Good Chemistry but Bad Biology: Contrasting evidence for the recovery of headwater streams

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Background





1990: ‘Capital Grant Study’ instigated on small headwater streams in Northern Ireland.

- Found widespread point source pollution of rural waters in lowland headwater streams.
  - Strong negative correlation between livestock stocking rates and biological and chemical water quality indices
  - Strong correlation between chemical water quality and biological (invertebrate based) water quality
- 1998 Some improvement in farm pollution and chemical water quality but not in biological quality
- 2008 Part funded EPA study commenced to assess current status of same streams
  - Did the biology improve?

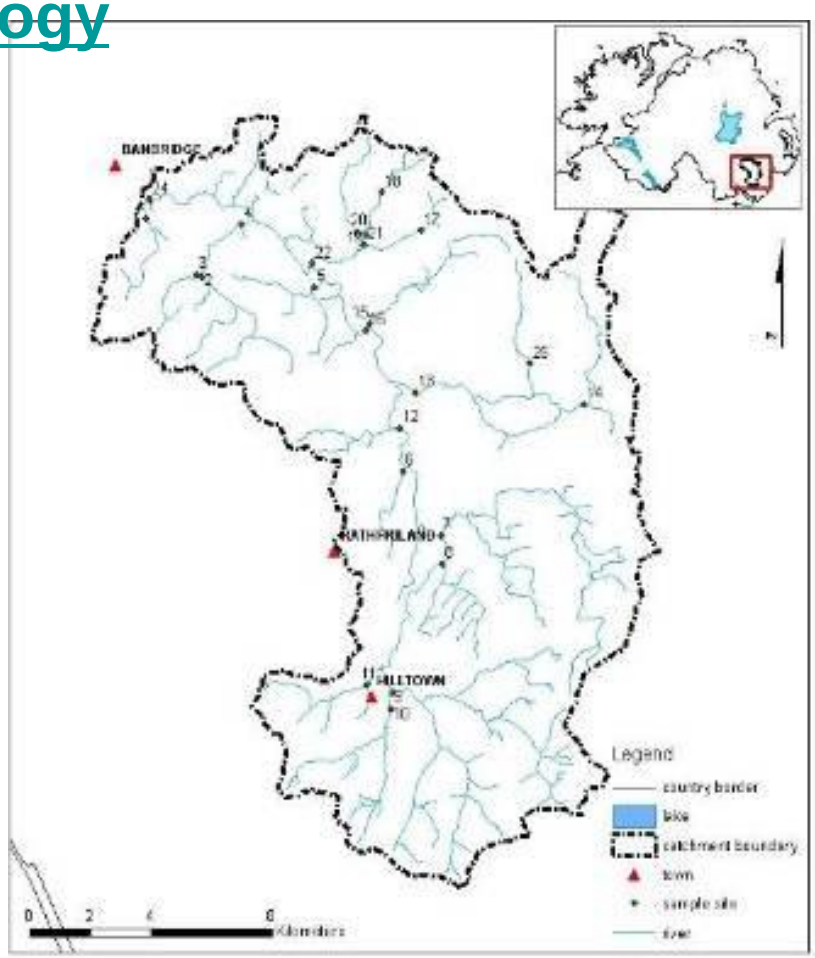
Since 1990

- New effluent tanks on farms in early 1990s
- Silage effluent volumes reduced through pre-wilting.
  - Point source pollution down
- Environmental cross compliance linked to beef sales and single farm payment
  - More legislation – required construction standards
- Erne Nutrient Management Scheme 1997/8
  - provided nutrient management advice for farmers in Erne catchment
- Closed winter season for slurry spreading:
  - Not effective until 2009/10 winter
- Since 2004 marked decline in N & P fertiliser use.
- New effluent tanks in 2008/9
- But an explosion of single dwellings in countryside in from 1997-2006.

Methodology

Colebrooke

- Less intensity grasslands
- 100% classed as LFA (75% SDA)
- Beef Cattle
- Unimproved / Coniferous forestry



Upper Bann

- Lowland intensive grassland
  - 50% lies outside LFA
- Dairy important
- Uplands -Sheep

Methodology

- Streams sampled every 14 days
- Chemical water quality assessment based on BOD, dissolved oxygen and ammonium to generate *Fisheries Ecosystem (FE) Classes*

	Salmonid		***Cyprinid***		***No fish***	
Fisheries Ecosystem class	**1**	**2**	**3**	**4**	**5**	**6**
Dissolved O_2	High →					Low
Ammonium	Low ←					High
Biological Oxygen Demand	Low ←					High

- Biological water quality assessment

Macro-Invertebrates sampled 3 times per year. Scored 1–10 based on their sensitivity to pollution

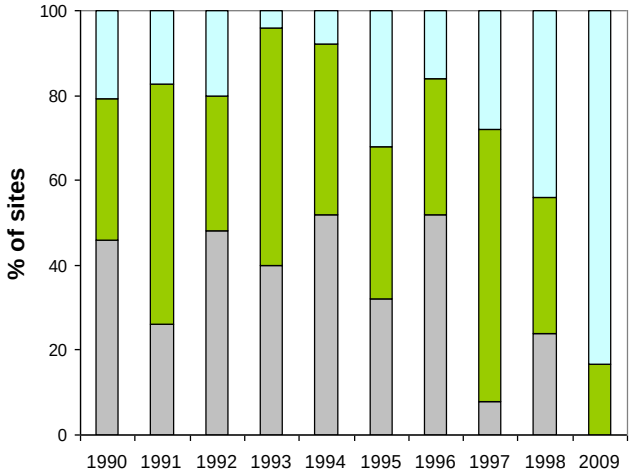
10 = pollution sensitive 1= pollution tolerant

