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ACNA4007 – Physical Landscape and the Geosphere



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Landscapes and Life

Biogeomorphology

The Earth surface - Landscapes



- What's missing ?

PART I Geomorphology and Its Tools

- 1 Earth's Dynamic Surface
- 2 Geomorphologist's Tool Kit

PART II Source to Sink

- 3 Weathering and Soils
- 4 Geomorphic Hydrology
- 5 Hillslopes
- 6 Channels
- 7 Drainage Basins
- 8 Coastal and Submarine Geomorphology

PART III Ice, Wind, and Fire

- 9 Glacial and Periglacial Geomorphology
- 10 Wind as a Geomorphic Agent
- 11 Volcanic Geomorphology

PART IV The Bigger Picture

- 12 Tectonic Geomorphology
- 13 Geomorphology and Climate
- 14 Landscape Evolution

Earth surface processes and life...?

- Do Earth surface processes influence life... e.g. over long timescales?



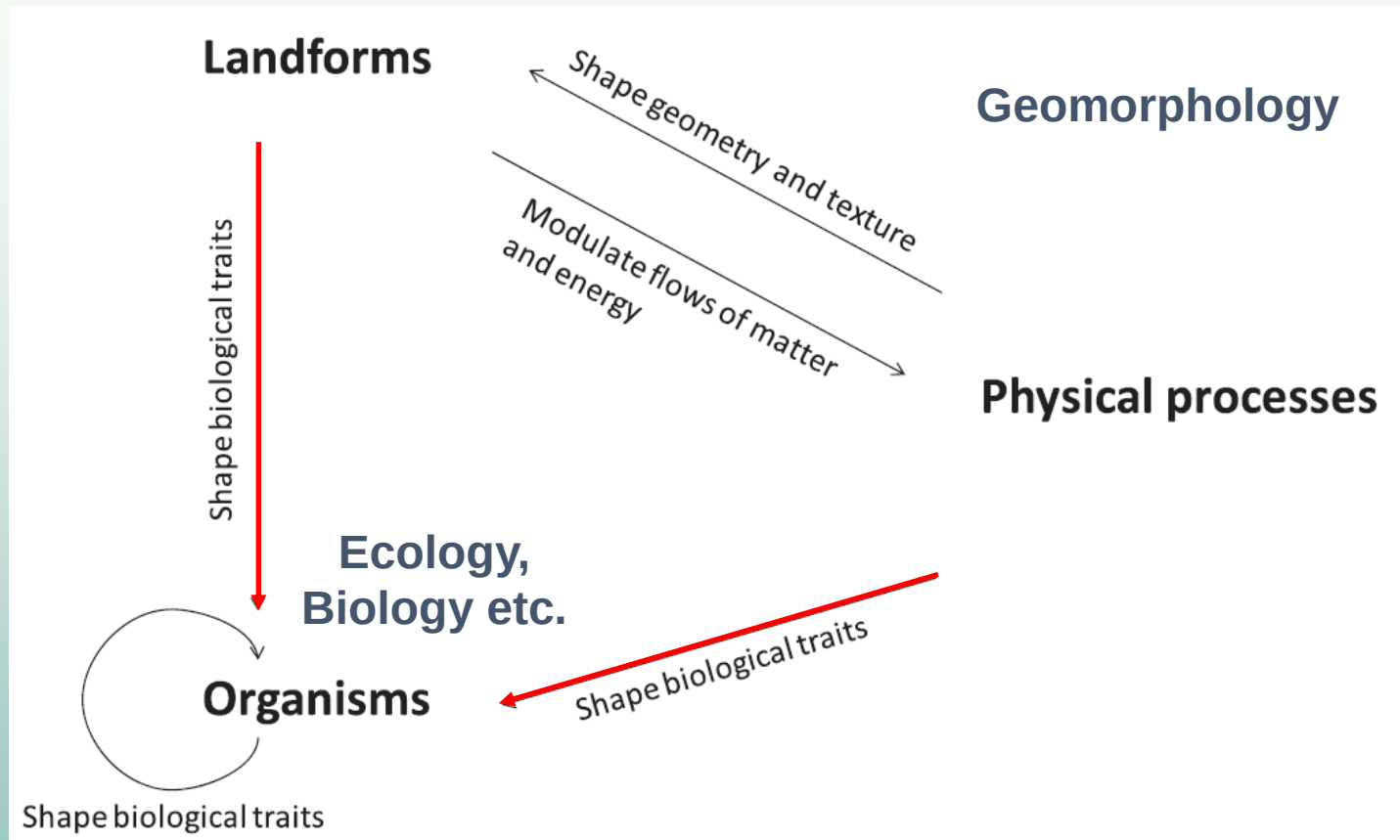
Vicariance – Dispersal barriers – Refugia – Ecology...

Earth surface processes and life...?



- ... over short timescales - Earth surface processes have multiple effects on life !!
- e.g. dust - Biogeochemical cycles
- e.g. volcanoes - Natural disasters

Earth surface processes and life...



