

Combining economic instruments with  
regulation to achieve dual environmental  
targets: Nitrate pollution and minimum river  
flows

Ashar Aftab and Nick Hanley  
Economics Dept., University of Glasgow

- Environmental problems are treated in a coordinated fashion under the Water Framework Directive, yet most academic work on has been conducted on a “single issue” basis
- We model Non-Point Source (NSP) pollution under a regime of variable river flow targets
- Recognises 2 environmental problems: nitrate levels and low flows
- Allows investigation of the benefits of coordinated actions; and the effects on policy instruments/policy choice of having multiple objectives. We also consider the implications of a changing climate for our results

POLICY OPTIONS: a) estimated emission taxes b) nitrogen input taxation c) emission quotas d) nitrogen input quota e) managerial restrictions on stocking density and, f) restrictions on the area of set-aside.

We are also interested in the relative efficiency of *combining* economic instruments with managerial measures. Therefore, four such combined or mixed instrument policy packages were simulated. These were: a) set-aside land with input taxation, b) set-aside with stocking density reduction, c) stocking density reduction and input taxation and d) both set-aside and stocking density reduction with input taxation.

## Main results:

- Implementing irrigation restrictions reduces severity of management restrictions/ level of economic instrument required to control N pollution
- co-ordination of N reduction and low flow policy produces net benefits relative to un-coordinated actions
- stand-alone economic instruments outperform mixed instrument policies under mean weather, but not under wetter weather conditions
- climate change alters the relationship between low flows policy and N policy, and changes the second-best N tax rate

# Case study

- West Peffer catchment, East Lothian, Scotland
- Problem with both nitrate levels and low flows
- Most abstraction is by farmers for irrigation
- 4,500 hectares

# Modelling

Catchment profit function:

*Revenue (Arable Crops + Potato types + Animal husbandry) + Subsidies*  
*– Costs (Arable Crops – irrigation – animal husbandry– nitrogen fertiliser) - Tax*

## Constraints

- EU Water Quality Standard 11.3 mg/litre N.
  - Flow restrictions:  
90<sup>th</sup> , 95<sup>th</sup> , 98<sup>th</sup> Percentile Flows
- 

## Weather Patterns

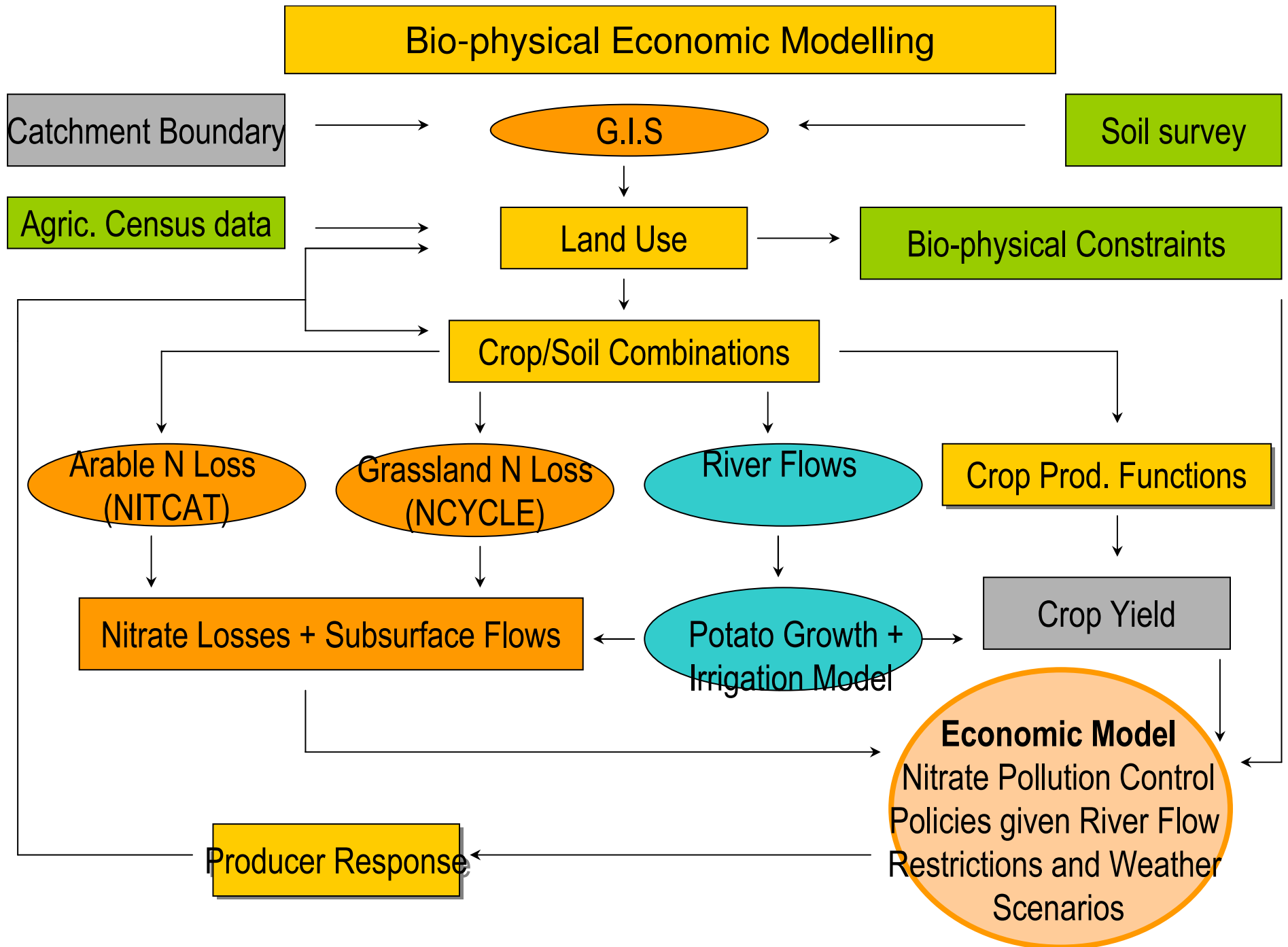
- Mean
- Wet  
(defined over last 10 yrs)