⇒ Generates an Average Score per Taxon (ASPT) for each site

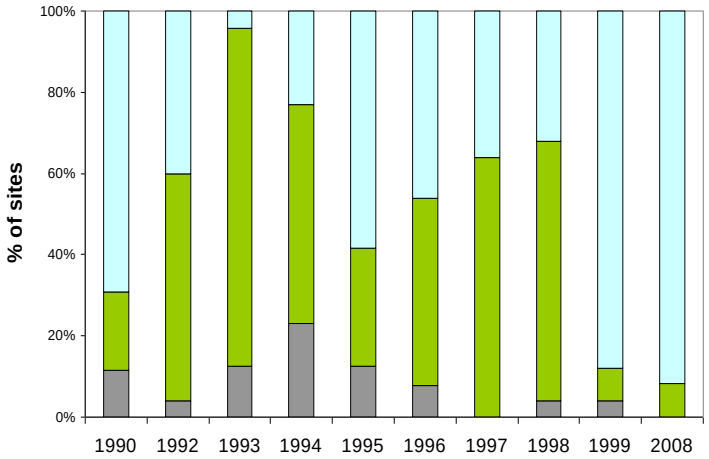
- Nutrient export Intensity - Rivers flows combined with nutrient concentrations
  - Flow weighted mean concentrations