- Botanists and landscape: **effects** of landforms, processes, and materials on vegetation structure, composition, and dynamics
- Geomorphologists - have traditionally treated vegetation as an **independent variable** that affects landforms and sediment routing at limited spatial–temporal scales

Processes → Community



- e.g. migrating dunes (Lomas de Arena, Bolivia) and dying of forest communities

Processes → Community



- e.g. River channel changes (avulsions) – hydrological change and tree death (Rio Grande, Bolivia)

Processes → Community

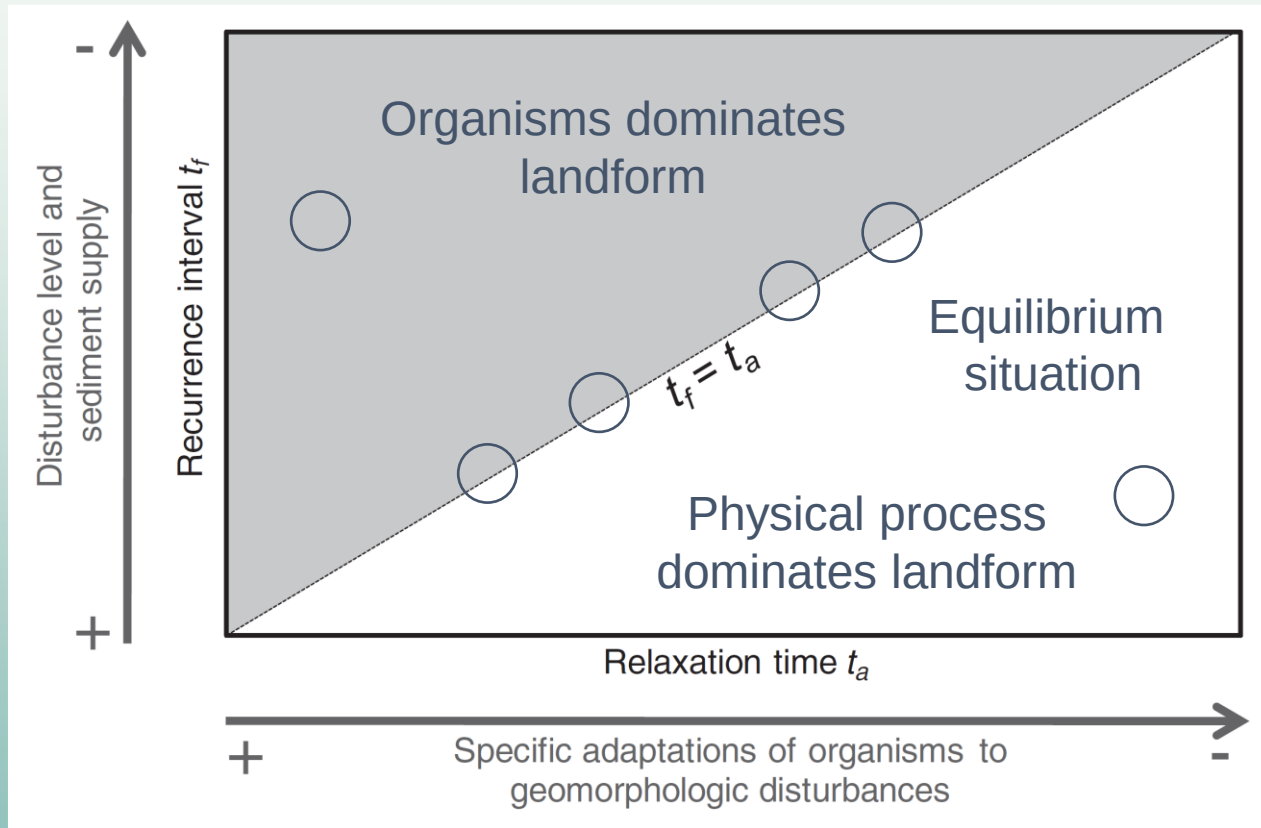


- e.g. River channel changes (avulsions) - (Rio Grande, Bolivia)
- **Disturbance** and succession



