Freshwater ecosystem service mapping:

Concepts and examples from South Africa

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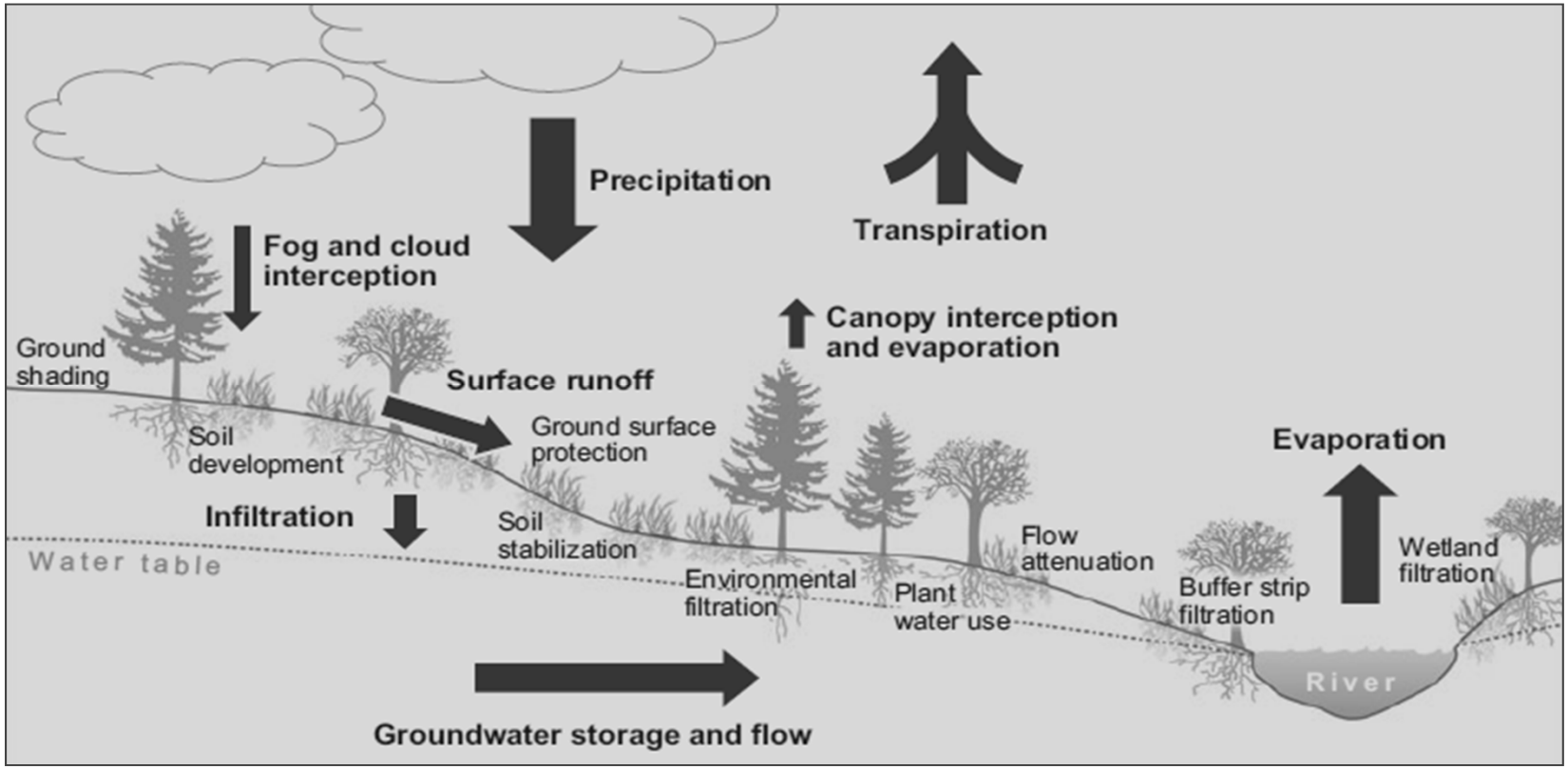
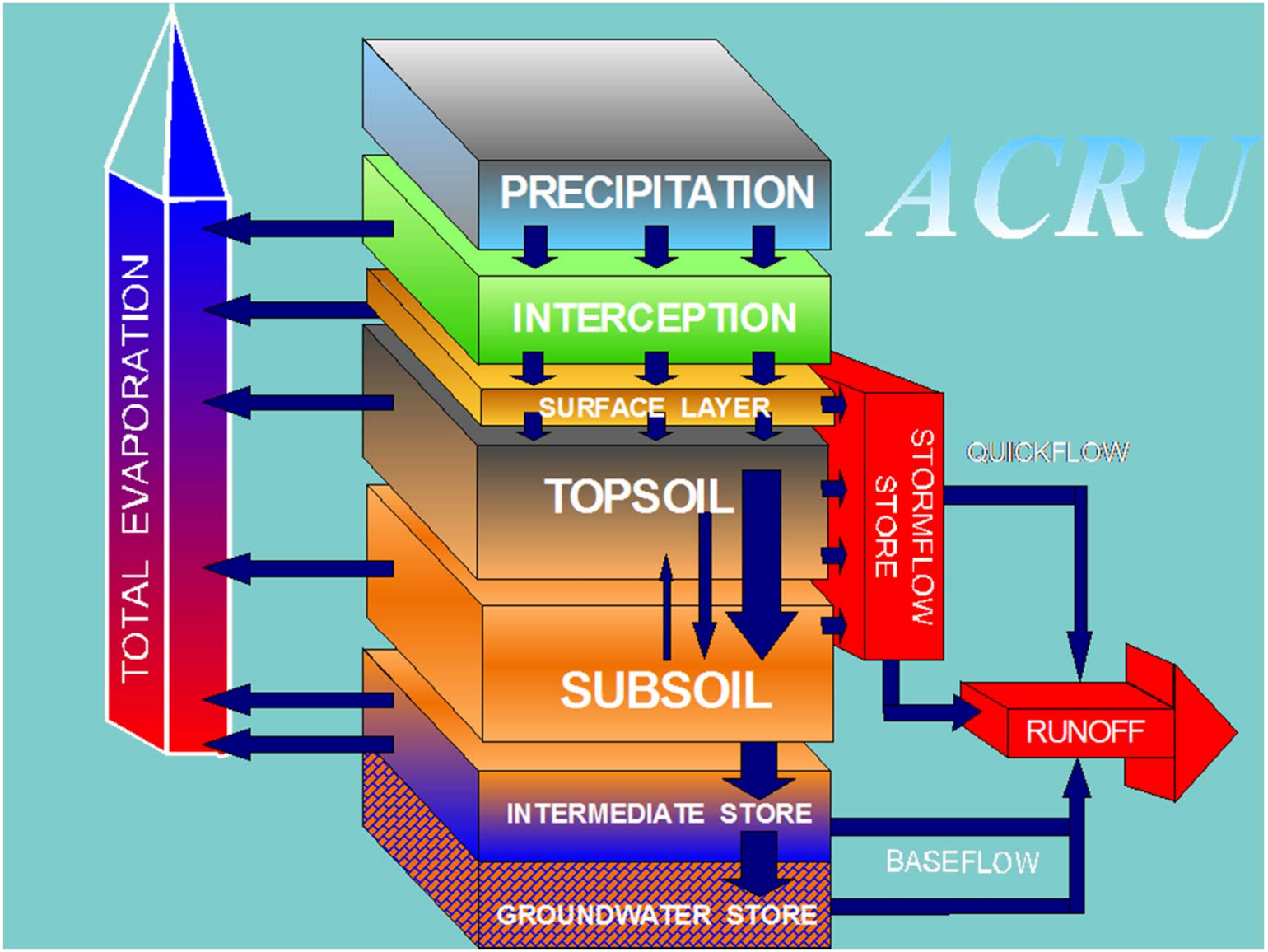
our future through science