Results: Chemical & Biological WQ

Chemistry

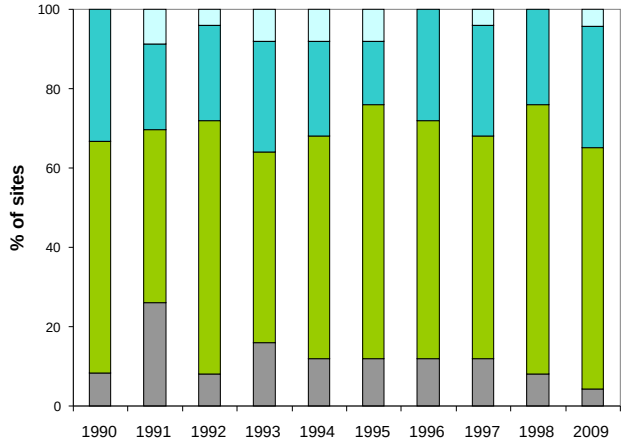


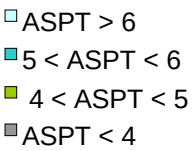
Upper Bann

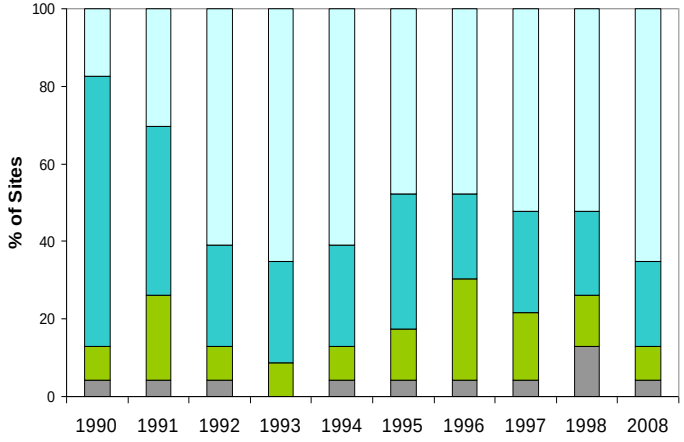


Colebrooke

Biology

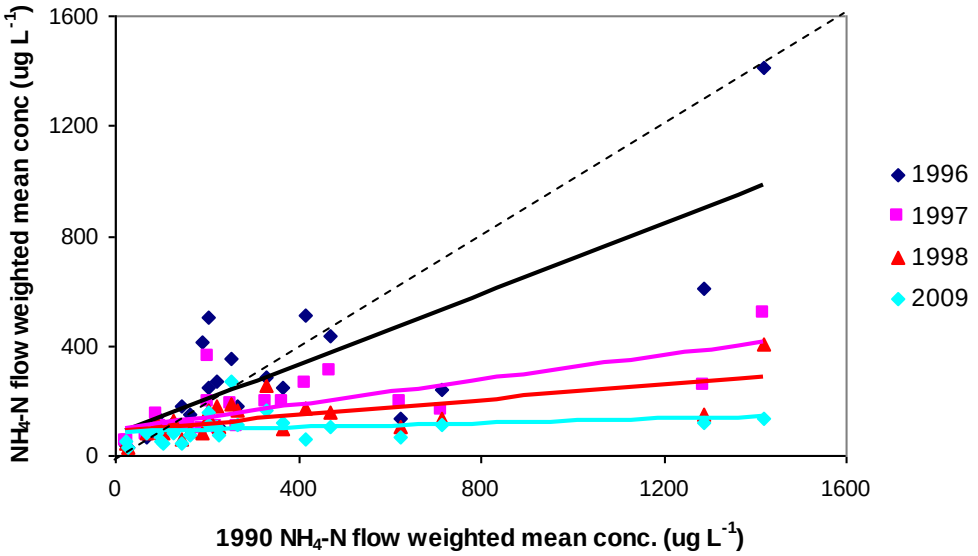






Results: Ammonium export Intensity

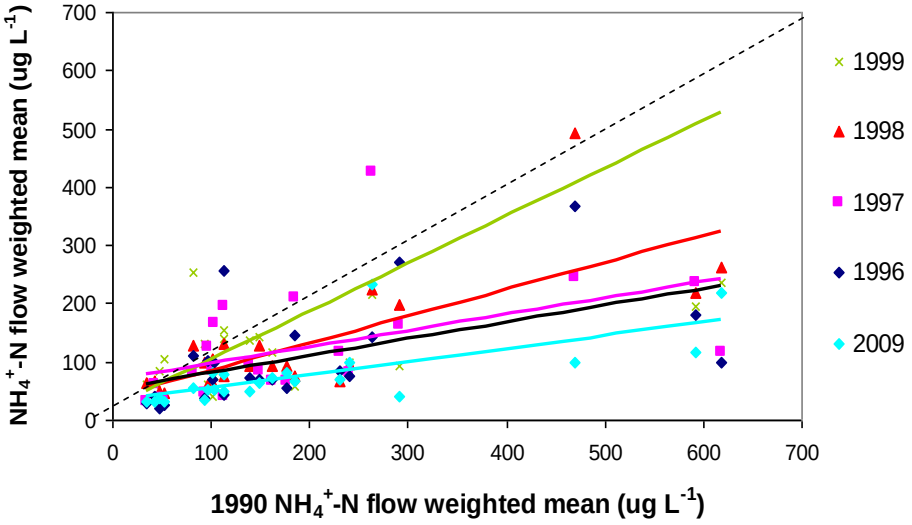
Upper Bann



NH_4-N	1990	1996	1997	1998
1990				
1996	NS			
1997	**decline***	**decline****		
1998	**decline****	**decline****	NS	
2009	**decline****	**decline****	**decline****	**decline****

***p* < 0.05, ****p* < 0.01, *****p* < 0.001**

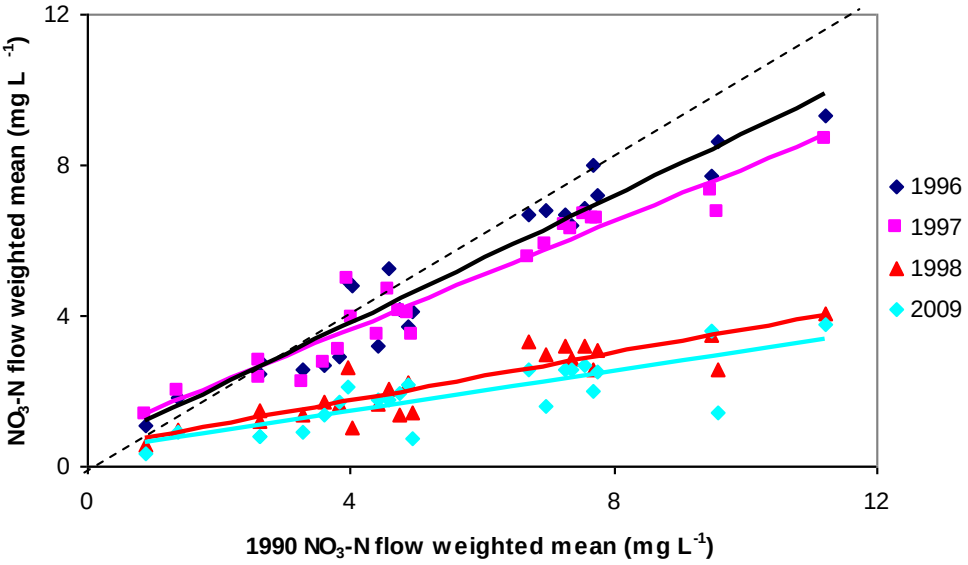
Colebrooke



NH_4-N	1990	1996	1997	1998	1999
1990					
1996	**decline****				
1997	**decline****	ns			
1998	**decline***	ns	ns		
1999	ns	ns	ns	ns	
2009	**decline*****	ns	**decline****	**decline****	**decline*****

Results: Nitrate exports

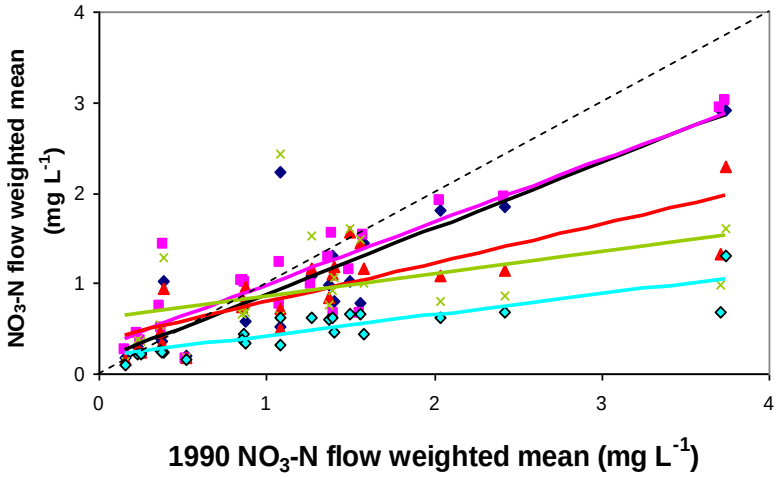
Upper Bann



NO_3-N	1990	1996	1997	1998
1990				
1996	decline*			
1997	decline***	decline**		
1998	decline****	decline****	decline***	
2009	decline****	decline****	decline***	decline***

