What environmental indicators can (and can't) do

Or nine lessons and no carol

Prof. David Briggs

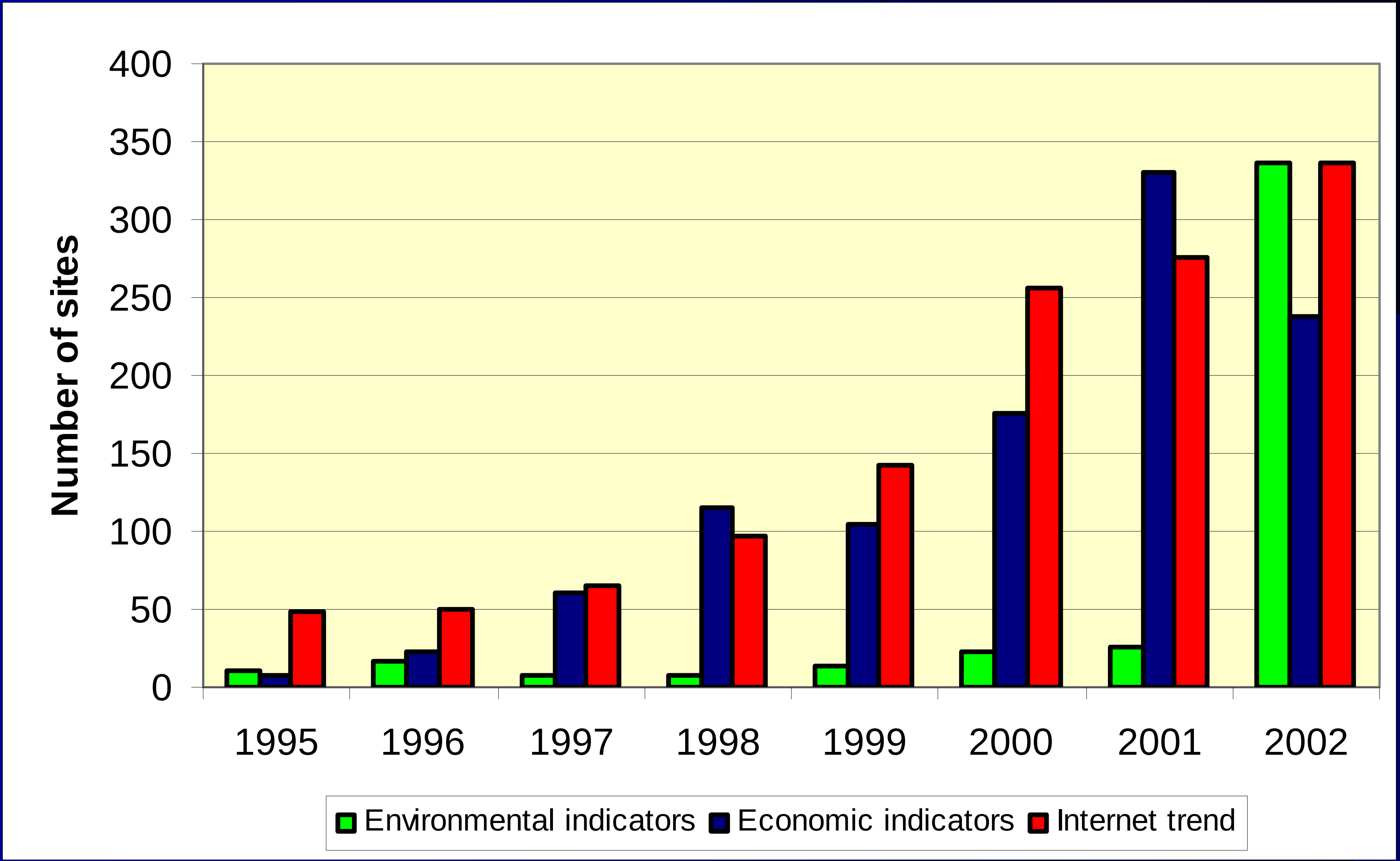
Small Area Health Statistics Unit

Department of Epidemiology and Public Health

Imperial College London

An Indicator

Numbers of Internet sites providing indicators, by year



The need for indicators

Public information and policy:

- **Accountability - costs and performance**
- **Liability - legal**
- **Transparency – open to scrutiny**
- **Subsidiarity – action at right level**

The nature of the problems:

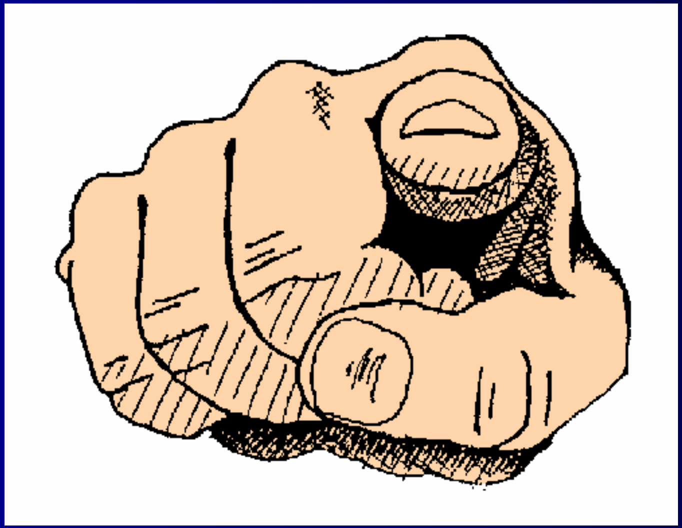
- **Complex – needs simplified (yet comprehensive) information base**
- **Cross-sectoral – needs means of communication and negotiation**
- **Trans-national – needs concerted understanding and action**

….and, of course, fashion

What do indicators indicate?

Latin - Indicare:

- to point or indicate



An indicator is something that points from one place, or one thing, to another

A definition

An indicator comprises a characteristic or condition which can be described or measured in a way that provides information about some other characteristic or condition which is, itself, not amenable to direct observation or measurement

How indicators indicate

Causal: The indicator causes (or is caused by) the target

- CO_2 emissions for global warming
- asbestos exposures and asbestosis

Component: The indicator is a major component of the target (or vice versa)

- indicator species for plant assemblage
- methane and hydrocarbon emissions

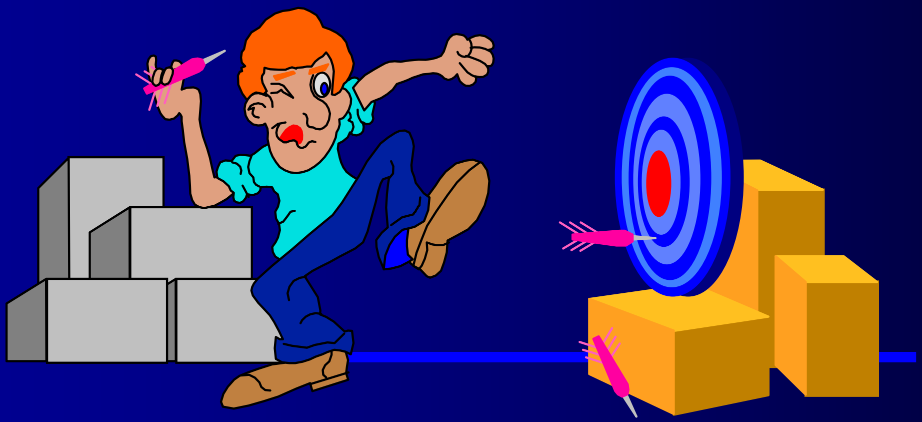
Conditional: The indicator is a precondition for the target (or vice versa)

- road length and traffic volume

Correlation: The indicator is statistically correlated with the target:

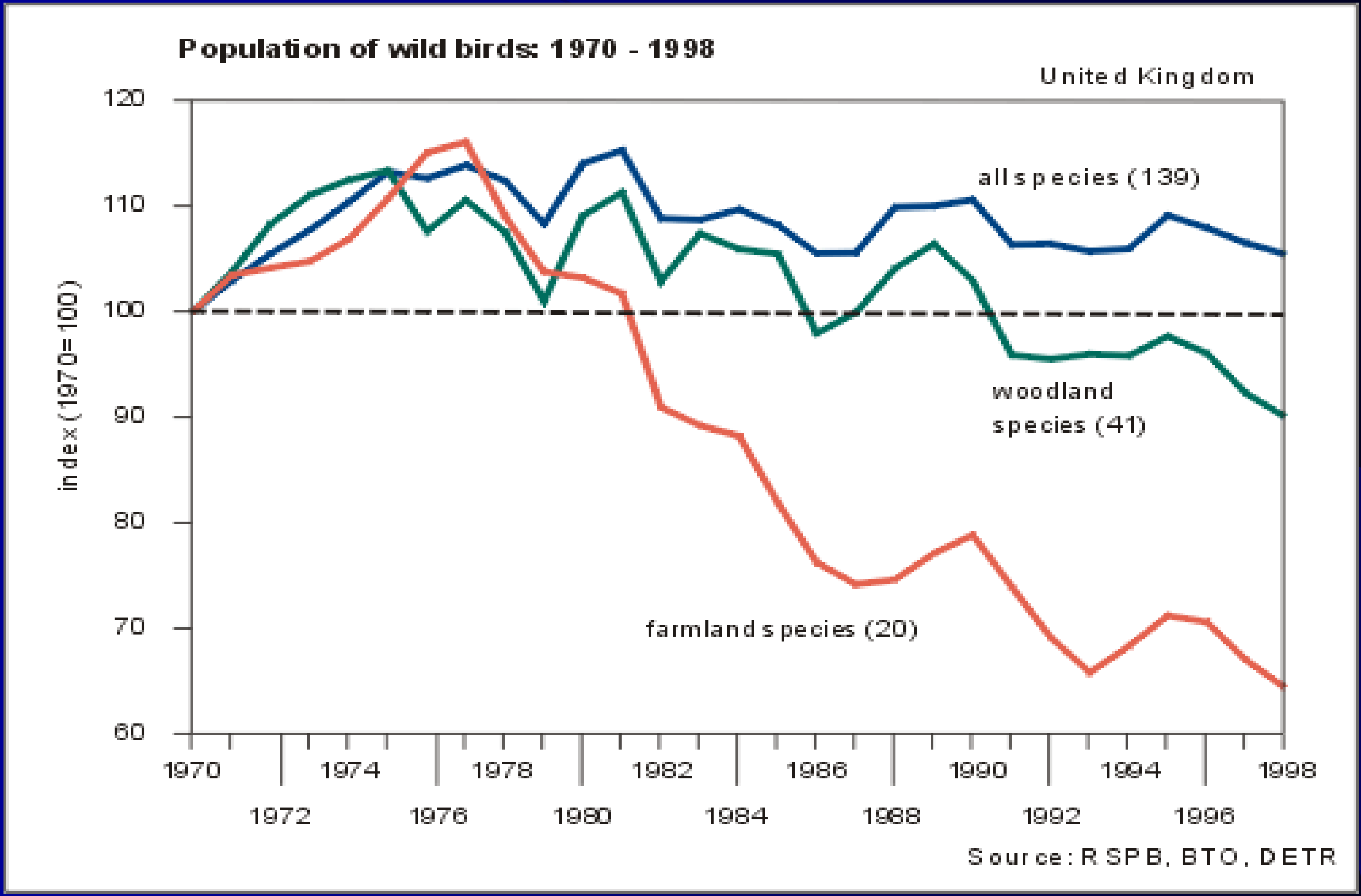
- deprivation and lung cancer
- carbon dioxide concentrations and particulate concentrations in

