Deciphering system change: extrinsically versus intrinsically driven system networks

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‘A community and its environment treated together as a functional system of complementary relationships, and transfer and circulation of energy and matter, is an ecosystem.’ (Whittaker 1975)

AIM

1. Provide filler for gap in programme
- Rapid response talk and audience requested to treat as such.
- No graphics

2. Toward conceptual framework for explicit spatial delineation of a system

Extrinsically vs intrinsically driven systems

An intrinsically driven system is defined as one in which the major material and energy flows and associated biotic interactions arise predominantly from within the system;

those of an extrinsically driven system are dependent mainly on an external input.

(The influence of climate is disregarded.)

Outline of Talk

- Examples of extrinsically vs intrinsically driven systems
- Concept of system networks
- Connectedness through biotic transfers

  - scale-related behaviour
- Impact of transformed landscapes
- Consequences for LTER & observation

Extrinsically vs Intrinsically

- Proposed that systems can be positioned along a continuum from extrinsically to intrinsically driven.
- Examples of the two poles are first provided.
- Majority of systems have components of both.

Extrinsically driven

1. Large wetland, estuary, aquatic system: depend on hydro-functioning and catchment therefore of primary importance

- St Lucia
- Okavango
- Richards Bay
- Kosi Bay etc

2. Deep ocean floor – detritus driven

St Lucia

- Ongoing crises ~ fresh water
- Umfolozi River diverted
- > 50 % catchment area lost
- Shallow system – sedimentation risk
- Recent prolonged exposure – bed deflation and incipient dune building
- *Catchment integrity the key – not studied*

Richards Bay

- Town established mid 1970s
- Bay split into harbour & sanctuary - new mouth for sanctuary through dune cordon
- Original mangroves were in harbour
- Degraded uMhlathuse River catchment as source sediment plus large floods
- Sanctuary – largest mangrove forest in SA
- *Catchment integrity the key*

Some key points

- Most examples of extrinsically driven relate to water on account of productivity

- Note geomorphological change at time scales relevant to management is a critical process in water-related examples

Intrinsically driven

1. Montane eg Drakensberg
- Habitat-specific biota
- Adapted bird and mammal assemblages
- High level plant & invert endemism
- Asymmetric relationship with lowlands
  - influence but not influenced by