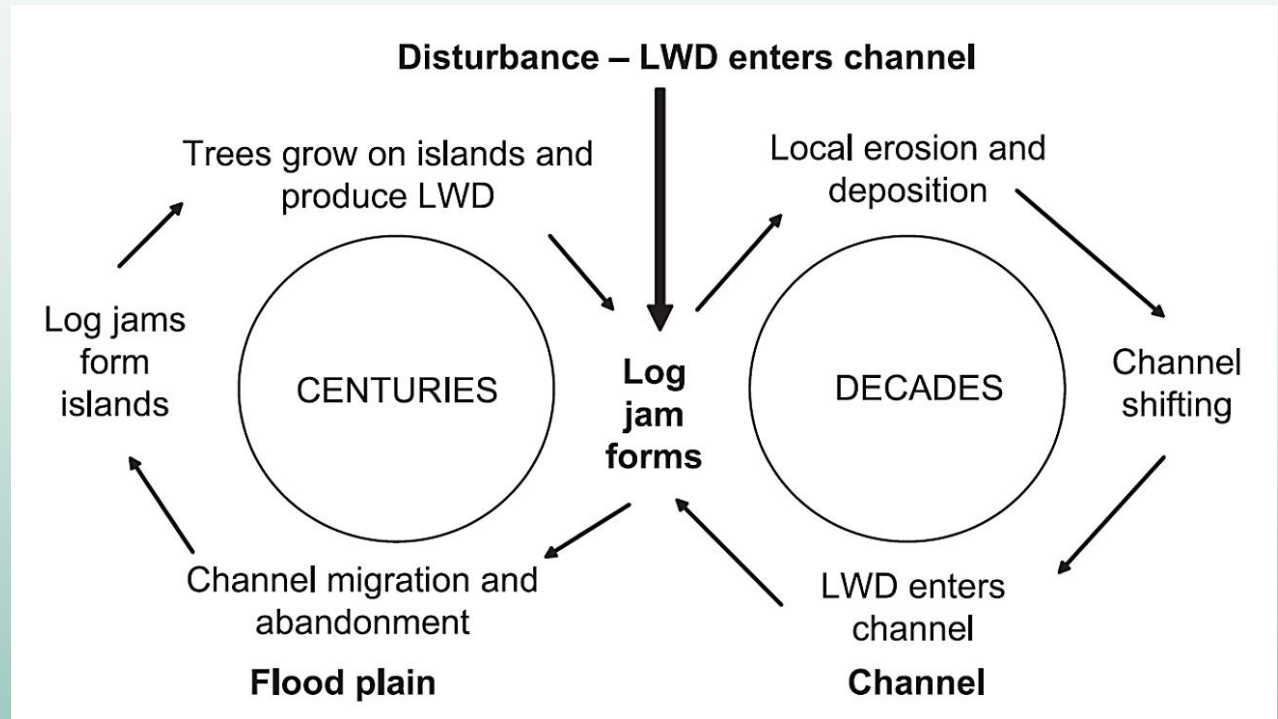
Process → Community

Flood frequency, flooding intensity and sediment supply etc.



Adaption by dispersal, (birth rates) etc.

Community → Landform Feedbacks



- Conceptual model of fluvial biogeomorphology, large woody debris (LWD) and disturbance

Community → Landform Feedbacks



Flooding → Sedimentation → Topography → Vegetation → Sedimentation ...