Indicators thus consist of two elements: the indicator itself (determinand) and the target (the thing it indicates)



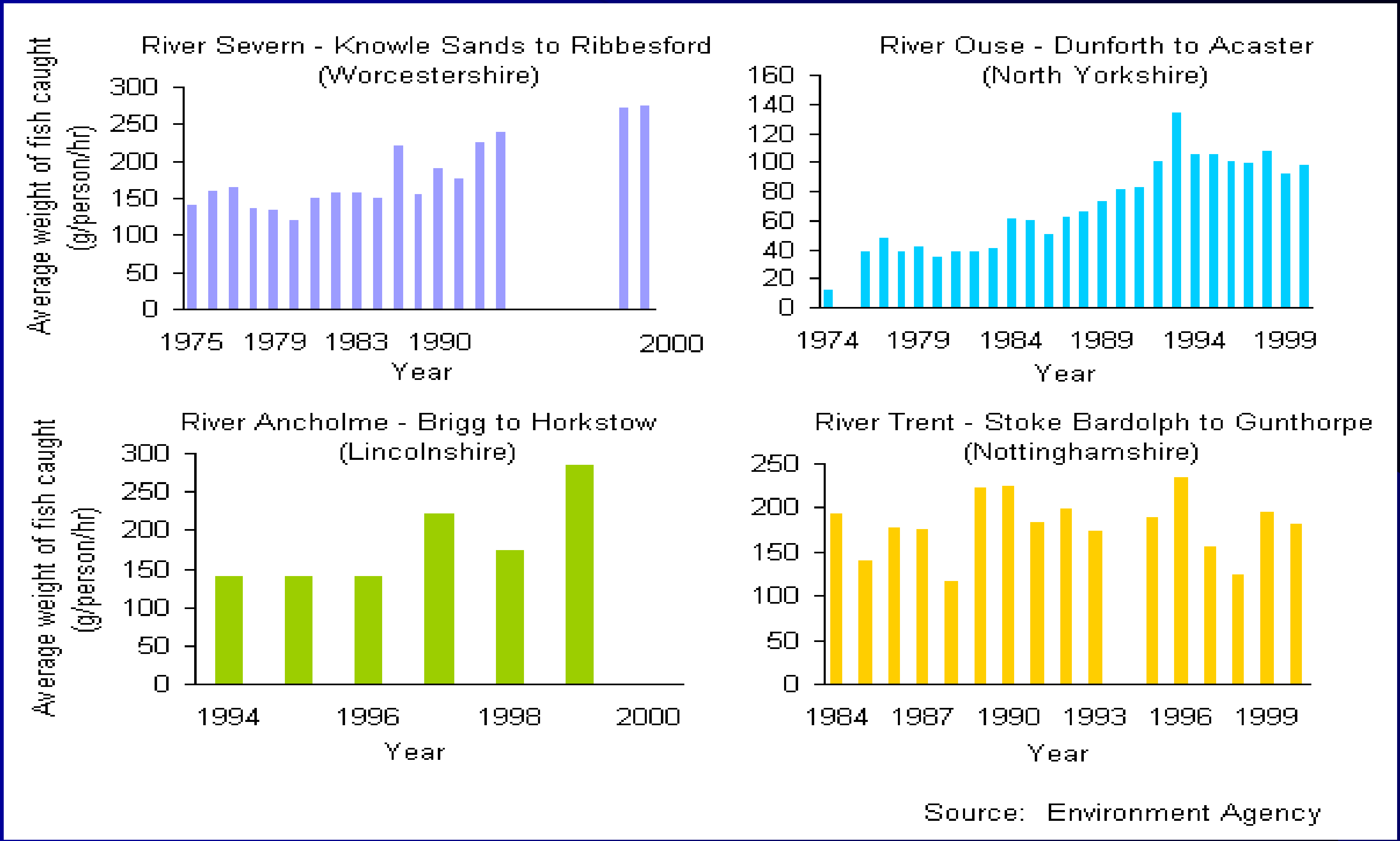
Unless we understand the link between the two, we cannot interpret indicators

Wild bird populations

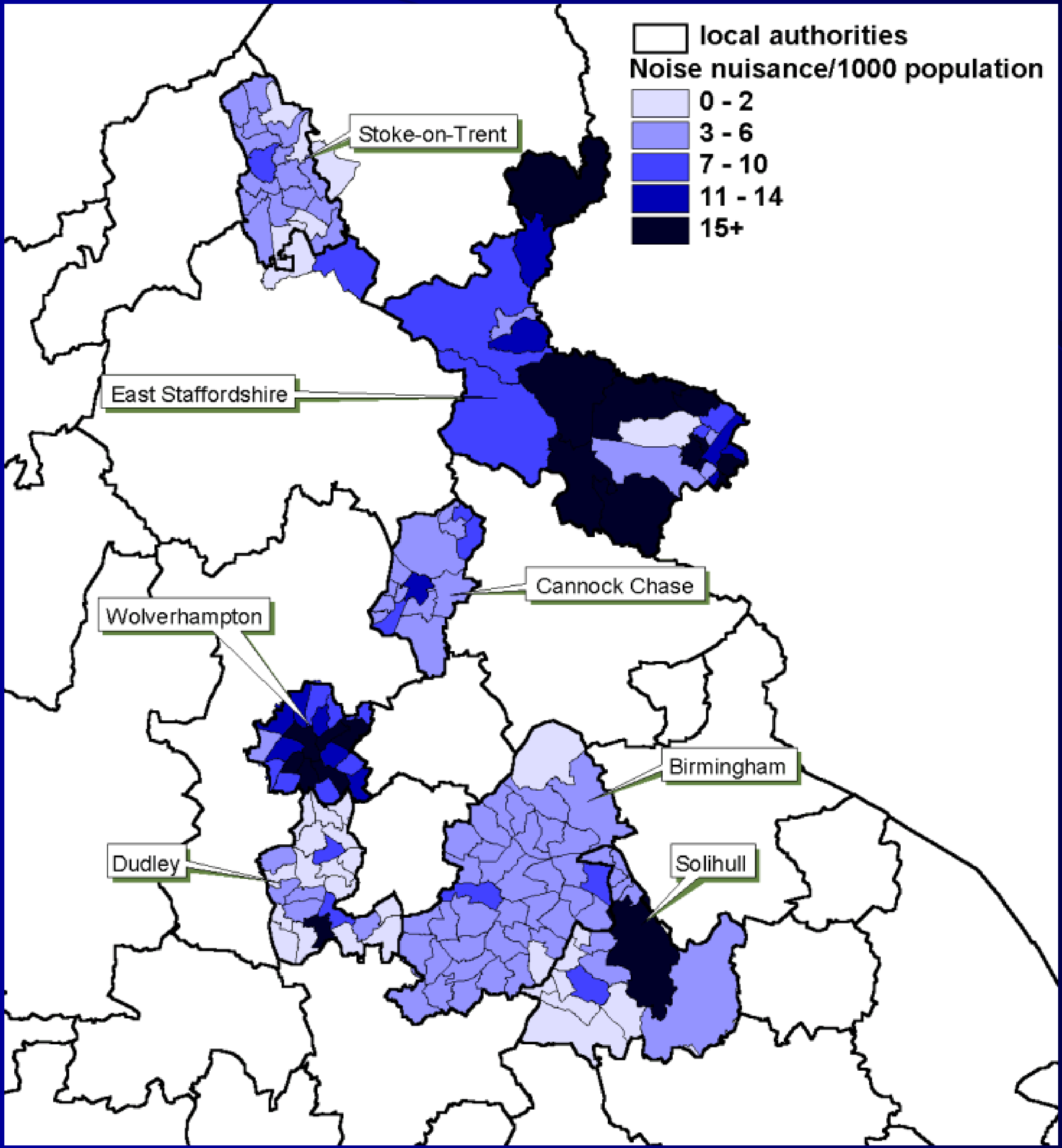


What does the indicator actually tell us – apart from trends in bird populations?

Coarse fish catches



Are fish population increasing? Are fish populations maturing? Are rivers better stocked? Are fishermen getting more skilled? Have fishing technologies improved?



Complaints about noise

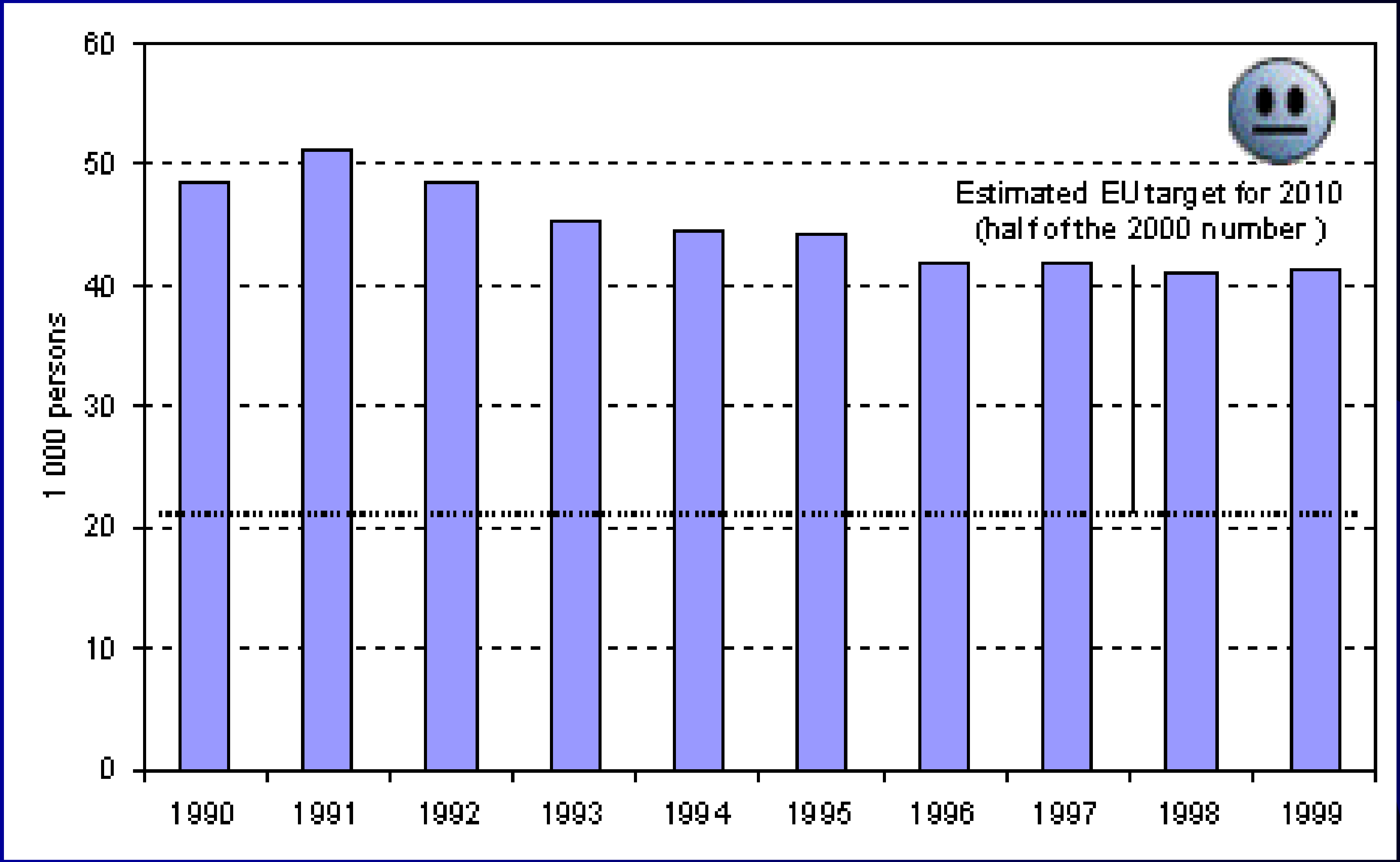
Are the dark areas noisier?

