Monitoring to understand sources of pollution in the Lunan catchment

M. Stutter , A. Vinten, J. Sample, S. Dunn and C. Birkel, J. Dawson

Macaulay Land Use Research Institute, Catchment Management Group, Craigiebuckler, Aberdeen AB15 8QH.

(E-mail: *m.stutter@macaulay.ac.uk*)

J. Potts Biomathematics and Statistics Scotland, Craigiebuckler, Aberdeen AB15 8QH

J. MacDonald and F. Napier

Scottish Environment Protection Agency Erskine Court, Castle Business Park, Stirling.FK9 4TR

W. Jeffrey and C. Christian

SAC Consulting Environment & Design Pentland Building Bush Estate, Penicuik EH26 0PH

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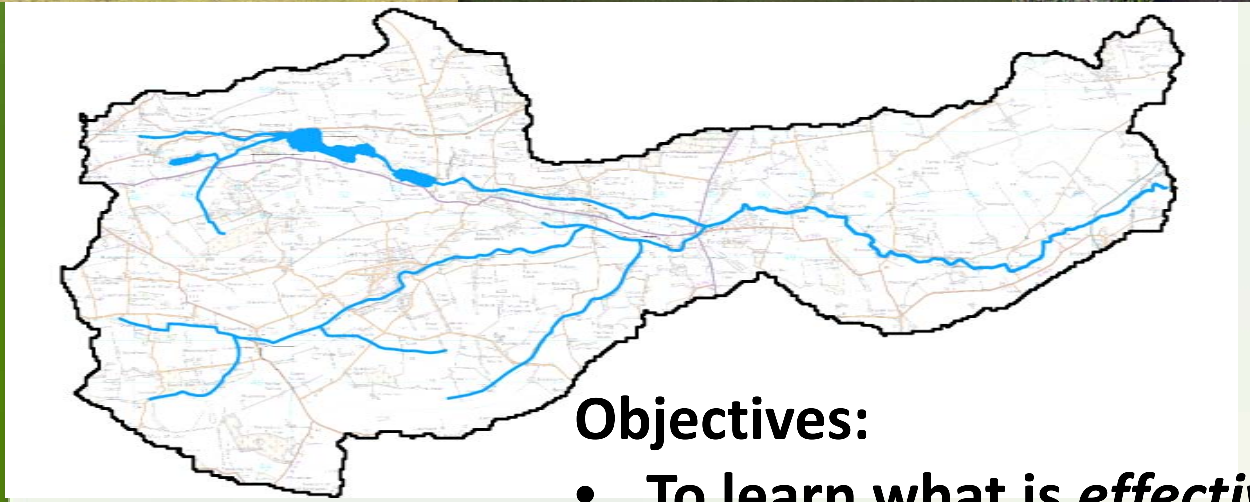
SEPA Scottish Environment Protection Agency

SAC

Lunan Water Monitored Priority Catchment
The role of diffuse pollution monitoring



Objectives:

- **To learn what is *effective and proportionate mitigation* of diffuse pollution pressures and how to assess it!**
- **What mitigation can be achieved using GBRs**

