Model limitations and prediction uncertainty in the context of analytic-deliberative catchment management

Acceptance by stakeholders and their role in improving model predictions

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Catchment management

Negotiating conflicting interests & impacts

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Agriculture

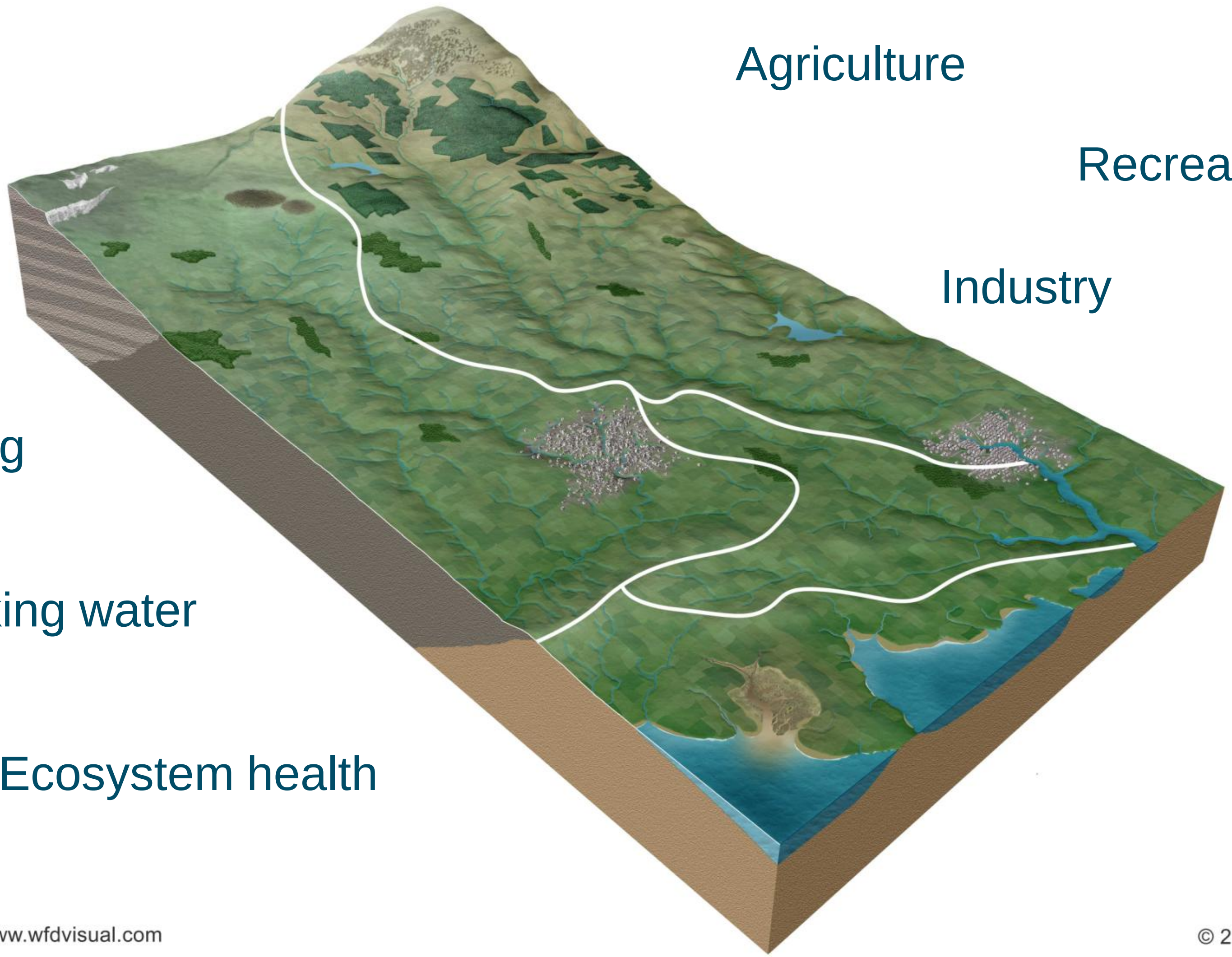
Recreation

Industry

Housing

Drinking water

Ecosystem health



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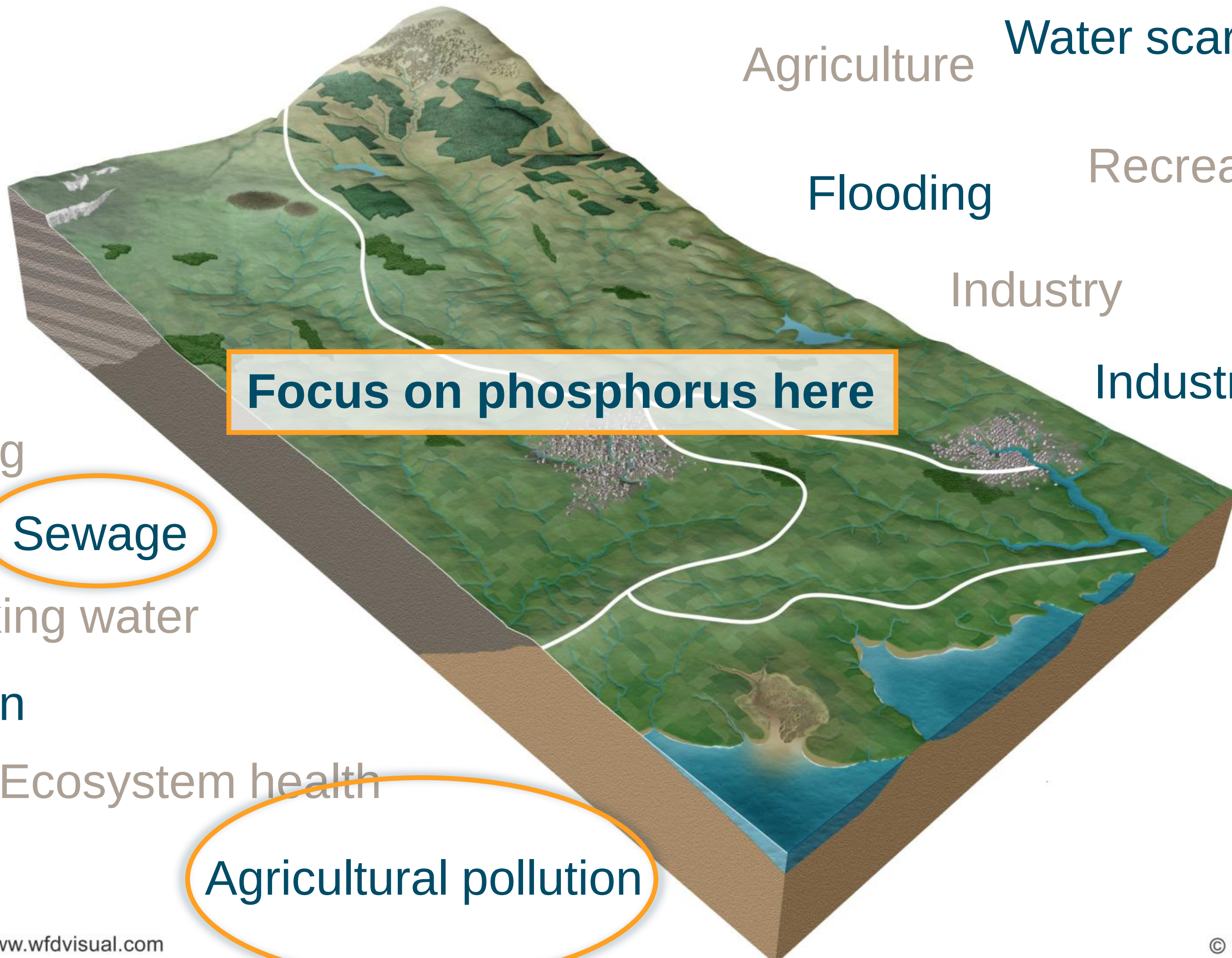
Catchment management