Or are complaints facilities better?

Or are people more sensitive?

Or do they each contain a few frequent complainers?

Interpreting indicators: road traffic fatalities in the EU



Are roads safer? Or car drivers better protected? Or have pedestrians and cyclists just been frightened or forced off roads?

Lesson 1

Linkage is all!

Indicators can show patterns and trends (within the limits of accuracy of the data on which they are based)….

But they do not provide explanations of those patterns and trends (except in relation to the inbuilt assumptions about their linkage)

The problems of linkage

- Many-to-many, not one-to-one
- Dynamic – not static
- Associations are heavily confounded
- Many associations are conditional, circumstantial and scale dependent
- Many associations are probabilistic, not absolute
- Indicators that encompass linkage may better reflect reality (e.g. measures of risk) – but difficult to compile and often impossible to measure

So does having families (sets/clusters) of indicators help?

Indicator Frameworks

The need for a framework:

- To provide structure for indicator sets
- To help ensure that key factors are covered (check-lists)
- To help identify proxies
- To show linkages and interdependencies
- To show implications of changes in indicators
- To aid interpretation
- To help target actions and interventions

The P-S-R Framework

Pressure

- Transport
- Agriculture
- Industry
- Energy

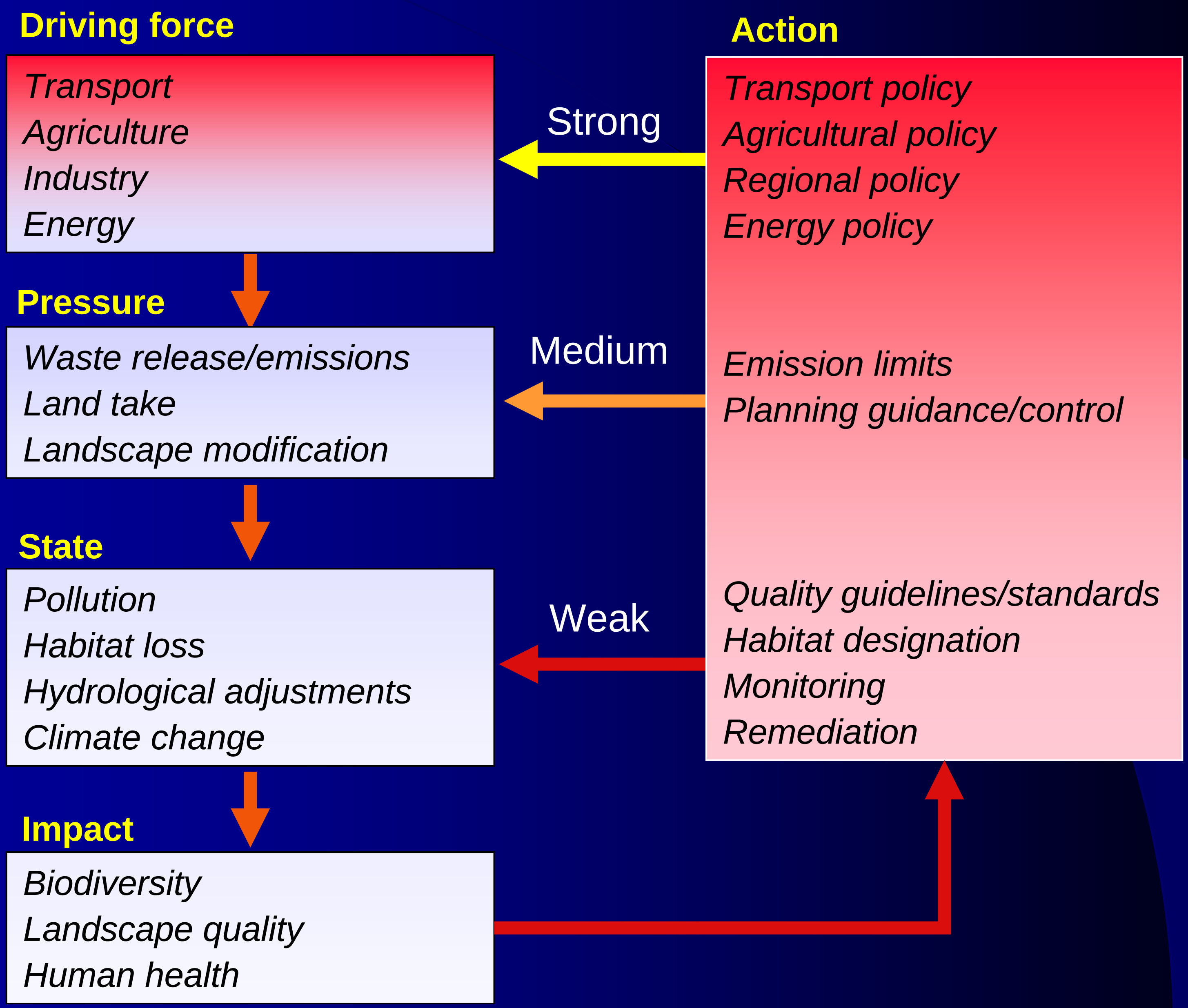
State

- Air pollution
- Water pollution
- Habitat and species loss
- Landscape damage

**Respons
e**

- Sectoral policies
- Environmental policy
- Planning controls
- Remediation

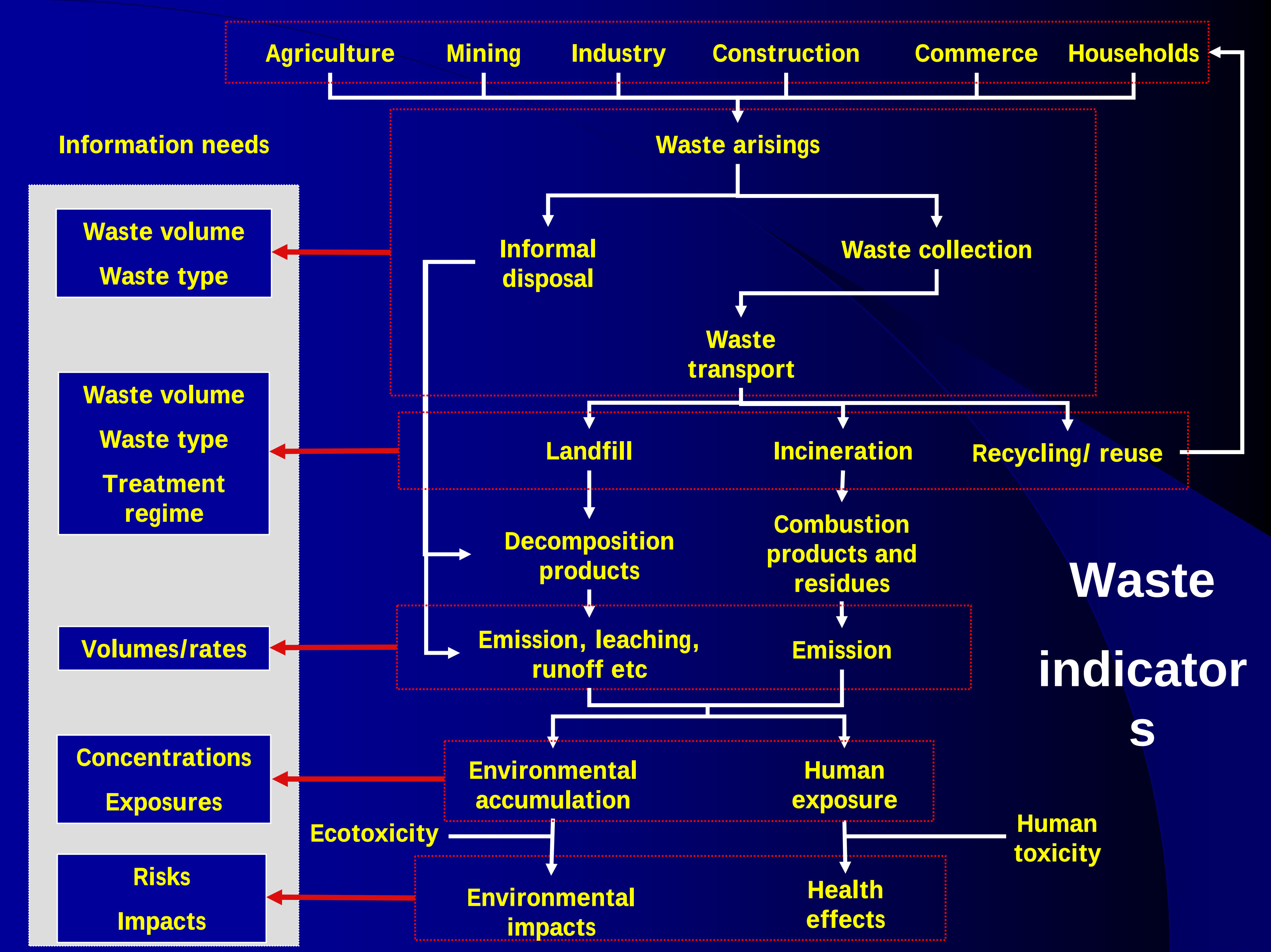
The DPSIR Framework



Formal frameworks – the limitations

PSR, DPSIR and DPSEEA widely used, but

- Too linear – do not reflect many-to-many relationships or feedback
- Too static – do not reflect flows and changes
- Do not work well for some issues – e.g. natural hazards, social/occupational risks
- Do not provide real basis for tracing effects back to causes
- Difficult to distinguish clearly between D, P and S in some cases
- Position in DPSIR chain depends on perspective (e.g. traffic flow, grazing intensity)


Agriculture
Mining
Industry
Construction
Commerce
Households
Information needs
Waste arisings
Waste volume
Waste type
Informal disposal
Waste collection
Waste transport
Waste volume
Waste type
Treatment regime
Landfill
Incineration
Recycling/ reuse
Decomposition products
Combustion products and residues
Waste indicators
Volumes/rates
Emission, leaching, runoff etc
Emission
Concentrations
Exposures
Environmental accumulation
Human exposure
Ecotoxicity
Human toxicity
Risks
Impacts
Environmental impacts
Health effects

Lesson 2

Linked sets (families/clusters) of indicators are usually better than single indicators…..

