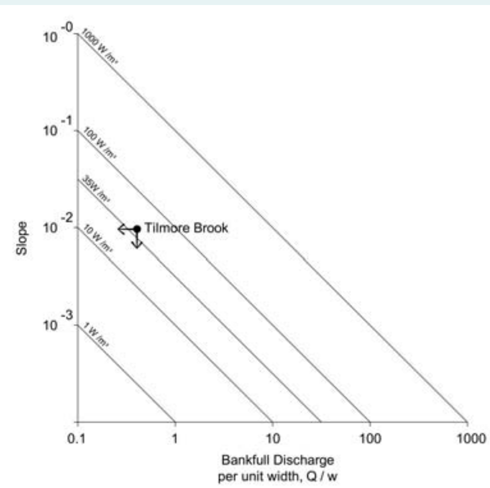
HR Wallingford

# Stream Power Screening Tool

Based on Specific Stream Power ($\omega$)

$$\omega = \frac{\gamma Q S_{(e/b)}}{W}$$

$\gamma$ = bulk unit weight of water, Q = representative discharge, S = slope (e = energy slope – preferable: b = bed slope), W = channel top width.




Continuity:

< 15 – 25 $Wm^{-2}$: Failure - Deposition

> 25 – 35 $Wm^{-2}$: Failure - Erosion

# River Energy Audit Scheme

Measure of channel stability through continuity of Excess Specific Stream Power - integrated over range of flows found in the channel

$$\Delta\omega_{e(r=n+1)} = \omega_{e(r=n)} - \omega_{e(r=n+1)}$$

$\Delta\omega_e$ = Specific Power differential for reach n + 1. r = reach, (n is from upstream to downstream), $\omega_e$ =

$$\omega_e = \omega - \omega_c$$

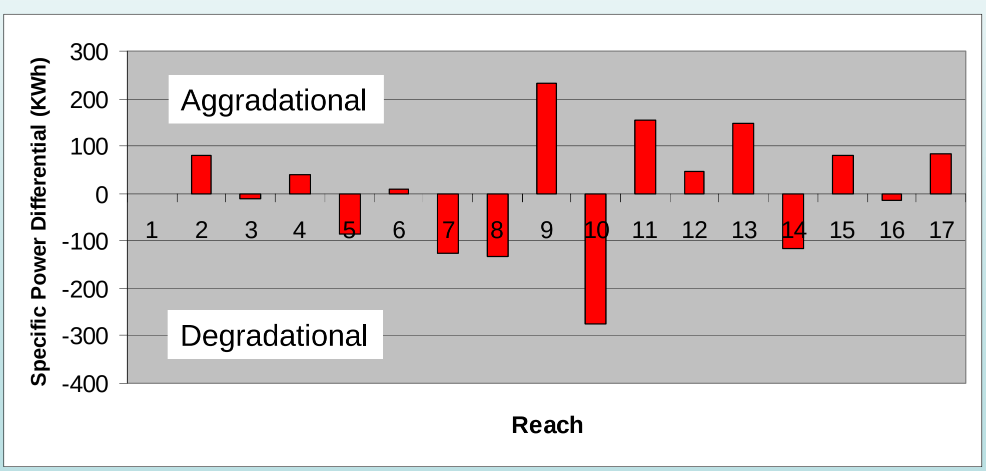
$\omega_e$ = excess specific stream power for a given discharge , $\omega$ = total specific stream power for a given discharge, and $\omega_c$, critical specific stream power =

$$\omega_c = 290 D_m^{1.5} \log\left[\frac{(12d)}{D_m}\right]$$

$D_m$ = grainsize m in the grainsize distribution, d = critical flow depth for that grainsize.

# REAS Output

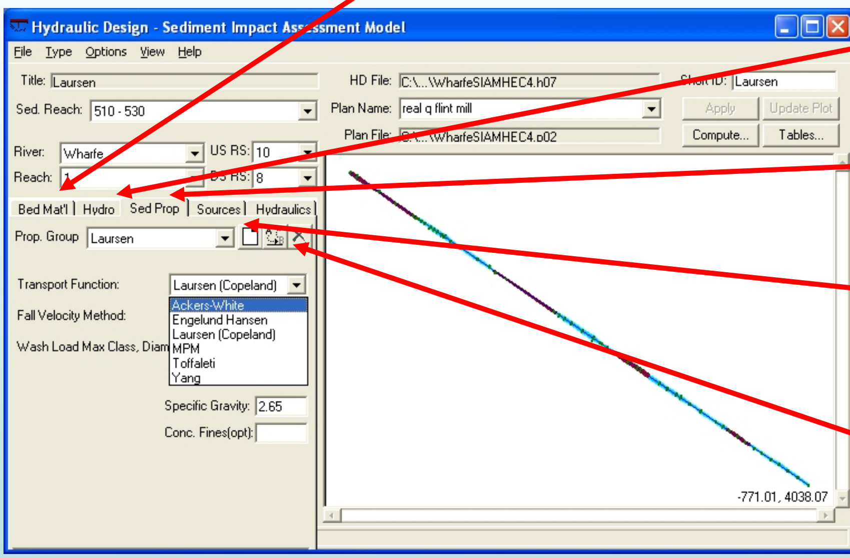
Aggradational / Degradational *tendency* in terms of channel ability to perform work (note that this work may also be performed in lateral adjustment)



# HEC RAS SIAM

- 1-D steady state flows run for a river based upon flow duration curve.
- River divided up into geomorphologically consistent reaches (User defined).
- Hydraulics passed to SIAM.

Reach bed material gradation record




Flow Duration record (days.yr$^{-1}$)

Sediment Transport Function

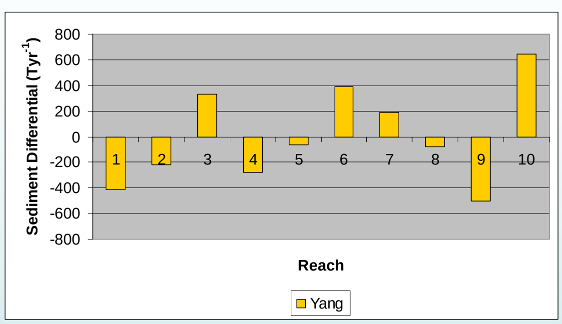
Bank material sediment sources (T)

Hydraulics from RAS require to compute sediment transport loads

- Sediment transport capacity for each reach subtracted from the incoming supply to give a tonnage budget…………..

# SIAM OUTPUT

Sediment tonnage differential in T.yr$^{-1}$ – indicating aggradation or degradation




# REAS / SIAM CAVEATS

1. Models assume prior knowledge of geomorphologically consistent reach limits.
2. SIAM uses sediment transport formulae which are highly difficult to calibrate.
3. Neither model routes sediment they are purely reach-by-reach balances and result are therefore time invariant – indicative of long term potentials.