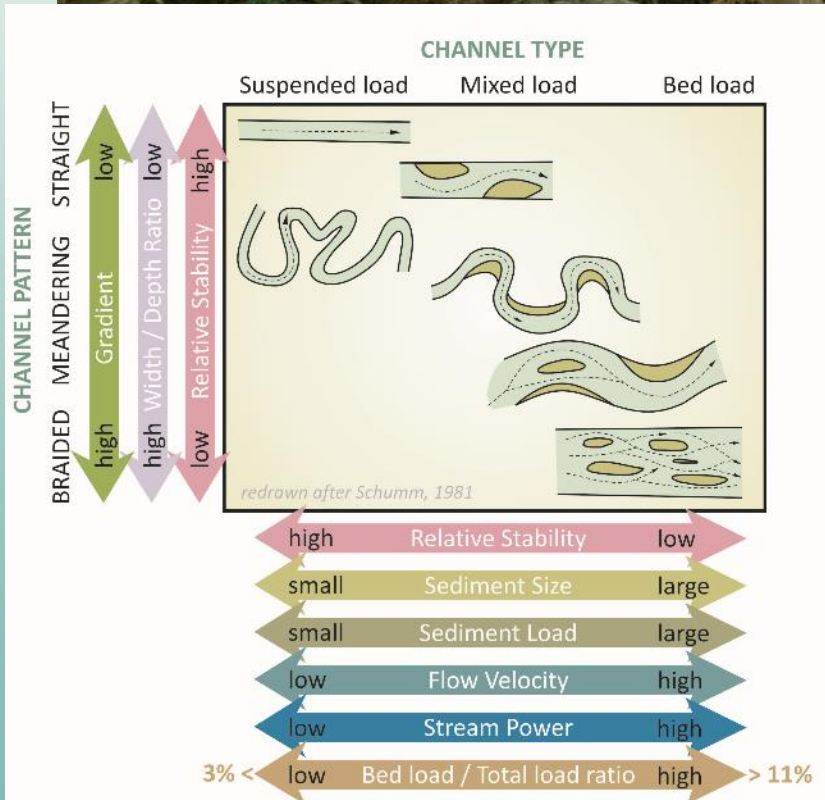
Community → Landform Feedbacks



Braided rivers



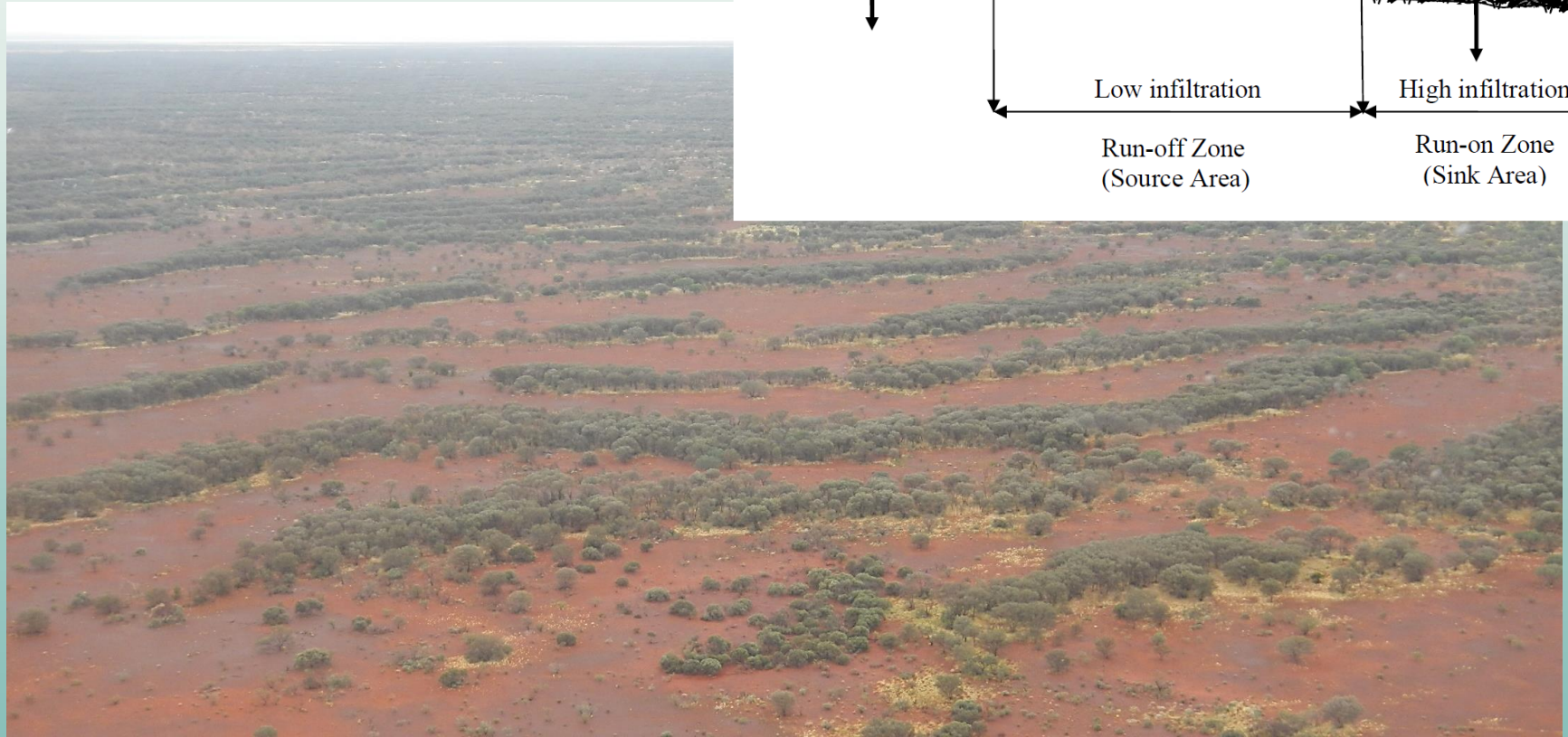
Meandering rivers



- Alluvial channel form - roots and river channel bank stability

Community → Landform Feedbacks

- Banded vegetation patterns



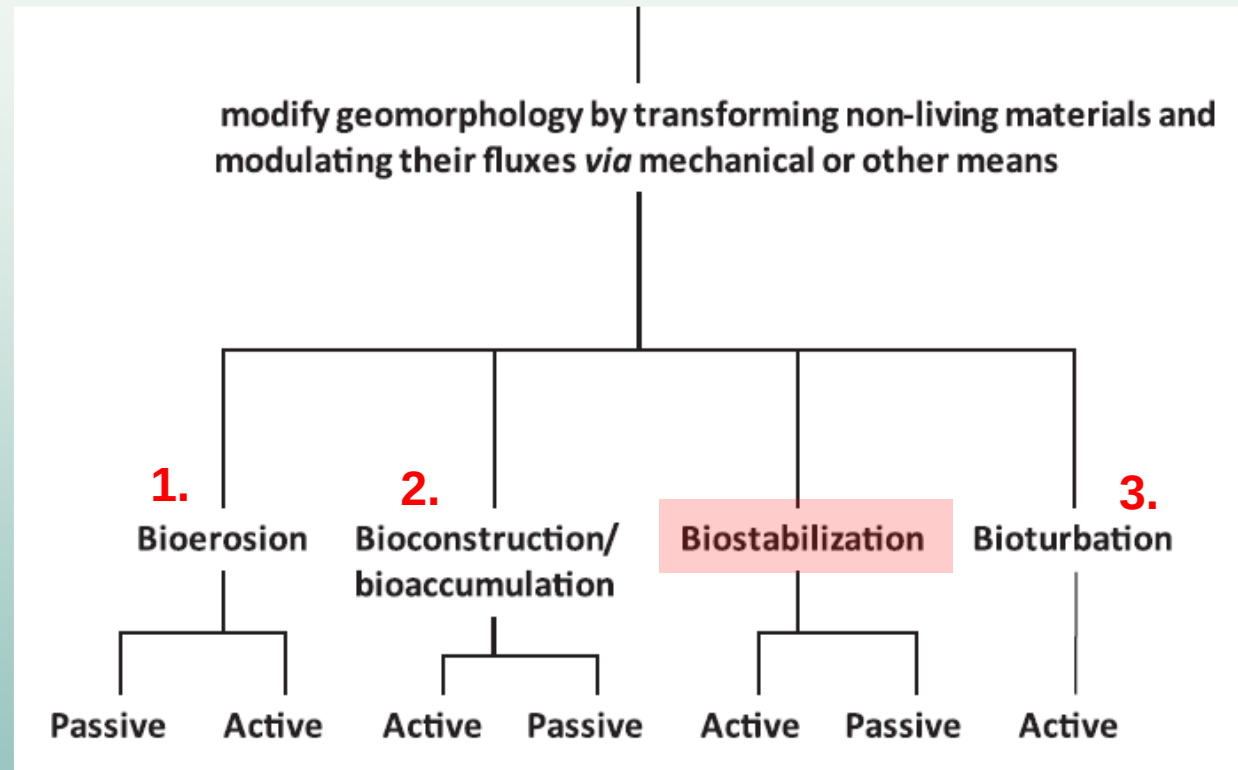
- Influence on flow redistribution (self-organization!!)

