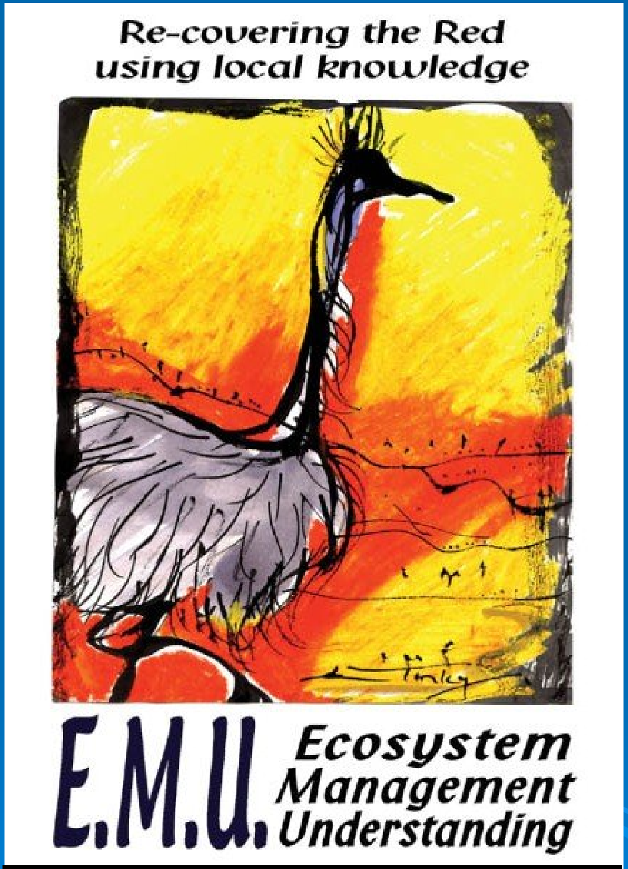
Rangelands as catchment ecosystems

- **Hugh Pringle**

Ecosystem Management Understanding (EMU) Project



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Acknowledgements

- Polytechnic of Namibia, especially Ibo Zimmerman
- Auas Oanob Conservancy
- Dr Ken Tinley
- Farmers in Africa and Australia

Background work for this approach

- Dr Ken Tinley's >40 yrs in southern Africa and Australia, especially:
  - Gorongoza, Londolozi, Namibia, Okavango, Natal Parks
  - EMU in Australia 2000 to present; WA, SA, NT
- Dr Hugh Pringle >20yrs mostly in Australia, but also Karoo and Namibia

Presentation structure

- Brief comment on development of range ecology
- Landscape Function Analysis
- Catchment Ecosystem Dynamics
  - Some key concepts
  - Illustrative examples in catchment context

.....

- Repairing catchment ecosystems
- Implications for monitoring (Australian context)

Traditional, climax-based assessment of rangelands:

- Plant Succession Theory was adapted by range ecologists, first in USA
- Mono-climax and allied approaches
  - ecologically unrealistic
    - promoted exaggerated views of retrogressive reversal
  - overlooked land succession processes

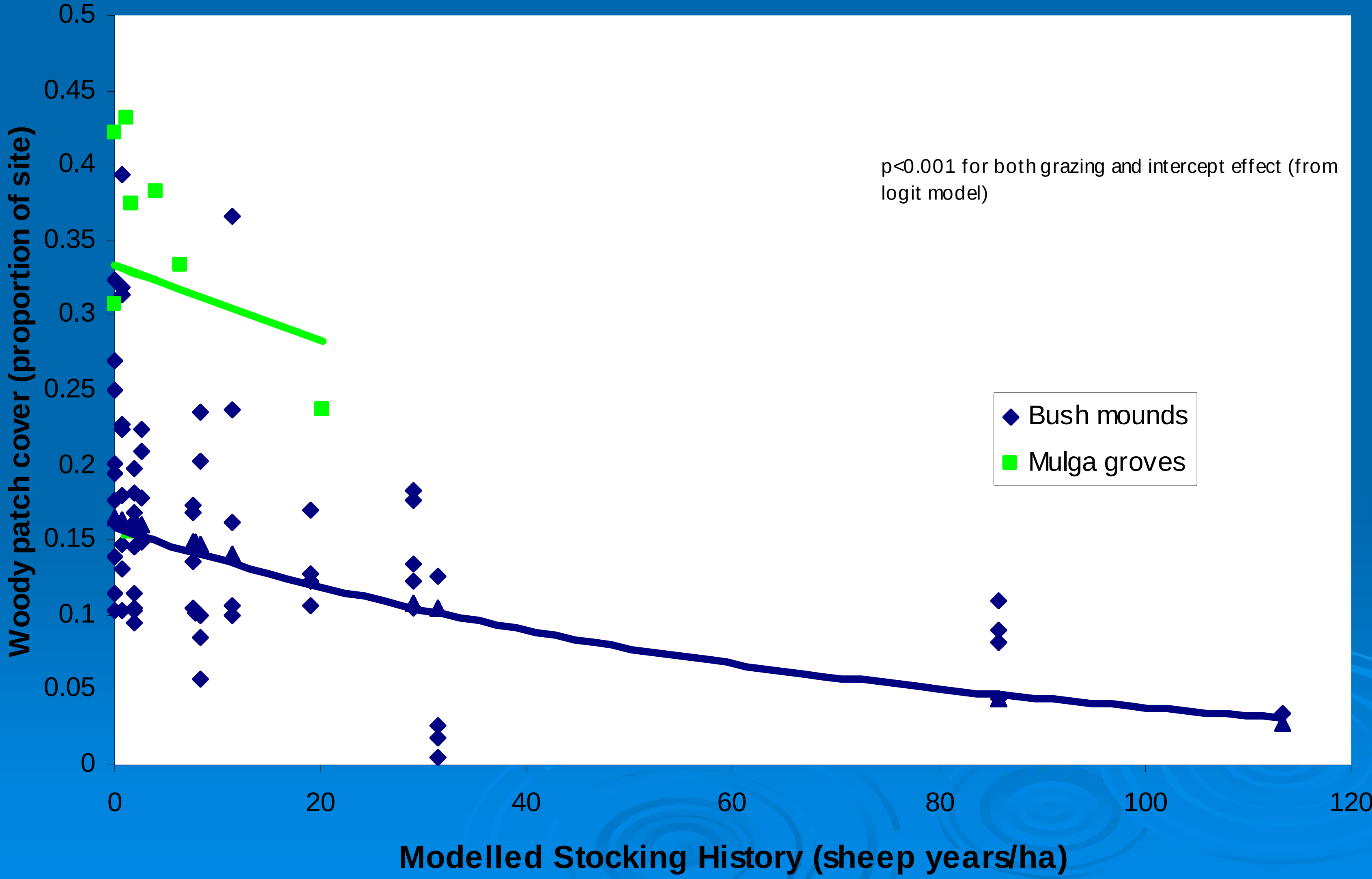
- S&T models

Landscape Function Analysis: Leaky landscapes concept

- **John Ludwig and Dave Tongway's work**
- **Within landscape changes in patch distribution and quality occurring over large areas**
  - **Fertile (source) patches decline in size and functioning under grazing**
  - **As the landscape becomes leaky**
  - **Causing major changes in vegetation and downward spiral through positive feedbacks**

Landscape Function Analysis in the north-eastern Goldfields of Western Australia (my PhD work)

Figure 7.2 Impacts of Stocking History on woody patches (with fitted trend-lines)