# ISIS Sediments

1 - D fully unsteady flow routing model coupled with sediment routing model. Aggradation - degradation model – through events.

Solves St. Venent Equations and Exner Equation

$$\frac{\partial Q}{\partial x} = \frac{\partial A}{\partial t} = 0$$

Conservation of mass

$$S_o - S_f = \frac{d(d)}{dx} + \frac{1}{gA}\frac{d}{dx}\left(\frac{Q^2}{dx}\right) + \frac{1}{gA}\frac{dQ}{dt}$$

Conservation of momentum

$$\frac{\delta z}{\delta t} = -\frac{\delta q_s}{\delta x} + i$$

sediment continuity

Advantage

- Time variant – can model events and therefore temporal change in bed elevation

# What can we do with the results from these models to aid physical habitat status prediction?..............

# So how about relating habitat to specific stream power thresholds?

Many habitat thresholds (e.g. fish) are based in part upon $\overline{V}$, $\overline{d}$ & $D_x$

Now………

$$\omega = (\gamma QS)/w \quad = \quad \tau_o \overline{V} \quad = \gamma \overline{d} S \overline{V}$$

And……....

$$\omega_e = \omega - \omega_c \quad \& \quad \omega_c = f\,(\gamma, S, \rho_s, g, \theta, d, D_x)$$

So, if we know a mean velocity, depth and substrate size range for a species, obtain from the literature the slope at which this data was obtained and assume: $\rho_s$ = 2650, g = 9.81, $\gamma$ = 9810, $\theta$ = 0.047

**We can calculate a Excess Specific Power Range for an animal ($\omega_{e(species)}$)**

Thus if we know that $\omega_e$ for a river reach commonly lies within the range $\omega_{e(species)}$ the reach hydraulics are favourable for the species.

# Example – Brown Trout

Rearing habitat variables. Data: Raleigh et al., 1984

| *Life Stage* | *Depth (m)* | *Velocity (m)* | *Substrate (m)* |
|---|---|---|---|
| *Fry* | 0.10 - 0.40 | 0.00 - 0.30 | 0.065 |
| *Parr* | 0.10 - 0.60 | 0.05 - 0.50 | 0.065 |
| *Adult* | 0.12 - 0.91 | 0.50 - 0.70 | 0.065 |

S = 0.001

Associated Specific Stream Power Variables

| Life Stage | $\omega$ | $\omega_c$ | $\omega_e$ |
|---|---|---|---|
| Fry | 1.1 | 15.2 | -14.0 |
| Parr | 2.9 | 15.2 | -12.3 |
| Adult | 5.3 | 15.2 | -9.9 |

Seems to make no sense? – actually it does – these values are in effect zero so these fish don't operate in channels where there is active adjustment although the older and more robust the animal there closer to the active threshold it can live

Correlate these values with known local and reach averaged ($\gamma$QS)/w – locate in your catchment where these species / life stages are likely to reside

# Example – Brown Trout

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|---|---|---|---|
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**WHY USE POWER:**

S = 0.001

- We may not have actual surveyed values of d and v but are much more likely to be able to obtain Q, S, and W from secondary data.
- Change the paradigm of thinking about species from individual hydraulic variables to a measure which is in line with channel morphological adjustment

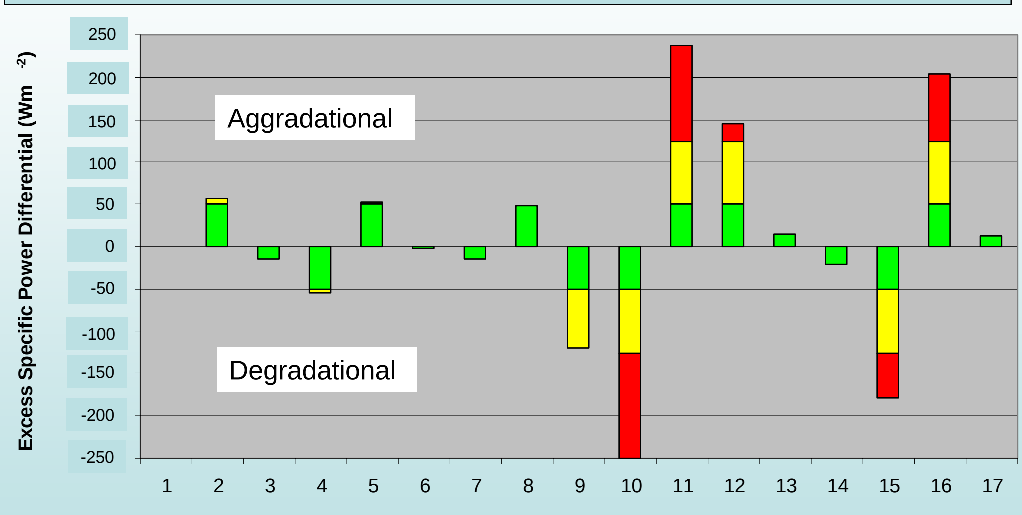
| | | | |
|---|---|---|---|
| Adult | 5.3 | 15.2 | -9.9 |

there is active adjustment although the older and more robust the animal there closer to the active threshold it can live

Correlate these values with known local and reach averaged $(\gamma QS)/w$ – locate in your catchment where these species / life stages are likely to reside

## As we (assume) habitat is strongly controlled by channel stability why not relate habitat to specific power balance?

### An Aggradation - Degradation Based Habitat Status Indicator




Good Habitat Status **&** Low habitat risk in future

Moderate Habitat Status **&** Moderate habitat risk in future

Poor Habitat Status **&** High habitat risk in future

## We Need Data to Calibrate such a model

i.e. in the UK what are the limits for certain species in terms of good, moderate and poor differentials.

In other words what level of stress in terms aggradation / degradation potential can species stand.

NEED DATA……………………………..