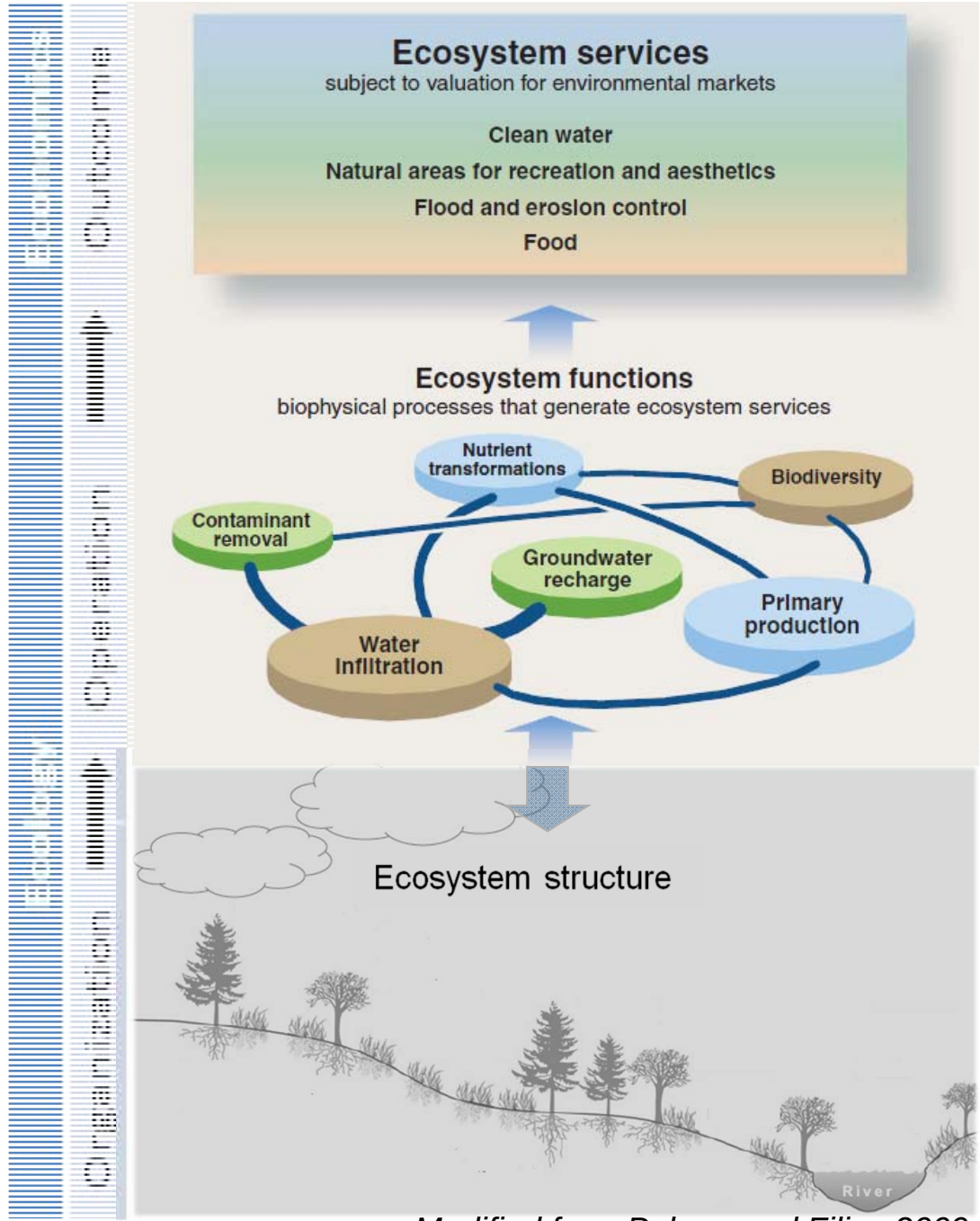
What are freshwater ecosystem services?

- Benefits to people provided by ecosystem effects on water quality, quantity, timing and location
- Studying ecosystem service delivery is like studying ecohydrology



