Developing a Sediment Management Framework for WFD River Basin Planning in the UK

The Sediment Risk Ranking Model

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Outline

- The need for a sediment management framework
- The Regional Risk Model (Landis 2005)
- The Sediment Risk Ranking Model (SRRM)
  - Conceptual approach
  - Calculations
- Summary

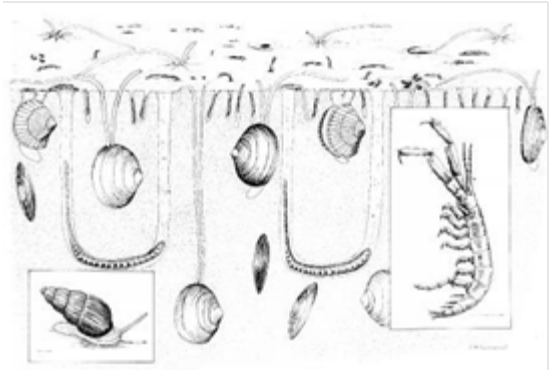
Our Starting Point: The WFD

The WFD focus on ecological status requires us to consider the impacts of sediment as a diffuse pollution pressure across catchments.

- Many of the WFD RBMPs invoke ‘development of a sediment river basin management plan’ where sediment is thought to be a reason for failure.
- We need the right amount of sediment of the right quality in the right place at the right time to support ecosystem function.
- The complication is the number of different, often conflicting, roles sediment plays in our environment.

Sediment is an essential component of many processes, and an important habitat and resource

Too much sediment	Too little sediment	Sediment as resource
Obstruction of channels Rivers fill and flood Reefs get smothered Turbidity	Beaches erode Riverbanks erode Wetlands are lost River profile degradation	Construction material Sand for beaches Wetland nourishment Soil enrichment Habitat and food for life

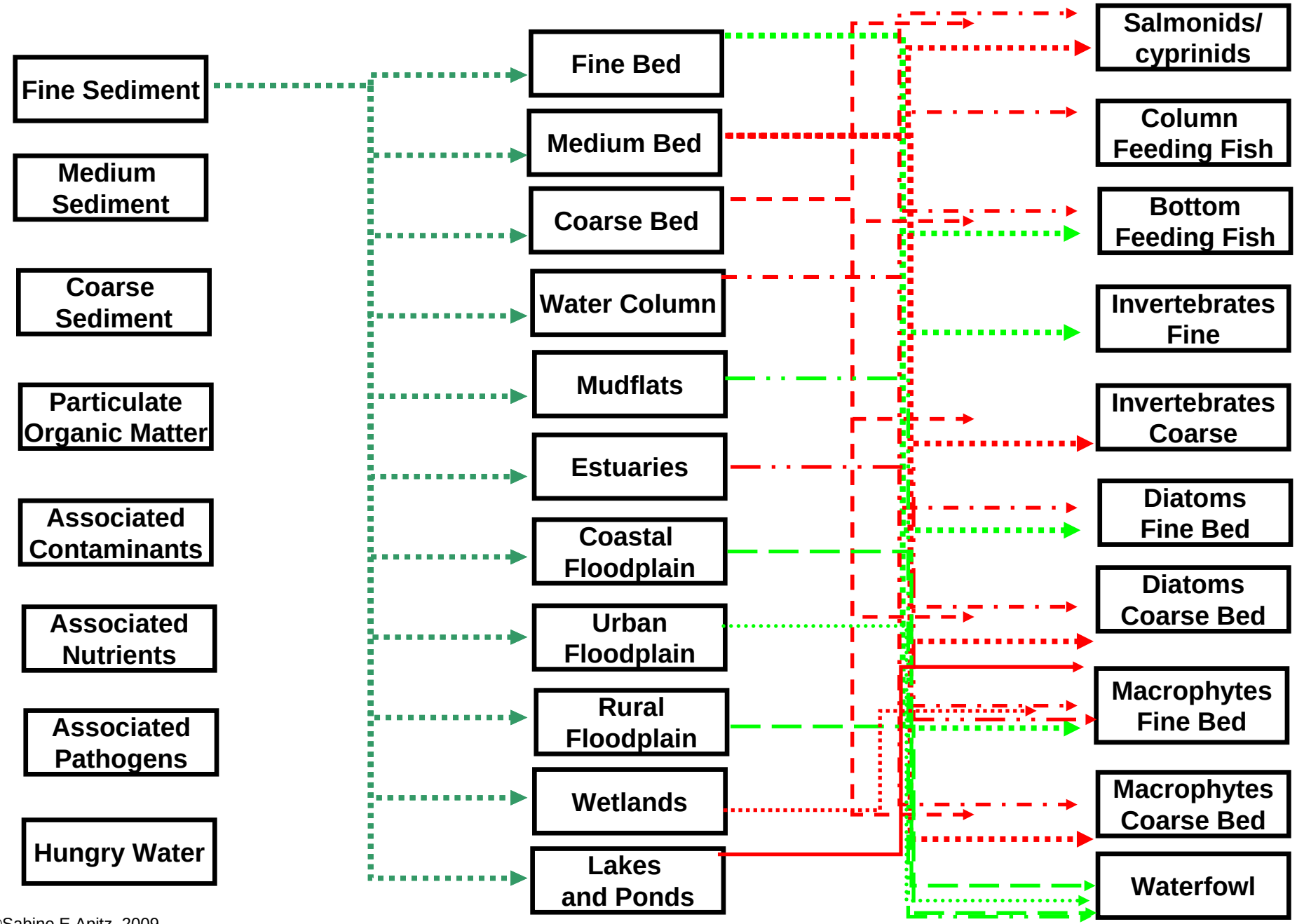


Sediment = essential and integral part of our river basins

SedNet
European Sediment Research Network

From Jos Brils, TNO, adapted from Martin 2002

Single Sediment Stressor "Horredogram" – fine sediment



The Sediment Management Framework

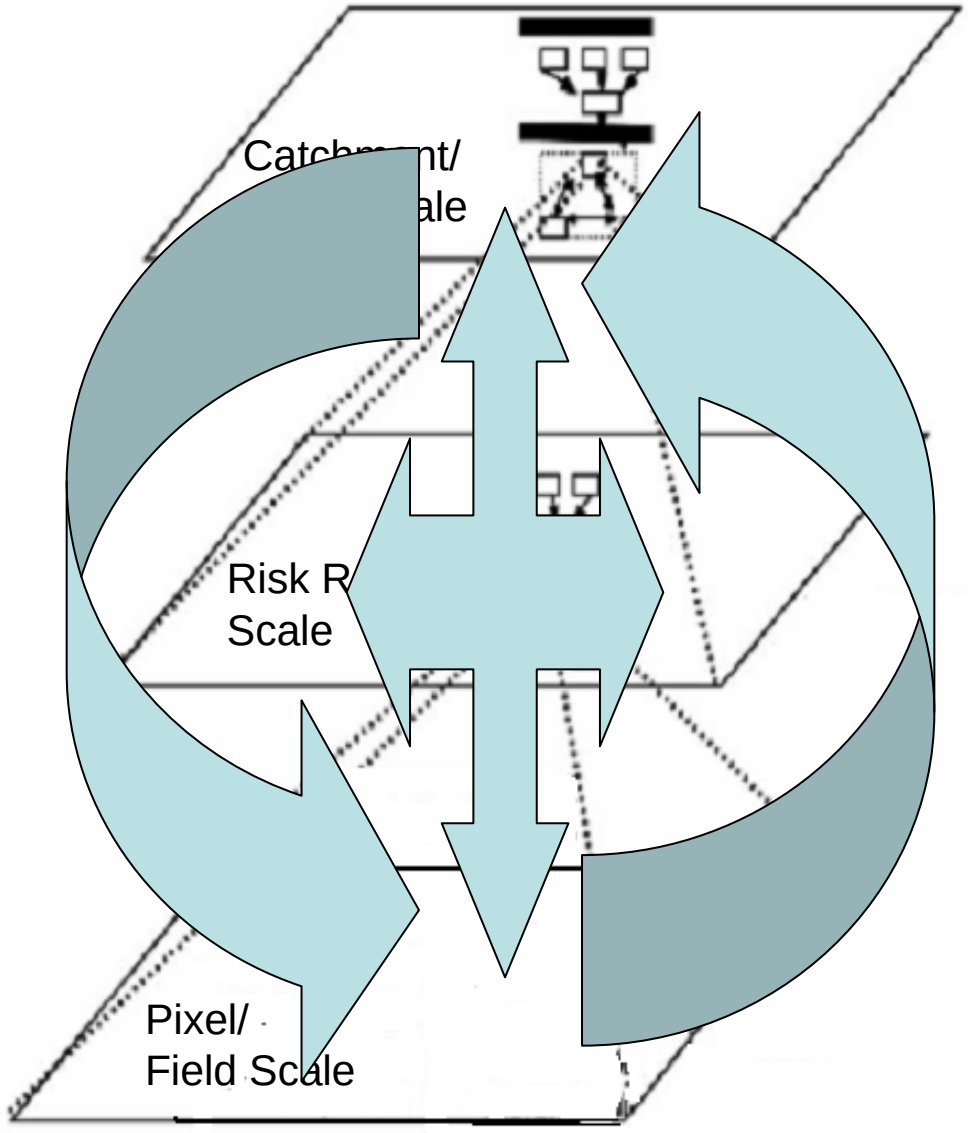
We need a framework that:

- Accounts for the different roles of sediment
- Looks at impacts and risks
- Is cross-sectoral, and holistic to avoid conflict, pollution swapping or unacceptable trade-offs
- Helps us to prioritise and plan interventions
- Is reconcilable at different scales
- Makes decision making transparent and communicable

Aim: sustainable sediment management planning.