Negotiating conflicting interests & impacts



Agriculture

Water scarcity

Flooding

Recreation

Industry

Industrial pollution

Housing

Sewage

Drinking water

Soil erosion

Ecosystem health

Agricultural pollution

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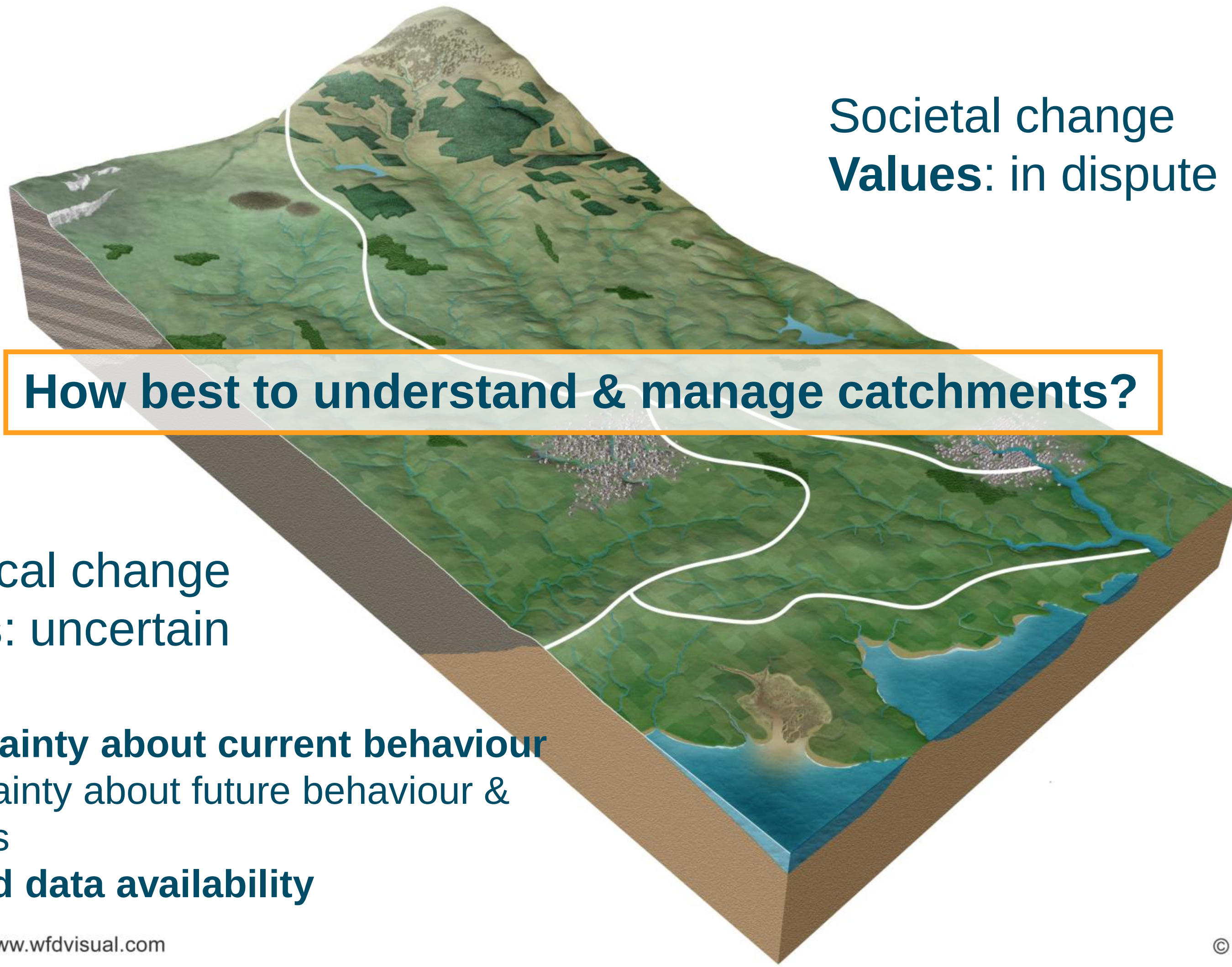
Catchment management
Under catchment change

Societal change
Values: in dispute



How best to understand & manage catchments?