Traditional hydrological sciences





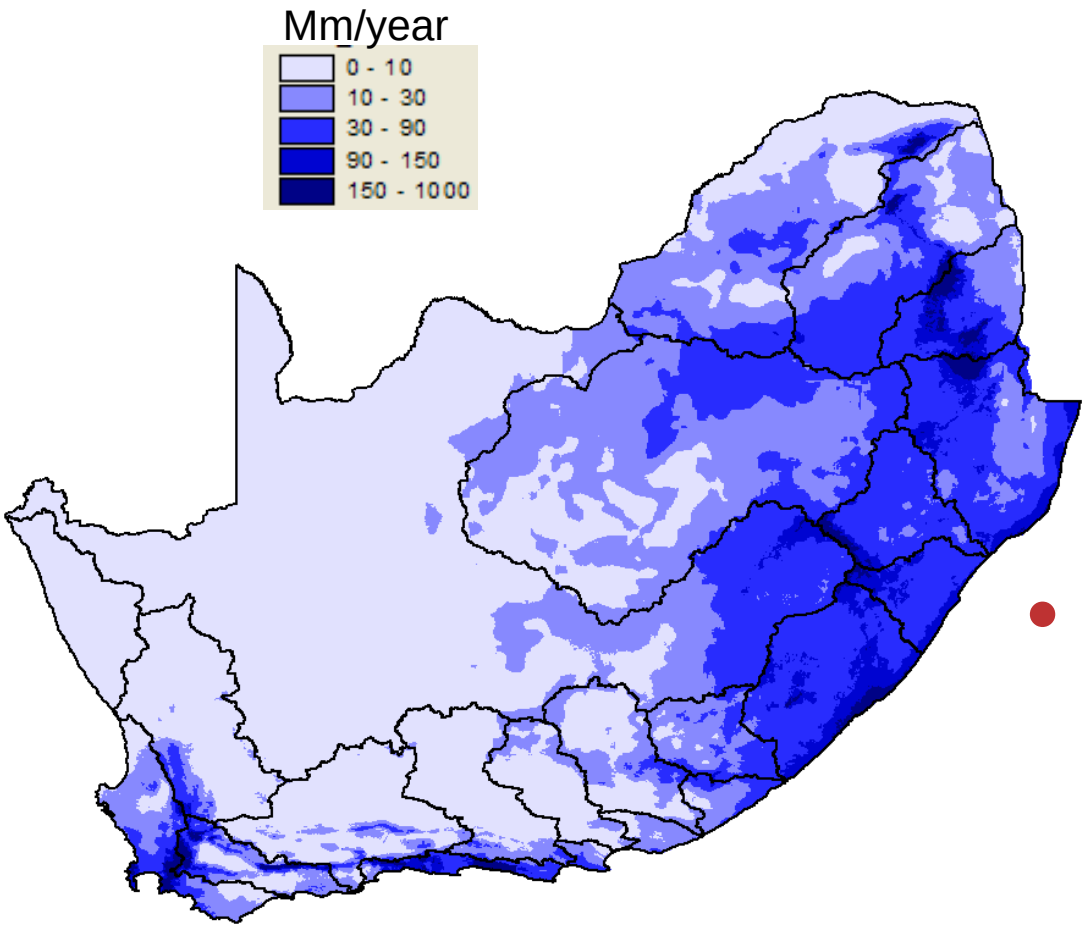
Modified from Palmer and Filiso 2009

- Eco structure/function → water quality, quantity, timing and location → ecosystem service delivery
- Relationships → hydrological sciences into an ecosystem service context

Key water-related regulating services

Flood attenuation	The spreading out and slowing down of floodwaters
Streamflow regulation	Sustaining flow during low flow periods
Groundwater recharge	Infiltration of water into groundwater
Sediment retention	Trapping and retention of sediment carried by running water
Water quality amelioration	Removal of phosphates, nitrates and other toxicants carried by running water
Climate regulation	Wetlands as carbon sinks??
Regulation of pests and pathogens	Distribution and abundance of invasive plants, malaria, bilharzia, black fly, and fish
Maintenance of refugia	Critical habitat for species utilized elsewhere

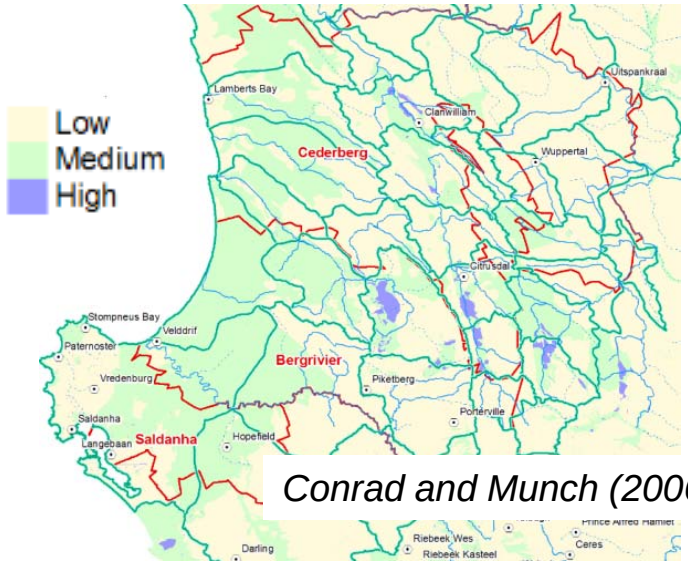
Groundwater recharge



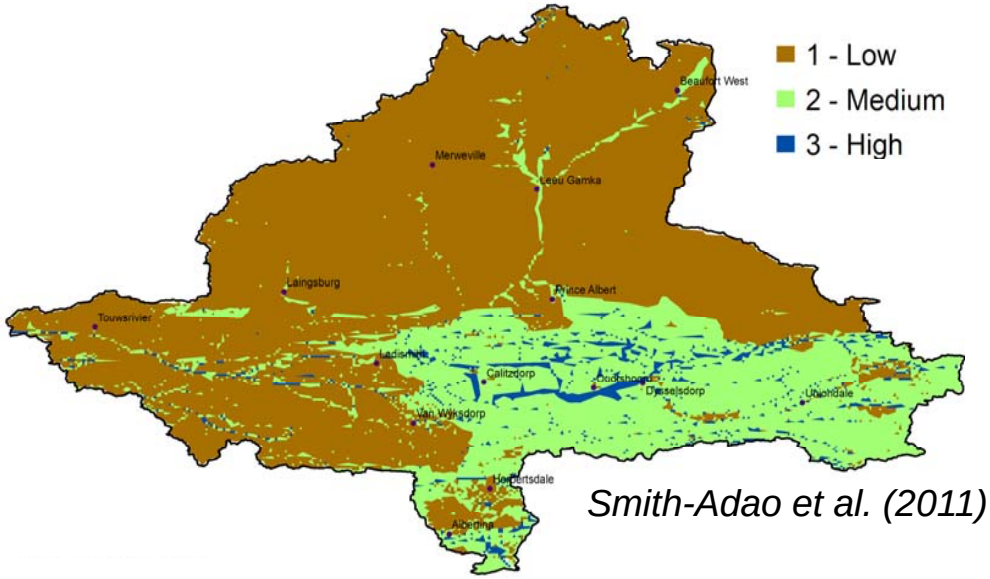
- 1 X 1 km grid, expressed as:
  - mm/yr
  - as a % of mean annual rainfall
  - as a % of primary catchment recharge (NFEPA)
- Infrastructure – natural vegetation

Streamflow regulation

- Groundwater discharge areas – high probability of ground water : surface water interaction
- Overlap of:
  - Groundwater response units
  - Groundwater levels
  - Springs
  - Geological faults
  - Aquifer dependent ecosystems
  - Groundwater contribution to baseflow