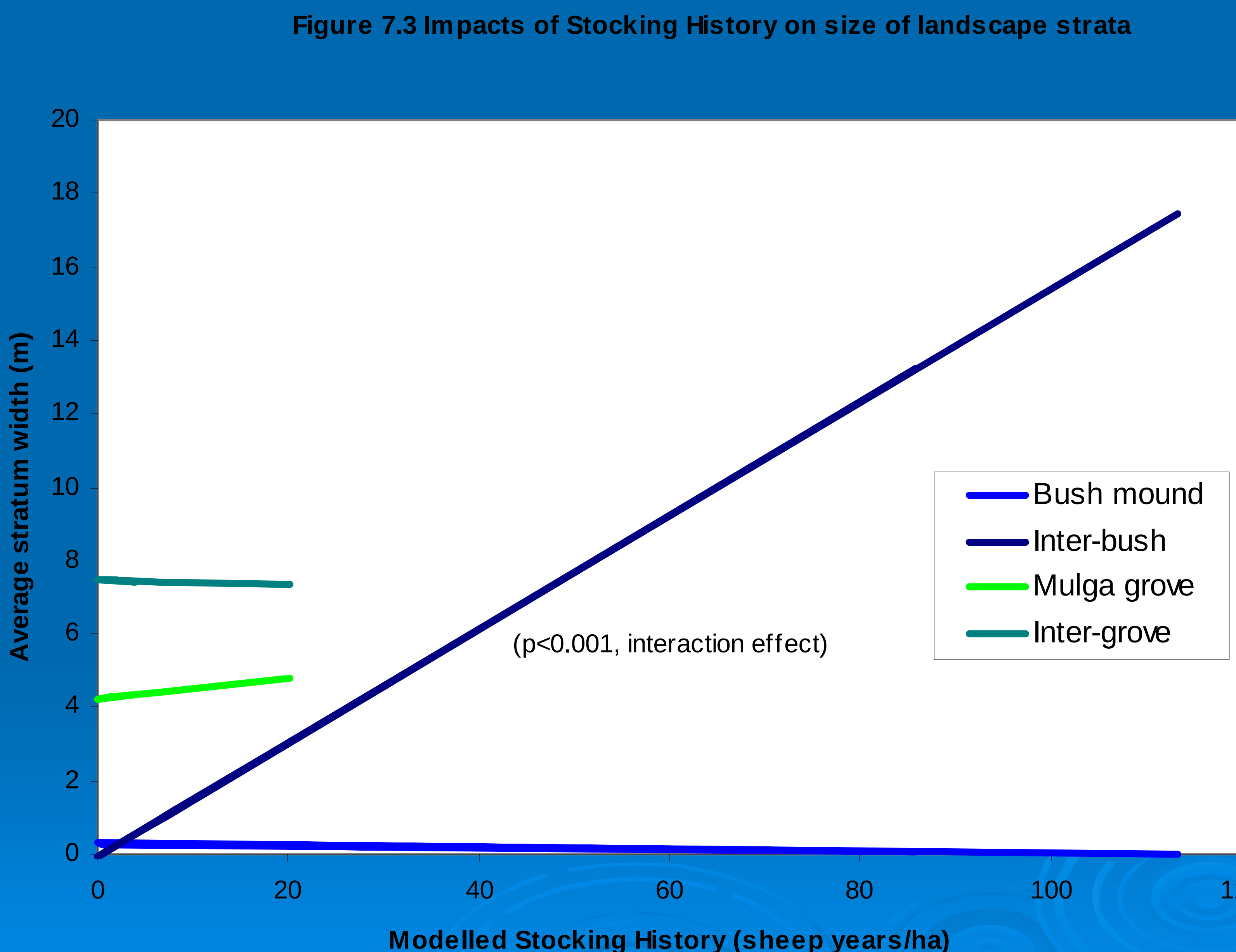
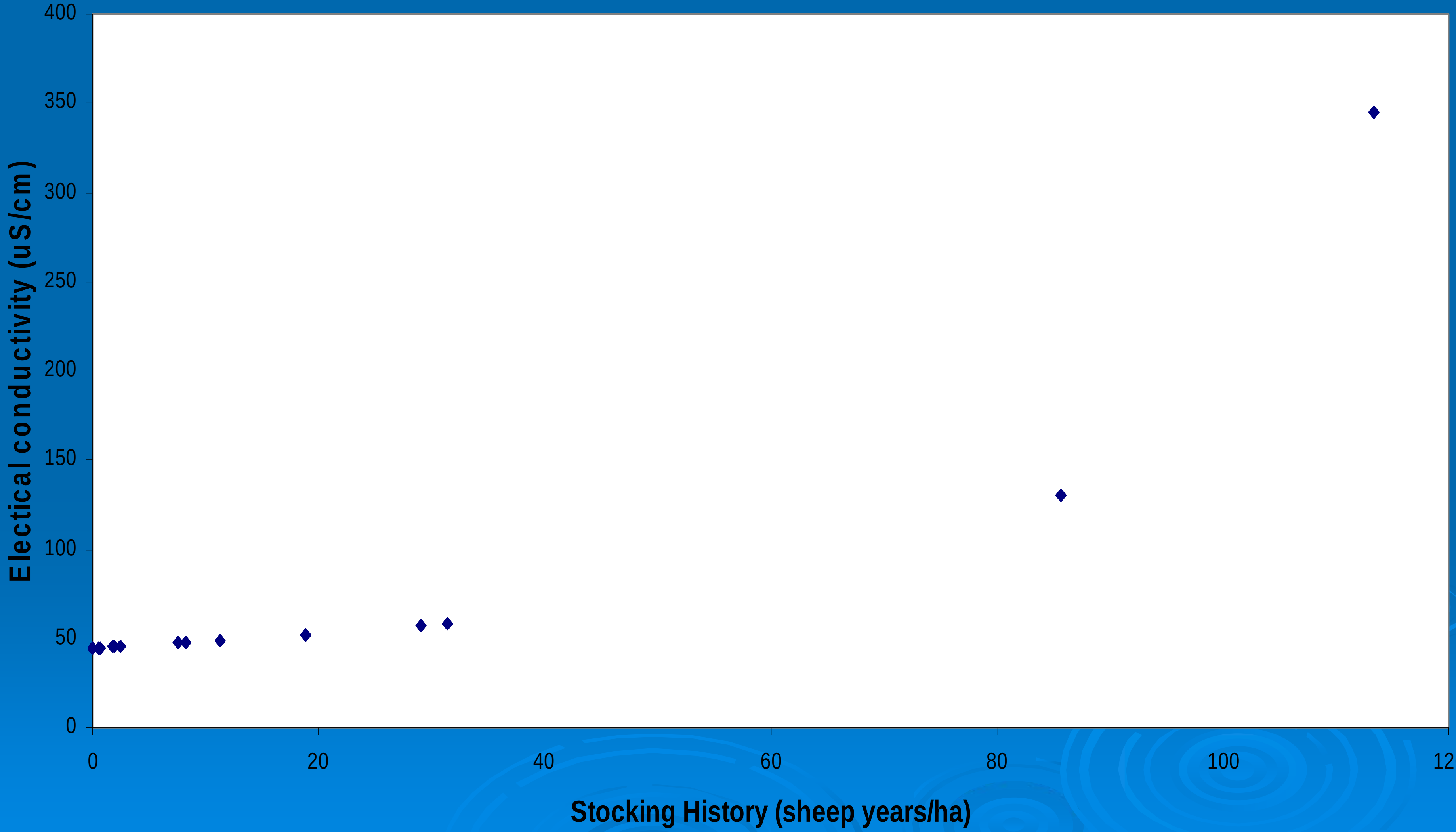


Figure 7.3 Impacts of Stocking History on size of landscape strata
Average stratum width (m)
0
2
4
6
8
10
12
14
16
18
20
Modelled Stocking History (sheep years/ha)
0
20
40
60
80
100
120
(p<0.001, interaction effect)
Bush mound
Inter-bush
Mulga grove
Inter-grove

Effect of Stocking History (SH) on topsoil salinity in inter-bush areas of chenopod landscapes (values shown are fitted)



Seems obvious???

- More grazing….less cover…a spiral towards "leakiness" and desiccation???
- As exemplified by increased lacunarity
- So…restore cover and decrease leakiness and lacunarity (open spaces)?????