There is a need to address the fact that impacts at the catchment and reach scale are affected by processes at the field scale

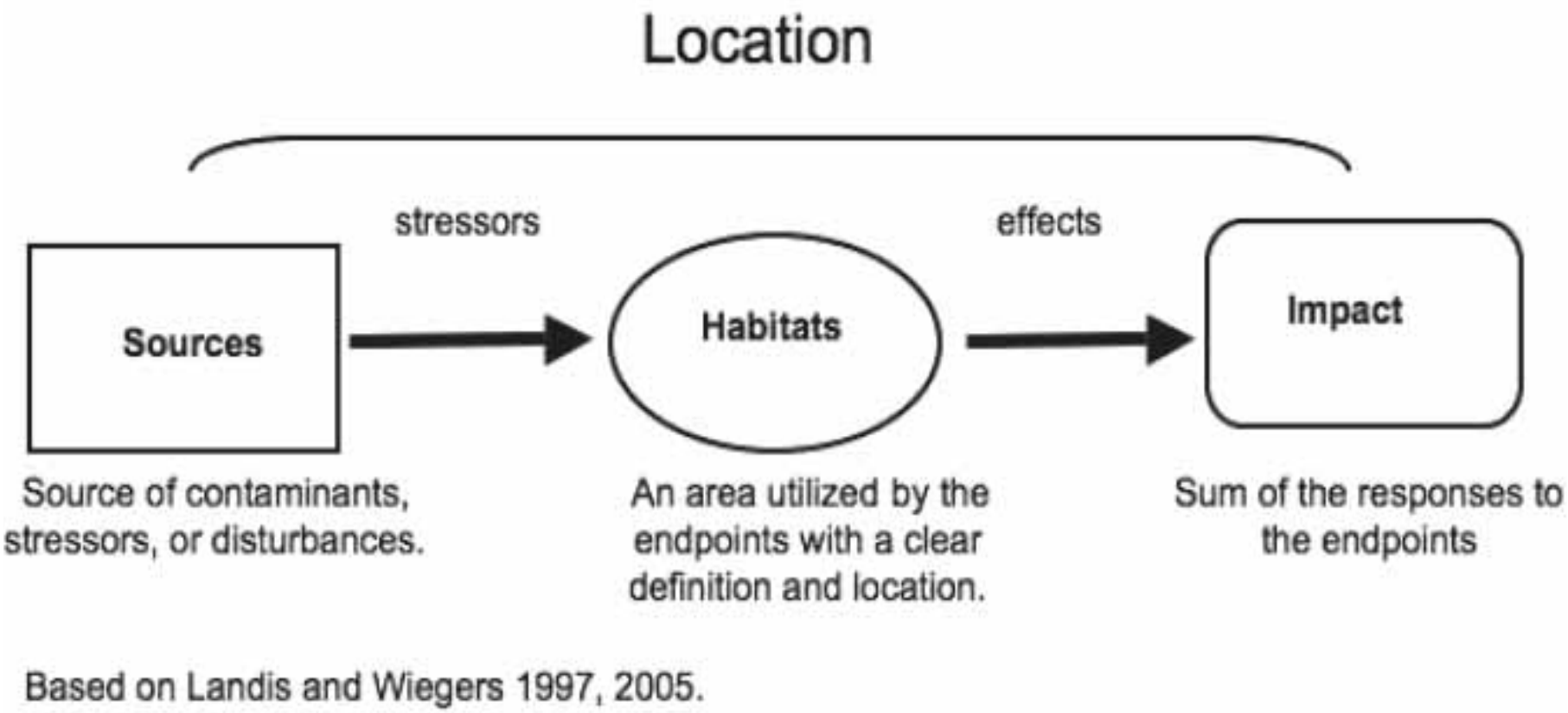
To protect endpoints within reaches and river basins, we must understand and manage sediment risk at the field scale



Adapted from Colnar, A.M. and Landis, W.G., 2007.

The Landis Risk Ranking Model

Ranks sources and impacts in a spatially explicit manner to inform management decisions:



from Landis 2004

Rank	Source Type	Habitat Type
6	Hig acti sou sub	
4	Mo disc acti sou sub	
2	Lov acti sou sub	
0	No this are	

Uses filters and ranking factors to assess the links between sources, habitats, and impacts in a transparent way

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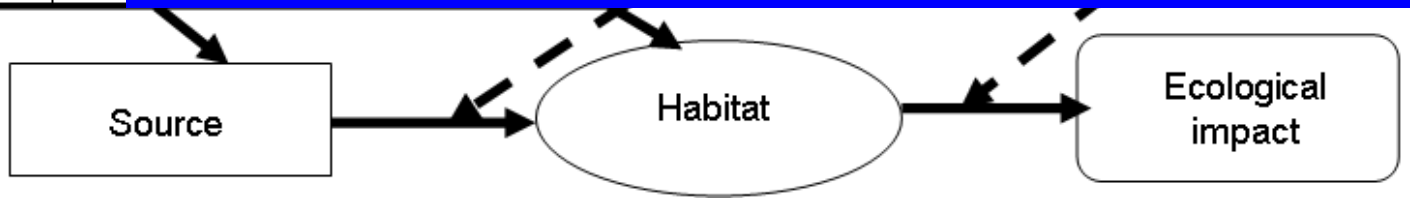
This is the Landis Regional Risk Model. However, this model does not account for the dynamic nature of sediments, or the fact that they are also essential ecosystem components. We adapted this model to support the risk assessment of sediments at the River Basin scale