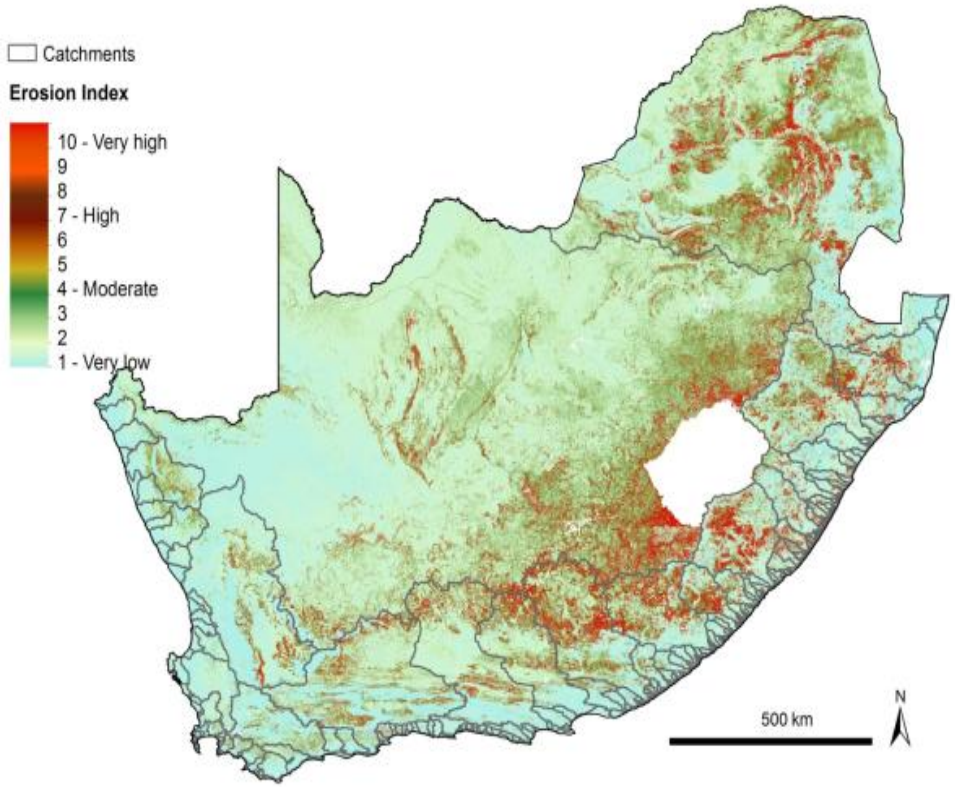
Conrad and Munch (2006)



Smith-Adao et al. (2011)

Sediment retention

- Soil erosion hazard classes
  (Le Roux et al. 2008 with slight modifications)
- Areas most in need of maintaining wetland and riparian vegetation



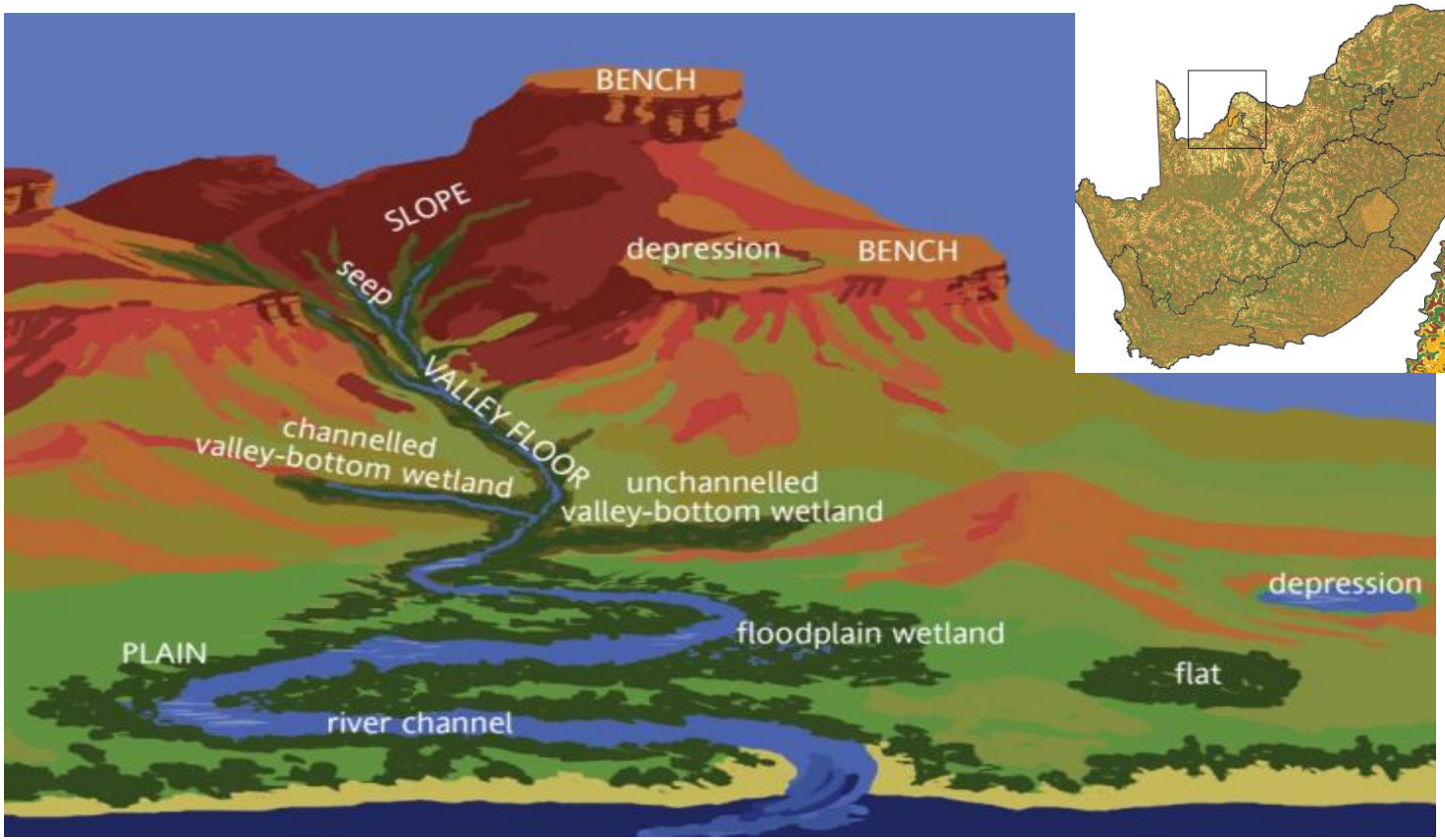
Le Roux et al. (2008)

National maps: summary

- Readily available national maps at fairly good resolution grid cell:
  - Groundwater recharge (rate of delivery; mm/year)
  - Sediment retention (rate of delivery; tons/year)
  - Groundwater discharge (relative importance)
- MAPPING GAPS: Flood regulation and water quality amelioration → wetlands

Wetlands and ecosystem services

- Wetlands can be classified based on their hydrological and geomorphological functioning → HGM types
- Landscape position and linkages to water network NB
- Different HGM types likely to deliver different services