LEAKINESS IS OCCURRING AT **MULTIPLE LEVELS**, SEVERAL OF WHICH ARE BEYOND LFA'S *WITHIN*-LANDSCAPE FOCUS

(and the SRM "ecological site" framework)

The most productive depositional features, from upland dambos to river floodplains are becoming <u>dehydrated</u> by HEADWARD, CASCADING LANDSCAPE INCISION

causing

declining SOIL MOISTURE BALANCES (SMB)

DEHYDRATION MAY OCCUR LOCALLY (eg loss of ground cover)

BUT IT IS ACCELERATED GREATLY WHEN CONTROLLING ***BASE LEVELS*** ARE ***INCISED***

Base levels

- Hierarchical levels that set drainage gradients and the ease with which water travels (escapes) down the catchment
- Depositional or erosional
- Primary: sea-levels, endoreic lake systems (Etosha), extensive sandplains with ineffective drainage

Salt lake palaeodrainages

Ineffective sandplain "catchments"

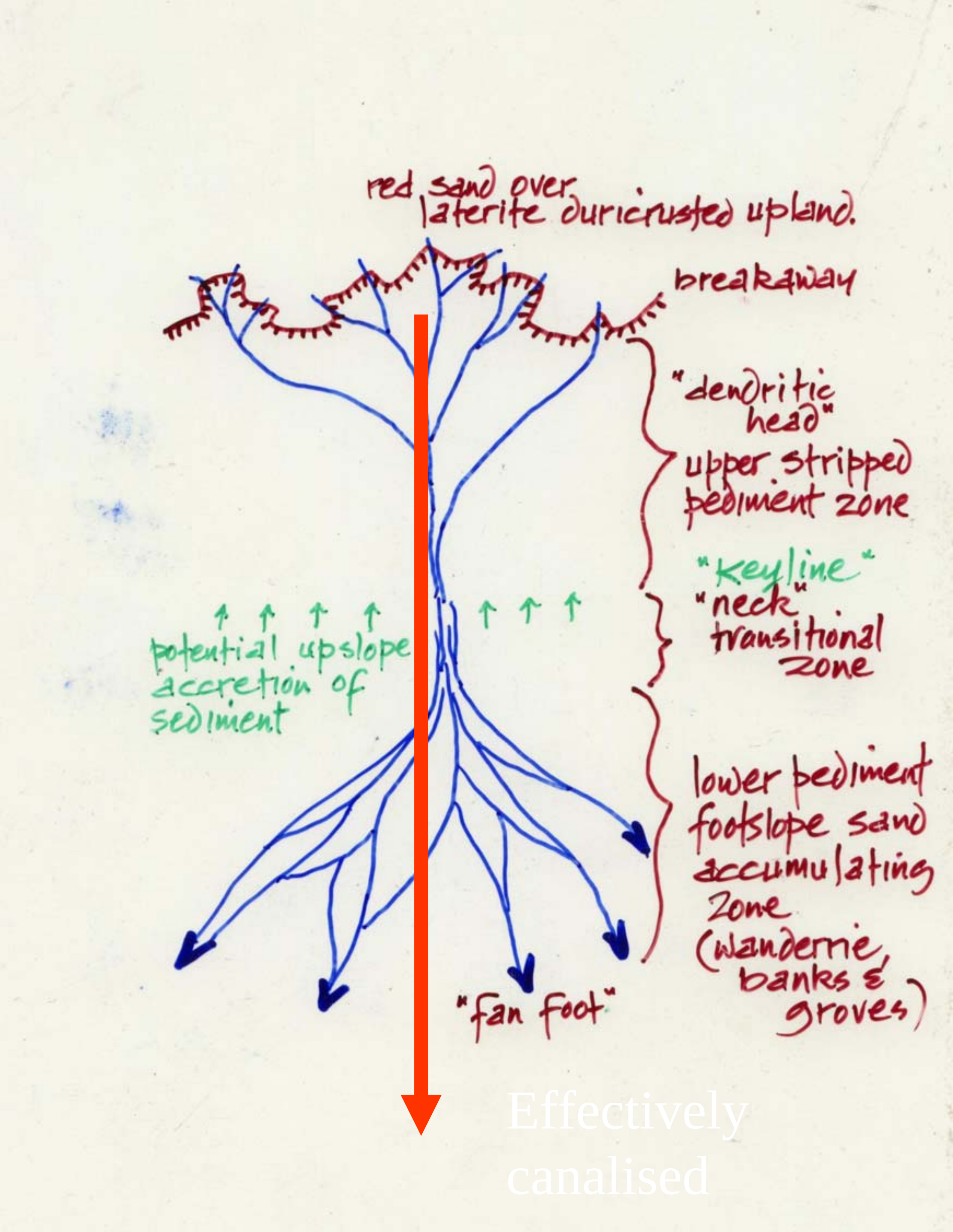
Lower order Base levels

- Secondary: rock bars across major river systems; flood deposits adjacent to salt lakes
- Tertiary sills: levee banks (control leakage of floodwaters back into channels)
- Quaternary base levels: subtle sills of floodplain and other ephemeral wetlands

Key-lines: Tributary and distributary flow

- Natural switch at pediment edge from
  - accelerating, straightening and joining flows
  - to slowing, spreading flows
  - best place to find groundwater (ie place troughs)

- Typical pattern is of incision having progressed through the key-line leading to a canalised drainage system without distributary flow



red sand over laterite duricrusted upland.
breakaway
"dendritic head"
upper stripped pediment zone
"keyline"
"neck" transitional zone
potential upslope accretion of sediment
lower pediment footslope sand accumulating zone (wanderrie, banks & groves)
"fan foot"
Effectively canalised

Soil Moisture Balance (SMB)

- Declining SMBs in space and time, spikier growth patterns
- Bush species released from drowning in seasonally inundated, highly productive bottomlands and dambos
- Succession to few, bush species over complex water-loving grasses, sedges etc
- Biological homogenisation and impoverishment

Recap of key factors

- Hierarchical base levels
- Key-line control points
- Soil Moisture Balances

The Murchison River Catchment

- Through the EMU Process; together we have built a model of landscape dysfunction due to breached base levels and are undertaking a major restoration project for the whole of the tributary Roderick River catchment as a pilot study