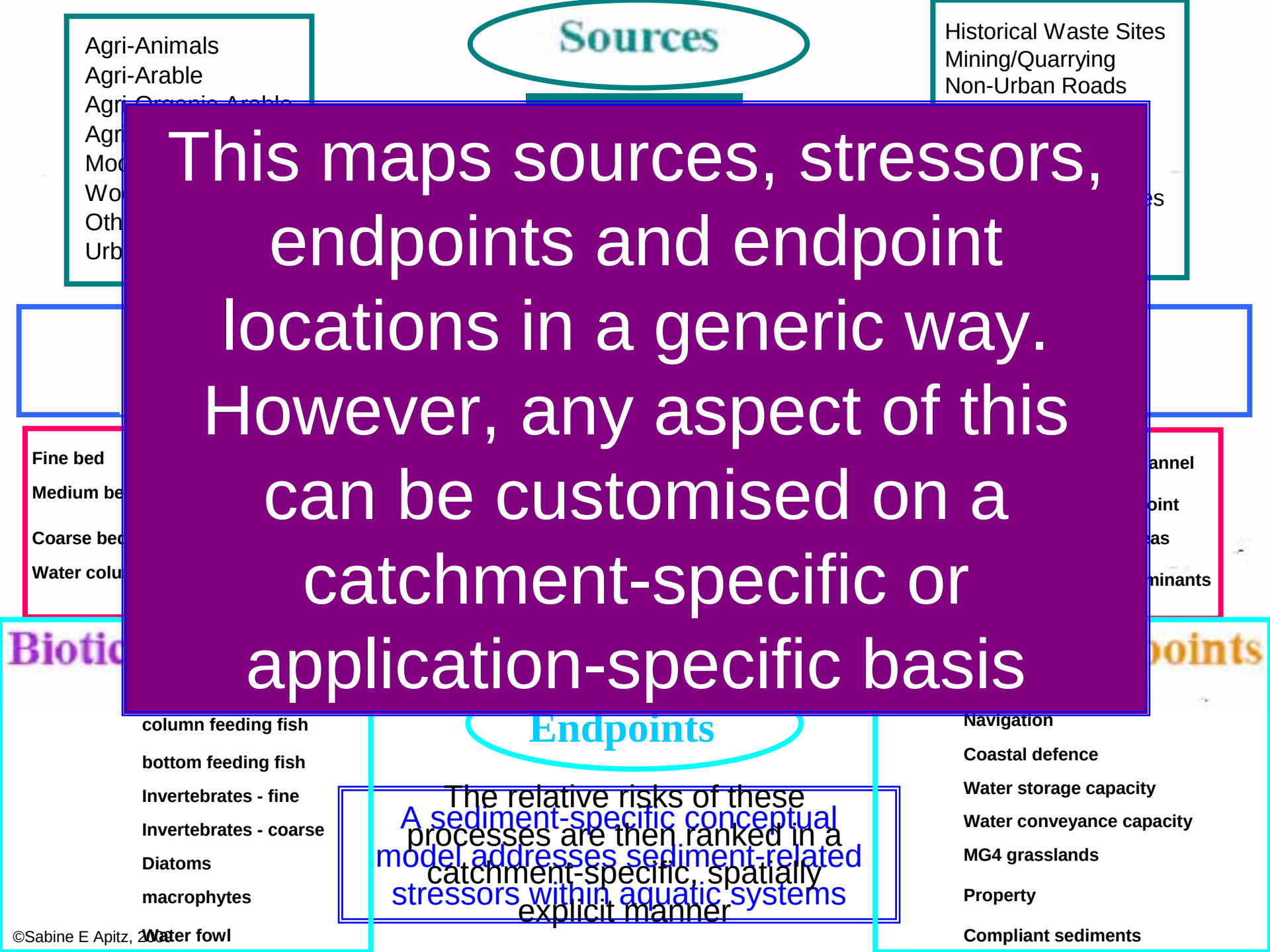


possible combination of sources and habitats

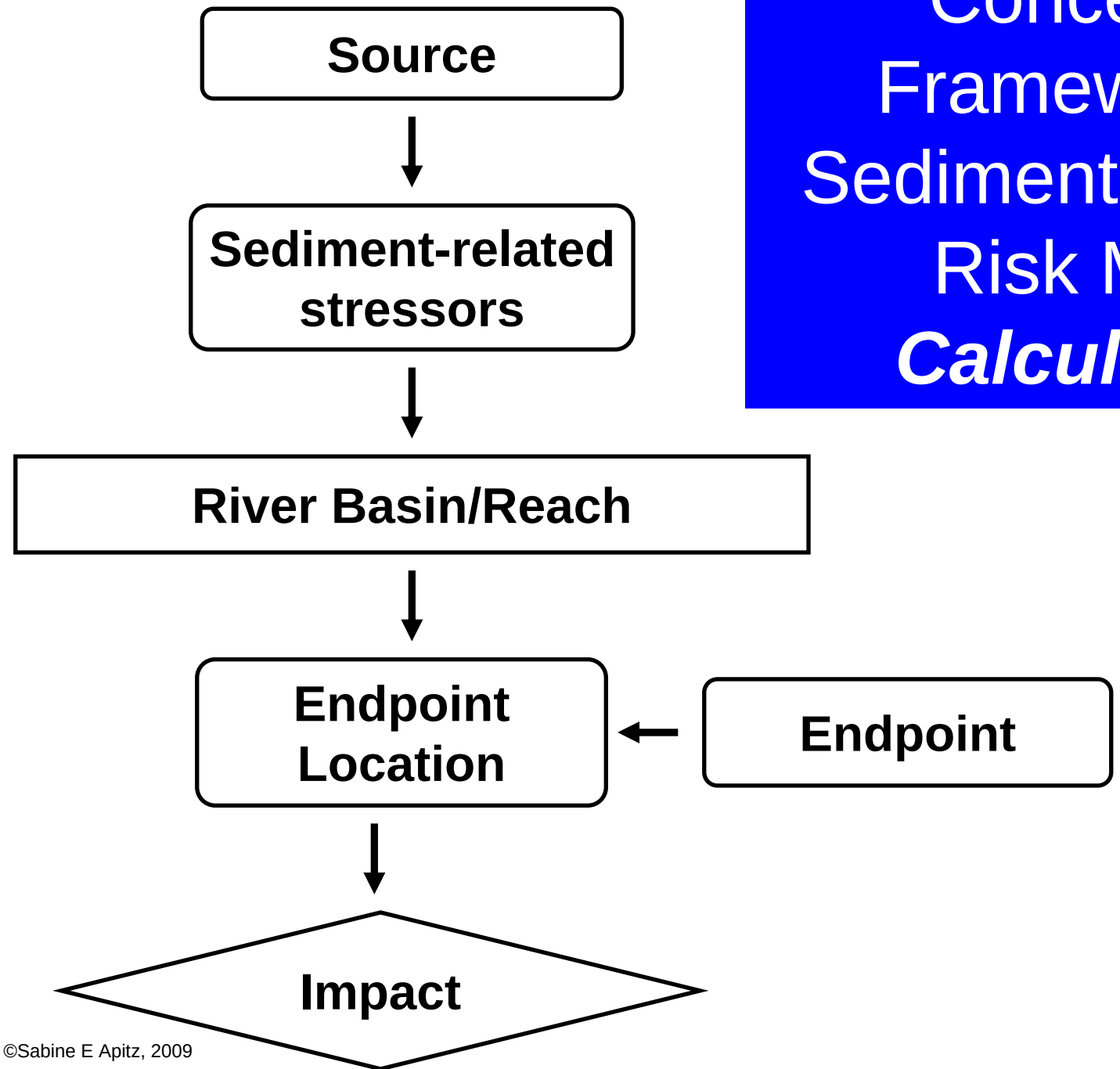
The *Sediment* Risk Ranking Model: Conceptual Development

How do sediments affect what we are trying to achieve?

- What are our objectives (ecological and socio-economic) within a river basin?
- What are indicators that represent these objectives?
  - Identify as endpoints
- What are the sources of sediment stressors?
  - Source classes (agriculture, industry, bank erosion...)
- Where do sediments affect these endpoints?
  - Endpoint locations/habitats
- How do sediments affect these endpoints?
  - Pathways of impact