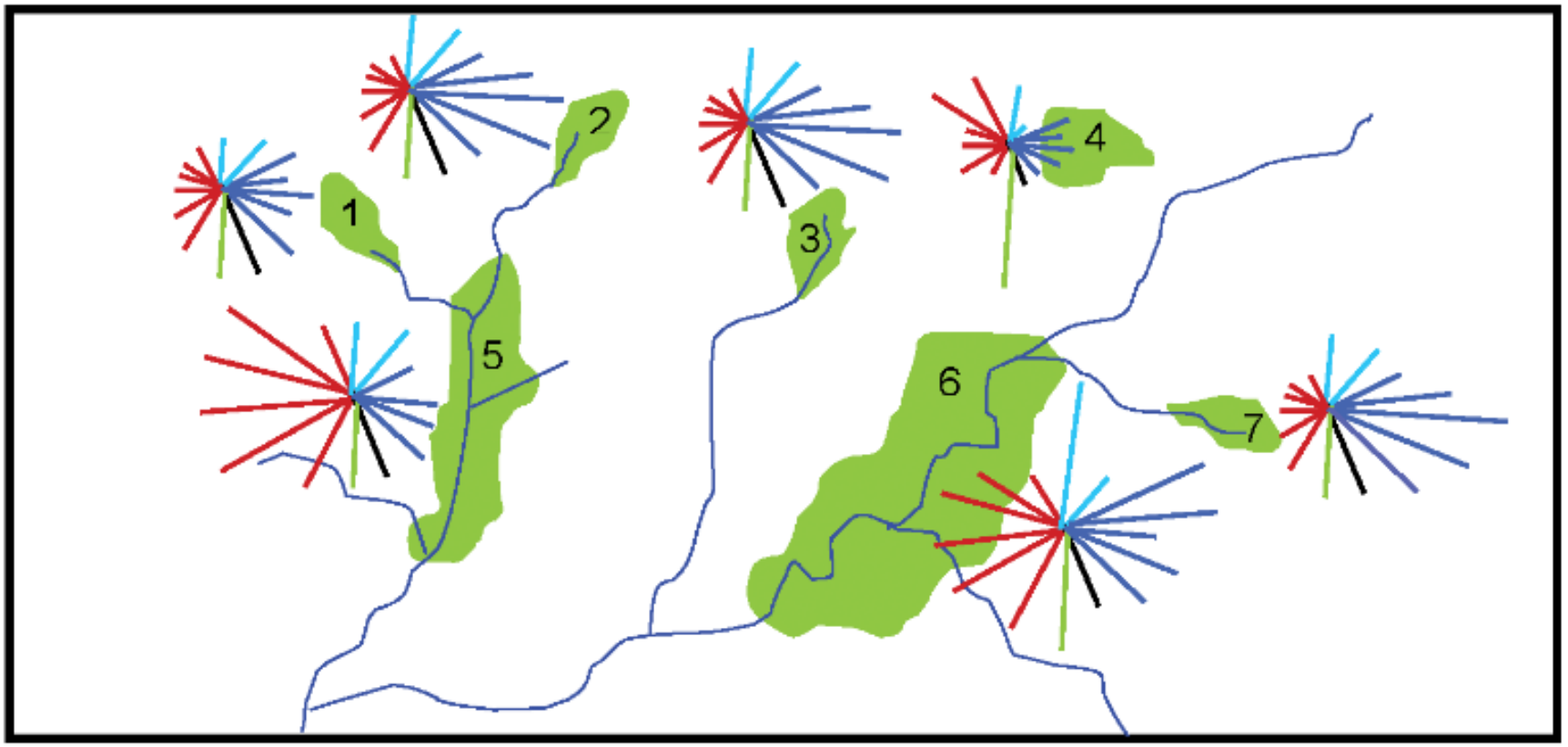


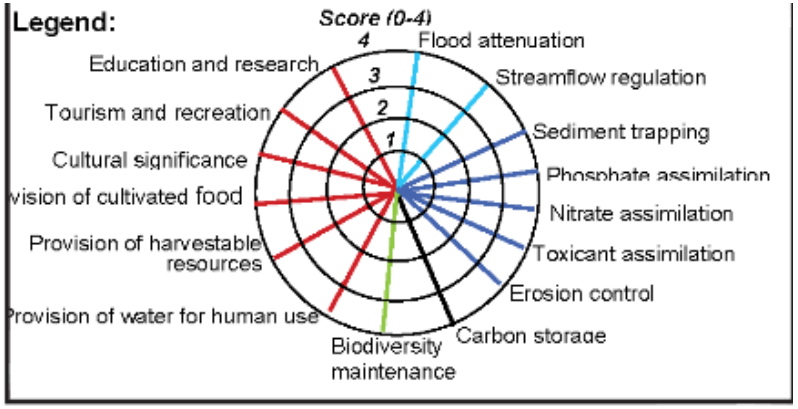
Courtesy Wilma Strydom

WETLAND HYDRO-GEO-MORPHIC TYPE	REGULATORY BENEFITS POTENTIALLY PROVIDED BY WETLAND						
	Flood attenuation		Stream flow regulation	Enhancement of water quality			
	Early wet season	Late wet season		Erosion control	Sediment trapping	Phos-phates	Nitrates
1. Floodplain	++	+	0	++	++	++	+
2. Valley-bottom - channelled	+	0	0	++	+	+	+
3. Valley-bottom - unchannelled	+	+	+?	++	++	+	+
4. Hillslope seepage connected to a stream channel	+	0	+	++	0	0	++
5. Isolated hillslope seepage	+	0	0	++	0	0	++
6. Pan/ Depression	+	+	0	0	0	0	+

Kotze et al. (2009). WET-EcoServices: A tool for rapidly assessing wetland ecosystem services. WRC Report TT339/09