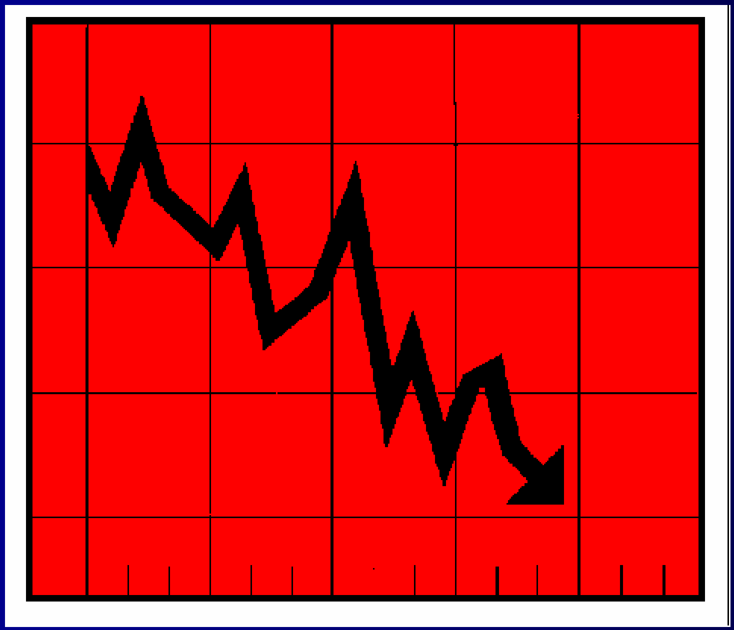
they provide a fuller picture, they provide robustness by triangulation, they imply interdependencies

So structures such as DPSIR or causal webs help

But interpreting covariation in indicators as evidence of cause and effect is dangerous….

Associations are highly confounded, partial and often incidental

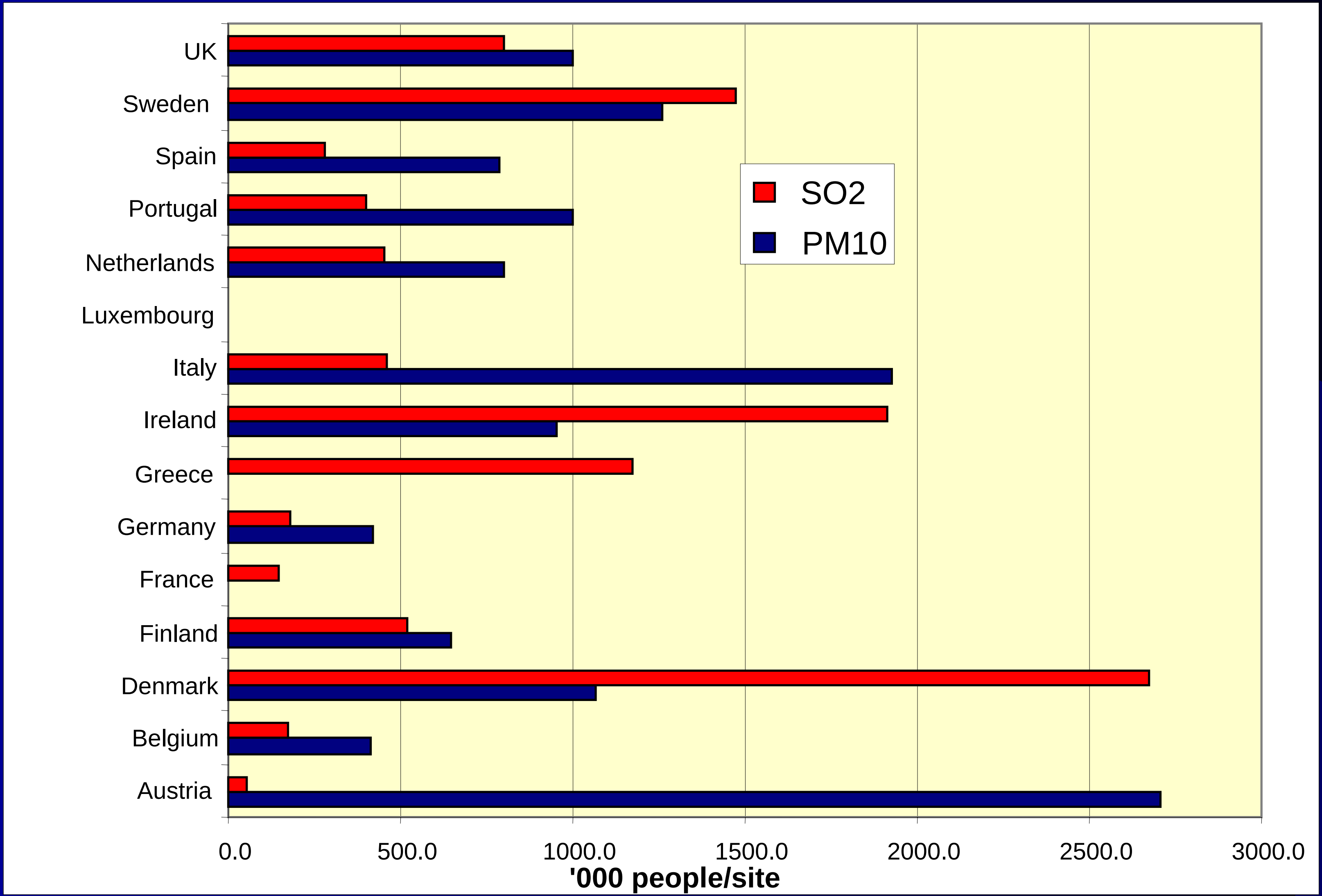
Can they be measured?



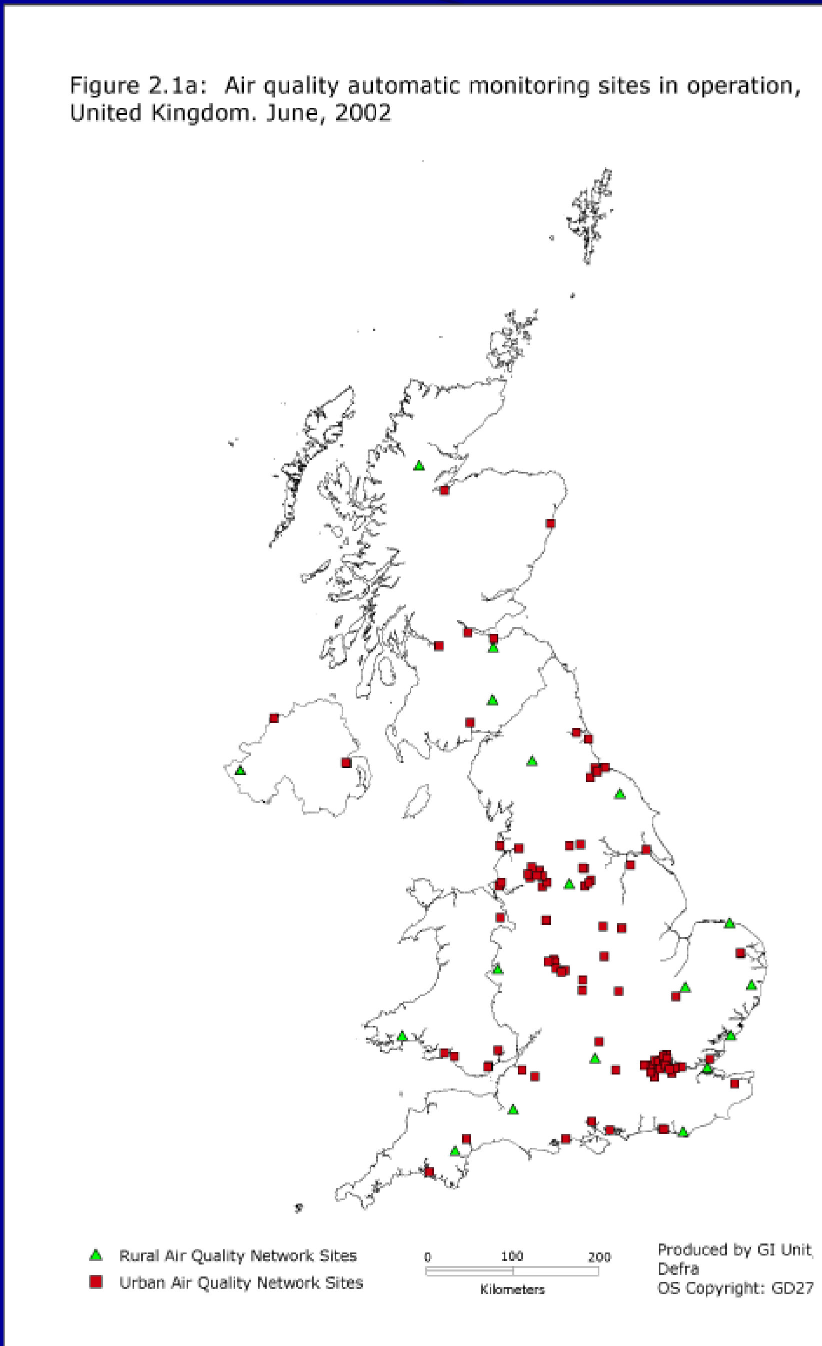
One site – JRC sustainable development indicators