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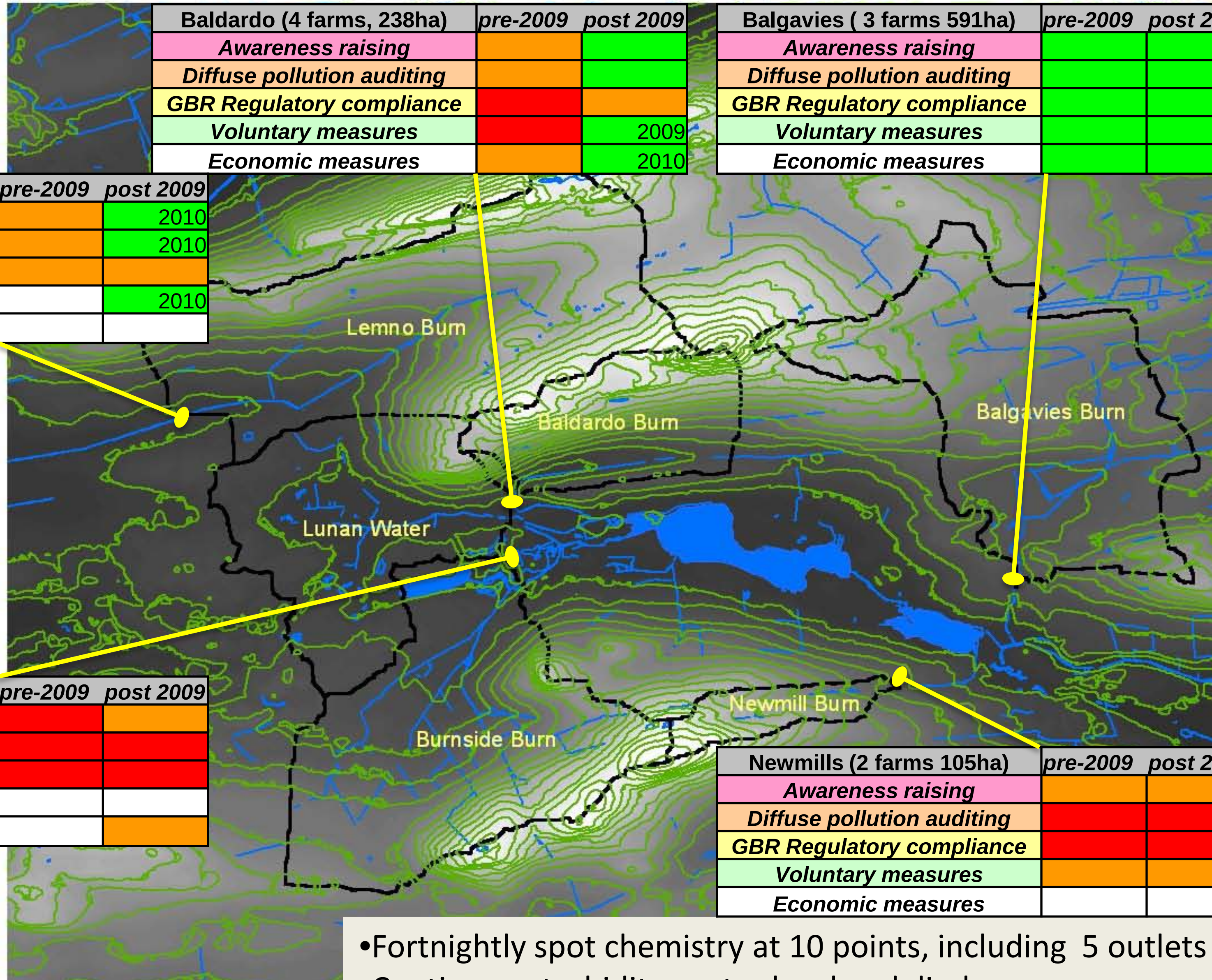

Baldardo (4 farms, 238ha)	pre-2009	post 2009
Awareness raising		
Diffuse pollution auditing		
GBR Regulatory compliance		
Voluntary measures		2009
Economic measures		2010

Balgavies (3 farms 591ha)	pre-2009	post 2009
Awareness raising		
Diffuse pollution auditing		
GBR Regulatory compliance		
Voluntary measures		
Economic measures		

Lemno (ca. 3 farms , 710 ha)	pre-2009	post 2009
Awareness raising		2010
Diffuse pollution auditing		2010
GBR Regulatory compliance		
Voluntary measures		2010
Economic measures		

Burnside (ca. 15 farms 538ha)	pre-2009	post 2009
Awareness raising		
Diffuse pollution auditing		
GBR Regulatory compliance		
Voluntary measures		
Economic measures		

Newmills (2 farms 105ha)	pre-2009	post 2009
Awareness raising		
Diffuse pollution auditing		
GBR Regulatory compliance		
Voluntary measures		
Economic measures		

- Fortnightly spot chemistry at 10 points, including 5 outlets
- Continuous turbidity ,water level and discharge
- Event sampling at 3 outlets