WET-EcoServices – Level 2 assessment

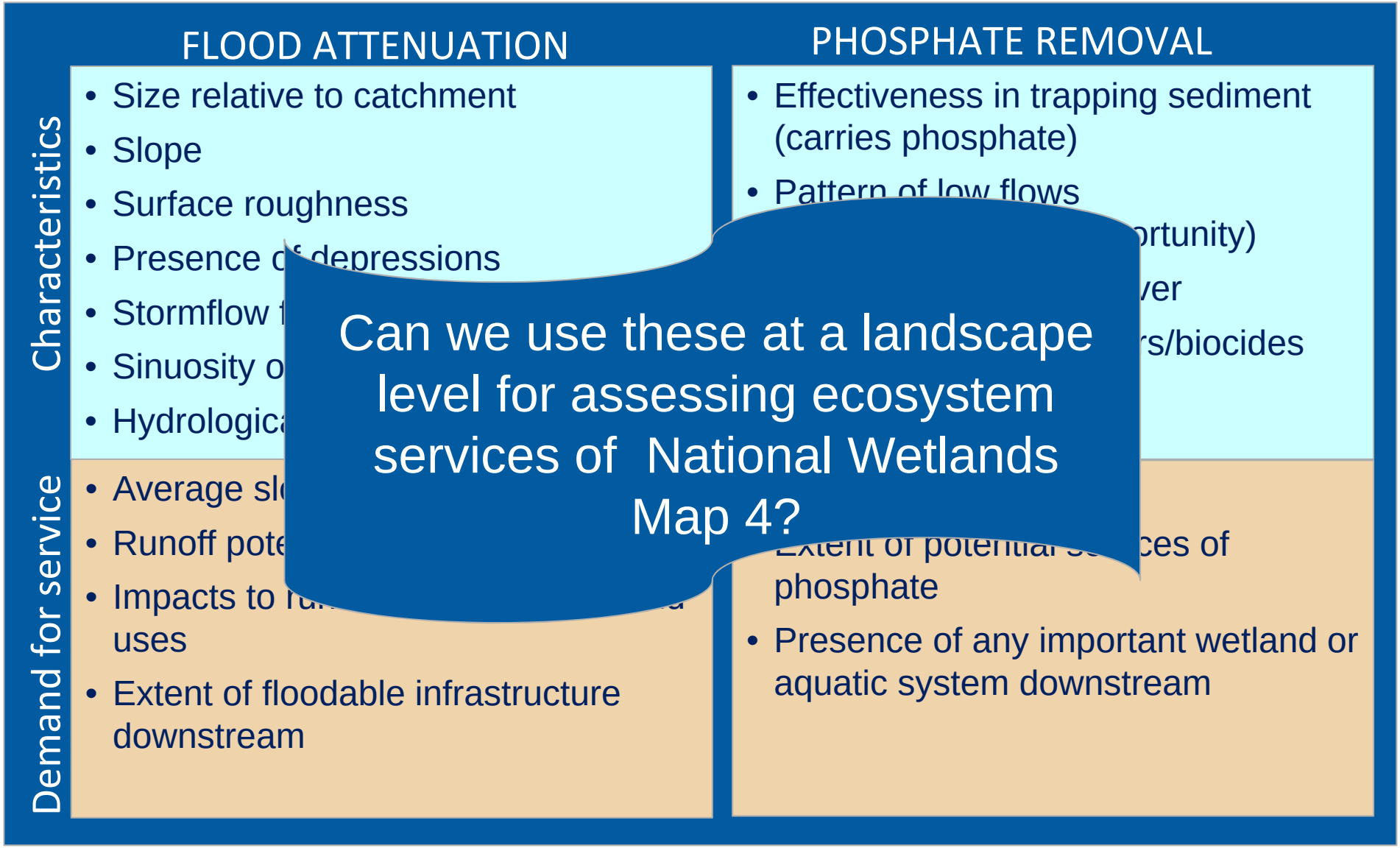




Kotze et al. (2009)

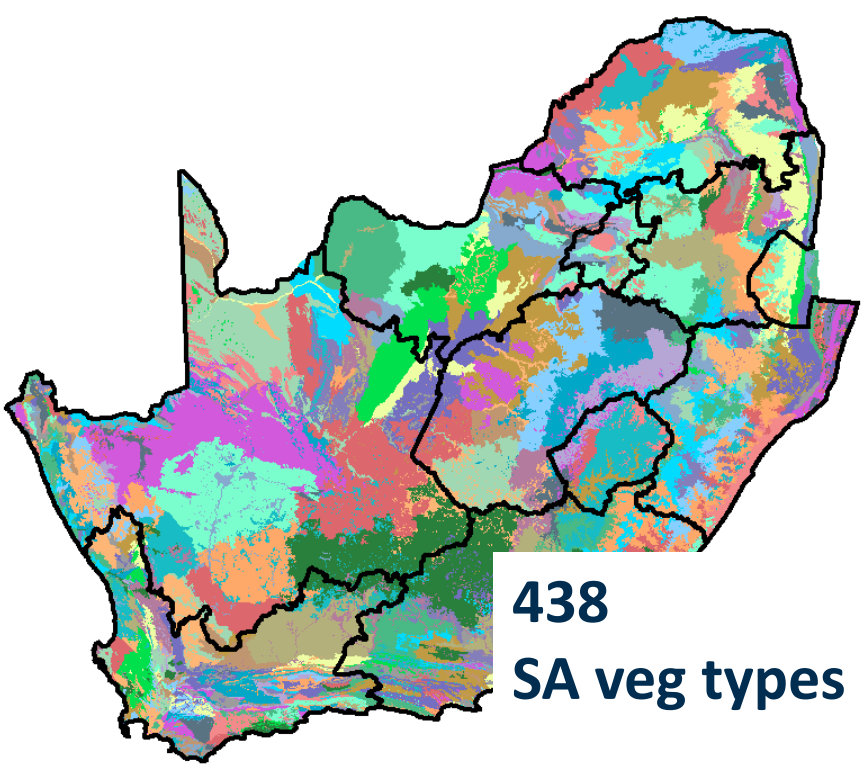
- Wetland condition not considered

WET-EcosServices



Wetland vegetation group

- Group wetlands that share broad regional characteristics
- Similar concept to the “Azonal” category on veg map
  - Azonal inconsistently mapped in across SA



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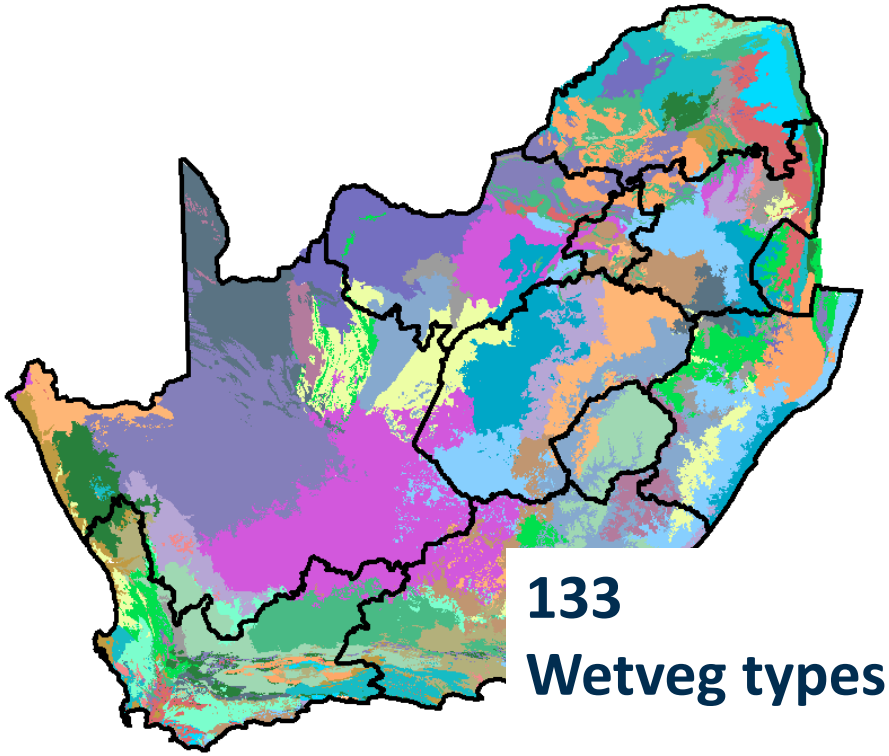
SA veg types