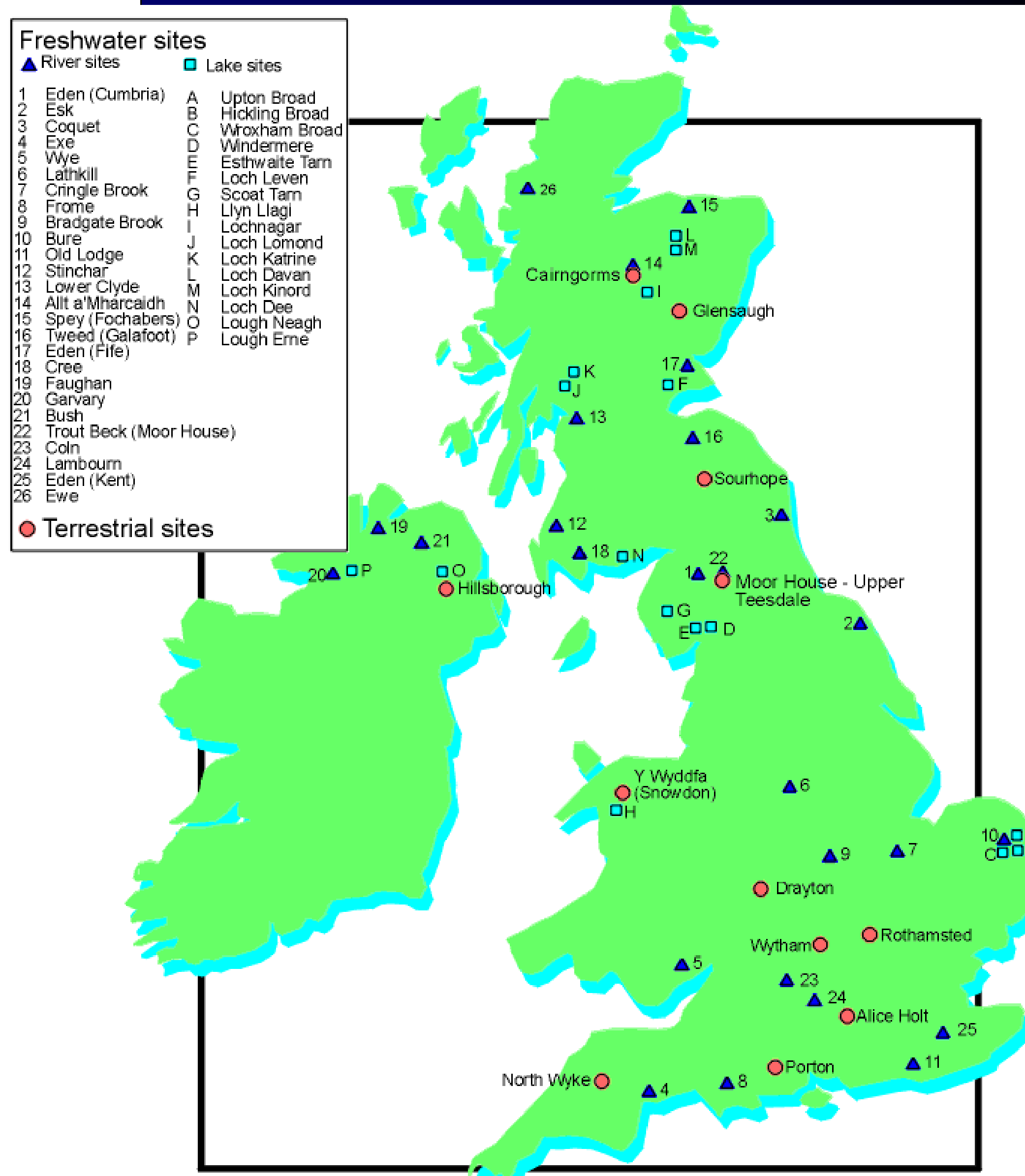
Air Pollution	Emissions of nitrogen oxides..	Emissions of non-methane volatile..	Emissions of sulphur dioxide..	Emissions of particles	Consumptio of gasoline & diesel..	Primary energy consumption	Emissions of ammonia (NH3)	Emissions of selected persistent..	Use of pesticides for agricul..	Electricity consumption
Climate Change	Emissions of carbon dioxide..	Emissions of methane (CH4)	Emissions of nitrous oxide..	Emissions of chloro-fluoro..	Emissions of nitrogen oxides..	Emissions of sulphur oxides..	Emissions of particles	Removals of carbon dioxide..	Emissions of non-methane volatile..	Emissions of hydro-chloro-fluoro..
Loss of Biodiversity	Protected area loss, damage..	Wetland loss through drainage	Agriculture intensity: area used for..	Fragmen-tation of forests &..	Clearance of natural & semi-..	Change in traditional land-..	Loss of genetic resources - non-..	Pesticide use on land	Loss of forest diversity -..	Riverbank loss through artificiali..
Marine Environment & Coastal Zones	Eutrophi-cation	Overfishing	Develop-ment along shore	Priority habitat loss	Discharges of heavy metals	Oil pollution at coast & at sea	Discharges of halogenated organic..	Wetland loss	Tourism intensity	Faecal pollution
Ozone Layer Depletion	Emissions of bromo-fluoro..	Emissions of chloro-fluoro..	Emissions of hydro-chloro-fluoro..	Emissions of carbon dioxide..	Emissions of nitrogen oxides..	Emissions of chlorinated carbons	Emissions of methyl bromide..	Emissions of methane (CH4)	Emissions of nitrous oxide..	Emissions of methyl chloro..
Resource Depletion	Water consumptio per capita..	Use of energy per capita	Increase in territory permanently	Nutrient-bal of the soil (nutrient..	Electricity production from fossil..	Timber balance (new growth/..	Use of mineral oil as a fuel	Surface water abstraction (for..	Exceedance of fish catch quota	Ground water abstraction for..
Dispersion of Toxic Substances	Consumptio of pesti-cides by agriculture	Emissions of persistent organic..	Consumptio of toxic chemicals	Index of heavy metal emissions..	Index of heavy metal emissions..	Emissions of radioactive material	Emissions of heavy metals by..	Production of chlorinated compounds	Consumptio of household toxic..	Vehicle distribution by technology..
Urban Environmental Problems	Energy consumptio	Non-recycled municipal waste	Non-treated wastewater	Share of private car..	People endangered by noise emissions	Land use (change from..	Inhabitants per green area	Water consumptio per capita	Emissions of sulphur dioxide..	Derelict areas
Waste	Waste landfilled	Waste incinerated	Hazardous waste	Municipal waste	Waste per product during a..	Waste recycled/ material recovered	Waste from other economic..	Consumptio of hazardous materials	Waste from energy production	Waste disposed to sea
Water Pollution & Water Resources	Nutrient (nitrogen & phosphorus	Ground water abstraction	Pesticides used per hectare..	Water treated/ water collected	Index of heavy metals emissions	Emissions of organic matter..	Industrial water uses	Waste water collected/ water..	Households & public utilities water..	Water recycling by industry