Physical change
Facts: uncertain

Uncertainty about current behaviour
Uncertainty about future behaviour & drivers
Limited data availability

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Catchment management

A collaborative & adaptive process

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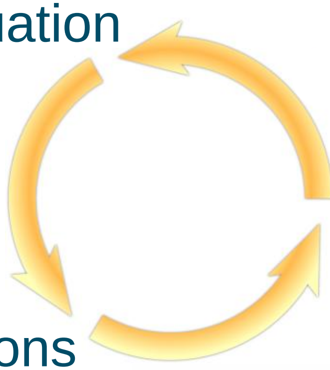
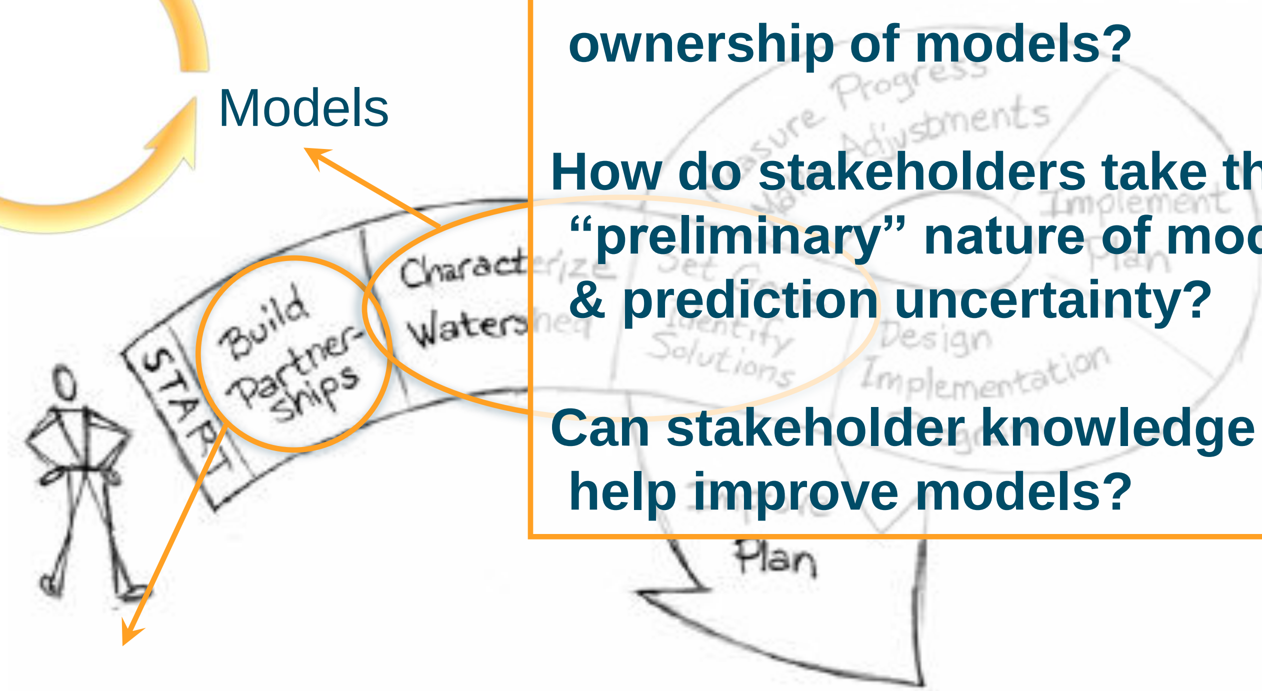
Evaluation



Models

Observations



How can stakeholders develop ownership of models?