***p* < 0.05, ****p* < 0.01, *****p* < 0.001

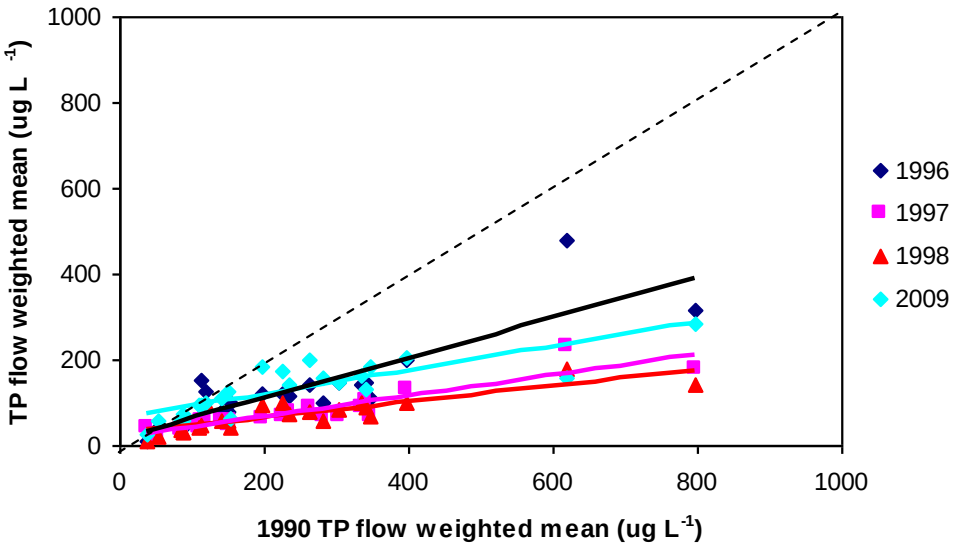
Colebrooke



NO_3-N	1990	1996	1997	1998	1999
1990					
1996	decline*				
1997	ns	ns			
1998	decline*	ns	decline*		
1999	ns	ns	ns	ns	
2009	decline***	decline***	decline***	decline***	decline***

Results: Total P Export

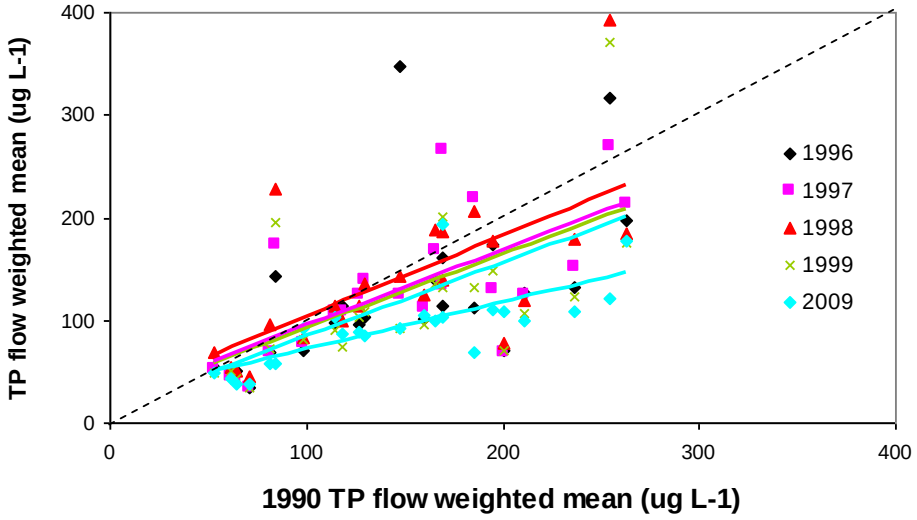
Upper Bann Total P



TP	1990	1996	1997	1998
1990				
1996	**decline*** **			
1997	**decline*** **	**decline*** **		
1998	**decline*** **	**decline*** **	NS	
2009	**decline*** **	NS	increase***	increase***