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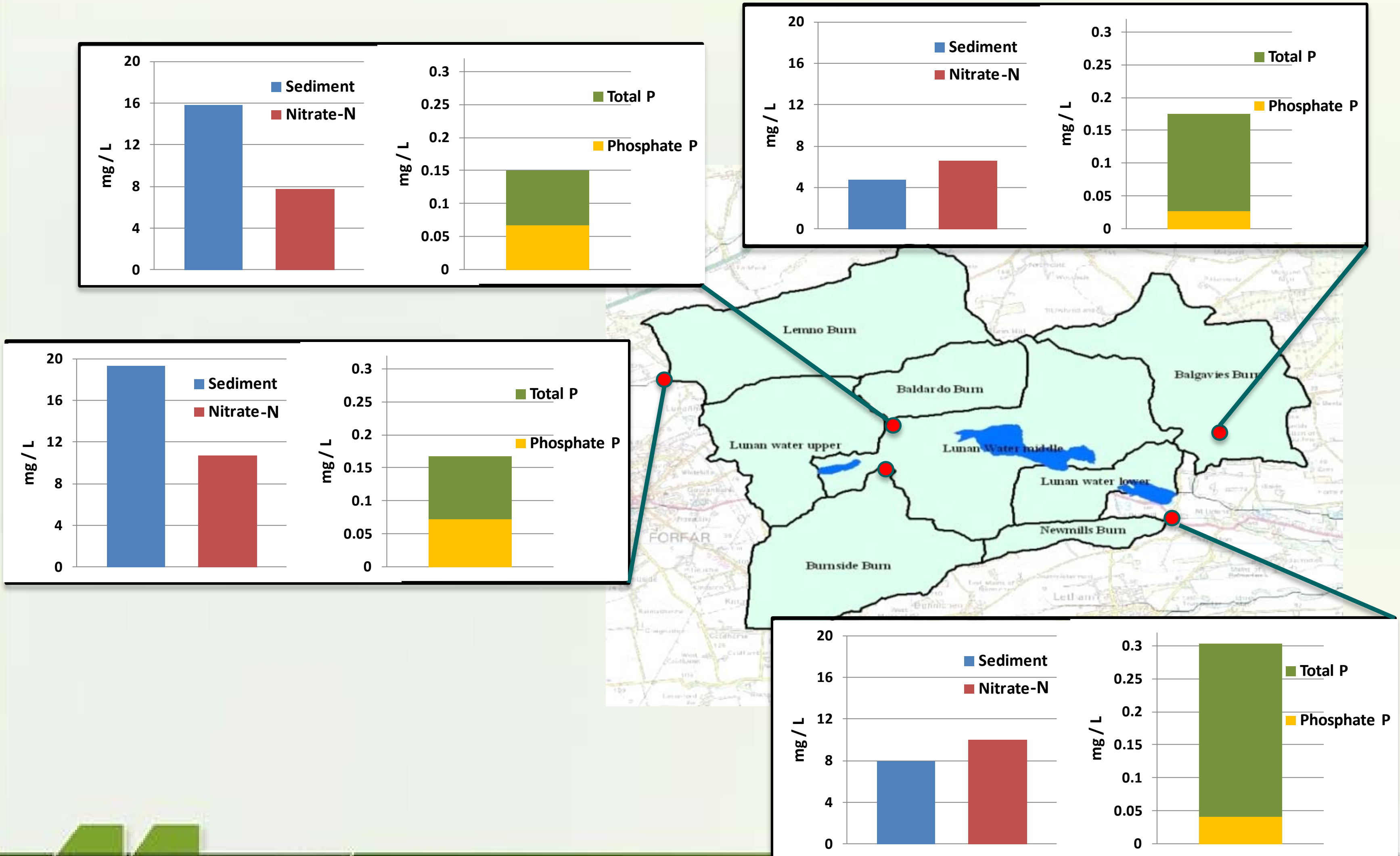
Monitored sub-catchments (2007-present)

Monitoring aims

- To understand the natural functioning of the system in terms of connection between watercourses, the function of the loch in transforming nutrients etc
- To locate areas or sources delivering disproportionate loadings of nutrients to the lochs
- To follow the changes in nutrient loadings with diffuse pollution mitigation activities
- To improve the way we monitor, in terms of
  - Providing high temporal resolution information
  - Minimising costs and workload
  - Developing new techniques and supporting methods

Subcatchment monitoring

Regular fortnightly monitoring data 2006-2011



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High resolution monitoring

- Transfers of certain pollutants (e.g. sediments) occur rapidly, driven by rainfall and flow