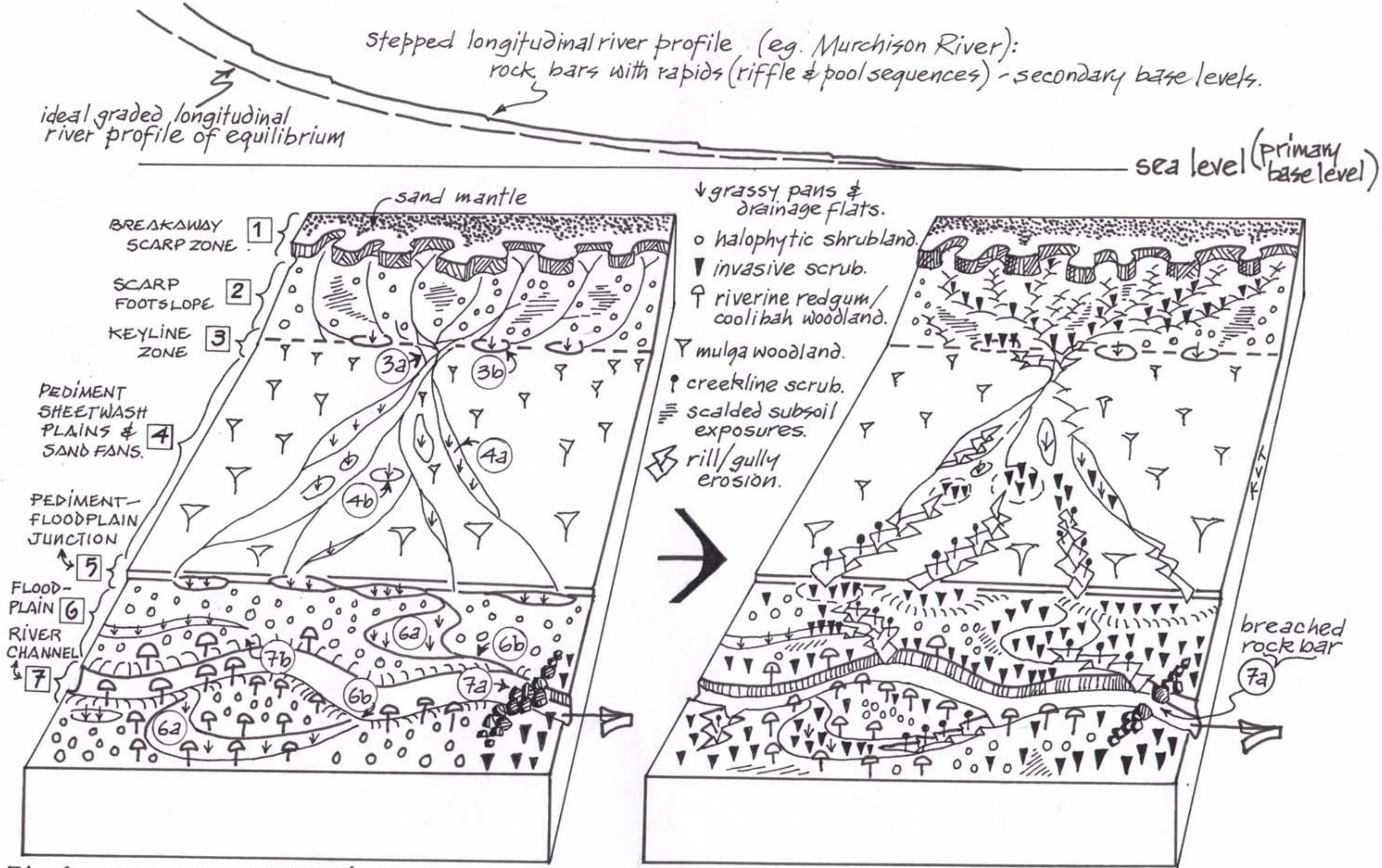
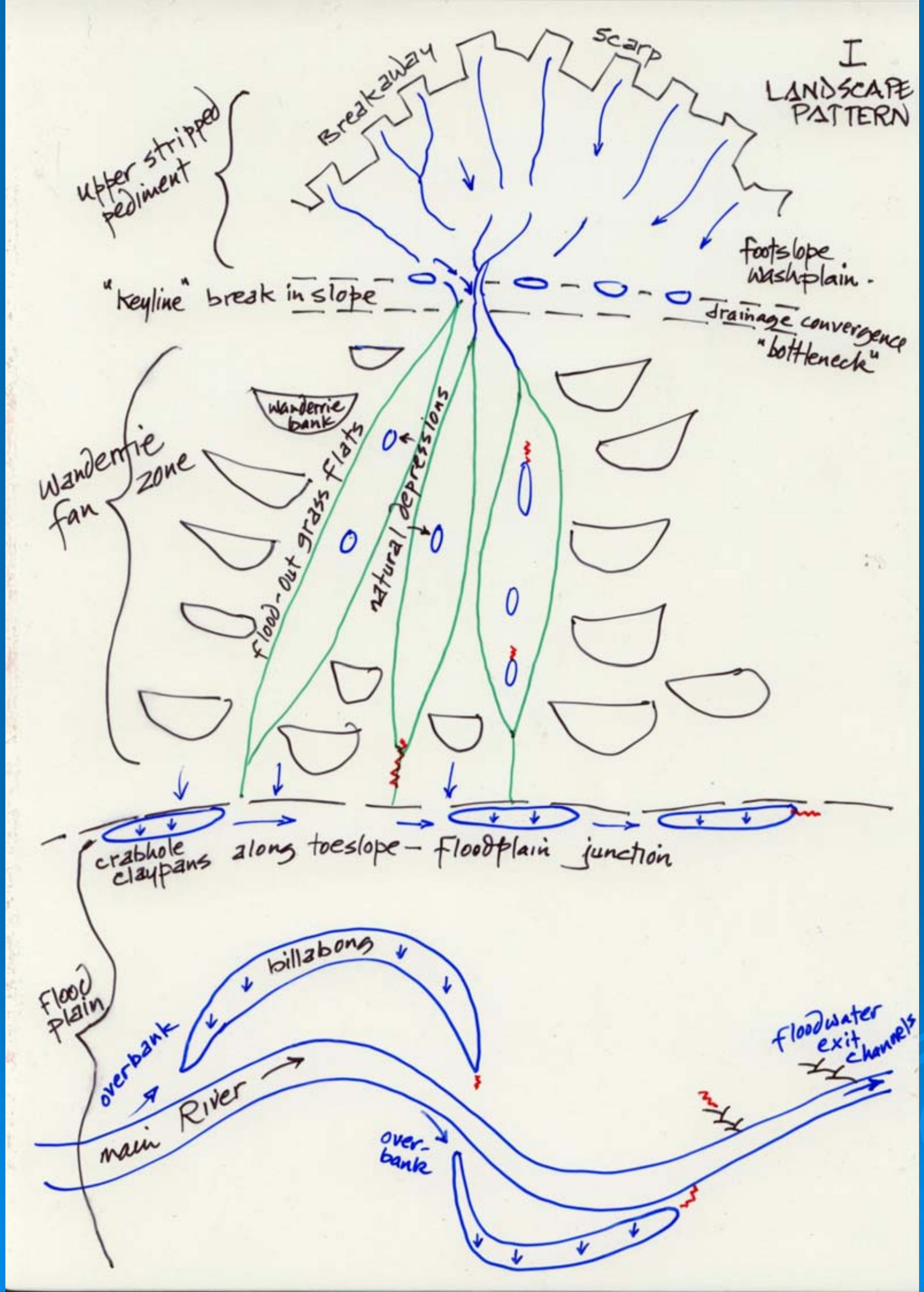


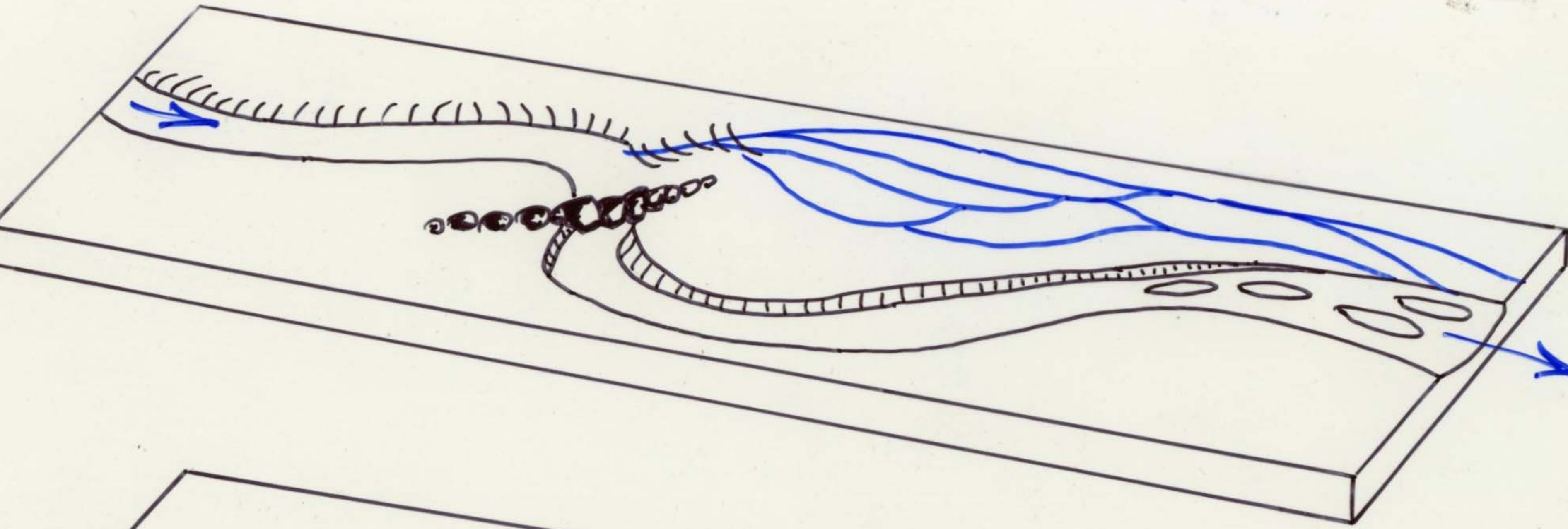
Fig 1. SEGMENT OF MAJOR RIVER & ITS FLOODPLAIN WITH ADJOINING VALLEY-SIDE CATCHMENT.