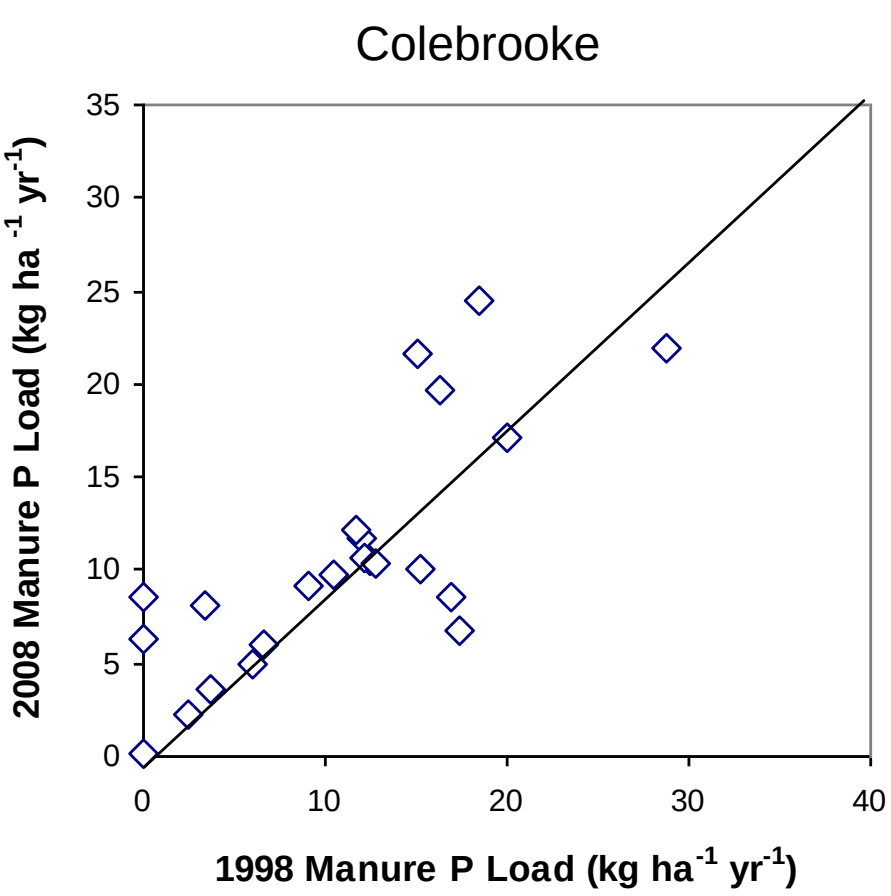
***p* < 0.05, ****p* < 0.01, *****p* < 0.001**

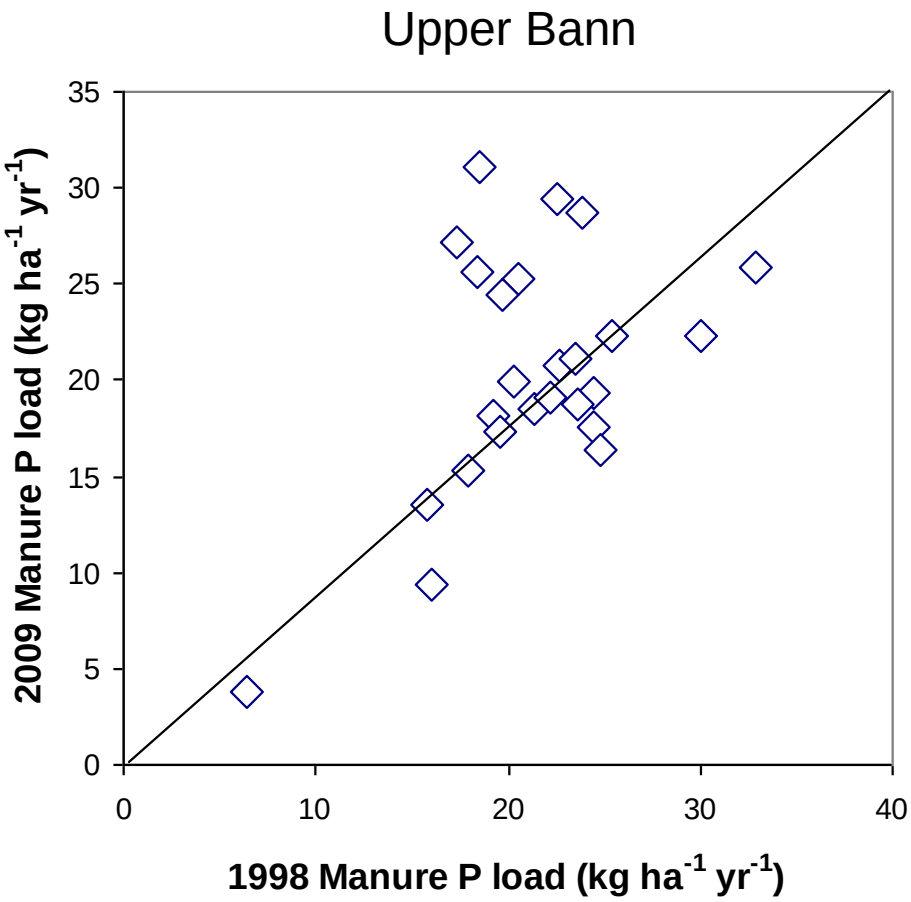
Colebrooke Total P



TP	1990	1996	1997	1998	1999
1990					
1996	**decline*** **				
1997	**NS**	increase*			
1998	**NS**	increase**	NS		
1999	**decline***	NS	NS	**decline*** **	
2009	**decline*** **	**decline***	**decline** **	**decline** **	NS