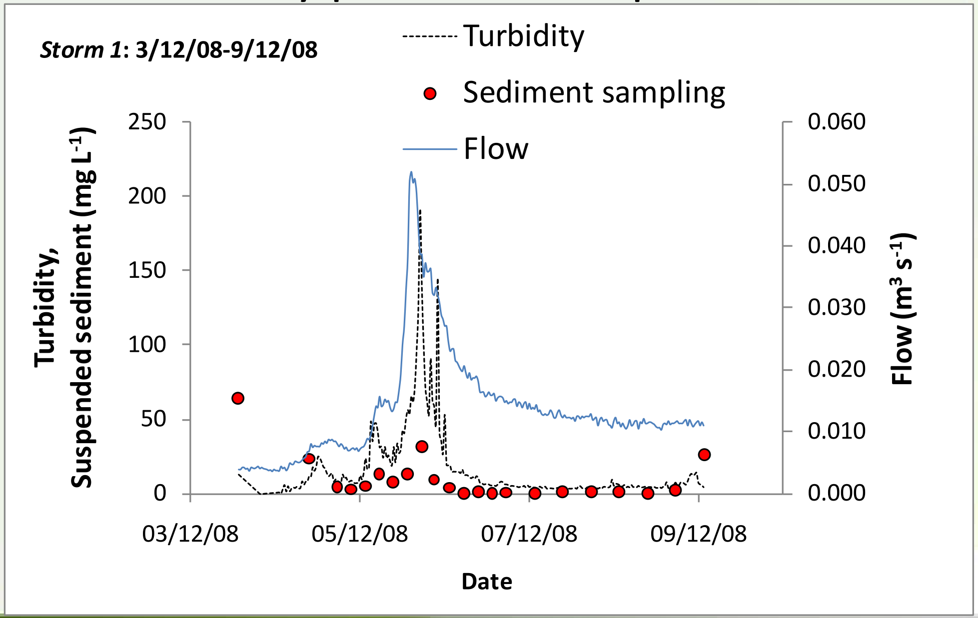
- Monitoring at high temporal resolution is required for accurate information on
  - Pollutant loads – the annual total mass transported downstream or to the loch
  - Contributing sources of pollution and their behaviour
  - Effectiveness of catchment management activities

Towards more cost-effective monitoring

- The use of electronic data gathering to evaluate and understand pollutant transfers and their sources
- Turbidity – *light scatter by particles suspended in the water*
- There is a huge amount of raw data, requiring an automated method of screening and matching of ‘real’ turbidity peaks to flow peaks

Evaluation

By comparing turbidity to stream samples taken four hourly during 8 storm events during 2008-2010



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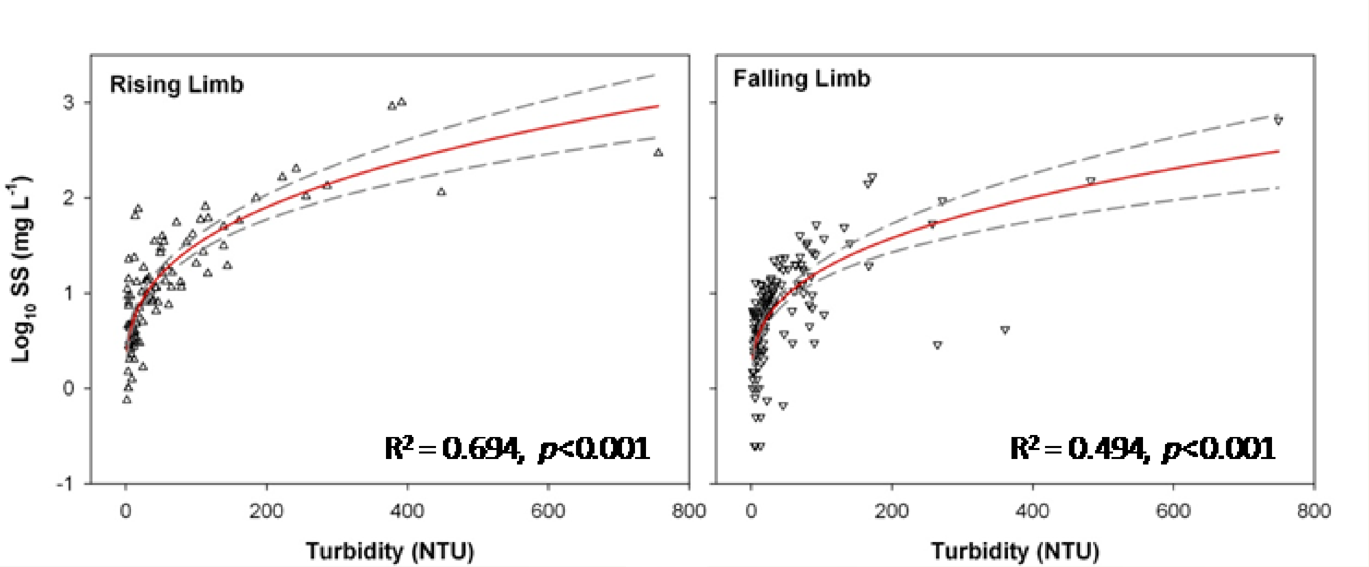
Using turbidity data

- Two methodologies:
  - Improved load estimations via calibration of the turbidity data against the pollutant of interest



  - Direct use of the turbidity signal looking for reductions in peak turbidity before and after catchment management actions