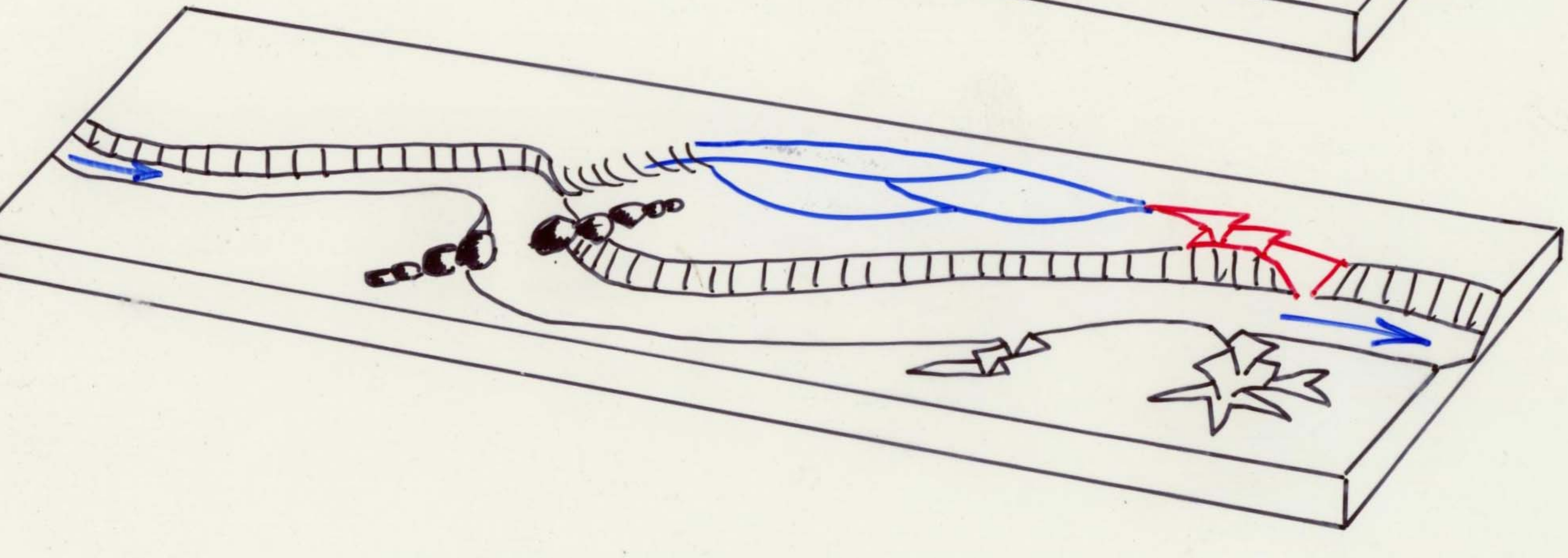
(a) landscape in dynamic equilibrium (minimal erosion). (b) same landscape in active, erosion driven transformation.

Source: Pringle & Tinley 2003, Ecol Mgt & Restn


I
LANDSCAPE PATTERN
Scarp
Breakaway
upper stripped pediment
footslope washplain.
"keyline" break in slope
drainage convergence "bottleneck"
wanderrie bank
wanderrie fan zone
flood-out grass flats
natural depressions
crabhole claypans along toeslope – floodplain junction
Flood plain
billabong
overbank
main River
over-bank
floodwater exit channels

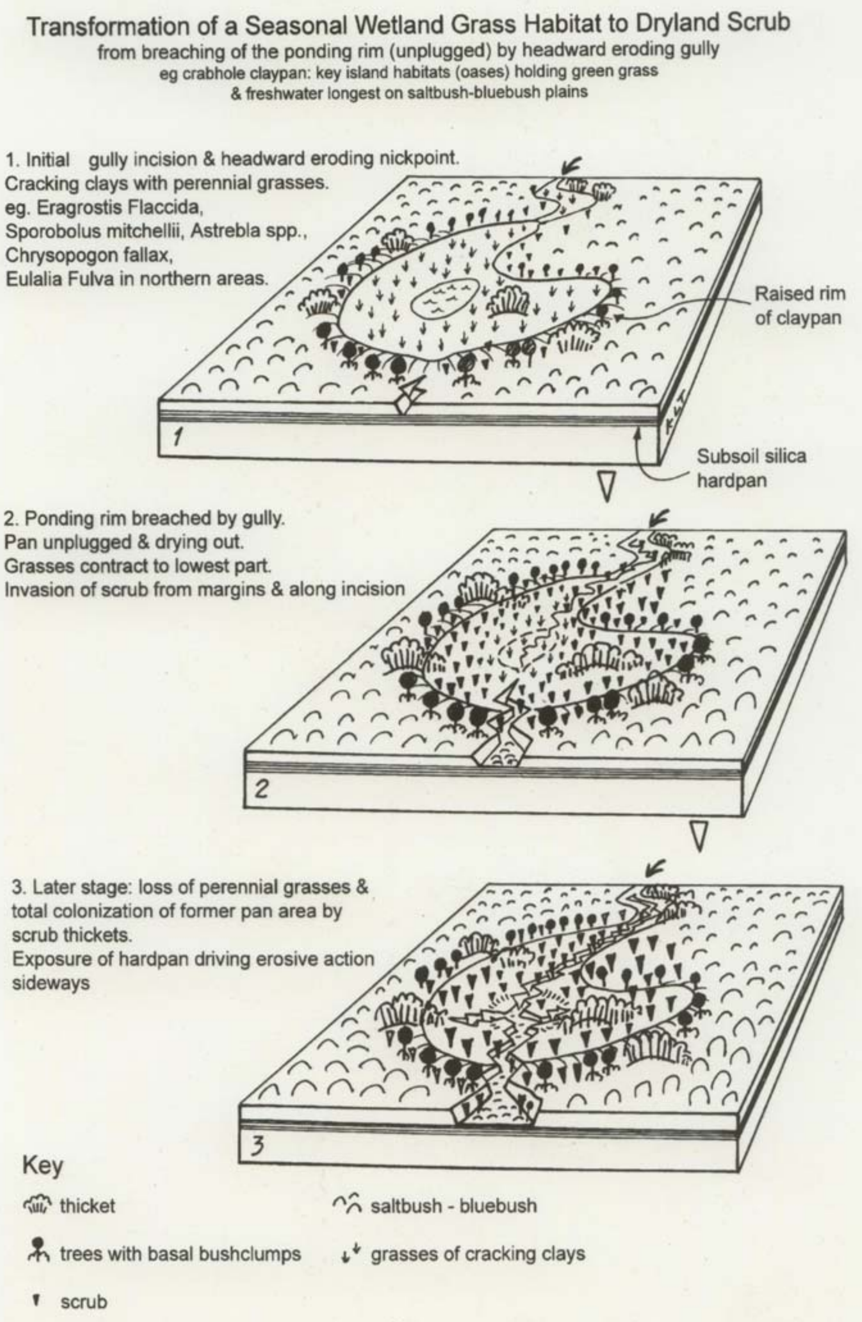
Floodplain perching and incision by breaching of rock bars (2^o base levels)