2. Forest
3. Offshore marine (deep ocean)

Dual: Namib desert

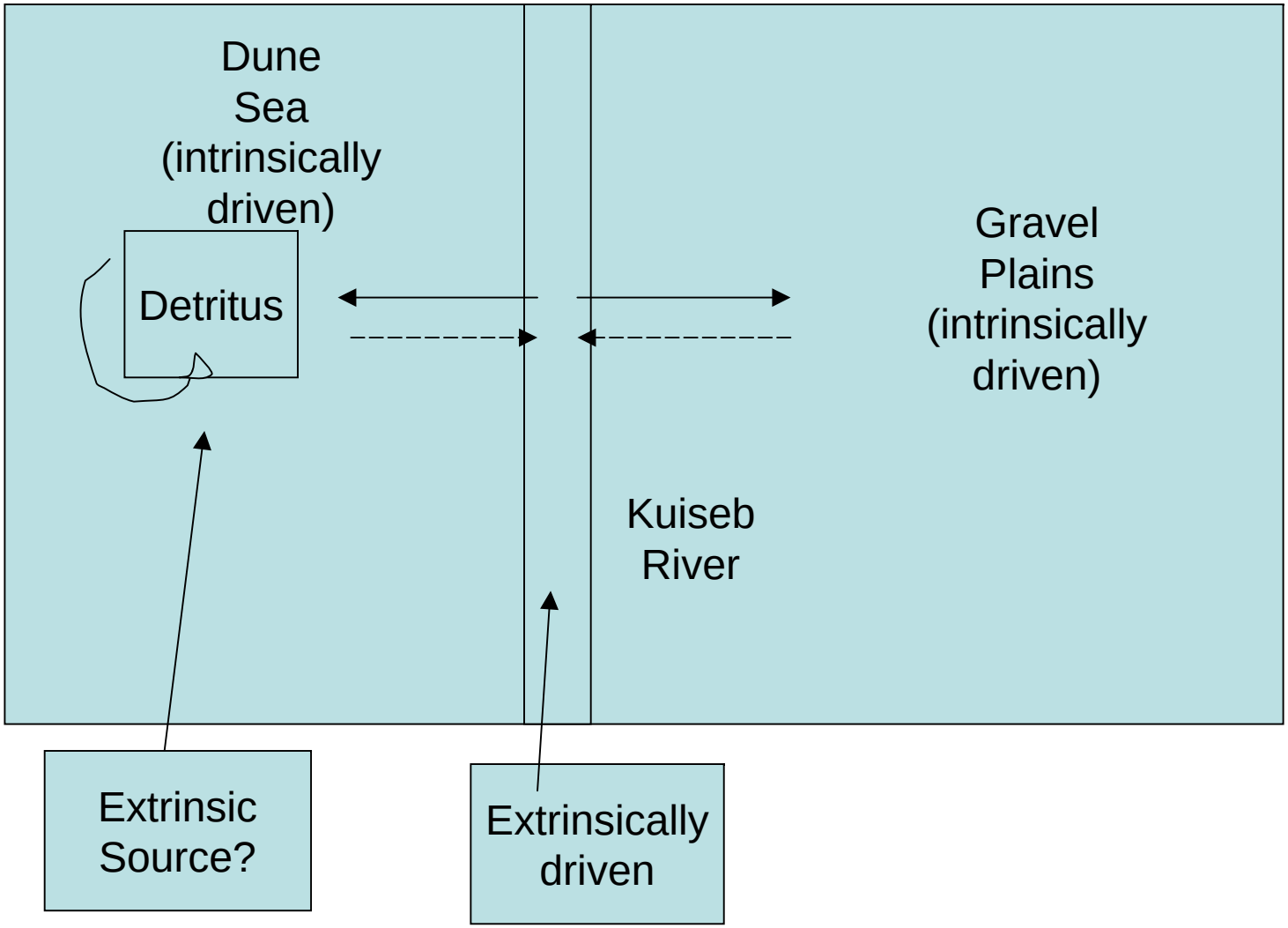
3 main components

- Kuiseb River and floodplain – extrinsic.
- Dune sand sea – detritus driven:

  - is most detritus derived *in situ* or from highlands?

  - changes in detritus quantity or quality?
- Gravel plains – intrinsically driven: hard surfaces redistribute water to give pockets of productivity.
- Q: how well connected are 3 components?

Connectedness of Namib desert components



Connectedness

- Spatial flow of materials and energy and responsible vectors

- System networks

System Network

Defined as relationships among systems' biota.

- trophic web

- obligate and facultative relationships: pollination, dispersal, 'nesting, resting, breeding'.

Point: No matter where species impacted has potential impact on relationships elsewhere

Trophic webs: conventional

	Lep host	Lep shrd	Wdbr host	Wdbr shrd	Ant host	Ant shrd	Prim feed –Lep
Burkea africana	9	1	6	1	4	11	21
Terminalia sericea	12	3	3	2	5	11	33
Ochna pulchra	3	1	3	0	1	11	13

Material/energy flows 1

- Abiotic (passive) or biotic (active) flows
- Abiotic – limit direction & mass transfer
- Biotic
  - animals terrestrial, plants also in aquatic
  - mobility (flight vs pedestrian)
  - Influence body size, ecology, social structure, environment
  - E.g. popn inverts life cycle in 1 tree; 200 km^2 for 1 pair raptorial birds

Material/energy flows 2

Pre-impacted systems

- Herds of large-bodied migratory mammals:

  - winter key resource area -> large popn;

  - summer impact 100s kms away;

  - loss key area -> disproportionate loss popn;

- Also small – locusts, quelea etc

Namib Connectedness

Illustration using large herbivores

1. Springbok, gemsbok, zebra, ostrich
   - extensive, opportunistic movement
   - influence water-dependence, habitat
2. Steenbok, klipspringer
   - sedentary, habitat specific
3. Baboon
   - Kuiseb floodplain (water, food)

Point: herbivory -> detritus -> inverts?; ungulate popns have collapsed in last 50 years

Transformed Landscapes

Based on indigenous vegetation

- Indigenous mammals -> livestock
- Open-ended systems to closed
- Pastoral, transhumance -> extinction
- Landscape – units with boundaries
- Small mobile elements maintained

Point: connectedness compromised (easier to study?)

Agricultural landscapes

- Loss of spatial scale
- Increasingly extrinsically driven by management interventions

  - fertilizer, irrigation, herbicide, pesticide, surface characteristics etc
- Highly altered material/E flow on site
- Wide shadow of influence
- Connectivity high but restructured compared with pre-impact

Implications LTER/Observation

Possible use:
Q: How is system defined?
Q: Extrinsic driving variables important?
Q: If so, spatial dimension of driver(s)?
Q: Connectedness – agents and scale?
OUTCOME: Spatial delineation of system

NB: NOT spatial bounds to study site

Would apply to DPSIR approach

Implications LTER/Observation

Does spatial delineation of system matter?

Test through application to case studies.

Namib: delete 1 component change others?

- hypothetical or real
- upstream impoundment Kuiseb
- loss riparian
- transferred effects other than dune sea march?

Utilitarian: site selection, study design, etc