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Wetveg types

Using wetveg & HGM types

Courtesy Thomas Peschak/WWF

- Wetland veg group indices
  - Sequestration capability of dominant spp
  - Roughness/flow resistance index
  - Sediment trapping capability
- HGM indices, e.g.:
  - Potential for phosphate removal
  - Potential for sediment trapping
  - Flow velocity
  - Connection to water
- Wetland size relative to catchment
- Steepness of wetland slope
- Scale of scoring system:
  - Individually-mapped wetlands
  - Generalised to catchment level

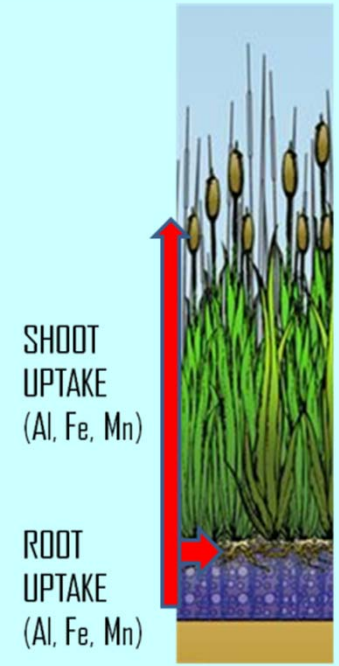
Ellery et al. (2010). Assessing cumulative impacts on wetland functions at the catchment or landscape scale. WRC Report TT 437/09

BUT!!!

- National Wetlands Map 4 has limitations we need to address:
  - Mapped wetland localities – present; historical
  - Wetveg groups need to be refined based on proper floristic techniques
  - HGM types estimated to have 50-60% accuracy
- Indices need to be established
  - Reference and modified conditions
  - Ecological response curves
- We need systematic field surveys
  - AND lots of them!!!

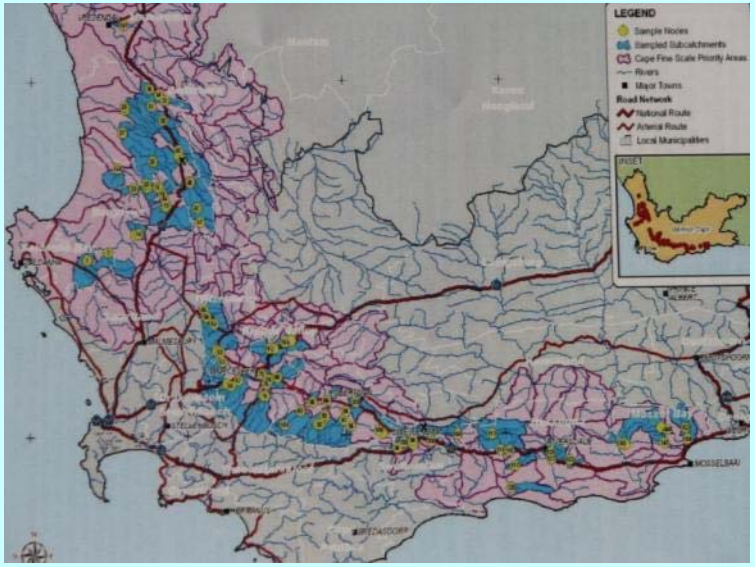
Water quality amelioration

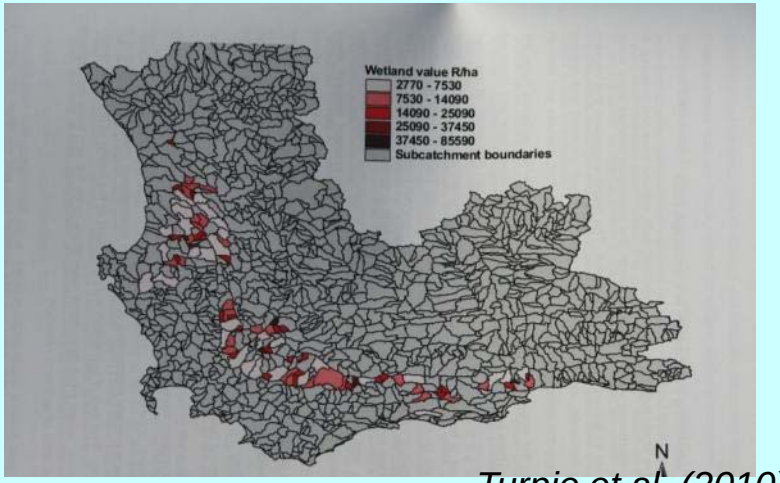
1. TEST ROOTS & SHOOTS OF DOMINANT SPP



Schachtschneider et al. (in prep)

2. TEST WATER QUALITY INFLOWS & OUTFLOWS





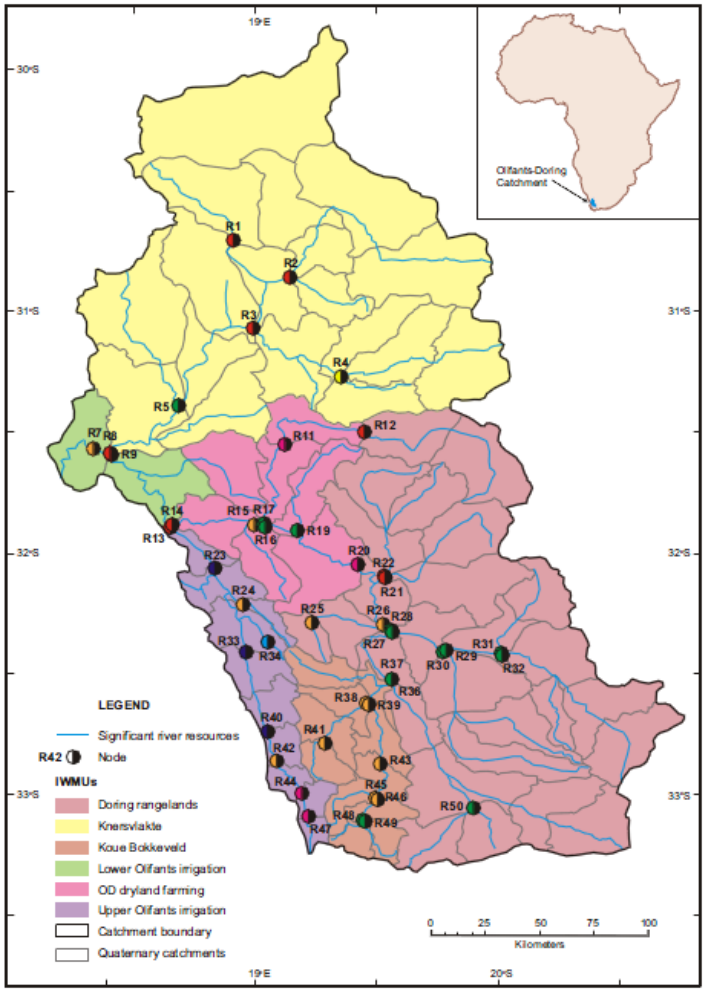
Turpie et al. (2010)