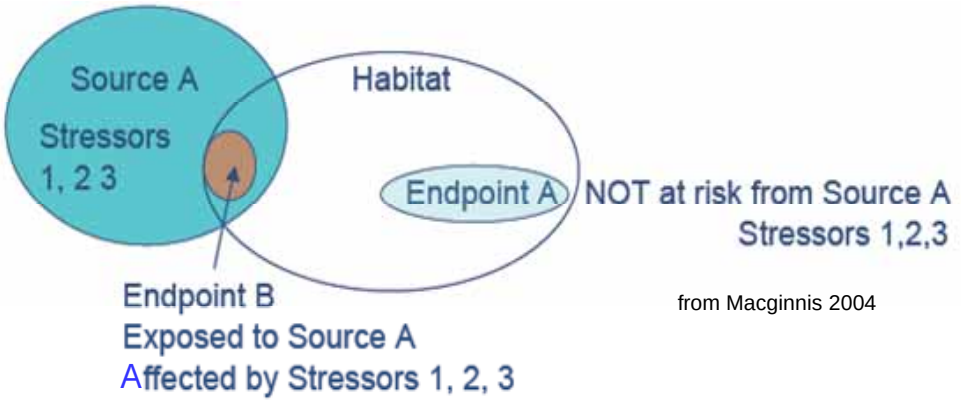


Conceptual Framework for Sediment Regional Risk Model ***Calculations***



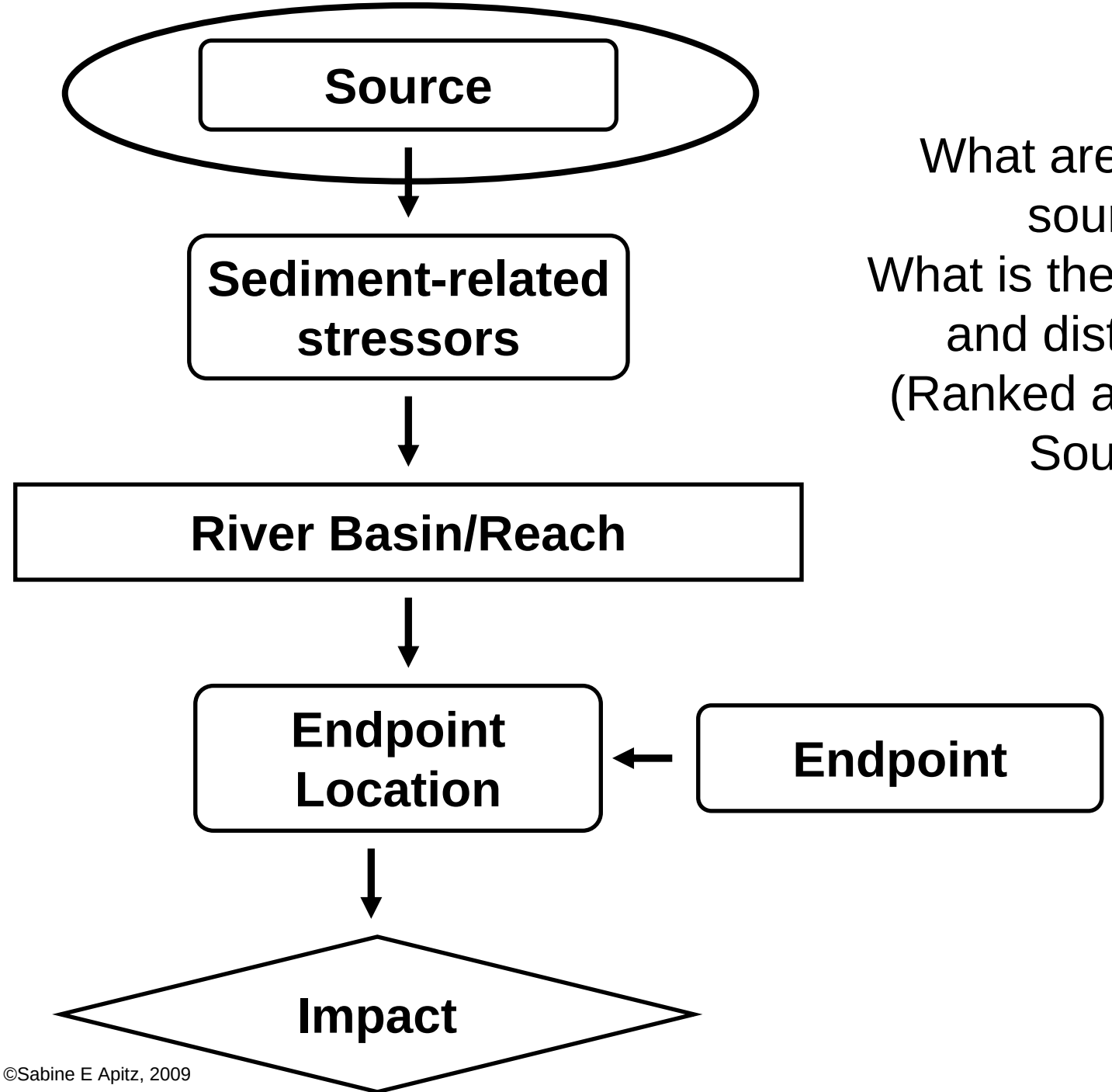
Calculating Risks:

- We have developed a conceptual model that defines which sediment-specific processes may impact endpoints
- Within that model, we have defined relationships between processes; these "map" onto a multi-dimensional matrix that provides
  - Ranks (source, habitat)
  - Filters
    - Exposure
    - Effects



from Macginnis 2004

- These are then used to carry out matrix calculations to determine pathway risks



What are sediment sources?
What is their magnitude and distribution?
(Ranked and Mapped Sources)

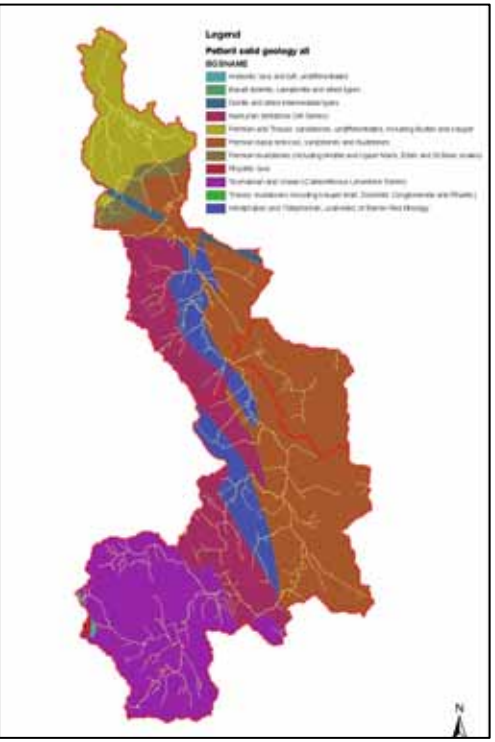
Sediment Source Strength

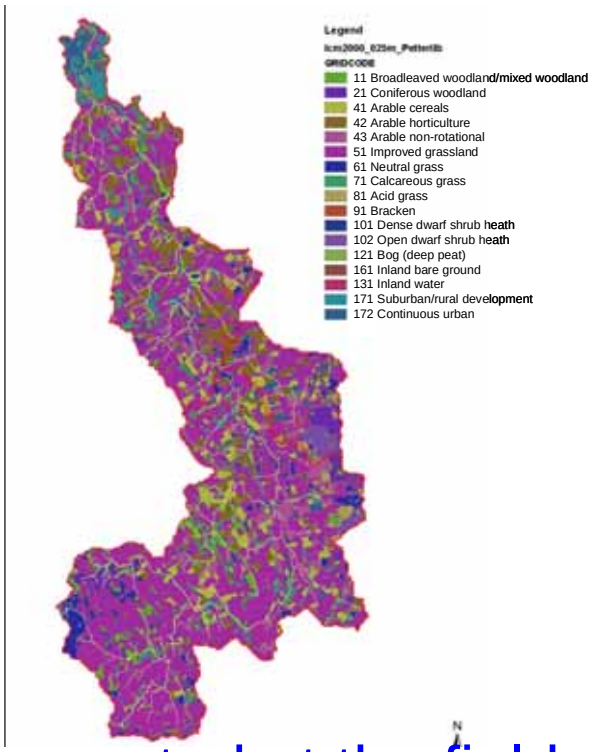
Rather than just *extent* of source in risk region, source strength in our model is a function of...

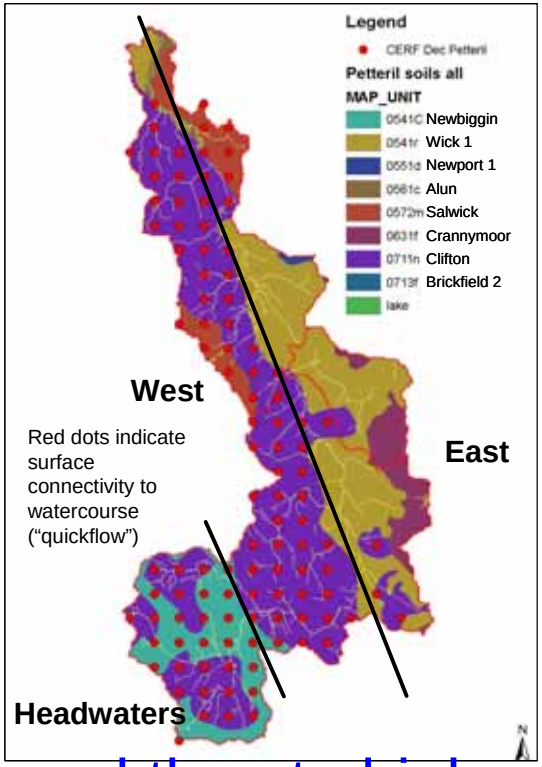
Intrinsic risk parameters –What factors affect how vulnerable soils are to erosion, compaction, etc?

Management risk parameters – what practices increase erosion, compaction, runoff risk?

Connectivity risk parameters – if stressors are released, what controls whether they reach the river?