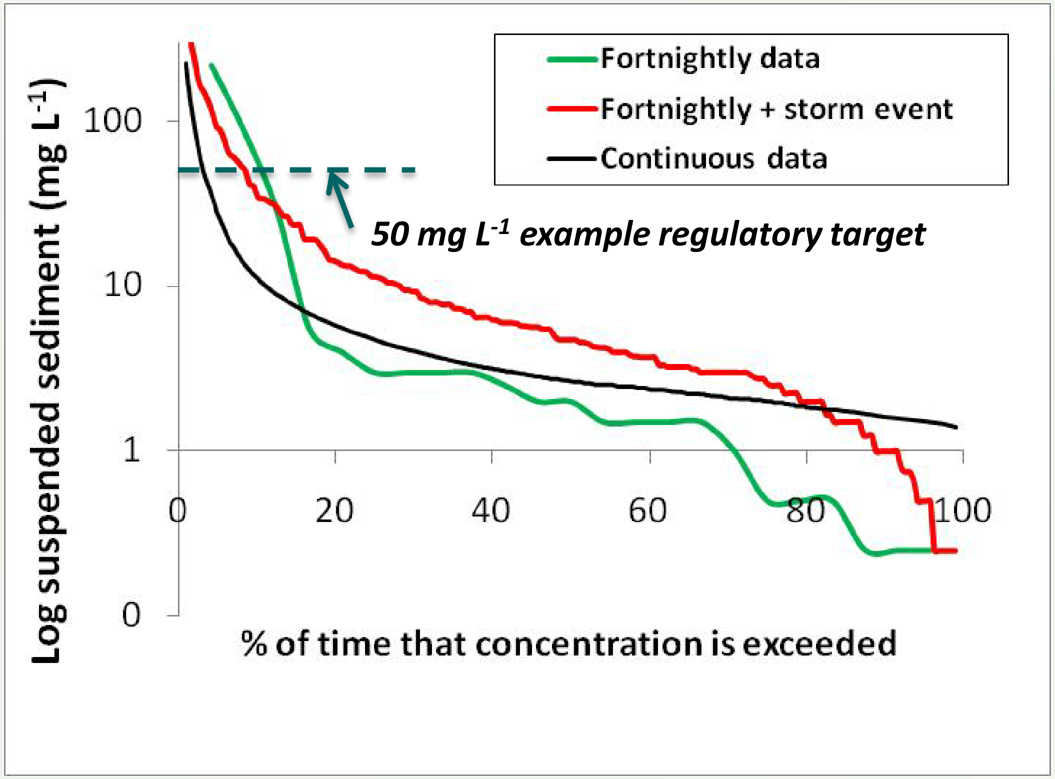
Monitoring: effort *vs* information

Calculated SS fluxes (± 95 % c.i.) from the Baldardo catchment for the hydrological year 01/10/2008-30/09/2009. All data are in kg SS ha^{-1} yr^{-1}

Monitoring regime	Number of samples	Flux method '2'	Flux method '5'	Via turbidity calibration	Cost of equipment	Sample + staff cost
Fortnightly sampling	24	124.6 (± 182.8)	153.8 (± 175.6)	-		£1K annually
Storm event	164	113.7 (± 101.4)	125.4 (± 74.10)	-	£2K	£5-10K annually
Fortnightly + Storm event	188	115.1 (± 90.96)	128.7 (± 68.23)	-		
Continuous turbidity		-	-	142.7 (83.61-251.3)	£2K	Minimal once calibration established

Increasing level of accuracy and characterisation of source behaviour

The effect of data temporal resolution on determined sediment concentrations



Generally you would assume that fortnightly monitoring would be biased towards baseflow and would underestimate the occurrence of higher concentrations!