## SIAM

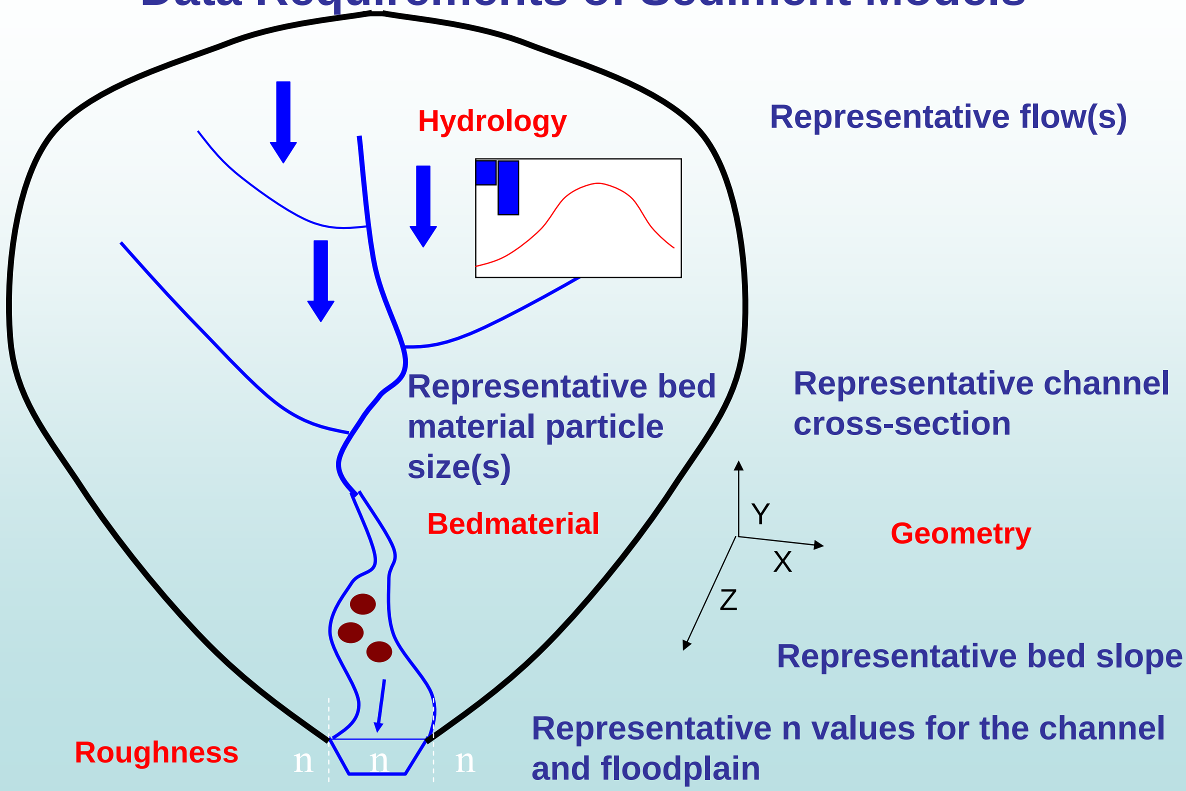
Could be used in a similar manner to REAS – habitat related to sediment load differentials. Difficult to calibrate a sediment load model.

## ISIS

Slightly different in that the output is time variant – can be used to show how habitat in a dynamic system may change spatially and temporally with locations of aggradation and degradation:

BUT – we do not know when these changes will occurs

## Data Requirements of Sediment Models




## Common Variables

| *Variables used in Habitat Models* | *Available from Sed. Models?* |
|---|---|
| Velocity (usually only mean) | ✓ |
| Depth (usually only mean) | ✓ |
| Substrate | ✓ (not from SPST) |
| Wetted perimeter | ✓ |
| Slope (bed/energy) | ✓ |
| $O^2$ | ✗ |
| Temperature | ✗ (v can be surrogate) |
| PH | ✗ |
| Chemical water quality | ✗ |

# Can Channel Stability Models be used to aid monitoring?

We must remember that rivers are dynamic in terms of sediment transport and therefore morphology both:

SPATIALLY & TEMPORILY

Therefore habitat status for difference plants / animals varies with Time and Space in any dynamic system.

It makes sense therefore to use a sediment modelling tool which predicts locations of change to highlight reaches that should be selected for special attention on post-project monitoring

*It does not make sense for monitoring to be spatially static*

# The HDMAR workshop

Association of Rivers Trusts
where there's water there's life

Alistair Maltby, Director (North)
Association of Rivers Trusts



# Some history…

# Late 2000

- 2000 Westcountry Rivers Trust completing the Tamar2000 project. Catchment wide programme of farm environment improvements. Economic outputs strong, what about environmental?
- Eden Rivers Trust starting ‘Restoring Eden’ project. Lack of targeting information from statutory sources (EN & EA).



# 2001/02

- Early version of RHS used on some of the Eden catchment.
- Proposal to start catchment-wide electrofishing survey in addition to statutory monitoring.
- Proposal to fund catchment-wide aerial habitat survey and develop a diffuse pollution risk model.

# 2001/02

- Establish a technical working group for the River Trusts to develop a 'matrix' or 'toolbox' of techniques appropriate for targeting and monitoring River Trust activity.
- Not prescriptive, but well described…
- Team includes key Trust scientists and representatives from the EA and originally EN.



# HDMAR

ART Charity Reg No 1107144

# The HDMAR workshop…

- Habitat description, measurement and assessment in rivers.
- Process really moved on thanks to the EA, FRS and Westcountry Rivers Trust. Funding, facilities and time. EU Interreg funding.
- 2 day workshop $8^{th}$ & $9^{th}$ March 2006 at the FRS laboratories Pitlochry
- To be published as an AST Blue Book and an updateable website (IFM?)



# Delegates

- SFCC
- FRS
- SNH
- ART
- Tweed Foundation
- EA
- Hull University
- CCW
- APEM
- FCB, NI
- Durham University
- McCaulay Institute
- Conon, DSFB
- EHS, NI
- CEH
- CEFAS
- Galloway RT
- Aberdeen University
- Cardiff University
- AST
- Eden Rivers Trust
- Marine Institute

ART Charity Reg No 1107144

# Introduction to workshop

- 'A common view amongst workers in the river fish habitat field is that there are inconsistencies in good practice, gaps in knowledge and lost opportunities that could be resolved, given better communication and co-ordination amongst the various bodies engaged in this work. '
- 'The intention is to set the workshop firmly in the context of the Ecosystems Approach and integrated catchment management to ensure that future developments in this area are fully compatible with contemporary European and national regulatory framework. This requires that analysis and assessment must extend, as appropriate, from site to whole catchments and take on understanding of the fluvial and geomorphological processes that govern habitats and their connectivity across all scales.'