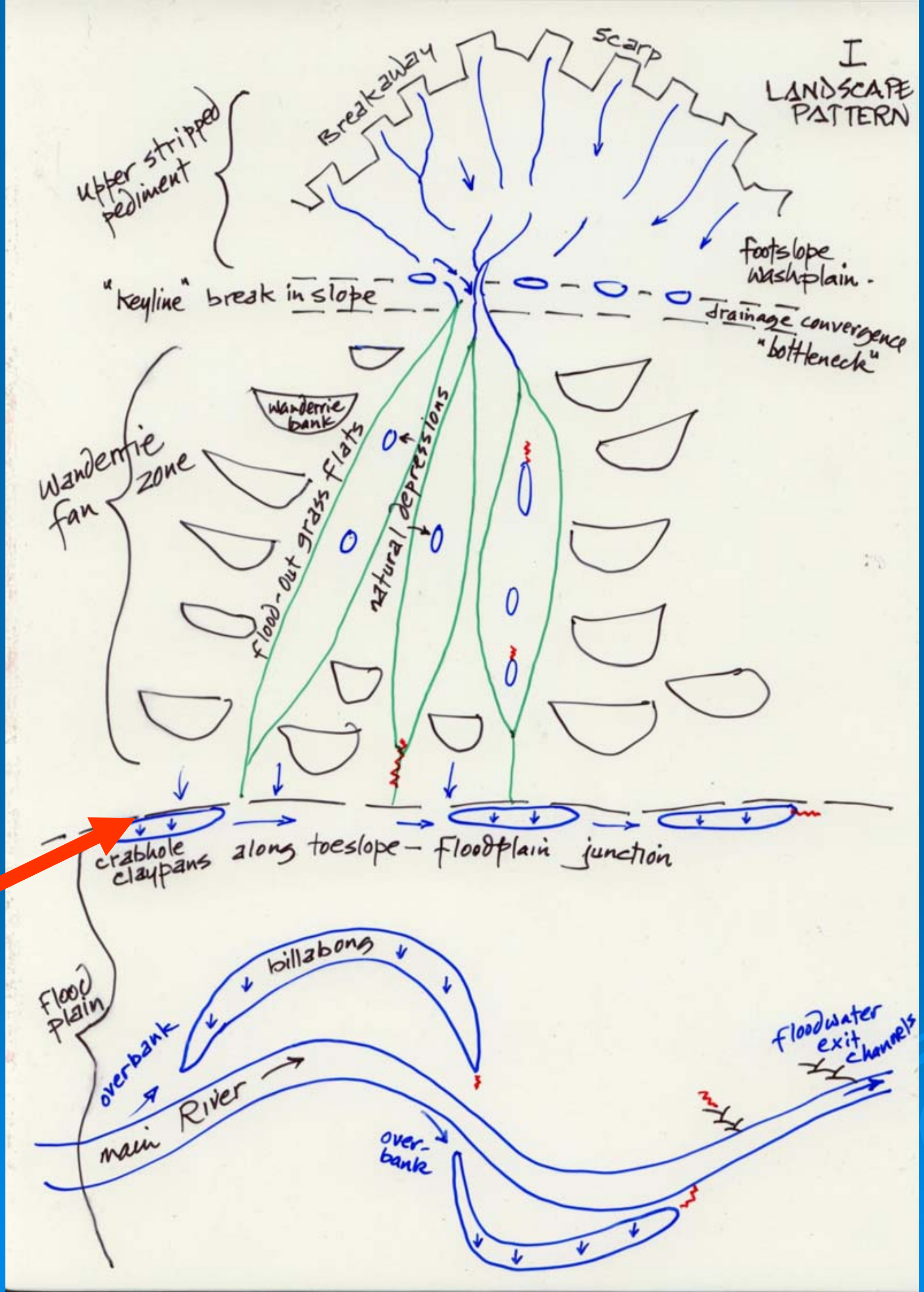




Cascading incisions leading to canalisation

Source: Pringle & Tinley 2003, Ecol Mgt & Restn





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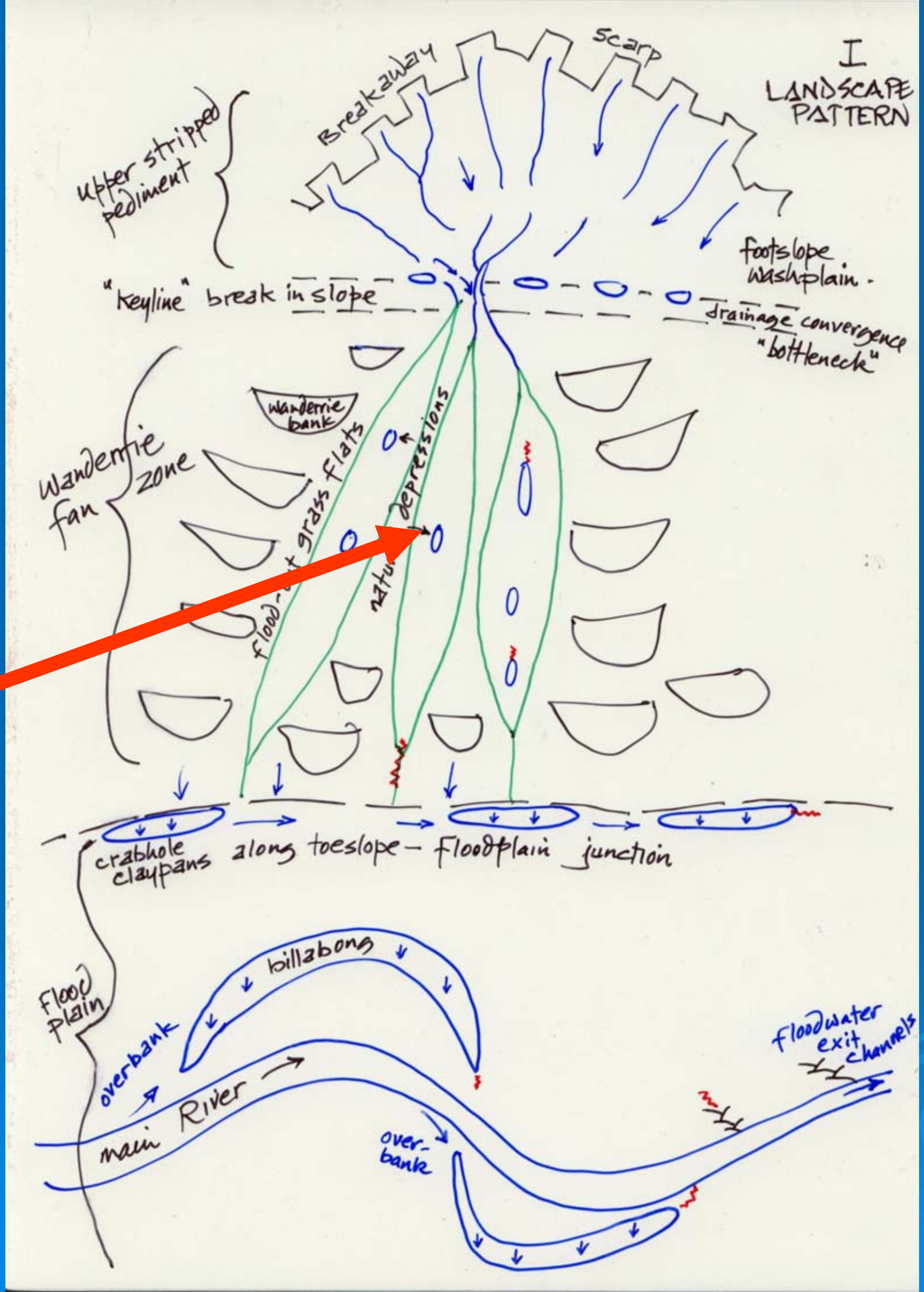