3 minutes...



Community → Landform → ...

- Organisms...



- Different types of landform modification – **Biogeomorphology**

Community → 1. Bioerosion

- Organisms as agents of weathering (physical, chemical) and erosion (bioerosion)

Roots
Fungi
Lichen
Bacteria
Clams etc.



Community → 2. Bioconstruction



Community → 2. Bioconstruction...

- e.g. Termites



- Up to $100 \text{ m}^3 \text{ km}^{-2} \text{ yr}^{-1}$ **soil moved...** (mixed)

Community → 3. Bioturbation



Elephant

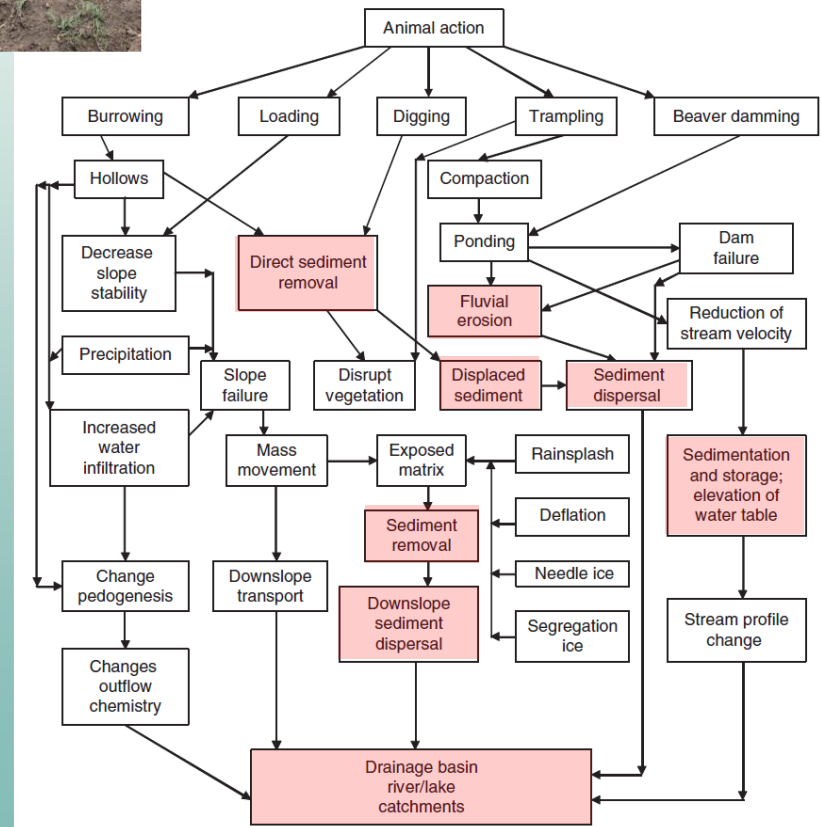


Marmot

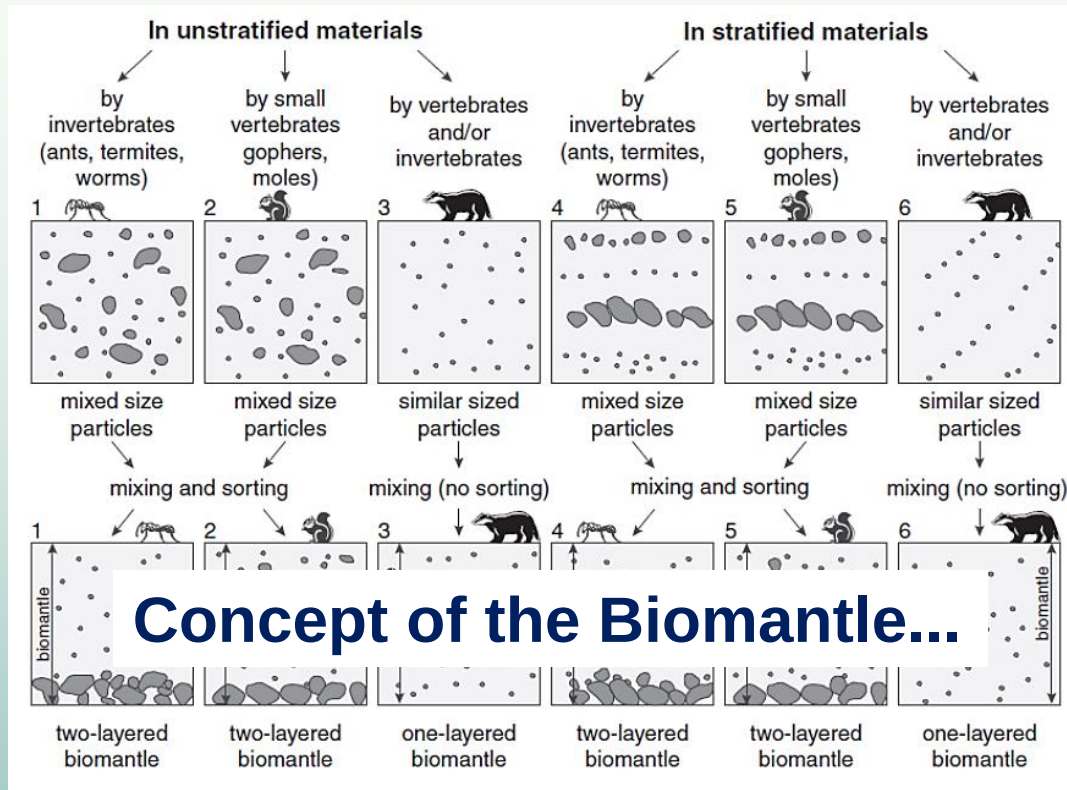


Hippos

- Faunal impact - examples and flow paths of the geomorphic impacts of animals (sediment dynamics!!!)



Community → 3. Bioturbation



- Digging mammals can shift around 1.8-3.6 t of soil per kg of body mass in a year