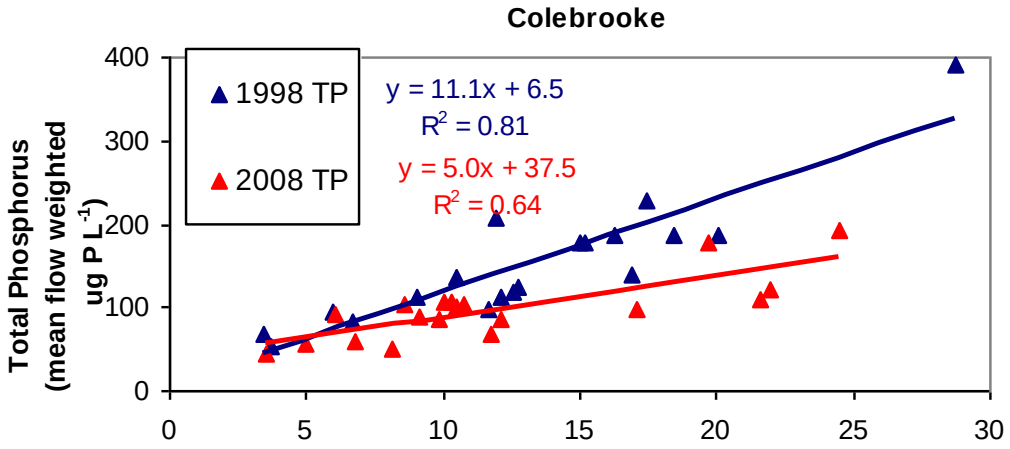
Manure P loads: 1998 vs. 2008

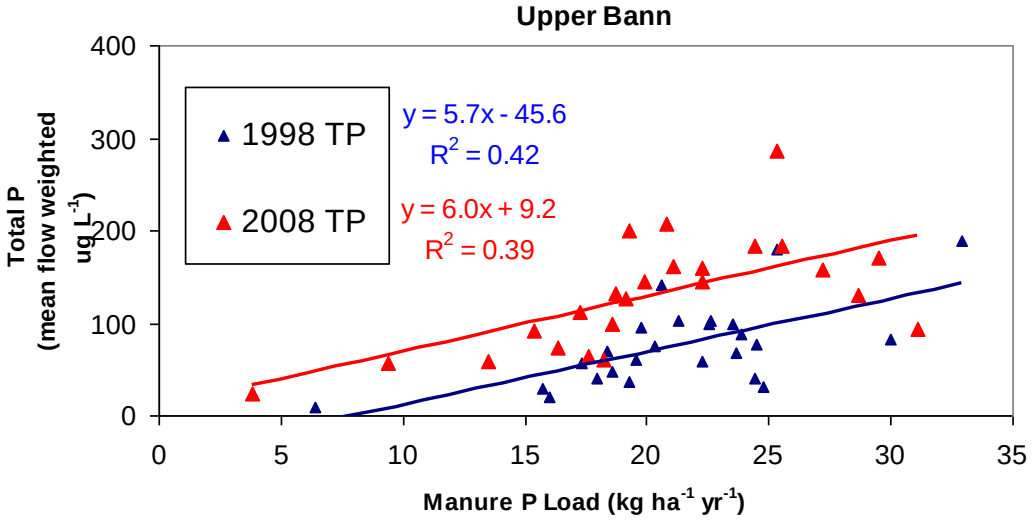




No consistent change to live-stocking rates

Stream TP concentration vs catchment manure P stocking rates compared for 1998 and 2008