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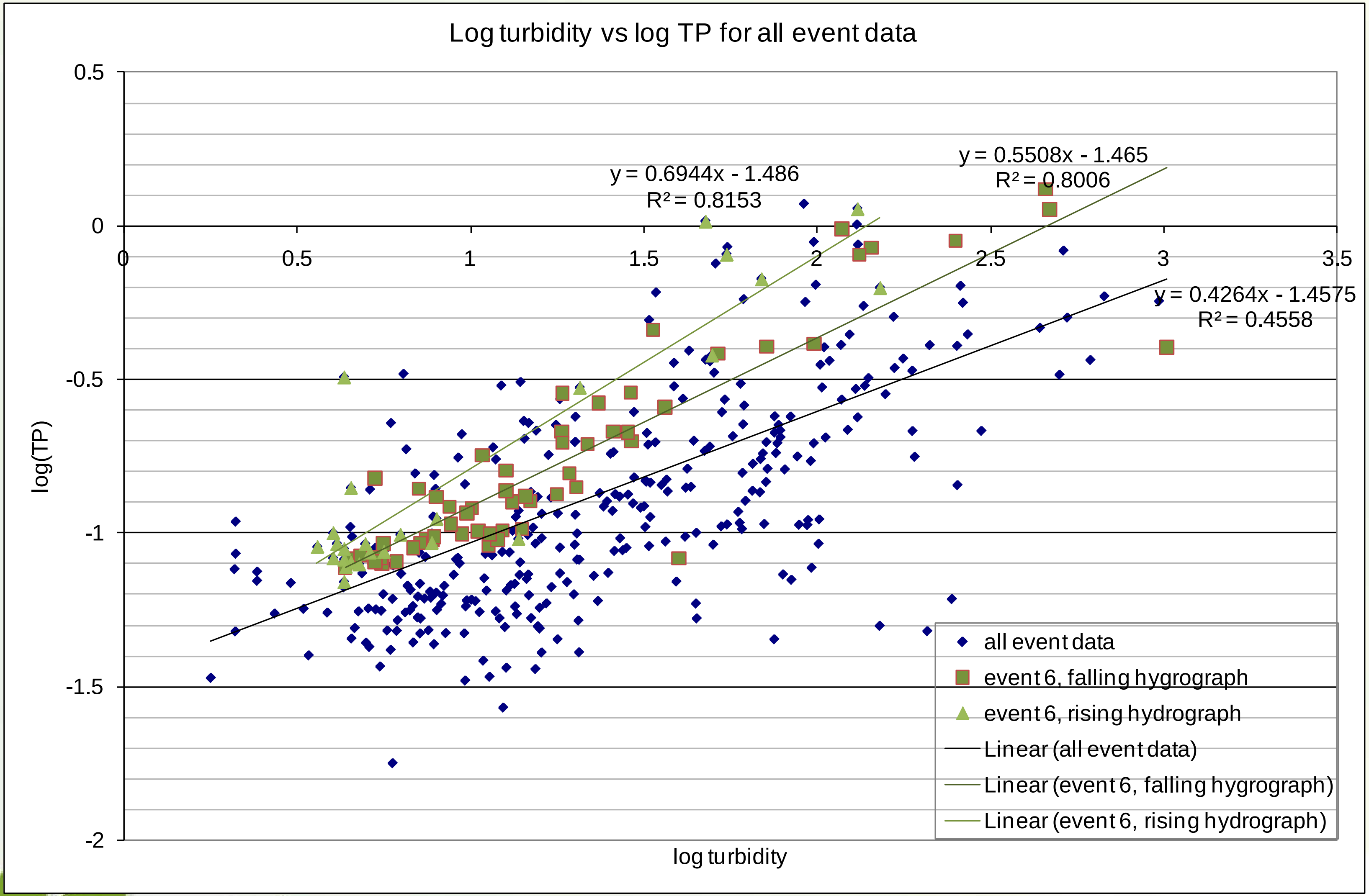
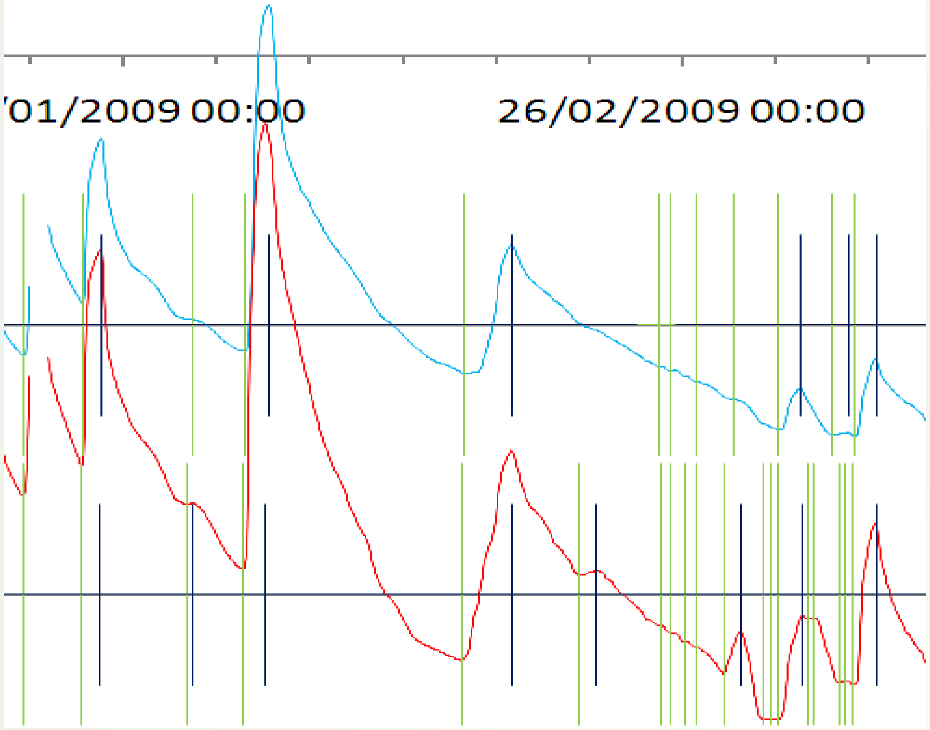
Calibration of total P *vs* turbidity data