- Australia: bettongs, potoroos, bilbies, bandicoots, echidnas
- Improves soil health by turnover and mixing organic matter (nutrients)
- Breaks through hard soils
- Improves water infiltration which increases soil moisture
- Spreads important mycorrhizal fungi across the landscape
- Reduces the amount of combustible plant material within a landscape, possibly altering fire regimes

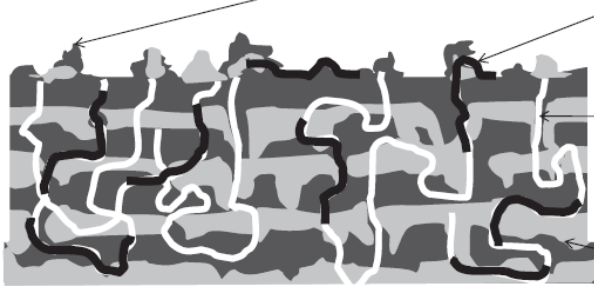


Community → 3. Bioturbation



← Stratified sediments (**abiotic**)

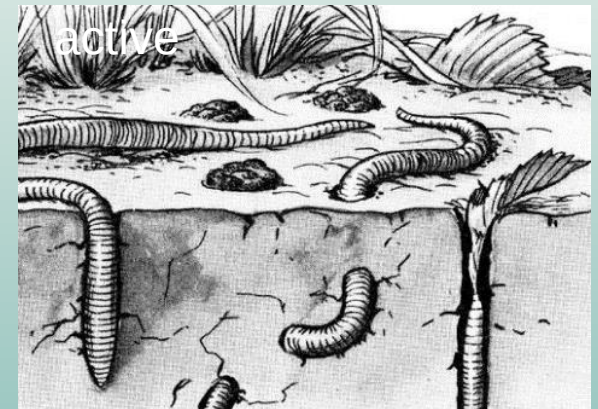
Mound (**residual** for earthworm / **functional** for other species)



Earthworm

Gallery (**functional** for earthworm)

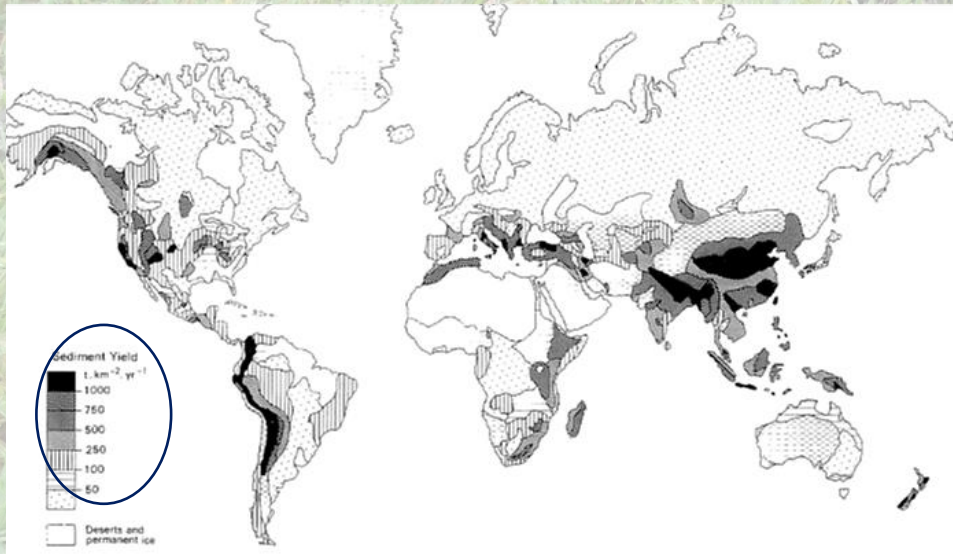
Mixed soil (**residual** for earthworms / **functional** for other species)