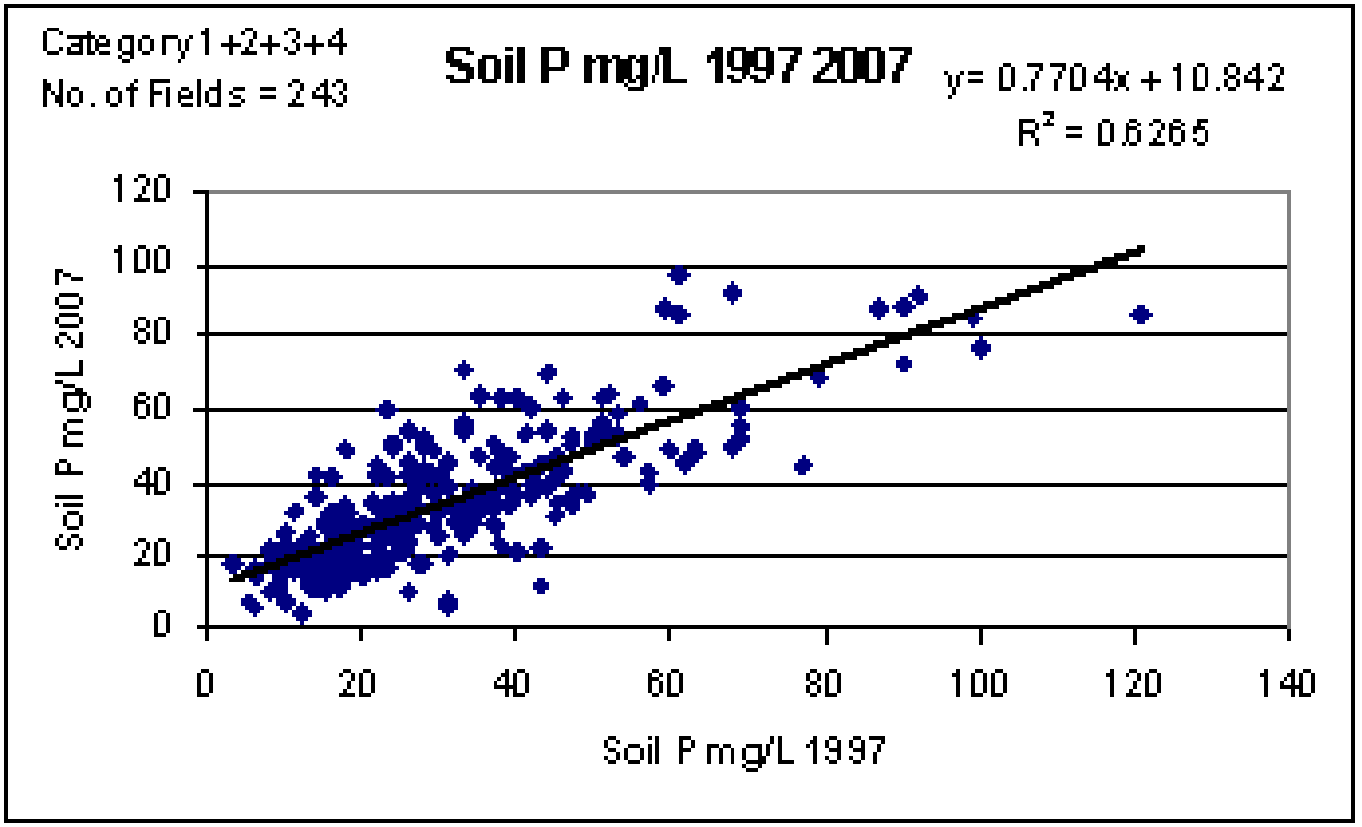




- Colebrooke shows less TP loss per unit manure loading in 2008 compared to 1998.
- Upper Bann is reverse
  - 2008 >1998
  - Manure P vs TP slopes same for 1998 & 2008
  - Higher TP loss in 2008 reflected in higher intercept.
    - Non-agricultural P source?