How do stakeholders take the “preliminary” nature of models & prediction uncertainty?

Can stakeholder knowledge help improve models?

Interested citizens, conservation groups, farmers, tourism industry, water companies, local to national government, environment agencies, …

An **adaptive management cycle** for catchment planning and process implementation
Source: US EPA Handbook 2005

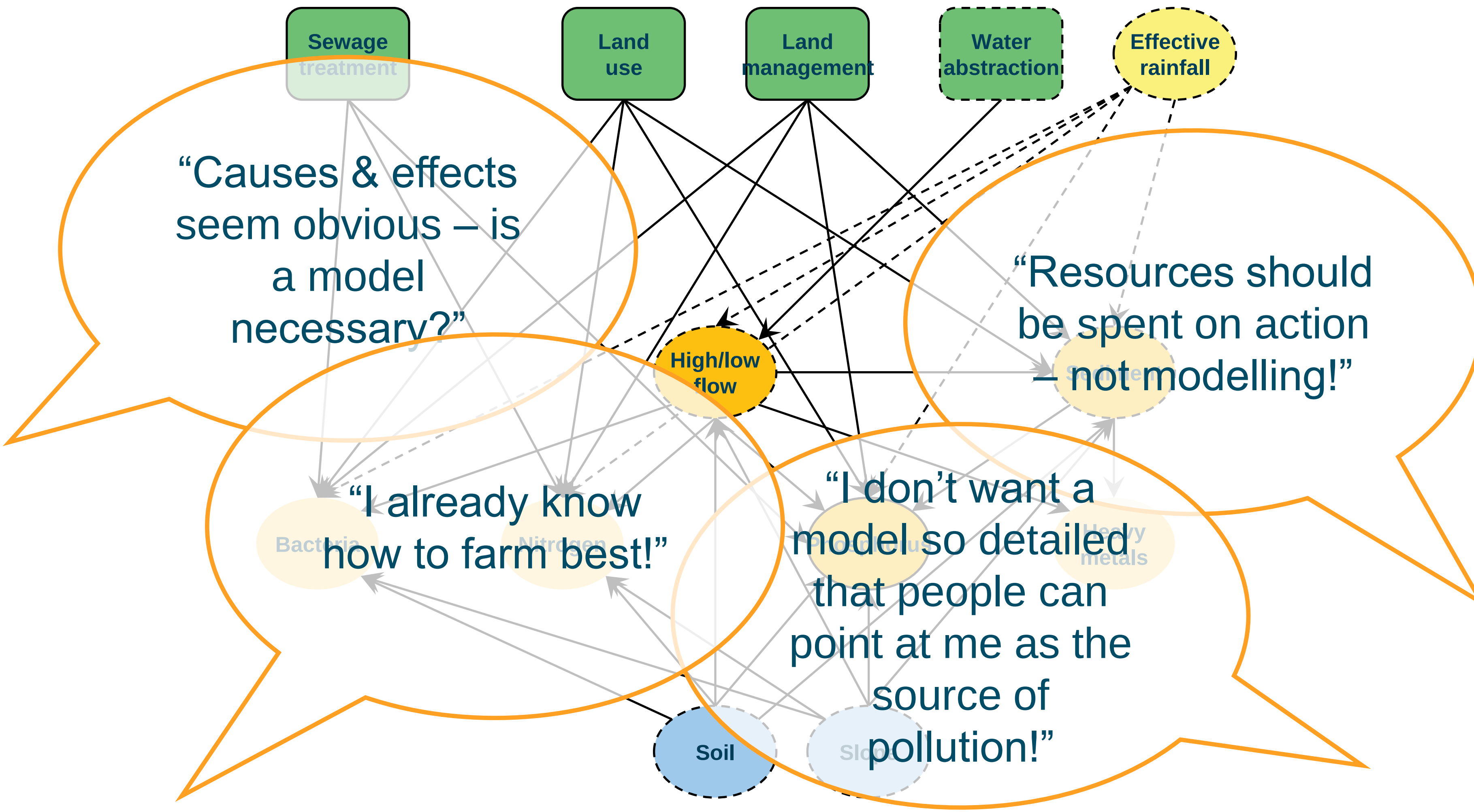
Developing & testing the process

Semi-real case study

- Stakeholder identification & engagement
- Workshop 1: Framing the problem
- **Workshop 2: Revision of perceptual model**
- **Farmers meeting: Review of formal model & crucial data input**
- **Workshop 3: Review of formal & procedural model; management scenario development**
- Workshop 4: How to implement management scenario

Perceptual modelling stage

Revision of graphical representation



Perceptual modelling stage
Lessons

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- However, it was agreed that models can lend scientific credibility to catchment management & serve as a basis for scenarios & cost-benefit analysis
- There remained the issue of invasion of privacy: who will govern the model that is collectively produced?
- Stakeholders advised that the model must not neglect the effects of soils, land management & roads