# Outcomes

- better awareness of the issues surrounding the description, assessment and application of habitat surveys;
- collation and dissemination of good practice that will bring more consistency to the activity, enabling easier sharing of results and a common language across workers in the field. Various media options, to be discussed at the workshop;
- a framework for future development – through for example a standing group on habitat assessment, e-discussion group or repeat workshops; and
- a prioritised programme of key future research needs and benefits to put to potential funding bodies

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# Aims

- **AIM 1  to identify principle applications and their scales**
- **AIM 2. To identify and describe current methods.**
- **AIM 3.  To propose a toolbox of techniques and good practice**
- **AIM 4  Data storage, access and management**
- **AIM 5 To summarise current research and recommend future work**



# 'The Matrix'

- RIVPACS, SERCON, EFI / FAME, FCS, HABSCORE, PHABSIM, aerial survey, walkover survey, RFHI, RHS, fluvial audit compared in matrix
- Scale divided into catchment, reach, site or micro.
- Other attributes included the objective, the methods, and the key variables.
- References

# Intense discussion!

- How to compare such a range of techniques developed for such a range of purposes!
- Some are techniques for collecting data, others more specific tools….
- Major concern from some of the fish biologists on the errors in HABSCORE and similar tools that predict 'ecology' from habitat when compared to electrofishing data – implications for WFD?



# …more discussion!

- Concern from proponents of 'linear' habitat data collection techniques (walkover, aerial survey) about point based survey techniques – depends on the objective perhaps?
- A lot of discussion on the relative merits of RHS against fluvial audit tools.

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# Conclusions….for now.

- Most of the disagreement seems to stem from applying tools beyond their design scope.
- HDMAR will attempt to fully describe the techniques and their applications in the Blue Book – give up on the matrix for now!
- River / fishery scientists are able to pick the most appropriate tool for their application and follow references back to origins.
- Of course, linear data collection techniques for raw data are robust (walkover – habitat/fluvial, aerial – habitat/fluvial), but is it fair to compare with more 'analytical' tools?



**Association of Rivers Trusts**

**Check out our website on:**

**www.associationofriverstrusts.org.uk**

# Monitoring & appraisal of river restoration schemes

Judy England
Environment Agency

Kevin Skinner
JACOBS

Matt Carter
Environment Agency

# Contents:

- Why appraise?
- Best practice
- Draft appraisal selection model
- Thoughts of the group
- Points for discussion

# PPA allows us to:

- assess project aims
- assess techniques
- understand planned & unforeseen consequences
- adaptive management
- test scientific hypotheses
- prioritise future investments

# Best Practice:

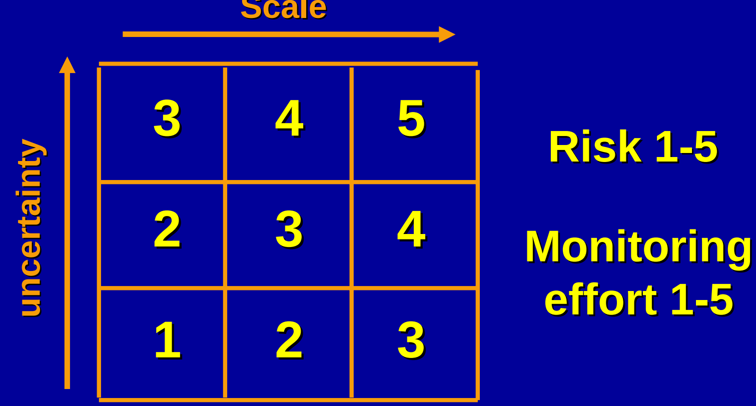
- objectives
  - Specific, Measurable, Attainable, Realistic, Timely
- baseline data
  - understand present state, help set objectives
- control/reference sites
  - attribute changes to scheme/target to attain
- timescales
  - balance between recovery & needing information
- reporting results
  - effective communication
- importance of science
  - BACI, replicated sample design, etc.

*“Almost as bad as no evaluation are poorly planned efforts that waste limited resources while providing meaningless or even misleading information.”*

Anderson & Dugger, 1998

# Which schemes to monitor ?

- prioritise based on risk
- risk = balance x uncertainty




From: Skinner (2002)

# Ecological Method Selection Model

Scale →

Restoration Technique: Established → New/Novel

| | Small (0m–100m) | Medium (100m–500m) | Large (500m–) |
|---|---|---|---|
| C | Photos<br>Plant mapping<br>Habitat mapping<br>Quantitative macro-invertebrate survey<br>Quantitative fisheries survey | Photos<br>Plant mapping<br>Habitat mapping<br>Quantitative macro-invertebrate survey<br>Quantitative fisheries survey | Photos<br>RCS/Plant mapping<br>RHS/Habitat mapping<br>Quantitative & qualitative macro-invertebrate survey<br>Quantitative & qualitative fisheries survey |
| B | Photos<br>Plant mapping<br>Habitat mapping | Photos<br>RCS<br>Qualitative macro-invertebrate surveys<br>Qualitative fisheries survey | Photos<br>RCS<br>RHS<br>Qualitative macro-invertebrate survey<br>Qualitative fisheries survey |
| A | Photos | Photos<br>RCS | Photos<br>RCS<br>RHS<br>Qualitative macro-invertebrate survey<br>Qualitative fisheries survey |

From: England, Skinner & Carter (in press)

# What you thought: Fisheries

Scale →

Restoration Technique: Established → New/Novel

| | Small (0m–100m) | Medium (100m–500m) | Large (500m–) |
|---|---|---|---|
| C | | | Hydro acoustic survey – 3D<br>Tracking/Tagging |
| B | Radio tracking<br>Species specific trapping | Radio tracking<br>Species specific trapping | Radio tracking<br>Species specific trapping<br>Hydro acoustic survey - 2D |
| A | Electrofishing<br>Fish counts / pass<br>Spawning habitat assessment (visual or quantitative)<br>Seine & stop netting<br>Tagging<br>Scale analysis (age & growth)<br>HABSCORE | Electrofishing<br>Fish counts / pass<br>Spawning habitat assessment (visual or quantitative)<br>Seine & stop netting<br>Tagging<br>Scale analysis (age & growth)<br>HABSCORE | Electrofishing<br>Fish counts / pass<br>Spawning habitat assessment (visual or quantitative)<br>Seine & stop netting<br>Tagging<br>Scale analysis (age & growth)<br>HABSCORE |

# Geomorphological Method Selection Model

Scale →

Restoration Technique: New/Novel (C) ↑ Established (A)

| Restoration Technique | Small (0m–100m) | Medium (100m–500m) | Large (500m–) |
|---|---|---|---|
| C | Fixed point photography<br>GeoRHS<br>Ariel photography<br>Repeat cross-sections<br>Bed material sampling<br>Bank conditions | Fixed point photography<br>GeoRHS<br>Topographic survey<br>Ariel photography<br>Repeat cross-sections<br>LiDAR<br>Bed material sampling<br>Bank conditions | Fixed point photography<br>GeoRHS<br>Topographic survey<br>Ariel photography<br>Repeat cross-sections<br>LiDAR<br>Bed material sampling<br>Bank conditions<br>Bed load |
| B | Fixed point photography<br>GeoRHS | Fixed point photography<br>GeoRHS<br>Topographic survey<br>Ariel photography<br>Repeat cross-sections<br>LiDAR | Fixed point photography<br>GeoRHS<br>Topographic survey<br>Ariel photography<br>Repeat cross-sections<br>LiDAR |
| A | Fixed point photography<br>GeoRHS | Fixed point photography<br>GeoRHS | Fixed point photography<br>GeoRHS<br>Ariel photography<br>LiDAR |