Colebrooke Catchment meta-analysis: Nutrient Export Intensity

Soil P

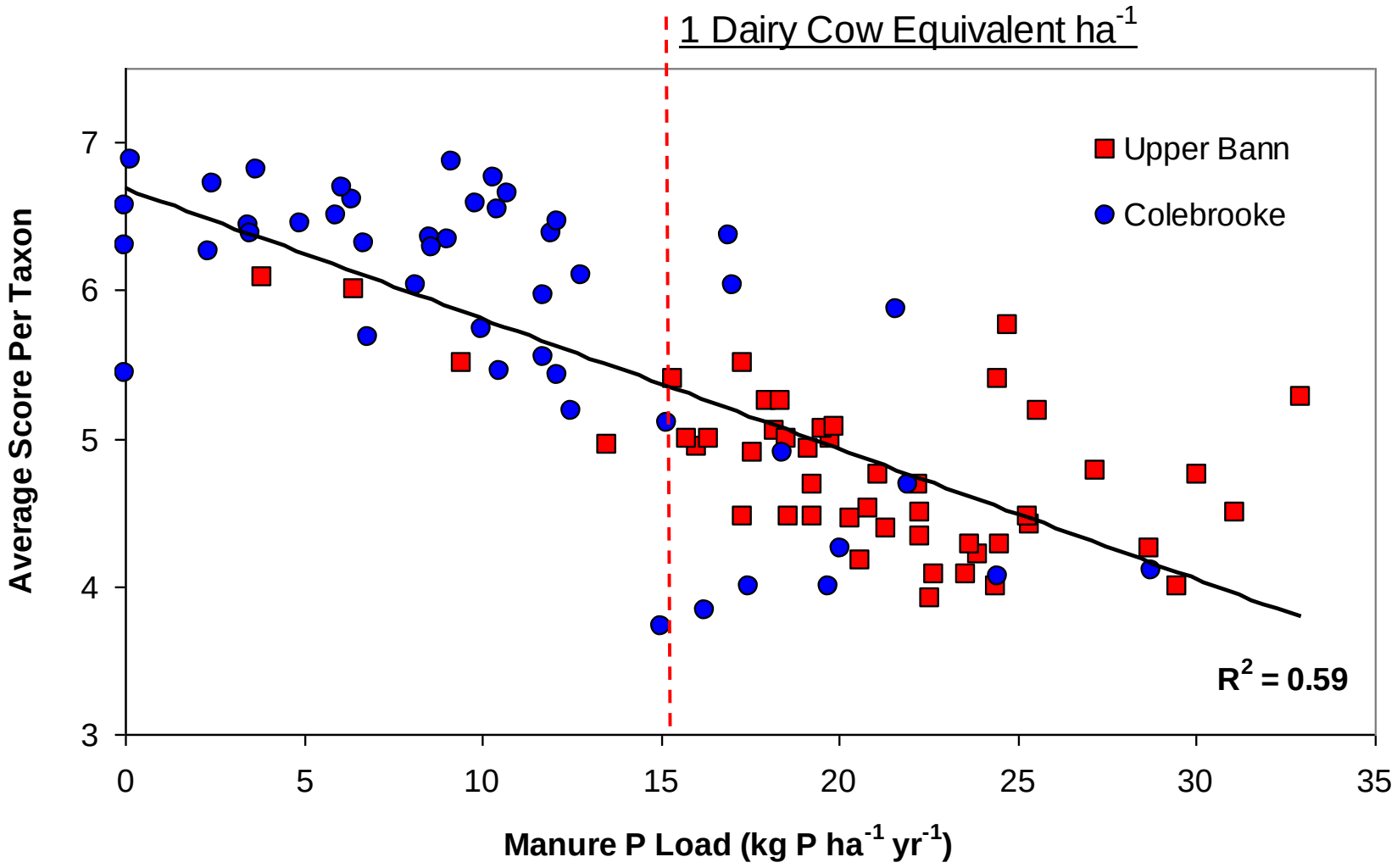


Overall small increase in P

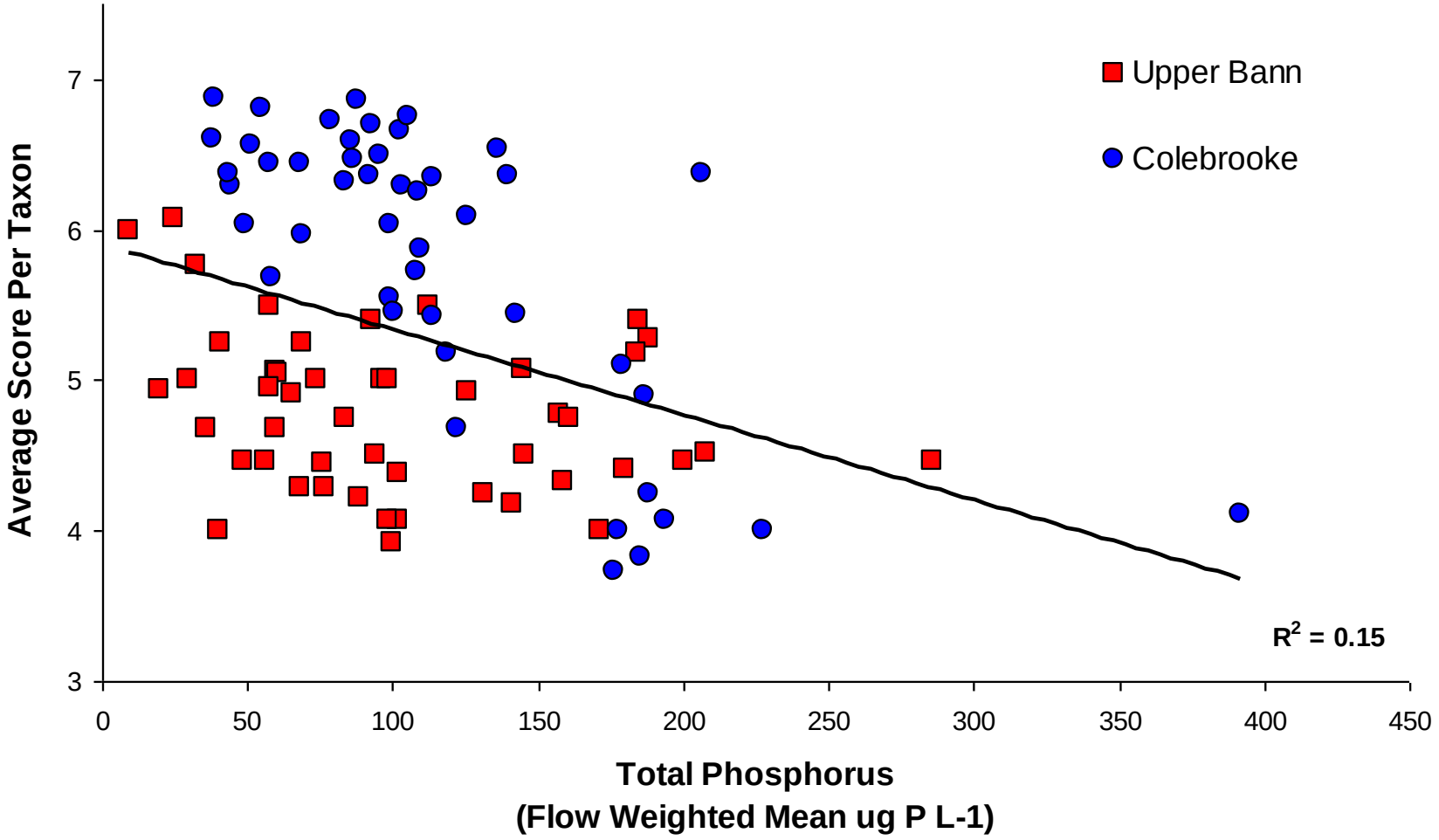
- change in P occurred on the low P soils
- no detectable change in high P soils

J. Mellon, K. Hamill & D. Matthews, The Colebrooke Catchment Revisited

Mini-catchment Manure P Loads vs. ASPT for 1998 and 2008



Mini-catchment Total P vs. ASPT for 1998 and 2008



Conclusions

- Still no improvement in biology
- Nitrate and ammonium export rates have significantly declined.
- P export response less clear
  - shows decline in most Colebrooke catchments but increase in Upper Bann
  - TP concentrations remain ecologically high (100 - 200 ④g P L^{-1}).
- Increases in P loss could reflect
  - new rural homes
  - Increased live-stocking rates
  - Clearfelling (headwaters of Colebrooke)

Ongoing & future work

- Monitoring has continued in 2010 at 50% of catchments
  - Examine data in regard to mini-catchment specific land use and rural housing over time.
- How to test for factors constraining biological recovery?
  - Are nutrients levels too high?
  - Is hydro-morphology too poor?
  - Is infrequent farm yard pollution sufficient to prevent recovery?

Acknowledgements

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  - Gloria McLaughlin and Raymond Stewart for water sampling
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