## Farm Heterogeneity

- 3 soil types
- 8 arable activities
- 2 crop rotations
- 5 livestock types
- 3 irrigation regimes (optimal, restricted and un-irrigated)

## Nonlinear Optimisation

- General Algebraic Modelling System (GAMS)
- 27000 equations
- maximise catchment profit



# Results

## 1. Impacts of flow targets on N control:

- as tighten NO<sub>3</sub> standard in terms of number of weeks when violation allowed, N tax and estimated emission tax rises
- Increasingly severe flow restrictions *reduce* the size of the N/estimated emission tax needed to hit a given target (eg 8 weeks)
- As standard is tightened, difference between the low flow control/no control regimes increases



## Results (cont.)

2. Benefits of co-ordination are significant, since higher N tax (etc.) required when no co-ordination.

# Benefits of co-ordination

## Benefits of co-ordination under 8 week NO3 standard with 90% flow restriction

(All values are in '000 opounds)

Note: N tax higher under no co-ordination

<b>Control Instrument</b>	<b>Un-coordinated</b>	<b>Coordinated</b>	<b>Benefit of Coordination (<math>\phi_{co}</math>)</b>
Emission Tax	81.15	69.23	11.92
Input Tax	144.57	124.93	19.64
Input Quota	186.83	130.45	56.38
Set-aside	1007.93	941.97	65.96
Stocking Density Reduction	965.32	960.77	4.54

## Results 3: single versus mixed instruments

- Economic instruments ranked higher, in abatement costs terms, than either regulation or mixed instruments under *mean* weather conditions
- But performance of mixed instruments improves a lot under wetter conditions

<b>Regulatory Target</b>	<b>Standard exceeded 8 weeks</b>			<b>Standard exceeded 6 weeks</b>		
<i>Weather</i>	<i>Mean Weather</i>		<i>Wet Weather</i>	<i>Mean Weather</i>		<i>Wet Weather</i>
<b>River Flow Restriction</b>	<b>90th percentile</b>	<b>No Flow restriction</b>	<b>With and without</b>	<b>90th percentile</b>	<b>No Flow restriction</b>	<b>With and without</b>
Emission Based Policies	1	1	1	1	1	1
Input Tax	2	2	4	2	3	4
Input Quota	3	3	6	3	4	5
Stocking density (1.4 glu/ha) + Input tax	4	4	5	4	2	8
Set-aside + Input tax	5	5	3	5	6	3
Set-aside, stocking density reduction + input taxation	6	6	2	6	5	2
Set-aside + stock density	7	7	8	7	7	7
Set-aside	8	9	9	9	8	6
Stocking density	9	8	7	8	9	9

## Results 4: climate change

- Predictions are for higher rainfall in Scotland
- Simulate using wettest years in last 10
- Implies not so much an effect of river flow regime on N pollution control
- But direct effect of higher rainfall on N pollution means N tax must be increased

# conclusions

- We have looked at the joint management of two externalities: nitrate pollution and low flows
- We find an interaction between the two, in terms of the level of economic instruments needed to achieve compliance with 50mg/l nitrate target depend on irrigation restrictions

- Benefits exist from coordinating actions on these 2 externalities, since significant savings in abatement costs are made
- Changing climatic conditions will impact both the level of an N tax and the interaction between N control and low flow policy
- Mixed instrument policies perform better under wetter conditions too
- This kind of analysis fits well with ethos behind the WFD and should be extended to other catchments/joint problems