- This created new challenges as the understanding of some of these processes is incomplete and data are limited – the stakeholders drove the agenda at this point

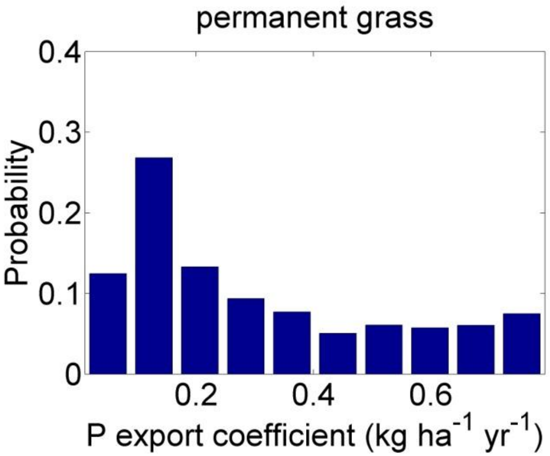
Formal modelling stage

Review of model assumptions & limitations

Export Coefficients[1], extended by farm practices & in-stream processes (SPARROW[2])

Source → **Mobilisation** → **Pathway**

Source	Mobilisation	Pathway
Septic tanks	Rainfall	Rainfall
Sewage treatment works	Soil	Soil
Phosphorus stripping	Slope	Slope
Land use & livestock	Land management	Land management
Land management		
Roads & tracks		Roads & tracks
		Net loss in rivers & lakes



[1]Johnes et al., 1996, JH
[2]Smith et al., 1997, WRR

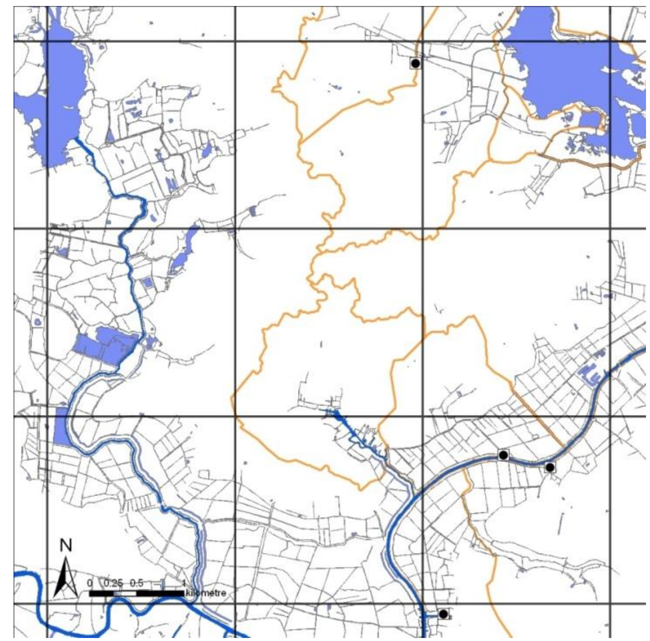
Formal modelling stage

Lessons

- All factors important to stakeholders were included in the model – this had been ensured at the perceptual modelling stage
- But discussions evolved around explicit vs. implicit representations, the dominance of some factors which justifies the exclusion of others & how model limitations are accounted for in effective uncertainty estimates
- In fact, the usefulness of the model despite its limitations could only be argued because uncertainties were quantified
- Farmers understood the concept of probability easily & were able to explain it to others in non-scientific terms (collective learning)