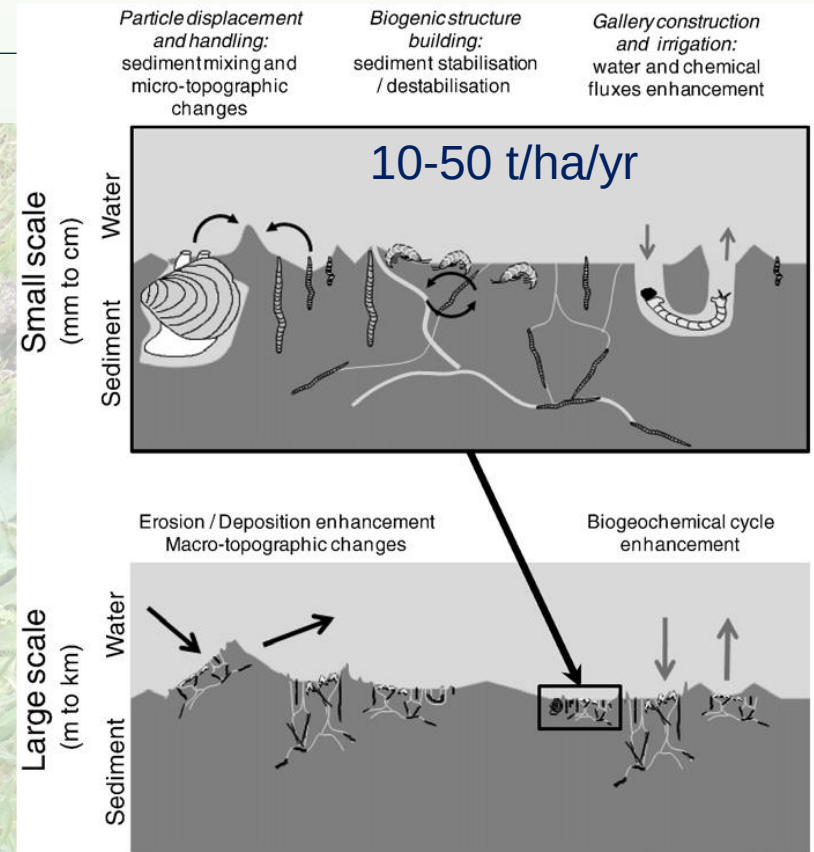
- Example of the effects associated to earthworms:
- Create **residual** (surface mounds and mixed soil) and **functional** (galleries) landform components
- Functions and traits – Natural selection !

Global effects...