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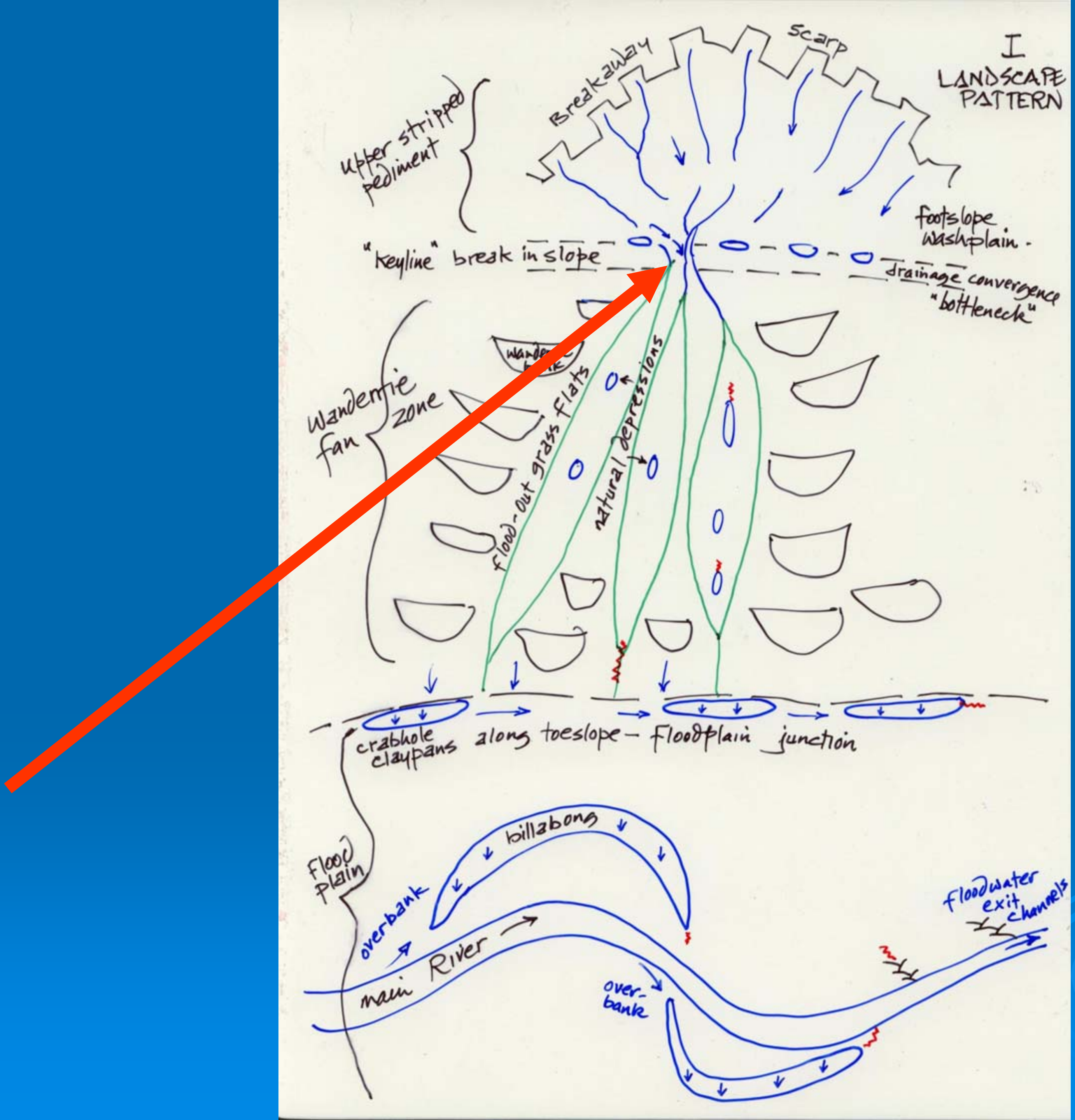

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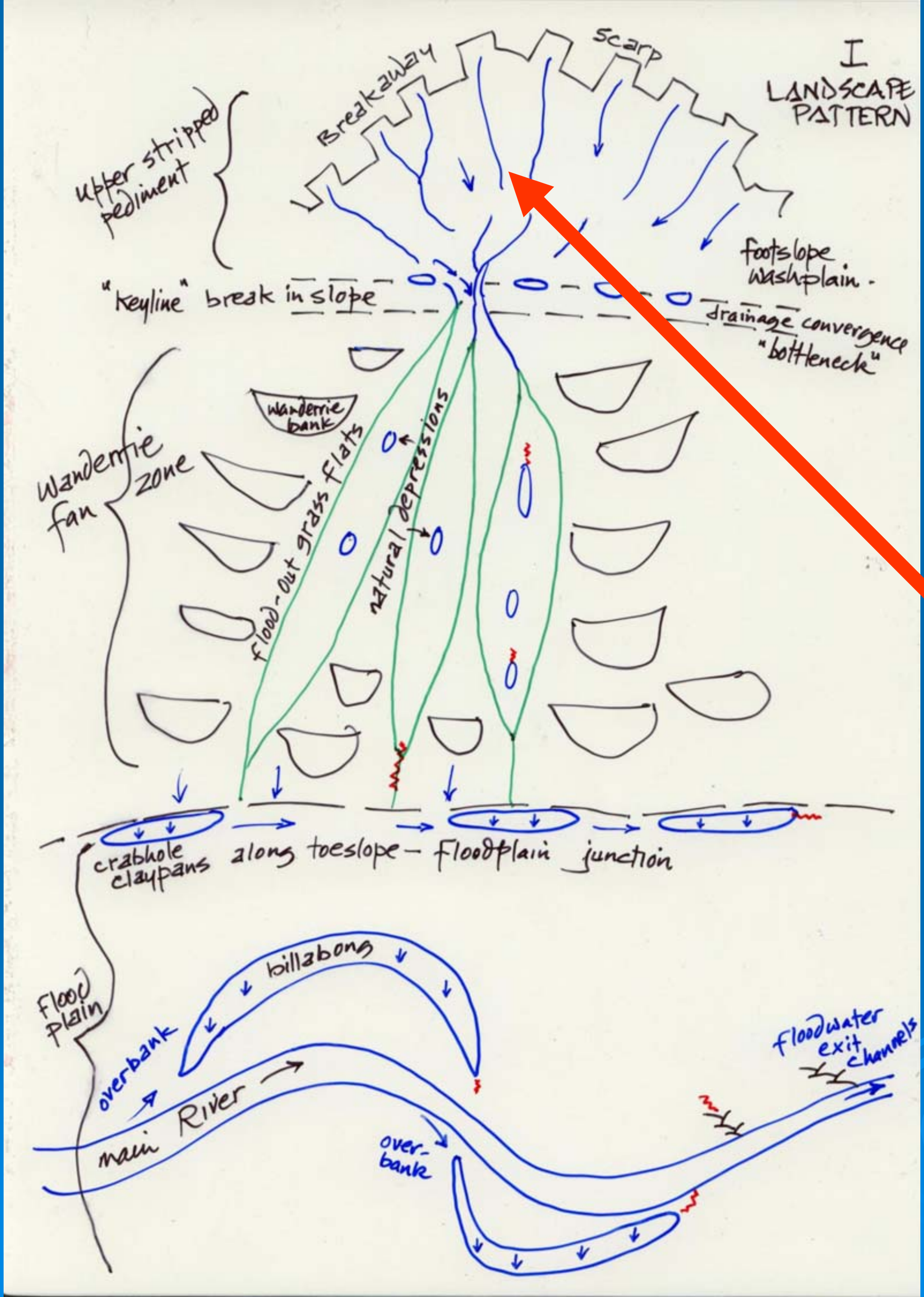
Vio
Vio
Chl
RAM PADDOCK
WELL
Brk
Car
Watering point
near key-line