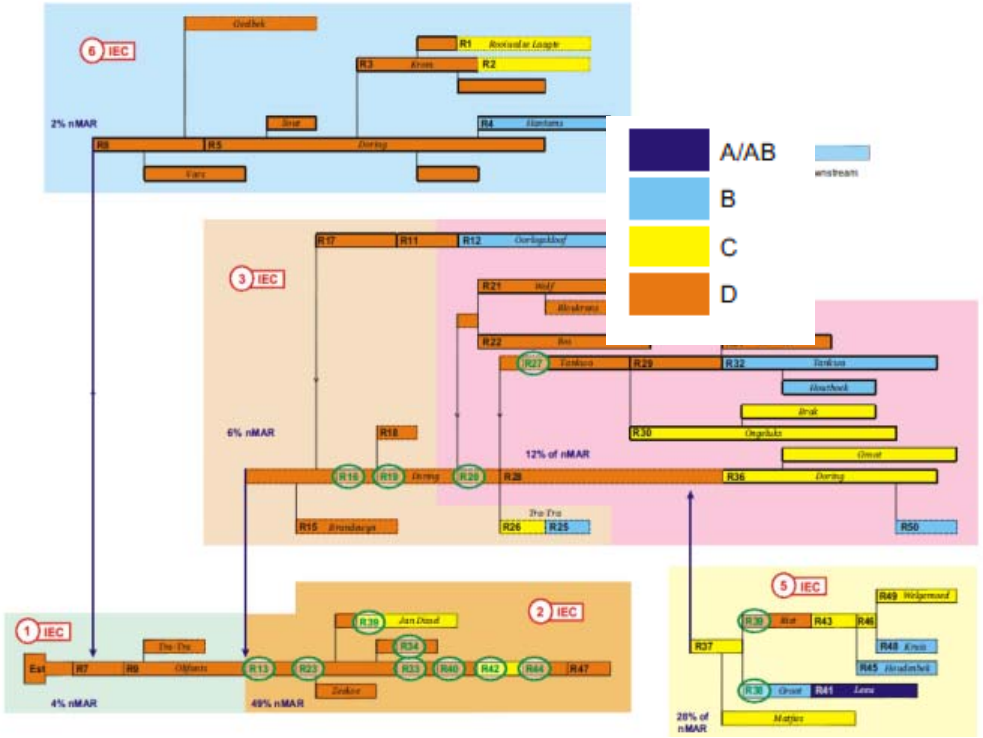
Rates of removal (kg/ha/yr)

OTHER EXAMPLES

Water resource classification system

- Explicitly links changes in water quantity and timing to outcomes





Ecological health

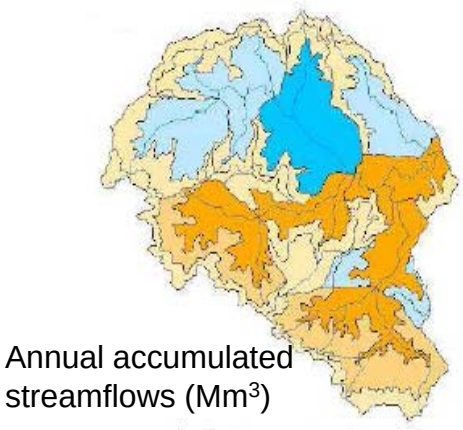
Economic prosperity

Social well-being

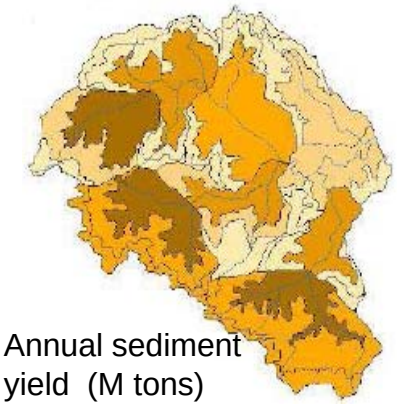
Brown et al. 2006

ACRU modelling of changes in hydrology

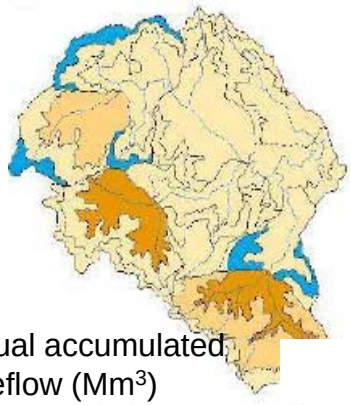
- Calibrated to simulate real life observations
- Model changes to baseline streamflow, baseflow, sediment yield related to degradation
  - Drivers of degradation: livestock management, changed veld fire regimes and/or invasive alien plants
  - Vegetation and soil changes → basal cover; soil infiltration
- Study areas
  - Upper Thukela
    Baviaankloof and Tsitsikamma
  - [Enkangala grasslands]



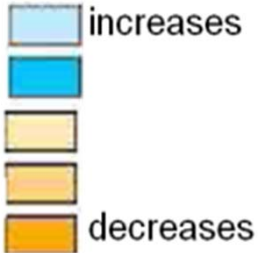
Annual accumulated streamflows (Mm^3)



Annual sediment yield (M tons)



Annual accumulated baseflow (Mm^3)



Schulze and Horan (2007)

Leaps we still need to make...

- From maps of relative importance to quantified service benefit flows
  - Relatively easy to map stocks or infrastructure
  - Less easy to quantify rate of delivery, flows and beneficiaries - how these change with changes in ecosystem condition
  - Supply must match demand
    - Downstream flood damages
    - Most valuable areas will be closes to the source of pollution and not based only on those that have the highest filtration capacity
- From sub-catchment to features scale
  - For integration into land use planning and decision-making processes
  - Possible at rapid, intermediate and comprehensive scale but confidence should be explicit

Where to from here???

Don’t be afraid to scale up
BUT while we are doing this, we also need.....

Have systematically-directed research at site levels to collect and map data

Create mechanisms for uptake of the scaled up assessments across all major sectors → maps of ecological infrastructure; Resource Critical Areas