Importance of local knowledge
Land use & livestock distributions

	Agricultural census 2004	Local farmers
Permanent grass (ha)	19	19
Temporary grass (ha)	3	3
Rough grazing (ha)	3	3
Cereals (ha)	33	33
Root crops (ha)	16	16
Field vegetables (ha)	3	3
Oilseed rape (ha)	0	0
Woodland (ha)	2	2
Bare fallow (ha)	0	0
Cattle	**158**	**300**
Pigs	**110**	**0**
Sheep & goats	**97**	**10**
Poultry	**35121**	**0**



Importance of local knowledge

Ranking & uptake of farming practices

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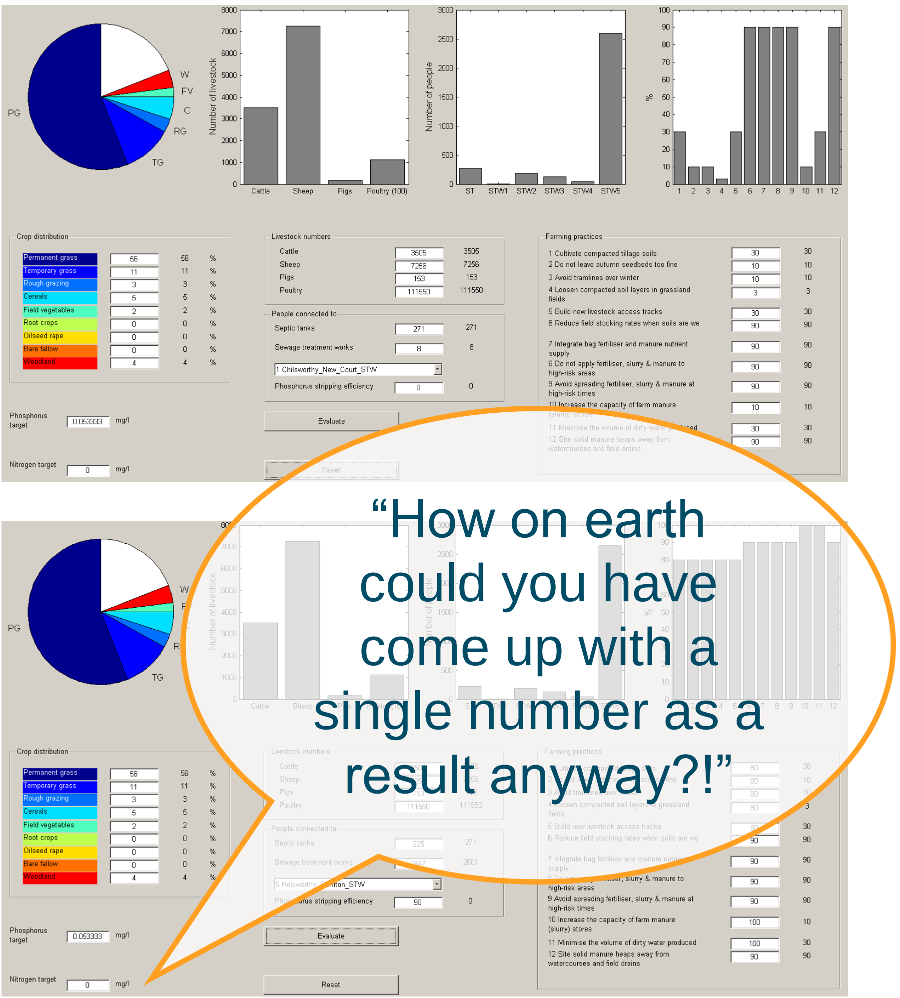
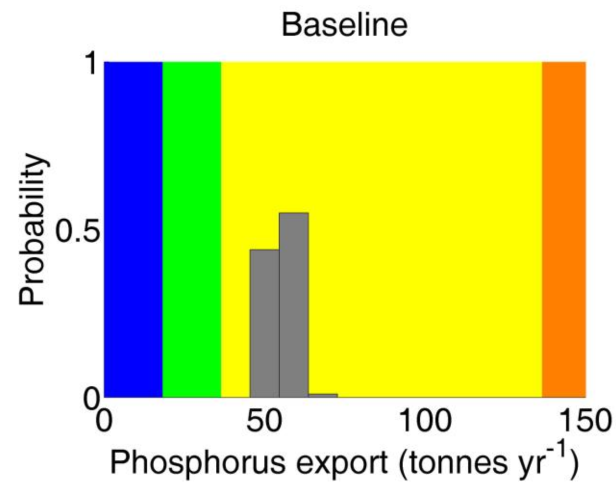
Local expert opinion		Scientific expert opinion	
	Current uptake (%)	P export reduction (% range)	
Cultivate compacted tillage soils	30	25	35
Do not leave autumn seedbeds too fine	10	25	35
Avoid tramlines over winter	10	25	35
Loosen compacted soil layers in grassland fields	3	50	70
Build new livestock access tracks	30	10	10
Reduce field stocking rates when soils are wet	90	10	10
Integrate bag fertiliser and manure nutrient supply	90	4	4
Do not apply fertiliser, slurry & manure to high-risk areas	90	27	40
Avoid spreading fertiliser, slurry & manure at high-risk times	90	15	50
Increase the capacity of farm manure (slurry) stores	10	25	25
Minimise the volume of dirty water produced	30	5	5
Site solid manure heaps away from watercourses and field drains	90	4	4