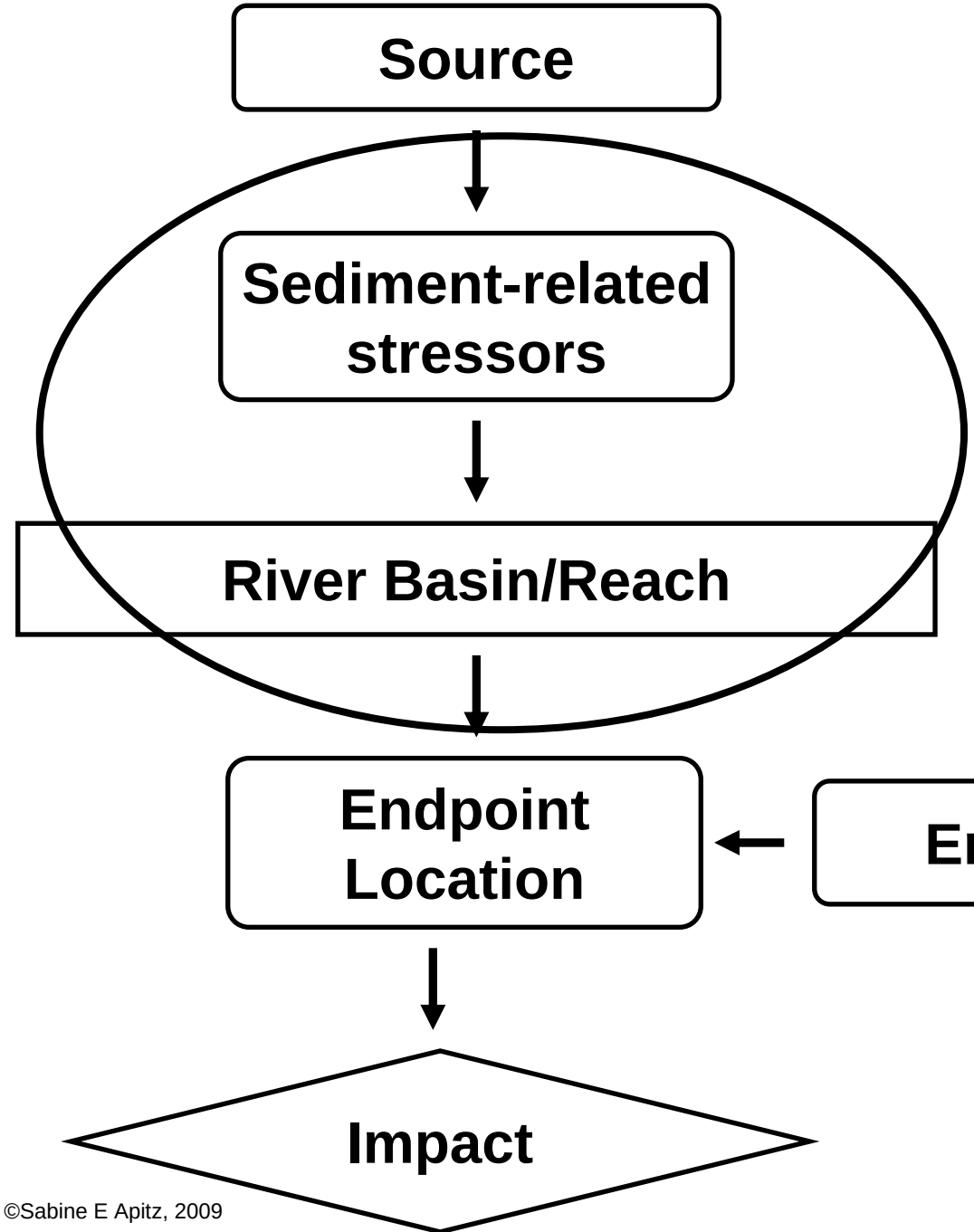






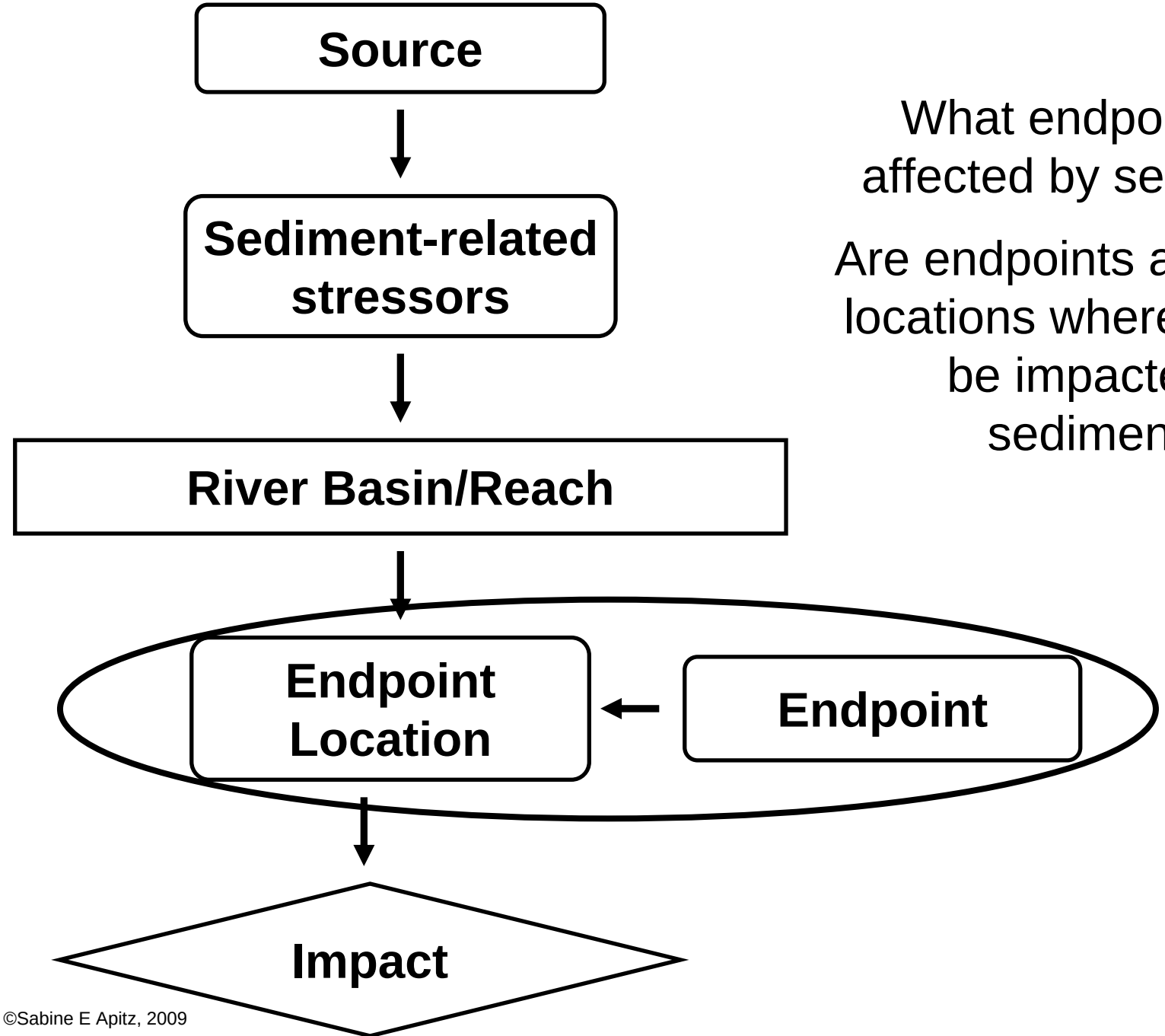
These are then aggregated at the field scale and then to higher scales

Illustrations source: John Phillips, Environment Agency



What stressors are released by sources? Can they reach the river?

How effectively does the river move stressors to habitats and endpoint locations?



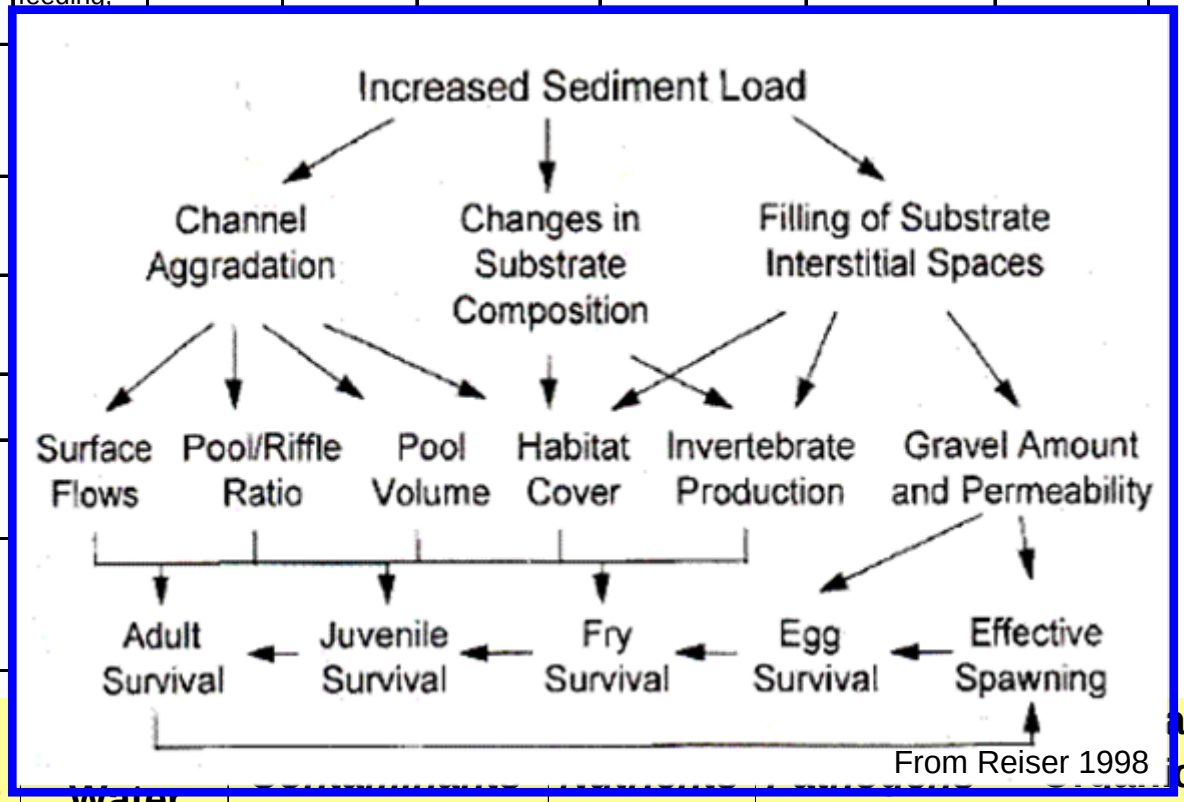
What endpoints are affected by sediments?