From: England, Skinner & Carter (in press)

# What you thought: Geomorphology

Scale →

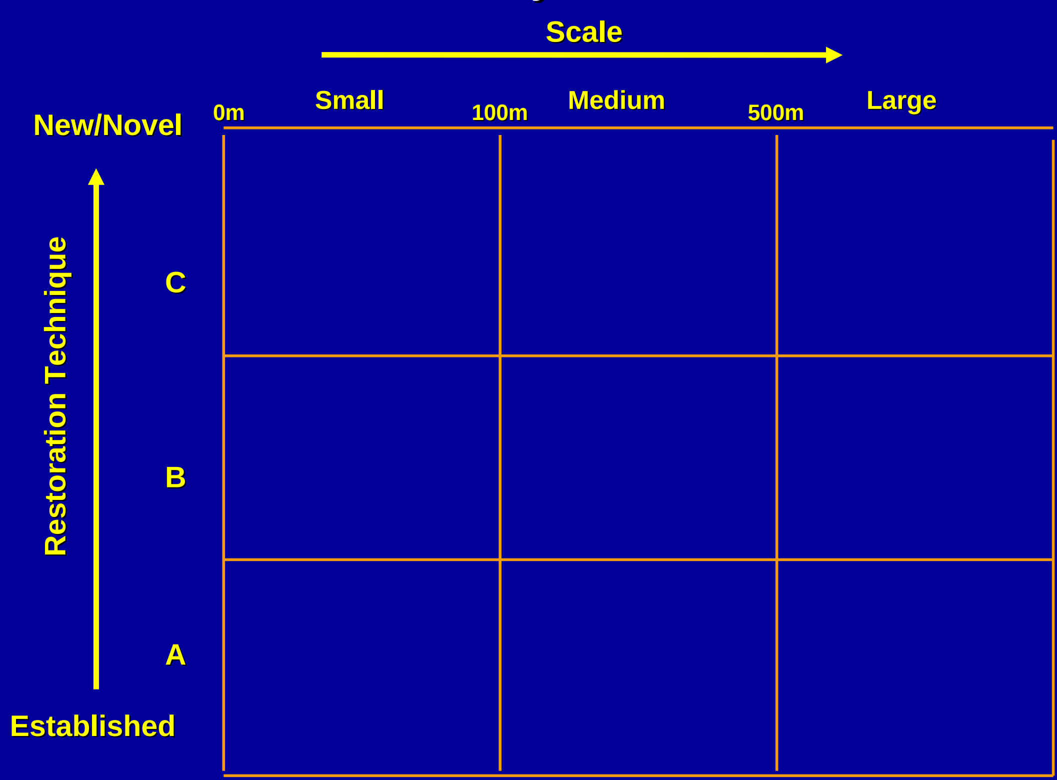
Restoration Technique: New/Novel (C) ↑ Established (A)

| Restoration Technique | Small (0m–100m) | Medium (100m–500m) | Large (500m–) |
|---|---|---|---|
| C | Field survey<br>Fixed point photography<br>Airborne photography<br>Cross-sections<br>GeoRHS<br>Subjective assessment<br>Post RR assessment | Field survey<br>Fixed point photography<br>Airborne photography<br>Cross-sections<br>GeoRHS<br>Subjective assessment<br>Post RR assessment<br>Topographic survey | Field survey<br>Fixed point photography<br>Airborne photography<br>Cross-sections<br>GeoRHS<br>Subjective assessment<br>Post RR assessment<br>Topographic survey |
| B | Field survey<br>Fixed point photography<br>Subjective assessment<br>Post RR assessment<br>Physical biotope mapping | Field survey<br>Fixed point photography<br>Subjective assessment<br>Post RR assessment<br>Topographic survey<br>Airborne photography<br>Rapid assessment<br>Geomorphological mapping<br>Cross-sections | Field survey<br>Fixed point photography<br>Subjective assessment<br>Post RR assessment<br>Topographic survey<br>RHS, Fluvial audit<br>Airborne photography<br>Rapid assessment<br>Cross-sections |
| A | Field survey<br>Fixed point photography<br>Subjective assessment<br>Post RR assessment<br>RHS<br>Fluvial audit<br>MImAS | Field survey<br>Fixed point photography<br>Subjective assessment<br>Post RR assessment<br>RHS<br>Fluvial audit<br>MImAS | Field survey<br>Fixed point photography<br>Subjective assessment<br>Post RR assessment<br>RHS<br>Fluvial audit<br>MImAS<br>Airborne photography<br>Repeated topographic survey |

# Points for discussion :

- **framework**
- do you agree with the philosophy?
- what should be on each axis?
- scale
- define small (<100m), medium (100-500m) & large (>500m)
- **uncertainty**
- establish what is known - catalogue schemes appraised & techniques used
- novelty of RR technique or monitoring technique?

## What do you think?



**Kevin Skinner**

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**Judy England**

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1996 2006 Environment Agency

# Why monitor river "restoration" projects?

Mark Diamond

1996 2006 Environment Agency

## River Basin Characterisation

About half of river waterbodies in England and Wales are at risk of failing good ecological status because of morphological pressures

## WFD: some key points

- No deterioration
- Aim for good ecological status
- Protected areas
- Heavily modified / artificial waterbodies
- Cost-effectiveness

## Objective setting

- Clear stating point
- Clear objective
- Clear required effect
- Competing measures selected on basis of cost-effectiveness
- Caveats

## Key deadlines

2006 Inception (River Basin Liaison Panels established)

2009 Final River Basin Management Plans

2012 Implementation of Programmes of Measures

2015 Ongoing implementation and review; start of second River Basin Planning cycle

2021 End of 2nd cycle

2027 End of 3rd cycle

## Good practice manuals

“Based on techniques that have been tried and tested in the USA over last 50 years”

1996 2006 Environment Agency

Journal of Applied Ecology 2003
40, 251–265

# River rehabilitation and fish populations: assessing the benefit of instream structures

J. L. PRETTY, S. S. C. HARRISON*, D. J. SHEPHERD†, C. SMITH, A. G. HILDREW and R. D. HEY†
School of Biological Sciences, Queen Mary University of London, Mile End Road, London E1 4NS, UK; and †School of Environmental Science, University of East Anglia, Norwich, Norfolk NR4 7TJ, UK

"From this substantial sample of lowland rivers, there is little evidence of any general benefit to fish of small-scale instream structures in river rehabilitation."