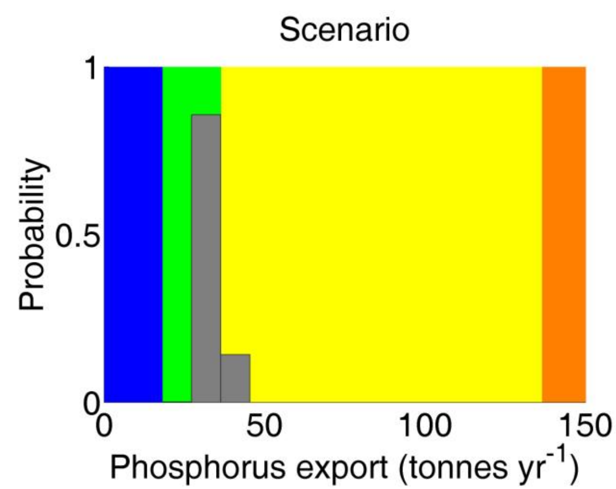
Importance of local knowledge
Lessons

- The input of farmer knowledge encouraged their ownership of the model & overcame initial mistrust
- We sensed a great enthusiasm for this type of engagement – for example, the farmers stayed longer than we expected them to in order to completed the task

Procedural modelling stage
Interactive scenario development







Conclusions

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- Collaborative modelling clarifies **expectations**, encourages **transparency & openness**
- Being explicit about **uncertainties** helps building **trust**
- Measured data will always be limited – stakeholder (esp. farmer) knowledge can plug important gaps & this encourages ownership
- It is expected that individual & collective learning makes communities more resilient & adaptive to catchment change

Future research questions

- How to formally test levels of **trust, ownership, social learning & resilience**?
- How to **engage stakeholders** efficiently?
- Only works if stakeholders have real **interest, demand & power**: how to restructure **governance of natural resources**?
- How to **weight** different types of knowledge in models?
- How deep can discussion of **model assumptions/limitations** go?