Are endpoints at endpoint locations where they can be impacted by sediments?

Biotic Endpoints

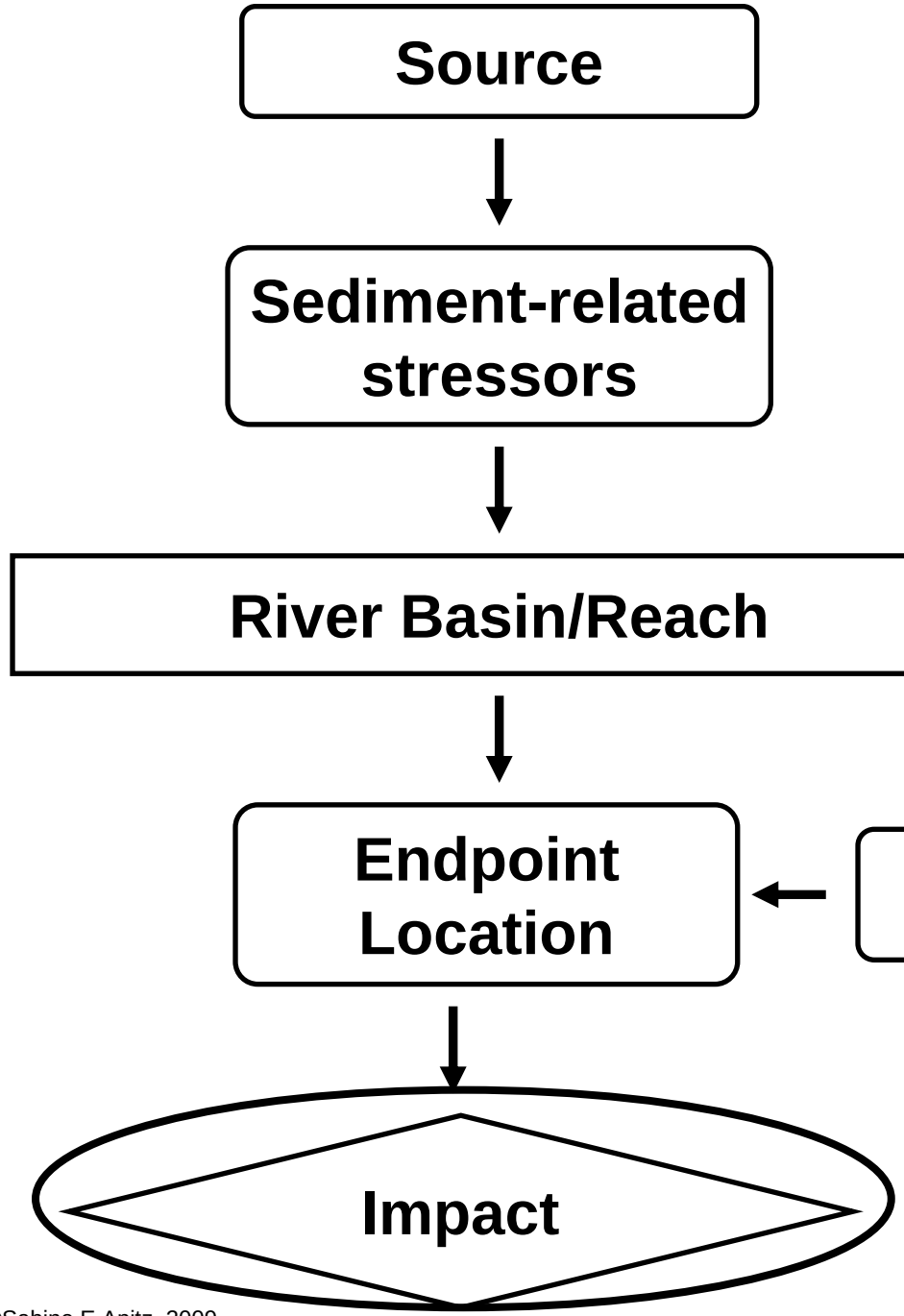
Assessment endpoint	Possible Endpoint Location (stressors causing positive benefits in parentheses)									
	Fine Bed	Medium Bed	Coarse Bed	Water Column	Mudflats	Estuaries	Coastal Floodplain	Urban Floodplains	Rural Floodplain	Wetlands
Salmonids/ cyprinids			FS, MS, C, pOM spawning; (CS)	FS, MS, C, N, pOM feeding, gills						
Column Feeding Fish				FS, MS, C, N, pOM feeding,						
Bottom Feeding Fish	pOM, C, CS, feeding; (FS)	pOM, C, feeding; (MS)	pOM, C, FS feeding							
Invertebrates - Fine	C, CS, N; (FS)	C, N								
Invertebrates - Coarse		C, N	C, FS, N; (CS)							
Diatoms										
Macrophytes										
Waterfowl										

Whilst many endpoints may be affected in many locations; focus is on critical impacts



From Reiser 1998

Fine Sediment (FS)	Medium Sediment (MS)	Coarse Sediment (CS)	Water (HW)	(C)	(N)	(P)	Matter (pOM)



What are the risks and benefits of sediment along one impact pathway?

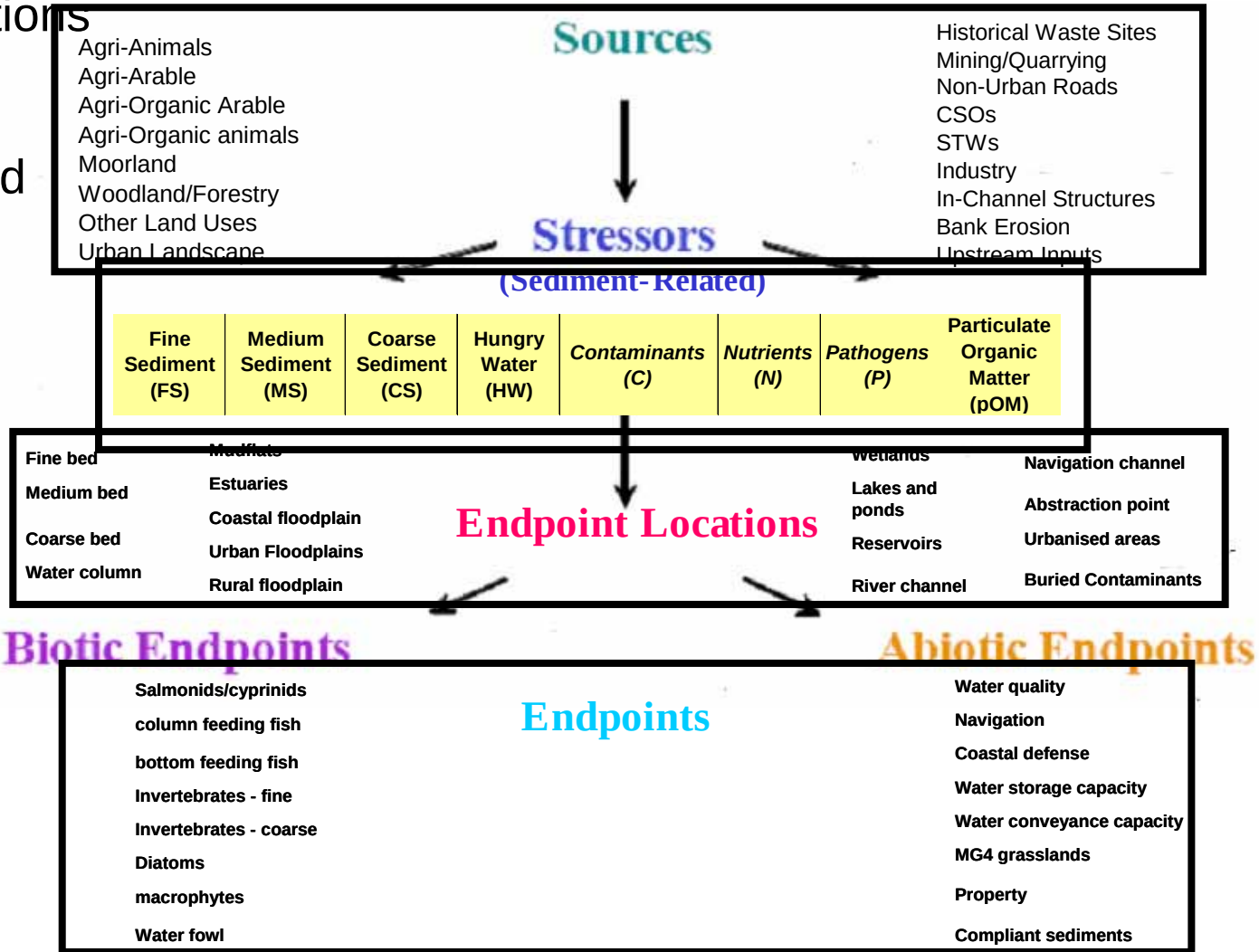
Is the impact from deposited or suspended sediment?