- Global denudation... 0.5 – 10 t/ha/yr

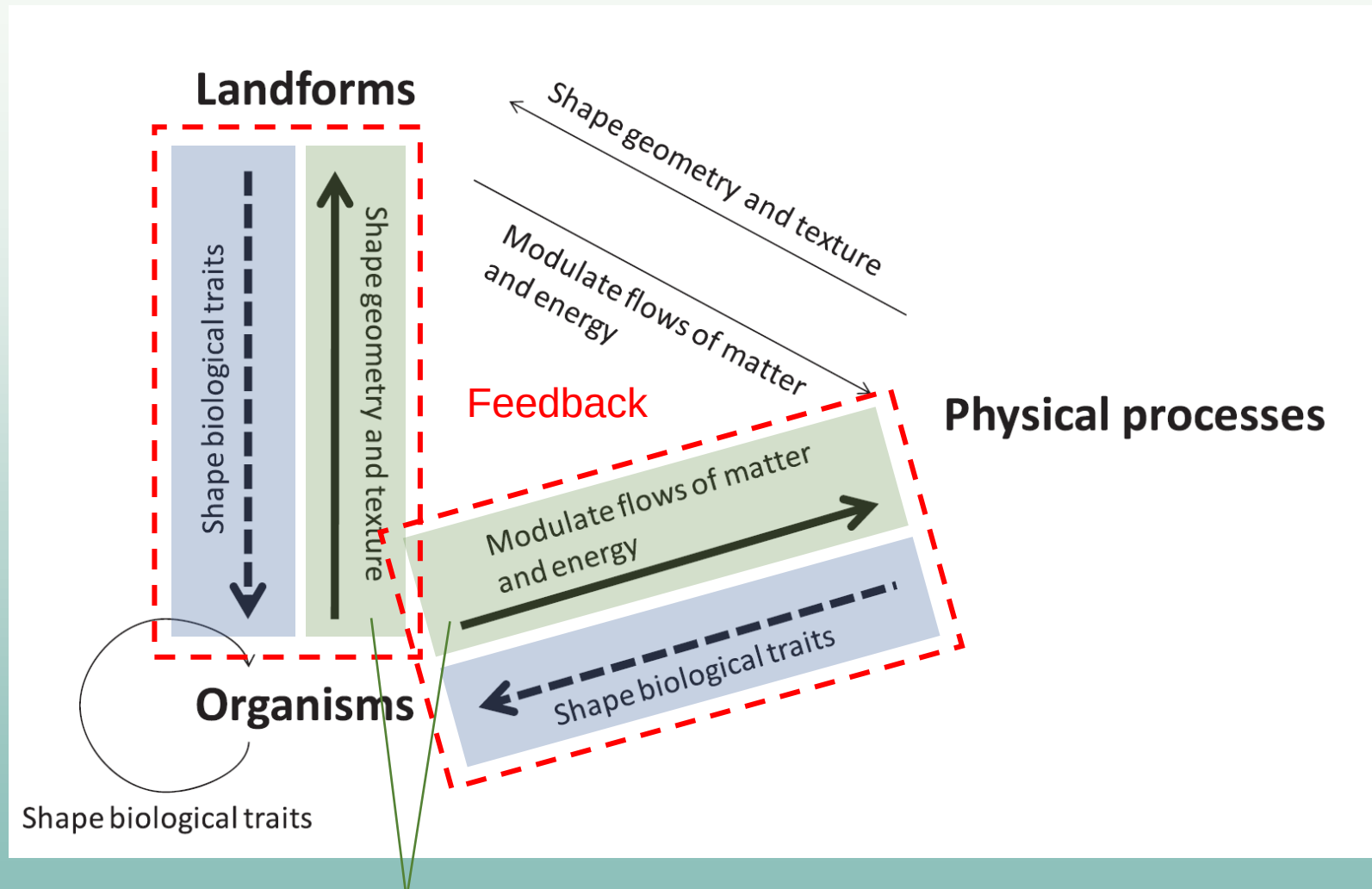


“Worms have played a more important part in the history of the world than most persons would at first suppose.... In many parts of England a weight of more than ten tons (10,516 kg) of dry earth annually passes through their bodies and is brought to the surface on each acre of land” (Darwin, 1881: 308)



“The powers of the organic creation in modifying the form and structure of the earth’s crust are most conspicuously displayed in the labours of the coral animals. We may compare the operation of these zoophytes in the ocean to the effects produced on a smaller scale upon the land by the plants which generate peat” (Lyell, 1875: 587)

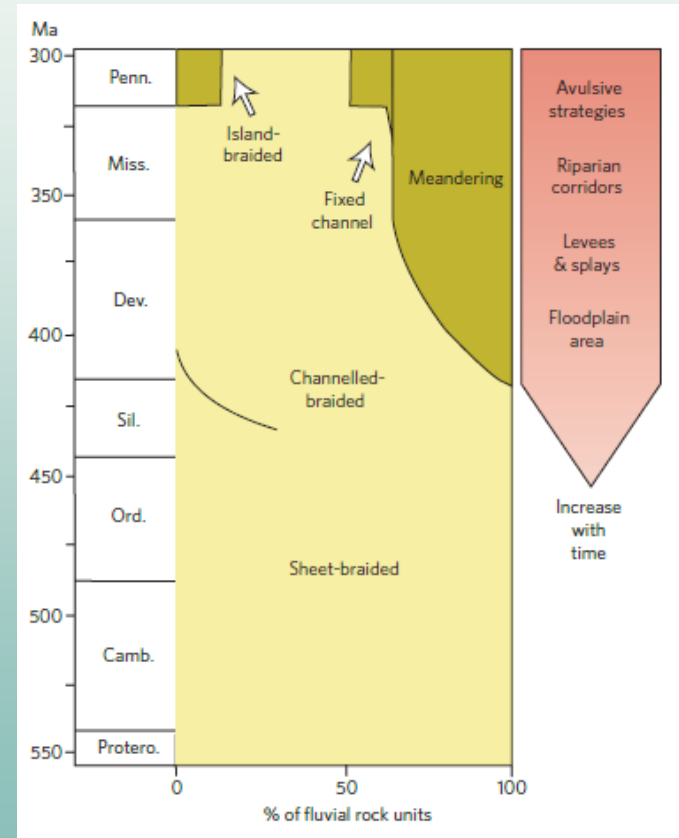
Community – Landform Feedbacks



- **Geomorphic-Engineer species** and Biogeomorphology

Implications 1 - Biogeomorphology

- If there are significant feedbacks between organisms and physical processes...
- and organisms have a strong control on landforms and landscape evolution processes, then...
- **what does that mean for the long term (geological) history of our planet?**



- Colonization of land plants = emergence of meandering rivers

Implications 2 - Biogeomorphology

- If there are significant feedbacks between organisms and physical processes...
- and organisms have a strong control on landforms and landscape evolution processes, then...
- **Maybe we should apply evolutionary perspectives and concepts to understand the evolution of Earth's surface...?**

Earth Surface Processes and Landforms

Earth Surf. Process. Landforms **32**, 2070–2073 (2007)

Published online 31 May 2007 in Wiley InterScience

(www.interscience.wiley.com) **DOI:** 10.1002/esp.1536



ESEX Commentary

Darwinian origin of landforms

Dov Corenblit,^{1*} Johannes Steiger,² Angela Gurnell³ and Eric Tabacchi¹

Summary - Biogeomorphology

1. In the presence of **engineer species**, which modify sediment and landform dynamics, **natural selection** operating at the scale of organisms may have consequences for the physical components of ecosystems, and particularly **Earth surface processes** and landforms
2. In return, these modifications of geomorphologic processes and landforms often feed back to the **ecological characteristics** of the ecosystem (structure and function) and thus to biological characteristics of engineer species and/or other species (**adaptation and speciation**)



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Feedbacks between geomorphology and biota controlling Earth surface processes and landforms: A review of foundation concepts and current understandings

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