Air quality monitoring networks: EU

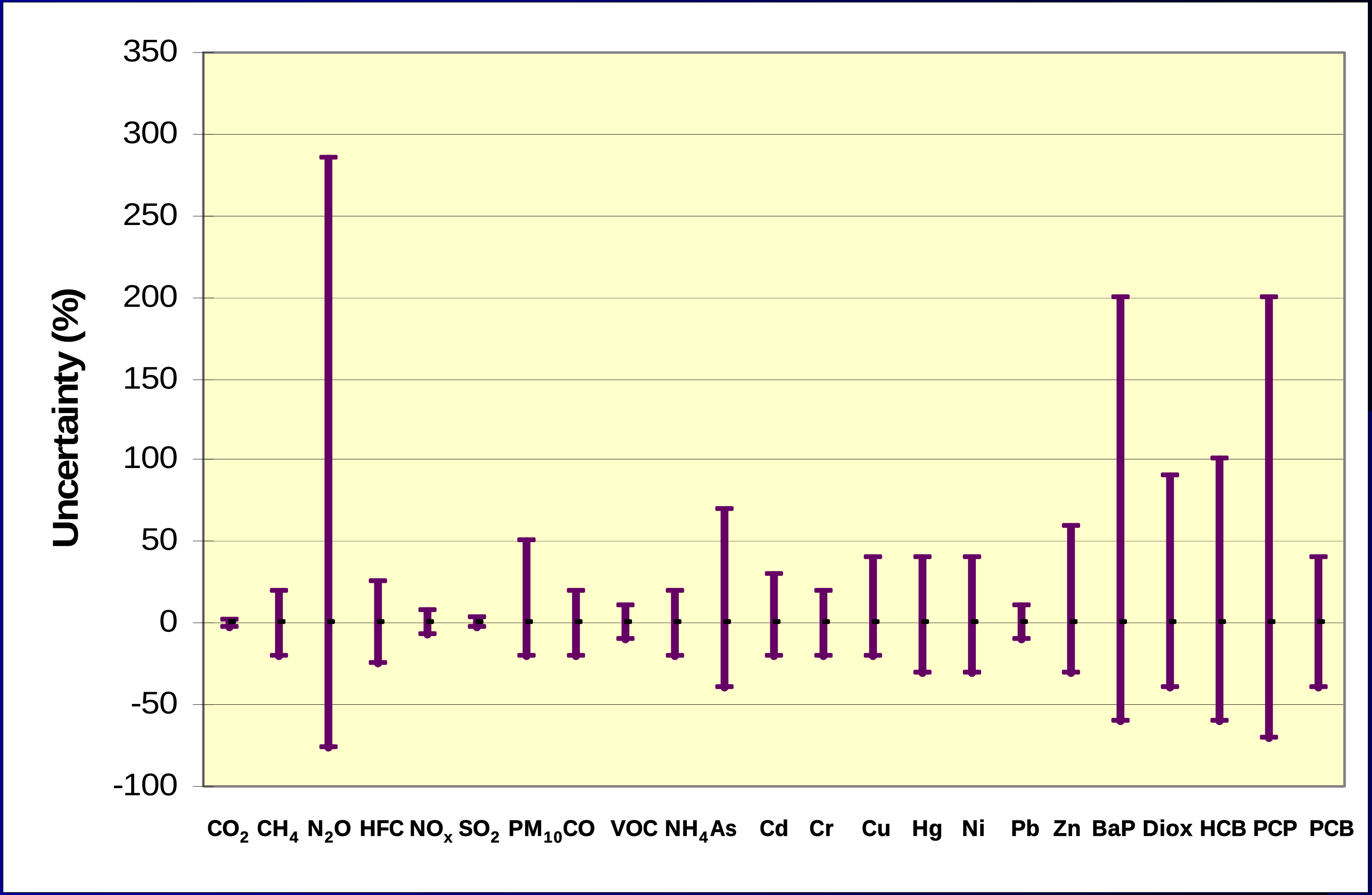


Monitoring networks: UK

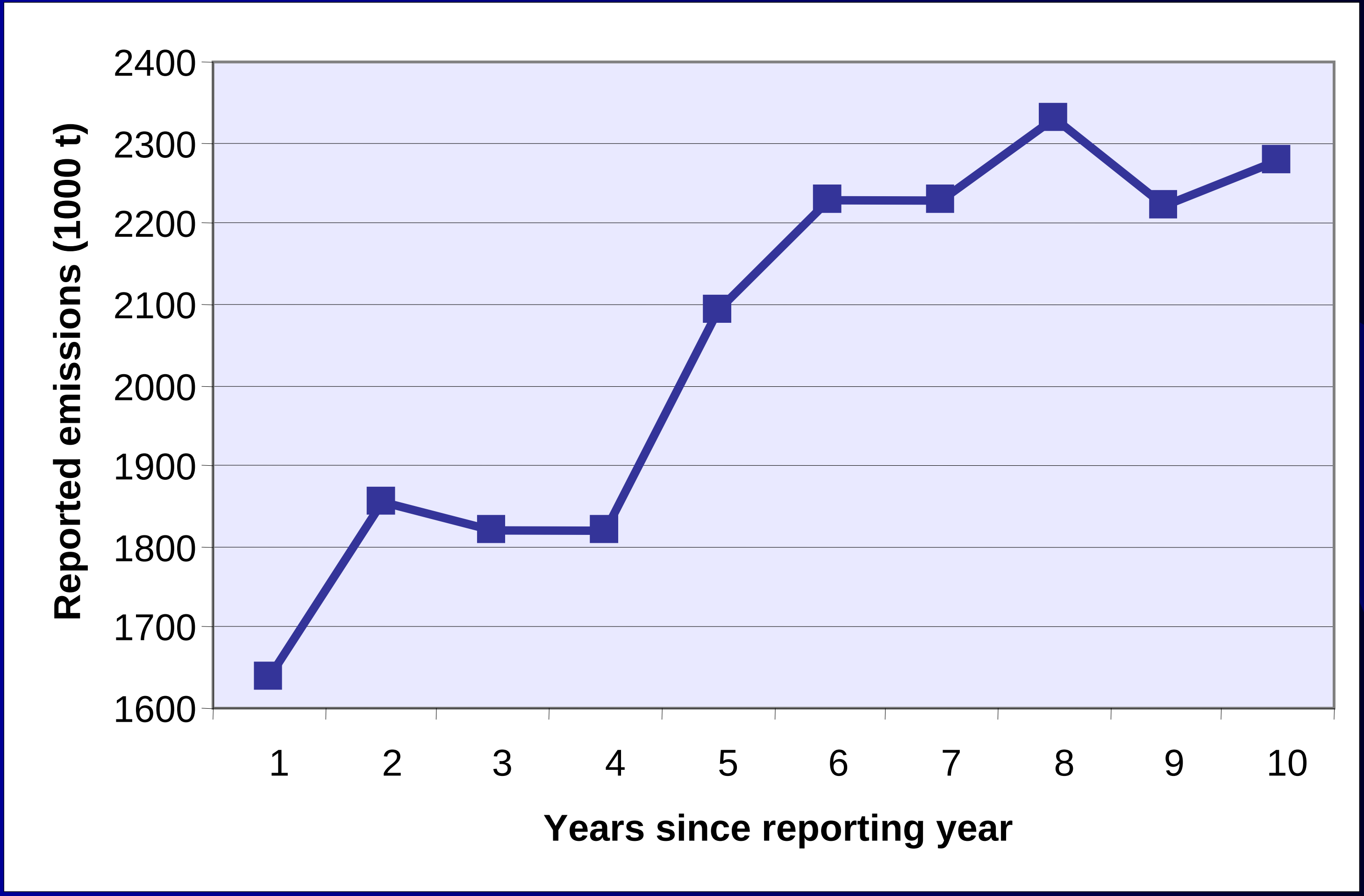




Uncertainties in emissions estimates



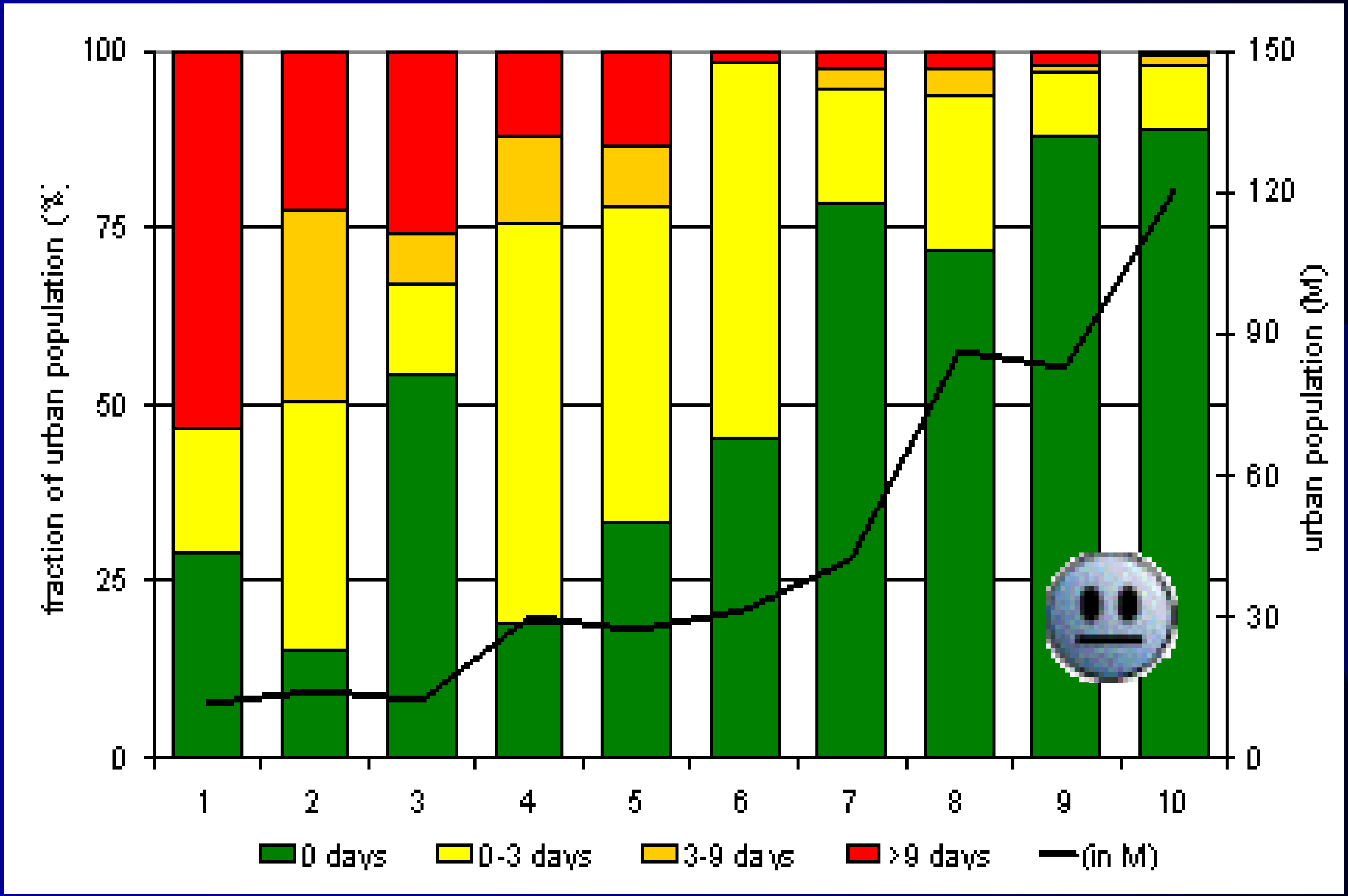
Revisions to reported nitrogen oxide emissions (UK)



Accuracy: industrial waste generation

Country	ERL	Eurostat	OECD	Range (x)
Belgium	-	8,000	26,700	3.4
Denmark	2,304	1,317	2,400	1.8
France	50,000	50,000	50,000	1.0
Germany	205,717	55,932	61,424	3.8
Greece	-	3,904	4,304	1.1
Ireland	1,962	1,580	1,580	1.2
Italy	43,950	35,000	39,978	1.3
Luxembourg	1,961	135	1,300	14.5
Netherlands	6,200	3,942	6,687	1.7
Portugal	-	11,200	662	16.9
Spain	12,000	5,108	5,108	2.3
UK (Eng/Wales)	71,315	50,000	50,000	1.4

Exposures to SO_2 exceedances in the EU



Lesson 3

The message depends on the data….

their accuracy….

their representativeness ….

their comparability

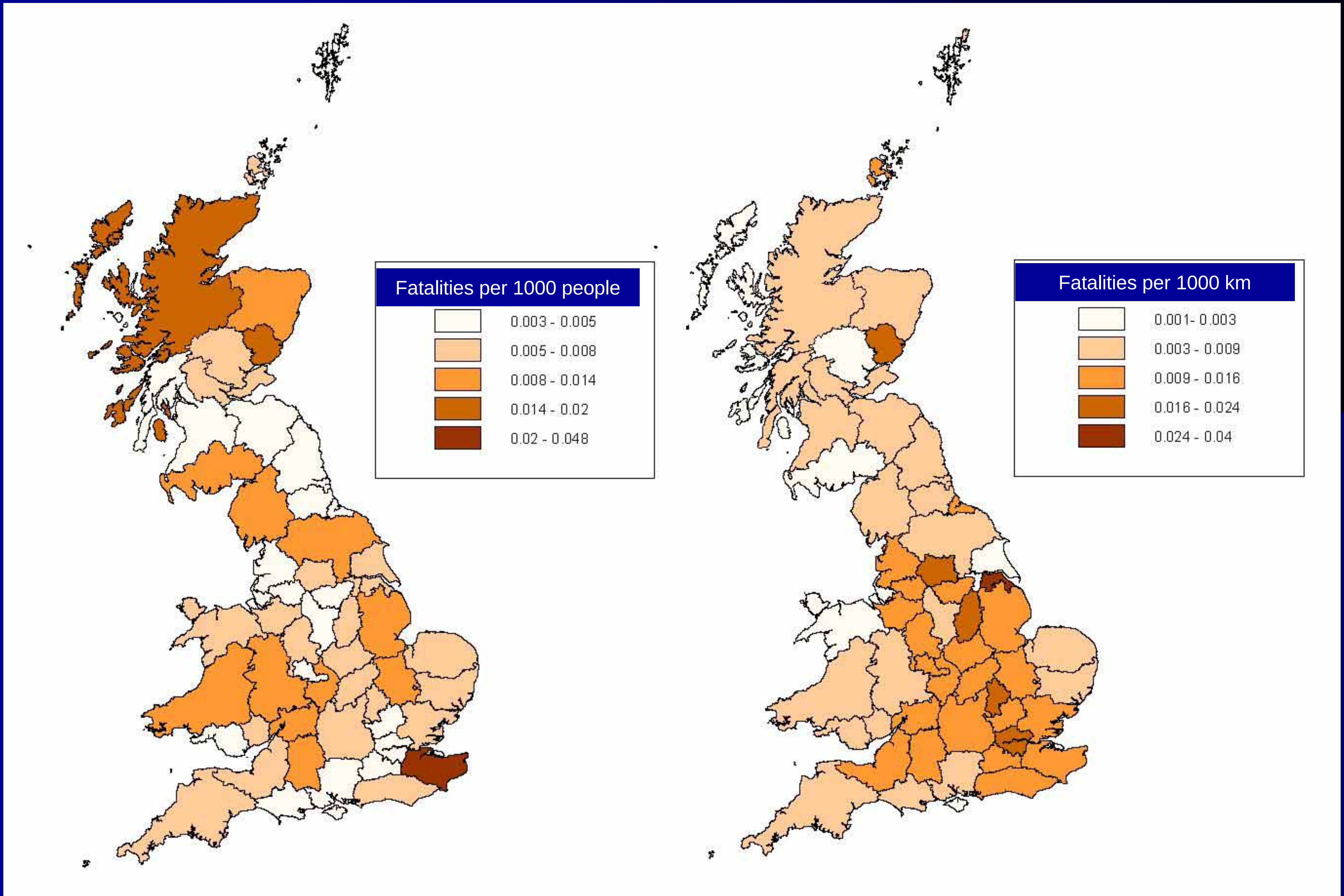
Data availability and quality are inescapable constraints

Enhancement can be the enemy!