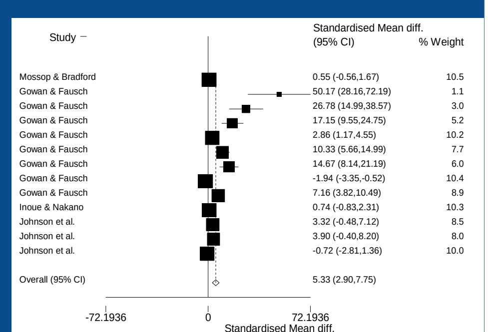
1996 2006 Environment Agency

CEBC

## Do instream devices increase salmonid abundance?

- Systematic review of existing data
- Adding woody debris significantly increases salmonid abundance
- Large effect size
- Traditional in-stream devices significant but negligible effect size

**Stewart et al @ www.cebc.bham.ac.uk**



1996 2006 Environment Agency

# Review of pre-1980 data

Ecological Applications, 16(2), 2006, pp. 784–796


## DID THE PRE-1980 USE OF IN-STREAM STRUCTURES IMPROVE STREAMS? A REANALYSIS OF HISTORICAL DATA

Douglas M. Thompson[1]

*Department of Physics, Astronomy and Geophysics, Connecticut College, Campus Box 5585, 270 Mohegan Avenue, New London, Connecticut 06320, USA*

*Abstract.* In the 1930s, after only three years of scientific investigation at the University of Michigan Institute for Fisheries Research, cheap labor and government-sponsored conservation projects spearheaded by the Civilian Conservation Corps allowed the widespread adoption of in-stream structures throughout the United States. From the 1940s through the 1970s, designs of in-stream structures remained essentially unchanged, and their use continued. Despite a large investment in the construction of in-stream structures over these four decades, very few studies were undertaken to evaluate the impacts of the structures on the channel and its aquatic populations. The studies that were undertaken to evaluate the impact of the structures were often flawed. The use of habitat structures became an "accepted practice," however, and early evaluation studies were used as proof that the structures were beneficial to aquatic organisms. A review of the literature reveals that, despite published claims to the contrary, little evidence of the successful use of in-stream structures to improve fish populations exists prior to 1980. A total of 79 publications were checked, and 215 statistical analyses were performed. Only seven analyses provide evidence for a benefit of structures on fish populations, and five of these analyses are suspect because data were misclassified by the original authors. Many of the changes in population measures reported in early publications appear to result from changes in fishing pressure that often accompanied channel modifications. Modern evaluations of channel-restoration projects must consider the influence of fishing pressure to ensure that efforts to improve fish habitat achieve the benefits intended. My statistical results show that the traditional use of in-stream structures for channel restoration design does not ensure demonstrable benefits for fish communities, and their ability to increase fish populations should not be presumed.

*Key words:* *applied geomorphology; erosion control; habitat improvement; in-stream structures; stream improvement.*

"...the traditional use of in-stream structures for channel restoration design does not ensure demonstrable benefits for fish communities…"

1996 2006 Environment Agency

# Riparian fencing

- Sustainable fisheries project: Wales
- Sustainable rivers project North West
- Tweed Foundation
- Wild rivers Scotland
- Compelling evidence for recovery ?

# “Hydromorphology and river biota: linking river physical structure to ecology.”

“…links between assemblage composition, biological indicators, biological models, physical structure and physical processes are insufficiently quantified at any scale in European rivers to support key policies and legislation.”

S. J. Ormerod, I. P. Vaughan and I Durance

# Some priority questions

- Do the most frequently used reach scale measures work ? (£££’s, HMWB)
- What are their unintended consequences ?
- How extensively should they be applied ?
- How should we take account of the catchment context ?
- How should we analyse river systems to decide where interventions will be most efficient and effective?

# In conclusion

- We are are unlikely to use physical restoration as a major measure in the 1st cycle
- Exception: making barriers passable and cheap techniques
- Need experiments

# Towards an Integrated Approach to Monitoring River Restoration Projects.

David Sear
University of Southampton

## Why do we need Monitoring?

- Evaluate "success"
- Create knowledge.
- Codify experience.
- Promote learning.
- Transfer knowledge.
- Essential component in adaptive management.

Why, what and how you monitor a restoration project depends on the values of your management system.

"Making a difference" *vs.* "learning opportunity"

## Towards an integrated approach to monitoring: Problem Definition.

- Monitoring = What do we mean by it? How should we do it?
- Uncertainty = a measure of information quality – too high and we learn nothing and it limits what we can say about attaining targets.
- Integration = Multi-disciplinarity (understanding each others science & values). Across different scales (how many, how often?).

## What do we mean by monitoring?

| Monitoring Types | Description (Key Question) | Example |
|---|---|---|
| Baseline | Characterise existing system conditions (e.g. biology, geomorph.) | Presence /absence / abundance |
| Status | Characterise the condition (spatial variability) across a given area. | Abundance at time X in a catchment |
| Trend | Determines change in conditions/biota over time | Changes in over bank flooding over time |
| Implementation | Determines if project was implemented as designed. | Did contractor put the pools in right place? |
| Effectiveness | Determines if actions had desired effects on biota/processes etc. | Did the pool area increase? |
| Validation | Evaluates whether hypothesized cause and effect relationship between restoration and response variable were correct. | Did change in pool area lead to desired change in fish population? |

(After Roni (2005)

# What do we mean by monitoring?

| Monitoring Types | Description (Key Question) | Example |
|---|---|---|
| Baseline | Characterise existing system conditions (e.g. biology, geomorph.) | Presence /absence / abundance |
| Status | Characterise the cond[illegible]patial variability) acro[illegible]n area. | Abundance at time X in a catchment |
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| Implementation | [illegible]etermines if project was implemented as designed. | Did contractor put the pools in right place? |
| Effectiveness | Determines if actions had [illegible]ed effects on biota/pr[illegible] | Did the pool area increase? |
| Validation | Evalua[illegible]esized c[illegible]elationship b[illegible]storation and response va[illegible]ble were correct. | Did change in pool area lead to desired change in fish population? |