Paired catchment approaches: mitigation impacts in *treated vs control* sub-catchments

Methodology:

1. **Automated methods to identify paired flow events**
2. **Extract turbidity value at peak flow**



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Paired catchment approaches: mitigation impacts in *treated vs control* sub-catchments

3. Statistical approaches to comparing event turbidity

Univariate model of paired catchment response

$$\ln(T_{treat,i}) = a + b\ln(T_{notreat,i}) + e(treat_i) + \varepsilon_i$$

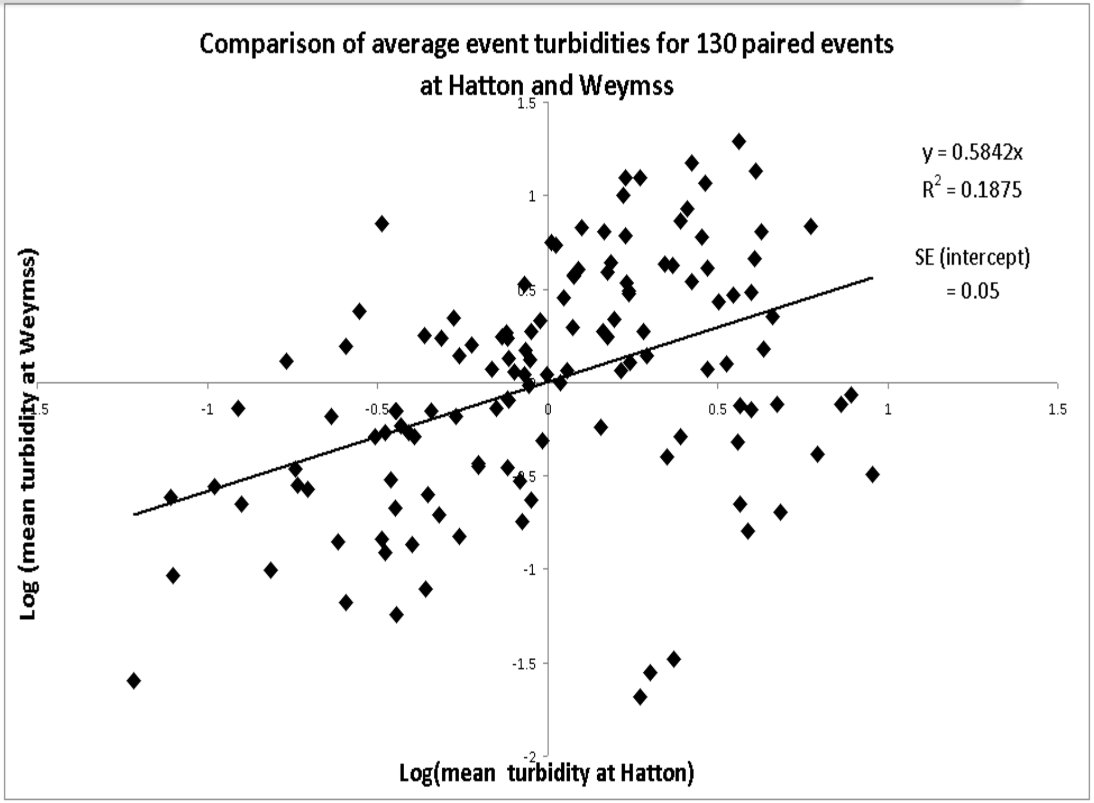
J Environ Qual 34:1087-1101 (2005)

$T_{treat,\,i}$ = turbidity load in treated catchment, for event I

$T_{notreat,\,i}$ = turbidity load in treated catchment, for event I

$Treat_i$ = treatment index variable (0 before treatment, 1 after treatment)

Load reduction	Change on intercept	Detection certainty (s.e. of intercept)
30 %	-0.155	70%
40 %	-0.222	93%