What are the cumulative risks among all pathways?

Our conceptual model considers

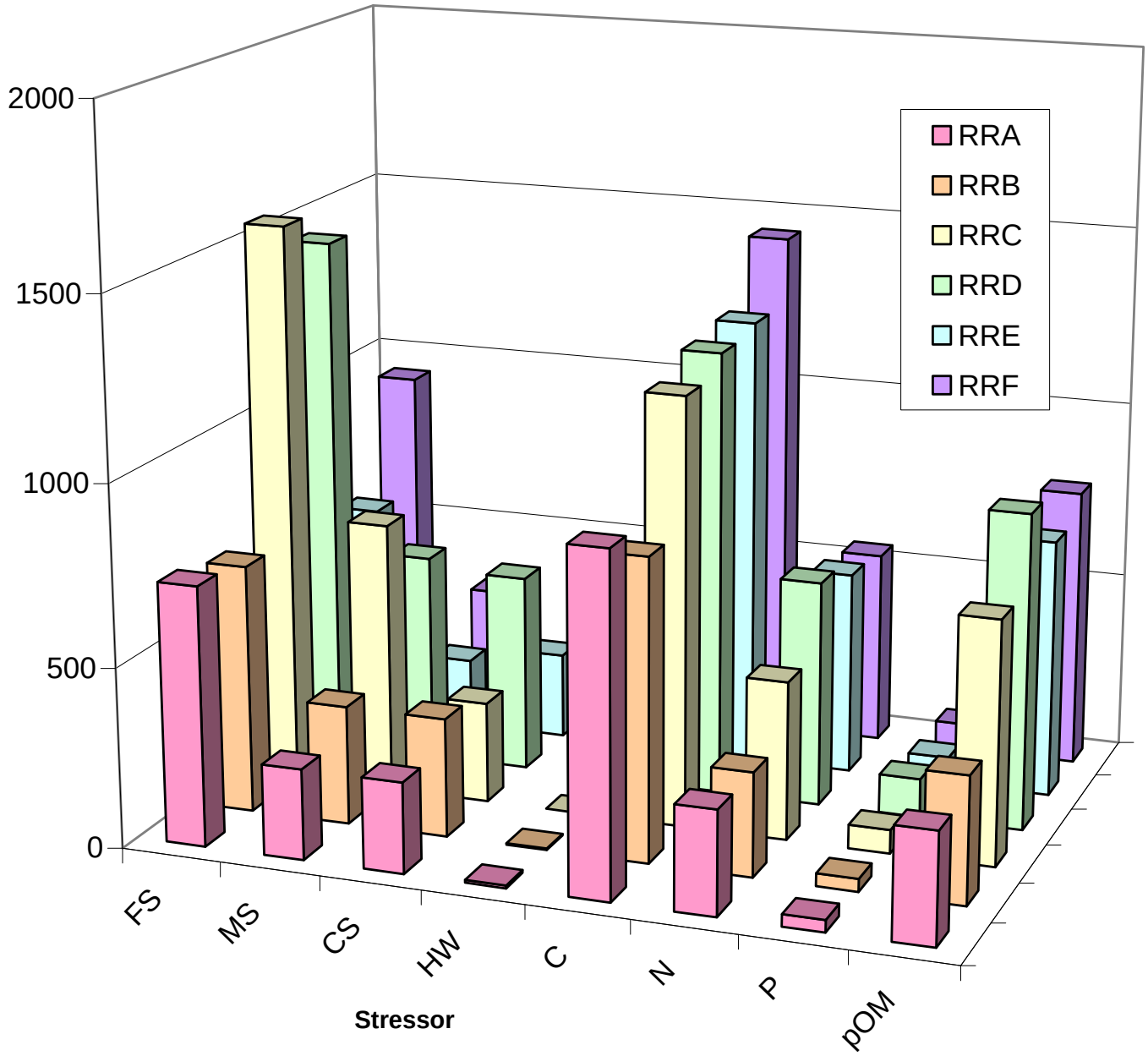
- 6 six regions, with
- **17** sources
- **8** stressors
- **17** endpoint locations
- **16** endpoints
- **2** types of impact (depositional and in suspension)

⇨ **443,904 risk combinations!!**



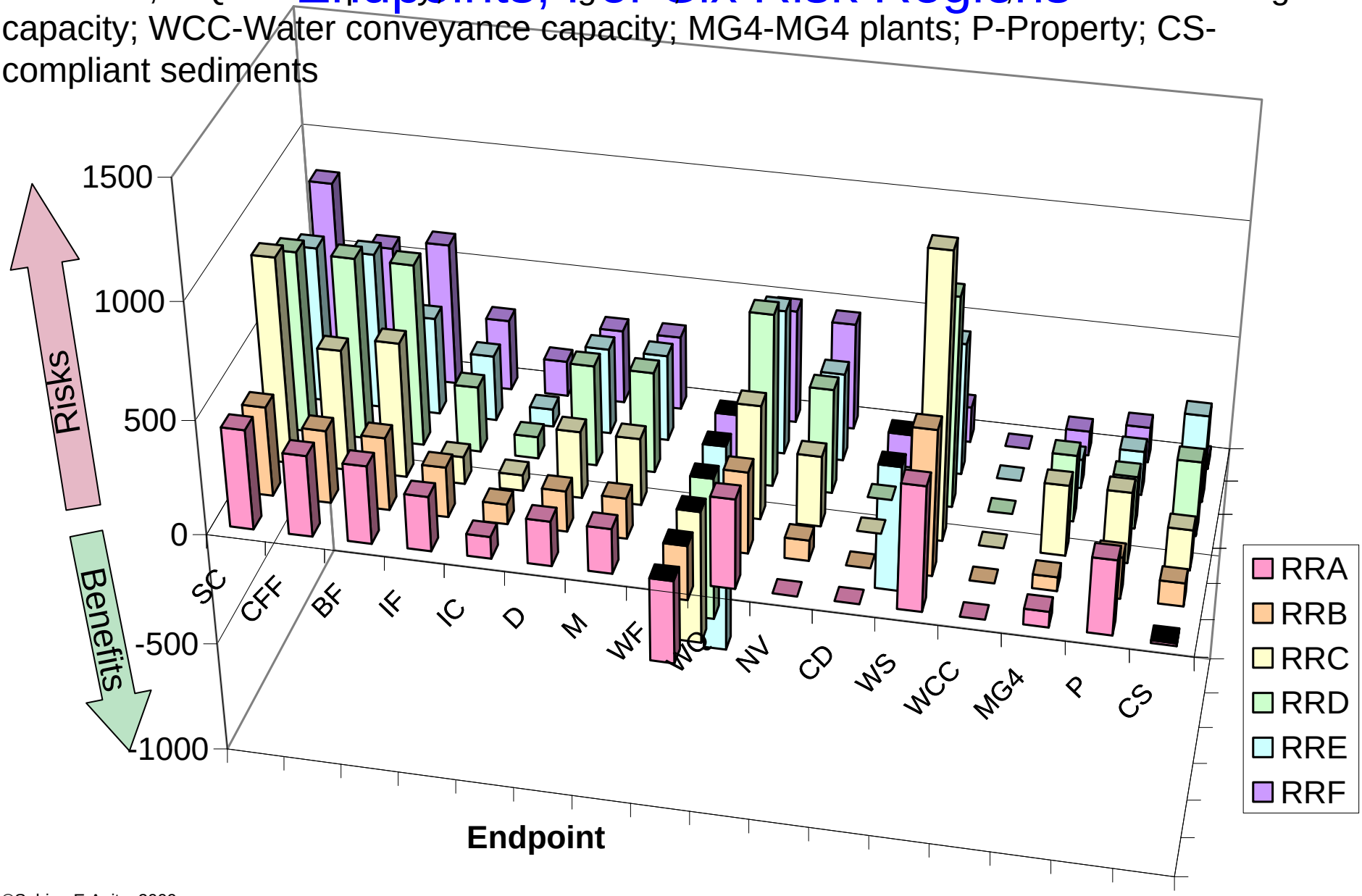
Cumulative Risks from Stressors, All Risk Regions

Stressor
Fine Sediment (FS)
Medium Sediment (MS)
Coarse Sediment (CS)
Hungry Water (HW)
Contaminants (C)
Nutrients (N)
Pathogens (P)
Particulate Organic Matter (pOM)