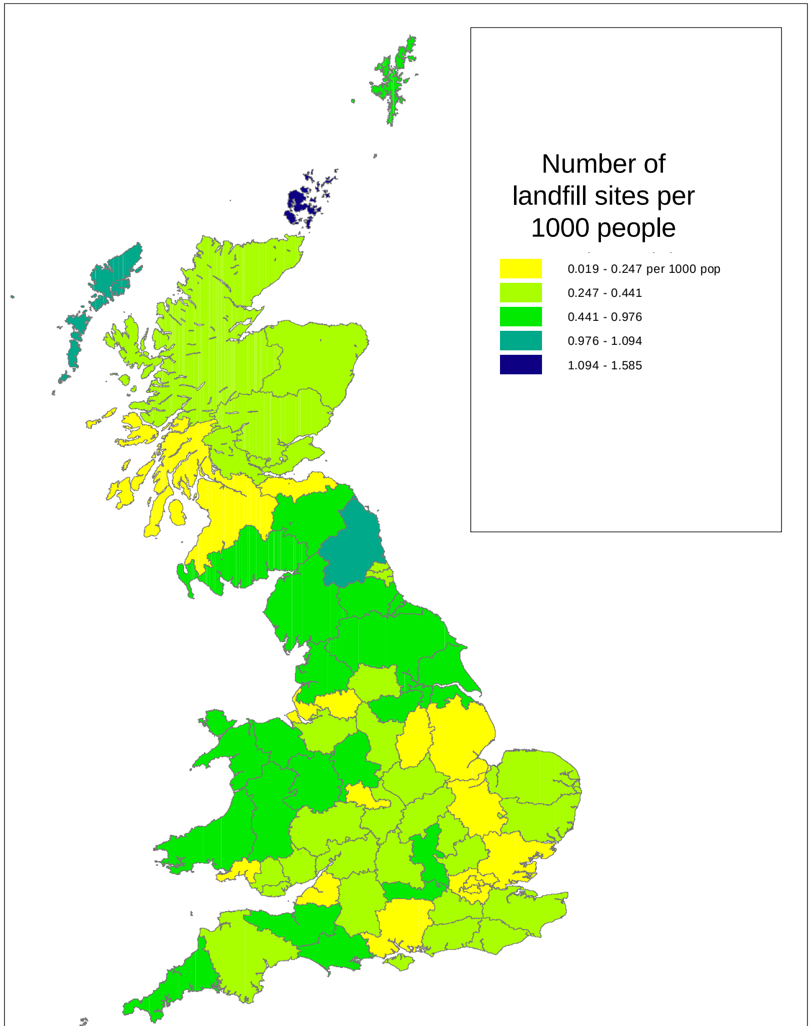
As monitoring (and modelling) develop and improve, data (and indicators) often lose their consistency…

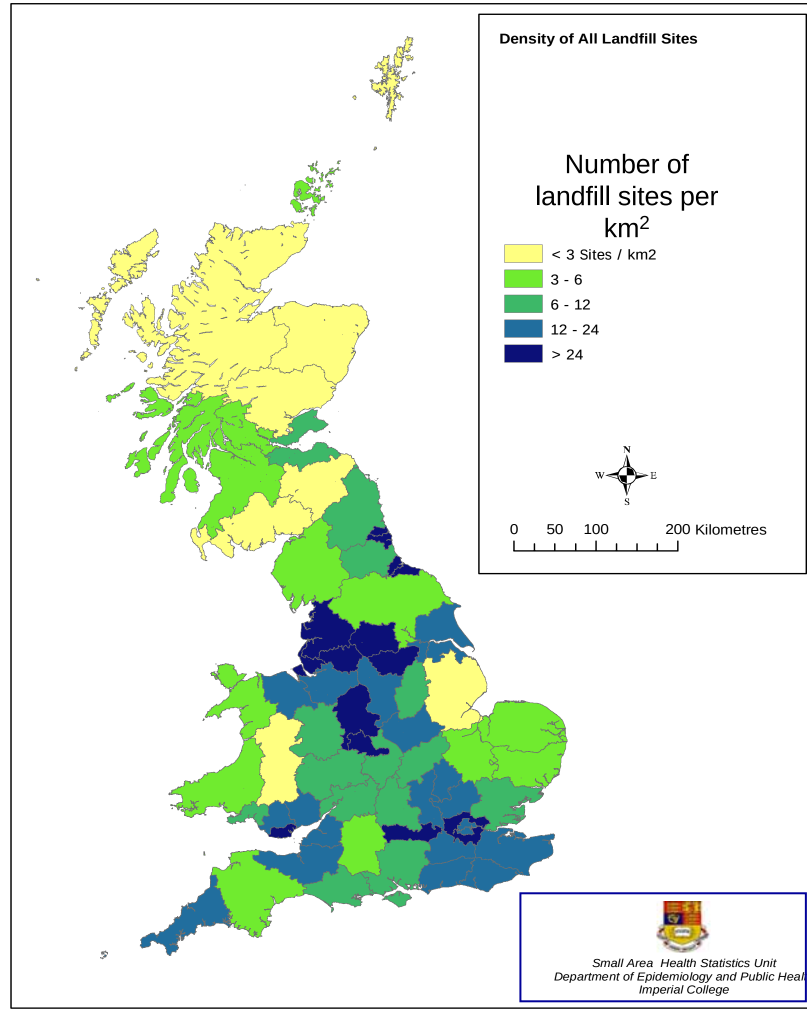
The land cover map problem!

Traffic accidents



Waste disposal





Lesson 4

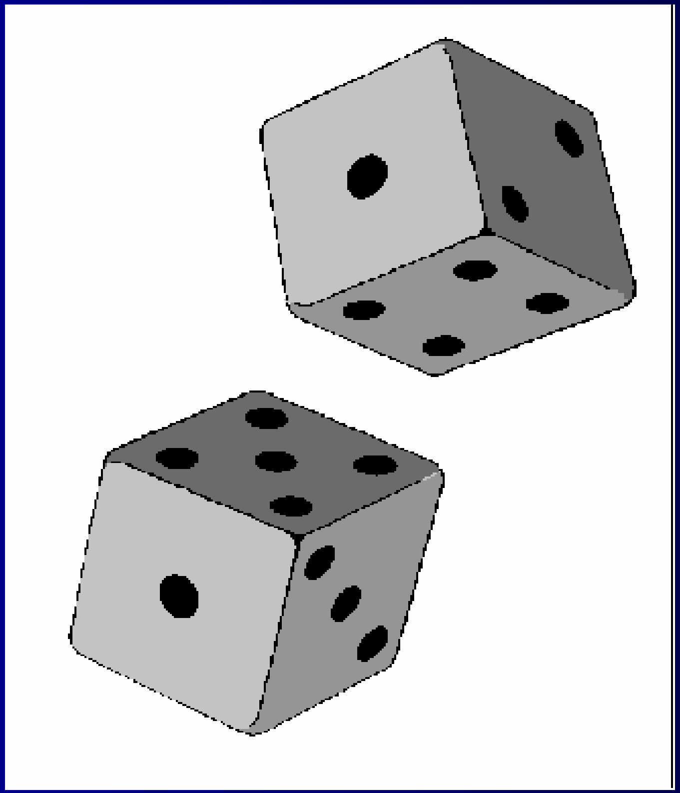
The message depends on the denominator…

(and the level of aggregation)….

So we need to frame our questions carefully, and build the indicator accordingly

And, incidentally, maps lie!

Will they be used?



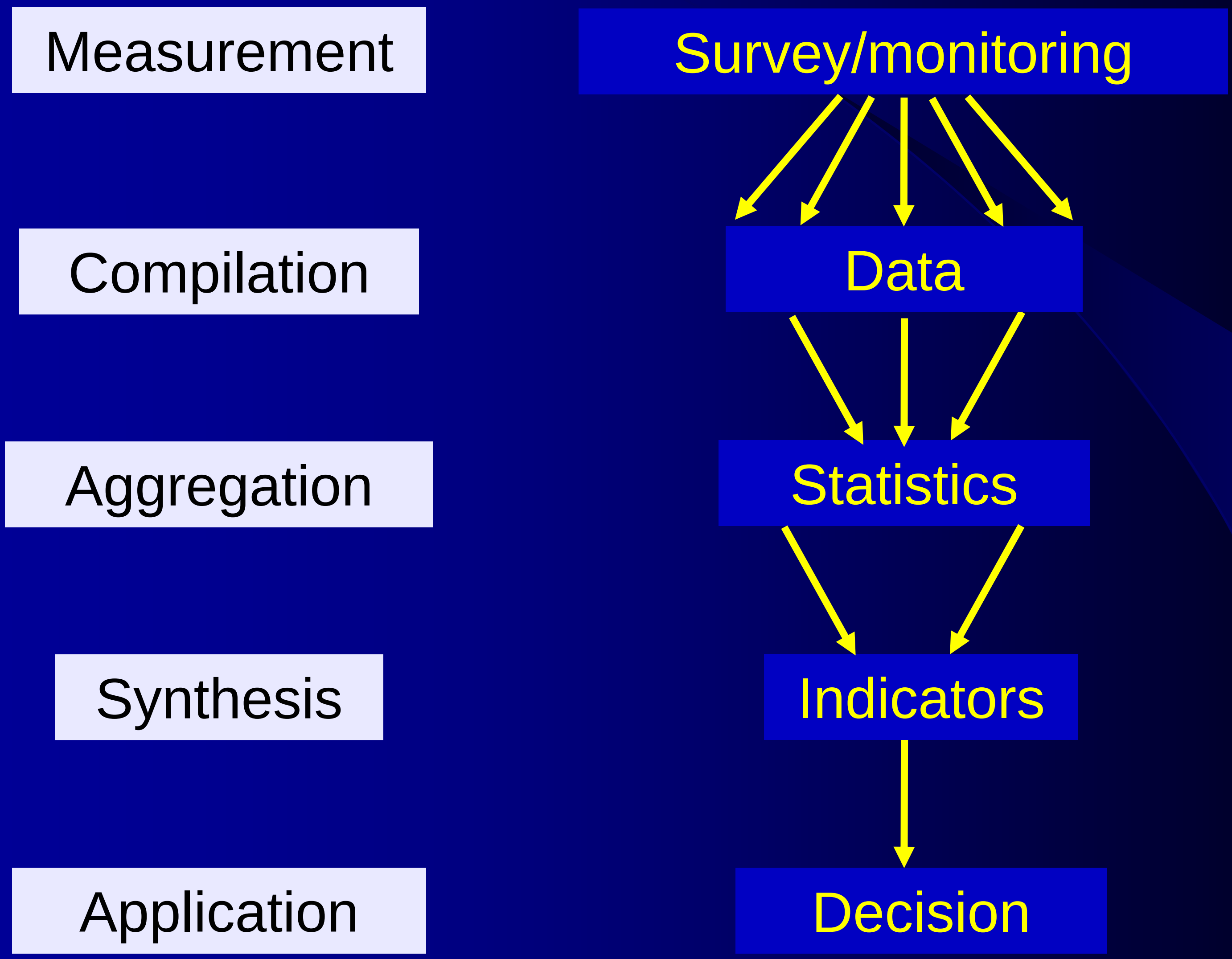
How can indicators be used?