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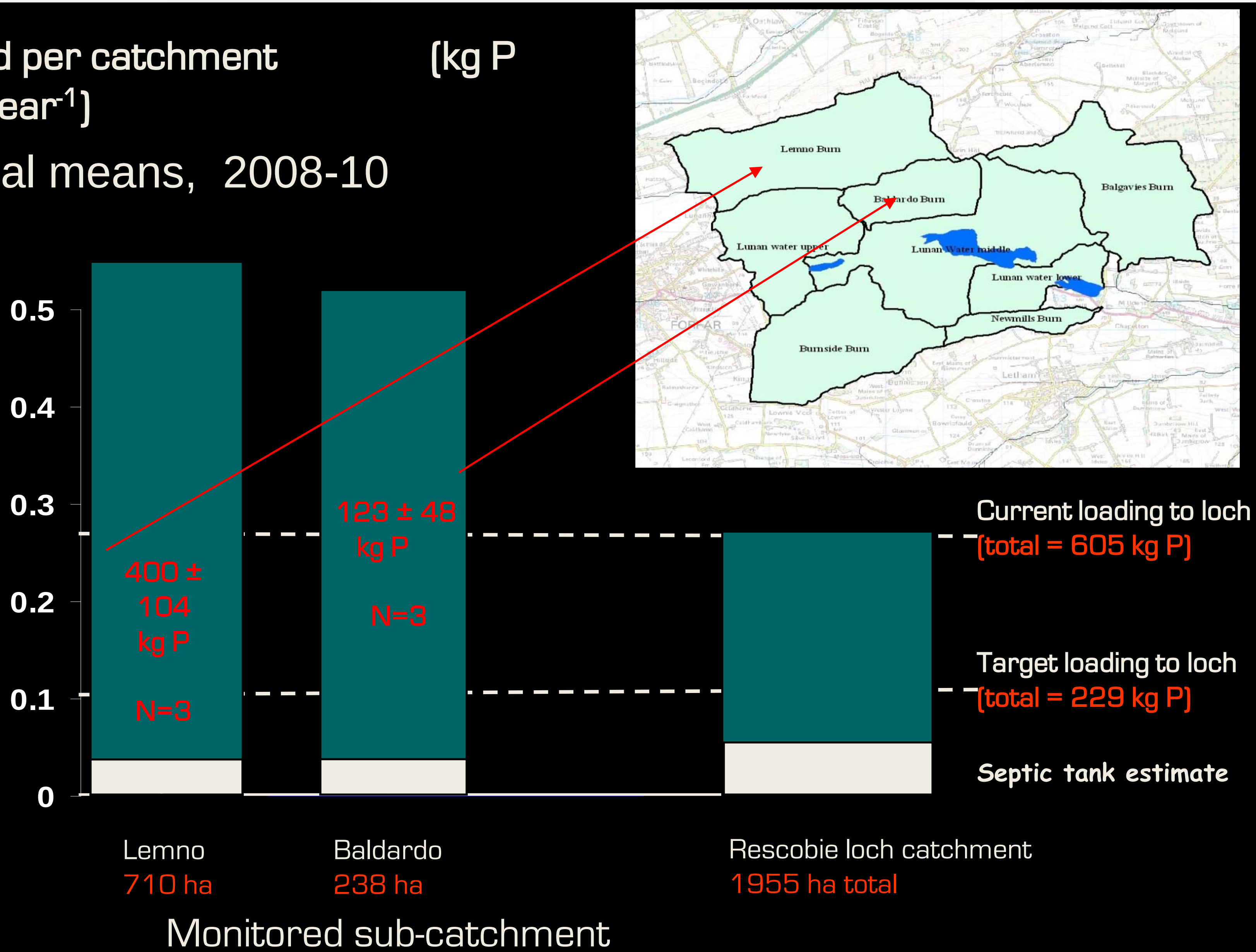
P loads to Rescobie Loch

P load per catchment (kg P ha^{-1} $year^{-1}$)

Annual means, 2008-10



Supporting methodologies

- Stream monitoring is only part of the story
  - Stream response displays the complex end-point of the story, encompassing system lags
- There is a need for supporting information on land management activities
  - Survey methods
  - Targeted monitoring and modelling
    - Sediment tracing
    - Soil analysis
    - Erosion modelling

Monitoring summary

- A goal was to establishment baseline conditions prior to implementation of catchment management
  - The level of information is okay, but there is no stable baseline
- Development of new methodologies
  - Turbidity represents a cost-effective monitoring tool, given appropriate calibration

Future requirements

- An understanding of the internal loch P cycling
- Improved modelling of P losses and sources
- Incorporation of land management data into modelling

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