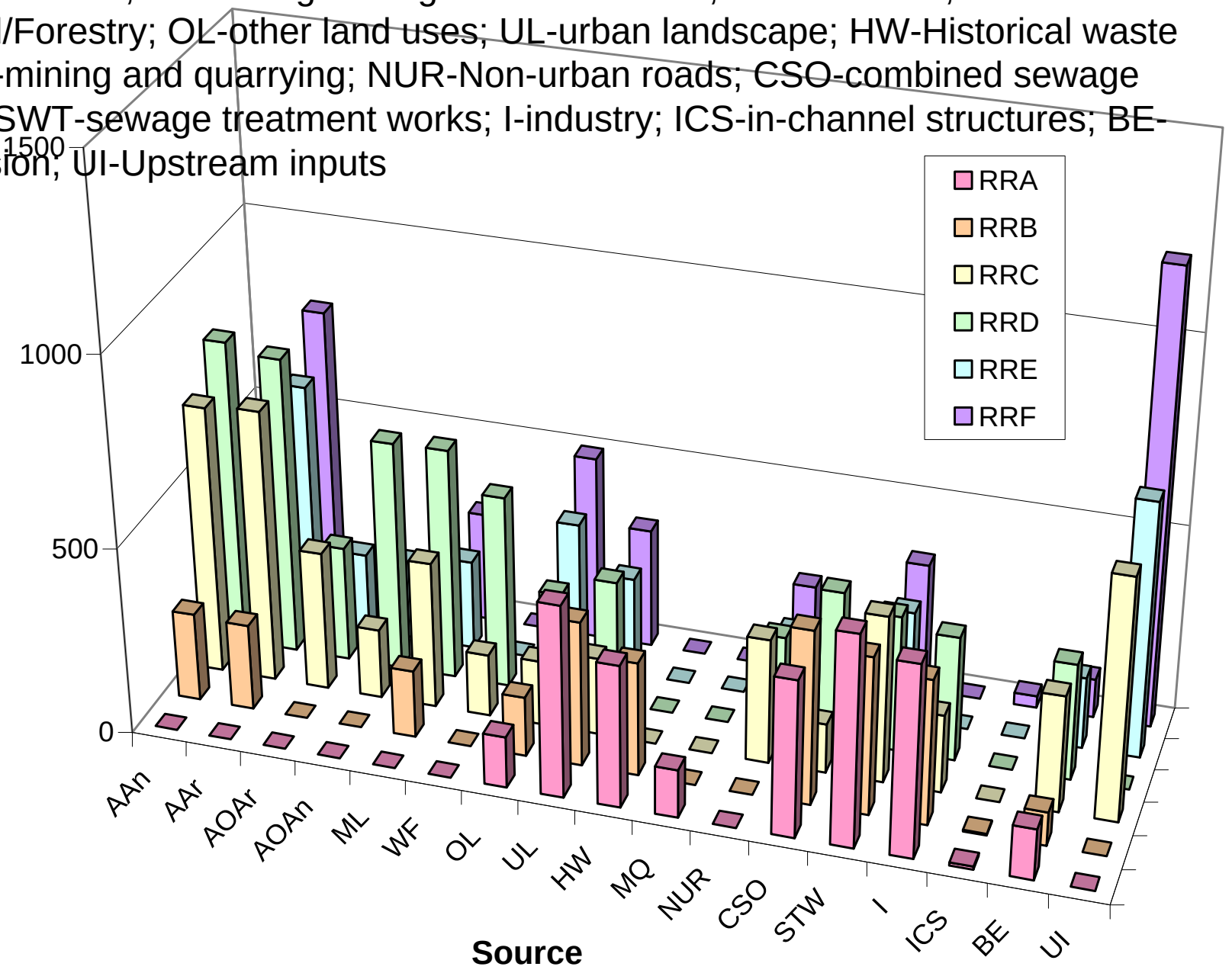
Example of Model Outputs: Cumulative Risks to Endpoints, For Six Risk Regions

Endpoints: SC-salmonids/cyprinids; CFF-column feeding fish; BF-Bottom feeding fish; IF-Invertebrates/fine; IC-invertebrates/coarse; D-benthic diatoms; M-macrophytes; WF-waterfowl; WQ-water quality; NV-navigation; CD-Coastal defence; WS-Water storage capacity; WCC-Water conveyance capacity; MG4-MG4 plants; P-Property; CS-compliant sediments

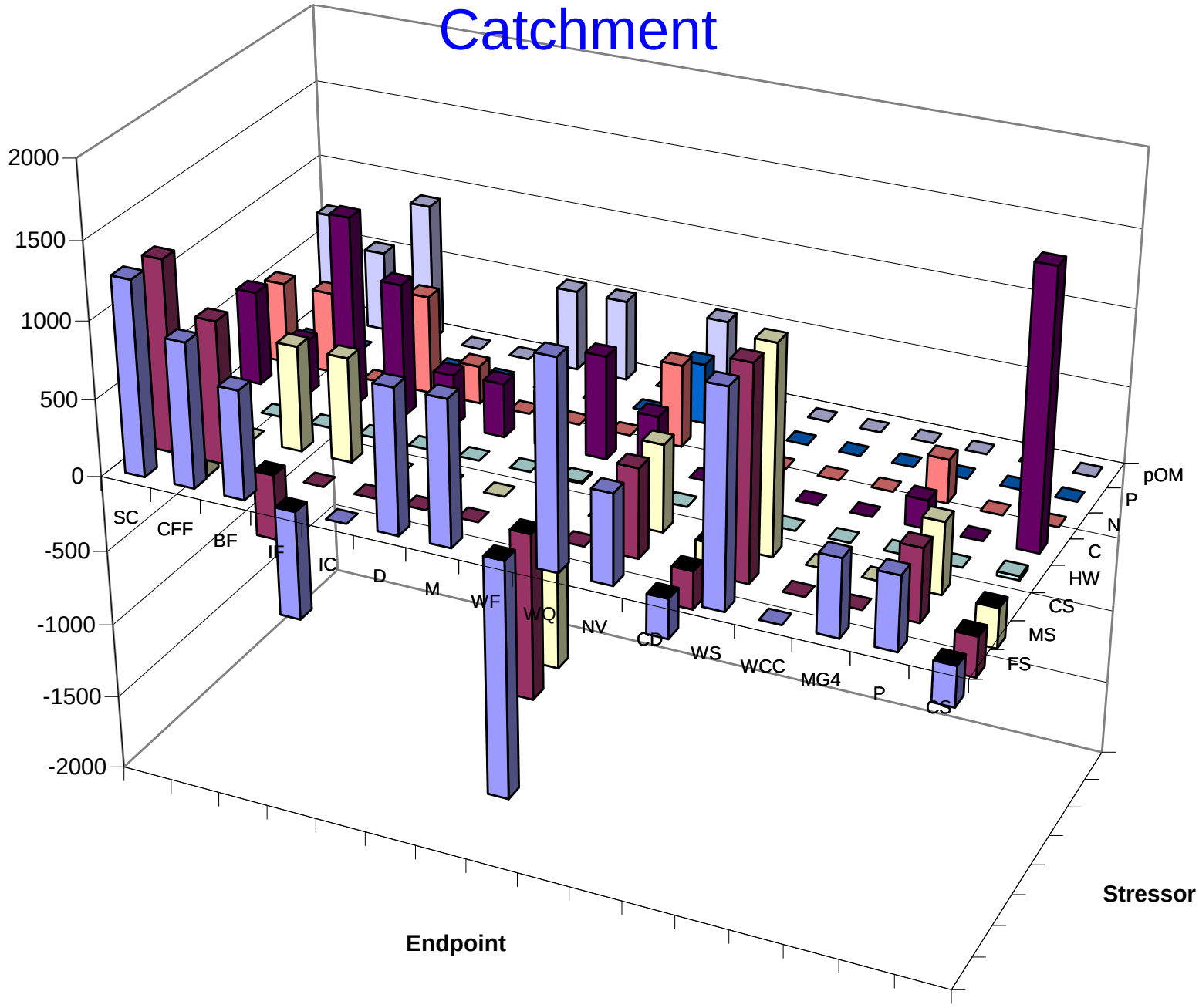


Cumulative Risks from Sources, All Risk Regions

Sources: AAn-Agriculture/animals; Aar-Agriculture/Arable; AOAr-Organic Agriculture/arable; AOAn-Organic Agriculture/Animals; ML-Moorland; WF-Woodland/Forestry; OL-other land uses; UL-urban landscape; HW-Historical waste sites; MQ-mining and quarrying; NUR-Non-urban roads; CSO-combined sewage outflows; SWT-sewage treatment works; I-industry; ICS-in-channel structures; BE-Bank erosion; UI-Upstream inputs



Cumulative Risks from Stressors to Endpoints, Entire Catchment



Summary:
The Sediment Risk Ranking Model

- Provides a framework to link catchment objectives to sediment sources
- Enables assessment of relative risk, including impacts and benefits
- Generates testable hypothesis about sources and potential impacts
- Can be linked to other tools
- Can be used to drill down to identify specific risks
- Can be used prognostically e.g. to avoid pollution swapping
- Can be linked to mitigation measures and economic appraisal.

Thank-you

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