- To support scientific enquiry and predict new issues
- To determine policy responses and priorities
- To monitor policy effectiveness
- To inform the public
- To decide on monitoring needs
- To name and shame
- To lobby

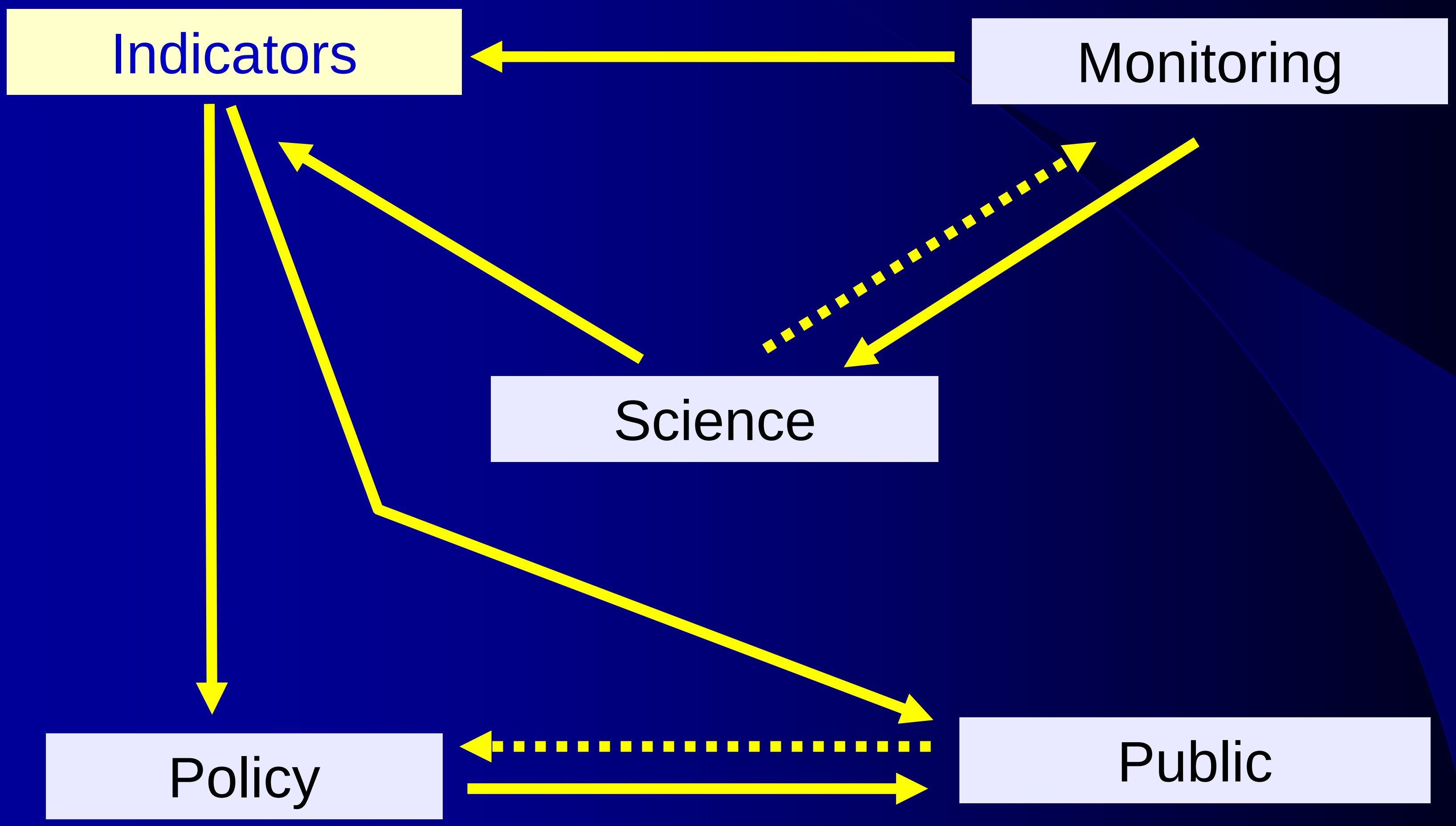
Determinants of utility

- *relevant* to an issue of policy or practical concern
- *actionable* – related to conditions that are amenable to influence/control
- *understandable* by and *acceptable* to those at whom it is addressed
- *timely* – up to date
- *specific* – targeted at an explicit phenomenon or issue
- *cost-effective* – capable of being constructed and used at acceptable cost

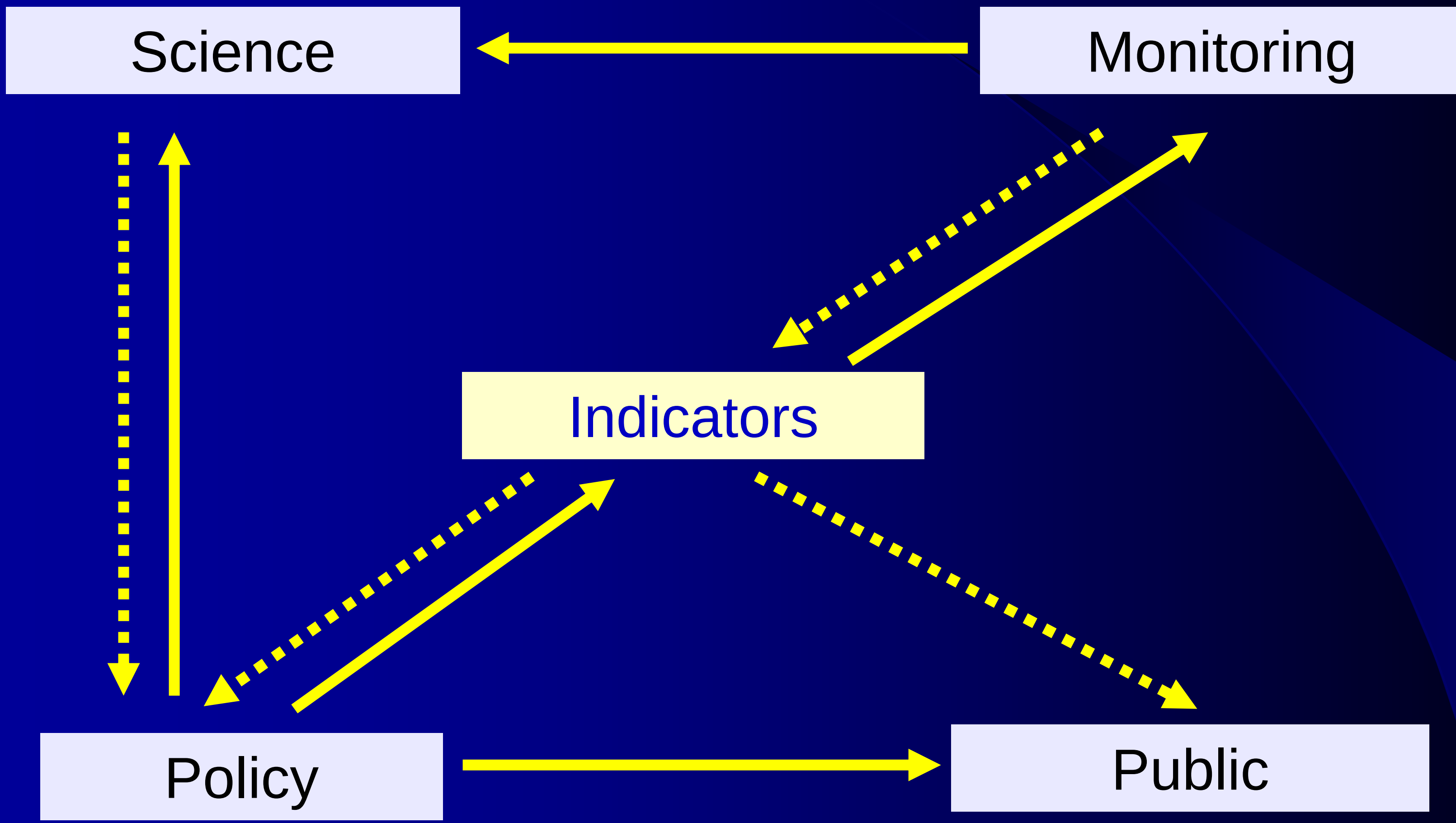
The information chain



Indicators and policy: the information-driven view



Indicators and policy: the policy-driven view



Deceits and distortions

The indicator becomes the goal (e.g. hospital waiting lists, school rankings)…

So policy becomes self-serving

Indicators determine monitoring needs….

Since we manage what we monitor, policy thus becomes inward-looking and self-constrained

Lessons 5-9

5. **What separates indicators from data is that they are targeted at a question**

   So most indicators are use (and user) specific

6. **Indicators only tell you what the world is (or was) like, not how it will be**

   So indicators can't look forward (they do not provide foresight)

7. **Indicators are difficult to interpret (because of confounding etc)**

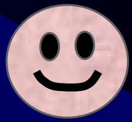
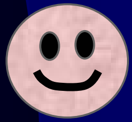
   So scientific analysis is needed to verify any apparent trend or attribute it to cause

8. **Policies change – and thus so do the needs for indicators**

   If indicators drive monitoring, then monitoring will be at the mercy of transient interests – and long-term data sets will rarely be maintained

9. **Indicators rely on routinely available data, but routine monitoring cannot be designed to serve all the different indicators that might**

How can indicators be used?

- To support scientific enquiry and predict new issues 
- To determine policy responses and priorities 
- To monitor policy effectiveness 
- To inform (and misinform) the public 
- To decide on monitoring needs 
- To name and shame 
- To lobby 

What indicators can do

- Summarise – though are they adding to, rather than reducing, problems of information overload?)
- Synthesise – but rarely, meaningfully, to a single index
- Simplify – but also obscure
- Select (prioritise)
- Speak (communicate) – especially on behalf of those without a voice
- Stimulate – in the hands of impassioned people

What indicators can't do

- Avoid (or reduce) the need for data (in fact they add to it)
- Determine or drive monitoring needs
- Answer questions we don't ask
- Address questions they are not designed for
- Predict and provide foresight
- Replace foresight and good science
- Select what matters (who does define the issues?)
- Avoid the need for thought

Conclusions

1. Focus on establishing and maintaining monitoring and surveillance systems that can provide a wide range of policy-relevant data on a routine basis
   - Indicators can then be developed (and discarded) according to need (not used as a comfort-blanket)
   - The data provide a resource for policy-based enquiry
2. To provide this ‘policy-based enquiry’, establish scientific systems that can analyse and interpret these data quickly and effectively:
   - To give early warning of new problems
   - To take account of emerging scientific knowledge
   - To assess and respond to new policy issues