CONTEXT FOR THE RESTORATION

EFFECTIVENESS OF THE RESTORATION

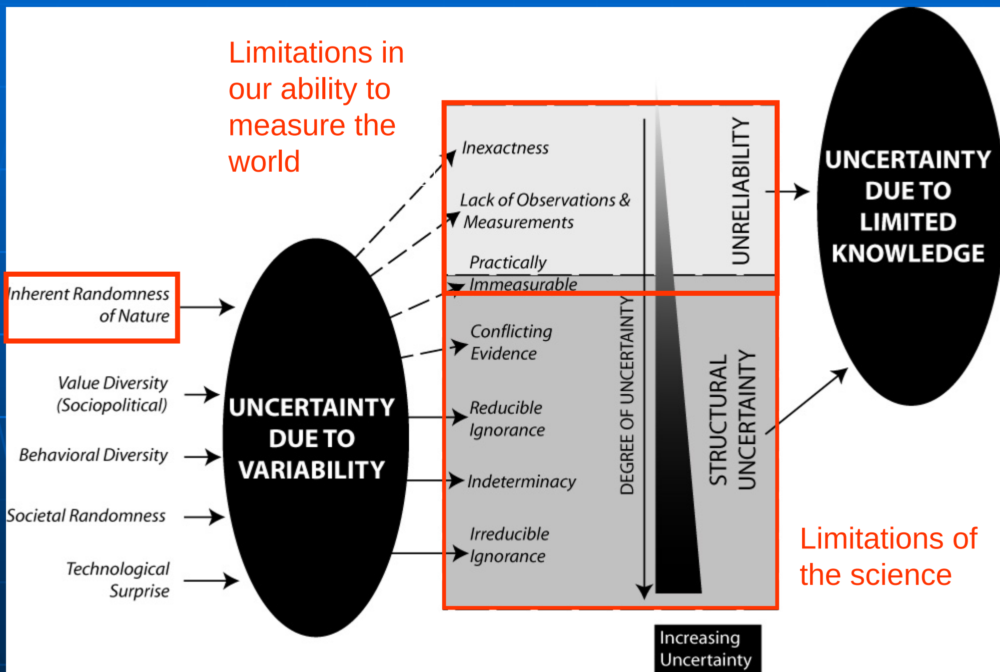
(After Roni (2005))

# What does the monitoring mean?

| Evaluation Level | Description | Example | Uncertainty in the results |
|---|---|---|---|
| LEVEL 1<br>Plastic Medal | No replication<br>No Control<br>Anecdotal observation | "We saw lots of fish in the reach" | VERY HIGH |
| LEVEL 2<br>Tin Medal | No replication<br>No control<br>Sampling after | "There was a gradual increase in fish numbers 2 years after work" | HIGH |
| LEVEL 3<br>Bronze Medal | No replication<br>No / Some Control<br>Sampling before & after | After the project there were more fish compared to a control. | MODERATE |
| Level 4<br>Silver Medal | Un-replicated<br>Controlled<br>Sampling before & after | The numbers of fish increased after the project but not in the control. | LOW |
| Level 5<br>Gold Medal | Replicated<br>Controlled<br>Sampling before & after | The increase in fish after the project was greater than in any control. | VERY LOW |

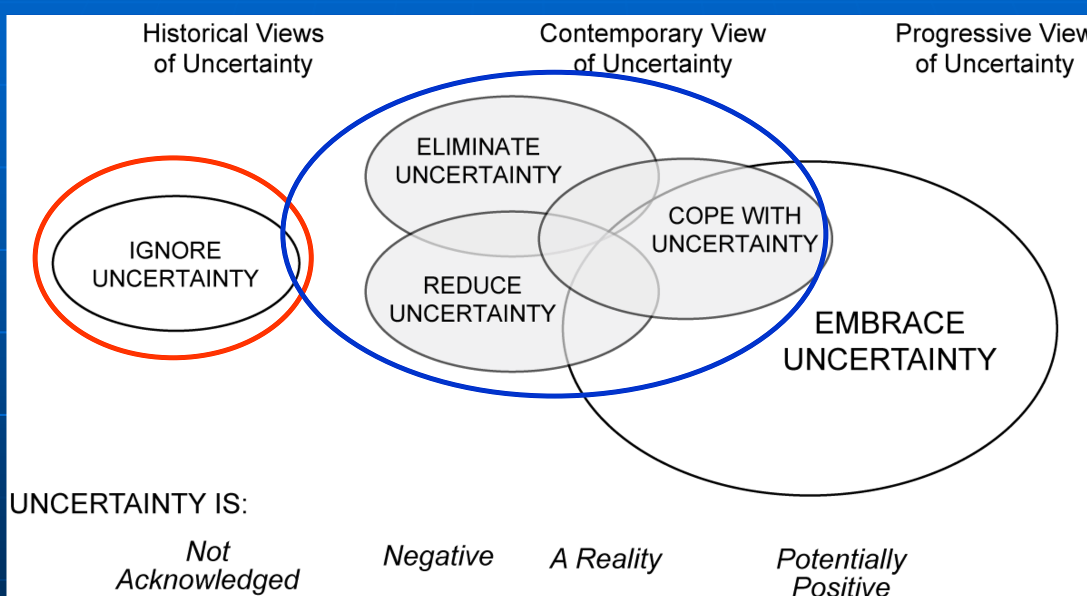
After Rutherfurd et al. (2000)

# What do we mean by uncertainty?




After Van Asselt (2000)

# Approaches to uncertainty




**Conclusion:** Uncertainty in River Restoration Projects is ubiquitous and pervasive. We currently do a very poor job of communicating it. Monitoring will reveal its effects!

## Key challenge to improved monitoring is to change our management approach.

A management approach that recognises:

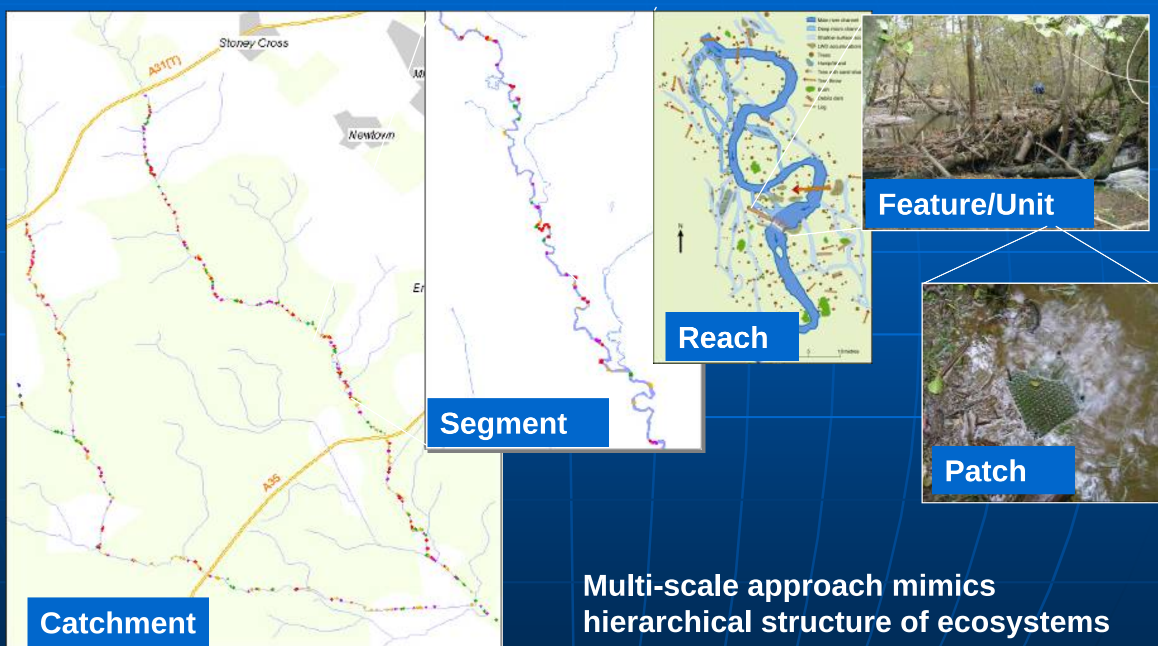
- Variability and complexity is an essential part of the system.
- Uncertainty is recognised and embraced.
- Management targets are flexible rather than restrictive.
- Education and participation are an essential method of management.

**Adaptive Management**

## Summary so far….

- Monitoring is perhaps the most valuable part of a restoration in this stage of the practice/science – it is an essential part of adaptive management.
- Need to determine WHY we are monitoring a restoration project before we attempt WHAT & HOW we should monitor.
- Need to recognise the uncertainty and limitations of different monitoring methods FIRST before rushing off to deploy them.

# Integration: across scales




**Multi-scale approach mimics hierarchical structure of ecosystems (Frissell et al., 1986).**

# Scale Matters!

- Catchment scale – restoration affect lost in natural variability.
- Segment scale – Reduction in pool and riffle habitat frequency rel. to a SN Reference site.
- Reach Scale – Less riffle habitat and more pool habitat compared to SN Reference.
- Patch Scale – Process rates same as SN Reference site.

## Integrated Monitoring & Multi-disciplinarity

- River restoration aims are essentially ecological but their implementation is typically physical!
- Essential to link the two more robustly!

1) Monitor at spatial & temporal scales meaningful across disciplinary boundaries.
2) Develop conceptual models for restoration together not in isolation.
3) Develop monitoring plans together.

## Integrated Monitoring: Some ways forward.

- Improved and increased dialogue between disciplines ( KTNetworks, R&D Projects).
- Establishing knowledge gaps and filling them (R&D Projects – EU/RC/DEFRA?).
- New use of existing datasets (RHS/Bio, Fluvial Audit & Bio) where relevant (Data Mining).
- Demonstration monitoring network? (trialling monitoring methods & techniques).
- Defining monitoring schemes for specific management requirements (not just WFD!).
- Disseminating the knowledge – Monitoring Handbook??


## Natural components that characterise a river

- Physical properties of water & channel
  - eg. flow, density, solubility, temperature, profiles, mesohabitats
- Chemical properties of water
  - eg. rain, catchment characteristics (geology/weathering; run-off; soil vegetation relations)
- Biology
  - eg. species presence/absence; species occurrence and abundance; detritus, particulate organic matter
- Temporal & spatial aspects
  - eg. seasonality, altitude & location
- Ecology
  - eg. trophic interactions, longitudinal connections, lateral connections, in-stream processes, predation & competition

# Scope out the project

- What do we need to know?

  What do we already know?

  eg. Objective = improving conservation value & biodiversity through physical reconnection

| | |
|---|---|
| River restoration engineering | |
| Stakeholders (incl. the experts) | |
| Biodiversity | - site vegetation community |
| | - site invertebrate community |
| | - site vertebrate community |
| | - floodplain |
| | - adjacent biotic sources |
| | - available data and further requirements |
| | - conservation designations |
| Land & water course use (incl. history) | |
| Hydrology | - water course |
| | - wetland |
| Flooding | - upstream |
| | - downstream |
| Recreation and amenity | |
| Other site associated environment plans (existing or future eg. LEAP) | |

# Assumed ecological consequences of undertaking engineering specifications - following scoping and characterising

- Increased habitat heterogeneity
- Increase invertebrate diversity & abundance
- Improved local in-stream conditions for macrophytes
- Increased hydro-morphological diversity
- Improved access to functional habitat (eg. refuge, nursery)
- Better potential for upstream and downstream movement (longitudinal connectivity)
- Reconnection laterally (ie. floodplain function)
- Slower rate of nutrient spiralling
- No significant implications for species of conservation or ecological importance (eg. Annex II *Luronium natans*) if conservation measures are put in place (eg. translocation)

Can form the basis of hypotheses

# Checklist & matrix assessment (dynamic)

| *Environmental component* | *Do nothing* | *Engineering works* | *Engineering works* | *Post-engineering works short term* | *Post-engineering works long term* | *Post-engineering works short term* | *Post-engineering works long term* |
|---|---|---|---|---|---|---|---|
| | | Current channel | Restored channel | Current channel | Current channel | Restored channel | Restored channel |
| Bankside vegetation | 0 | - | - | ± | + | ± | + |
| Floodplain vegetation | 0 | 0 | 0 | + | + | + | + |
| Floodplain fauna | 0 | 0 | 0 | + | + | + | + |
| *In channel* | | | | | | | |
| ~ vegetation | 0 | - | -- | + | ++ | + | + |
| ~ invertebrates | 0 (+) | - | -- | ± | + | ± | ± |
| ~ fish | 0 | 0 | - | + | + | + | ++ |
| ~ other vertebrates | 0 | 0 | 0 | + | + | + | + |
| Water quality | 0 | - | - | 0 | 0 | ± | + |
| Water flow | 0 | - | + | - | - | + | + |
| Flood waters | 0 | 0 | 0 | + | + | + | + |
| Ecosystem function | 0 | - | - | + | + | + | + |
| Ecosystem connectivity | 0 | - | + | + | + | + | + |
| *Socio-economics* | | | | | | | |
| Land use - agriculture | 0 | - | - | 0 | - | - | - |
| Recreation | 0 | - | - | 0 | + | 0 | + |
| Education | 0 | 0 | 0 | 0 | + | + | + |
| Fisheries | 0 | - | - | 0 | + | 0 | + |
| Conservation | 0 | - | -- | + | ++ | + | + |
| Aesthetics | 0 | - | - | 0 | ++ | 0 | ++ |

Note: Can be adapted to include uncertainty/confidence