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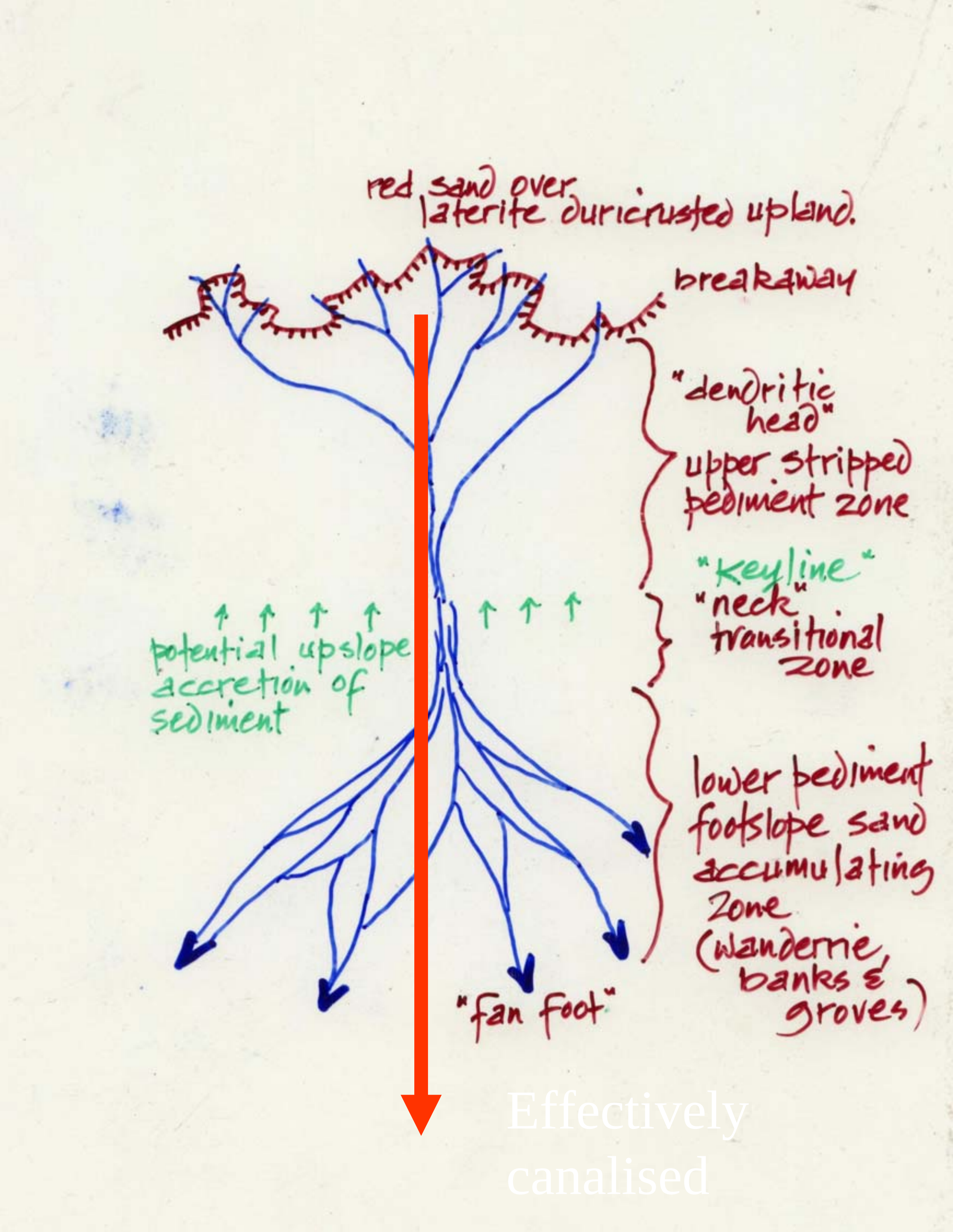


Effectively canalised

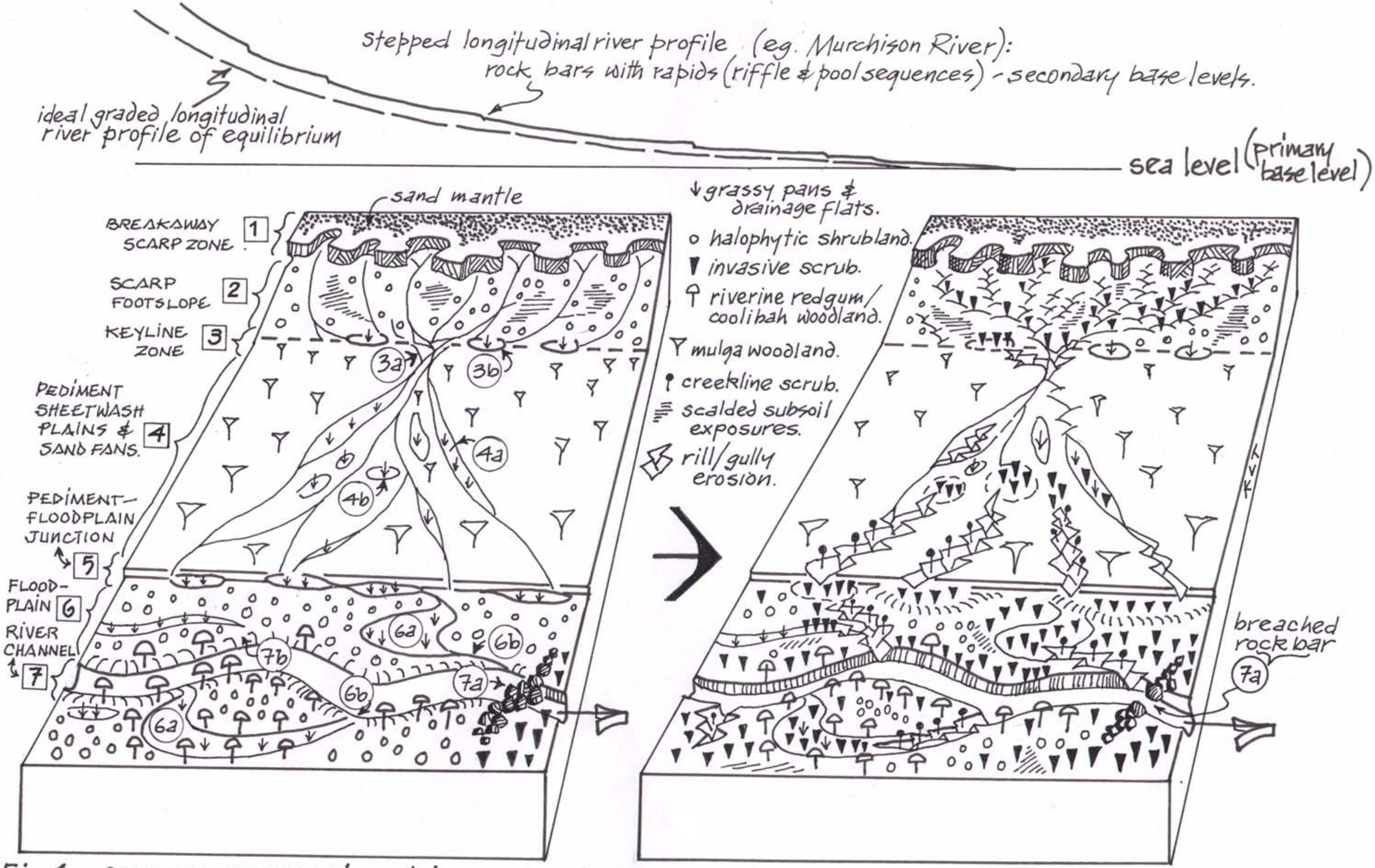


Fig 1. SEGMENT OF MAJOR RIVER & ITS FLOODPLAIN WITH ADJOINING VALLEY-SIDE CATCHMENT.

ⓐ landscape in dynamic equilibrium (minimal erosion). ⓑ same landscape in active, erosion driven transformation.

Inexorable rangeland dehydration:

- Incision of higher order base levels
- Incision through key-lines
- Canalisation and loss of distributary drainage
- Cascading accelerated soil erosion towards new equilibria
- Massive lignification and loss of critical local wetlands (& biodiversity values)

Bush encroachment

of *seasonally inundated* catchment process elements is driven primarily by cascading incision processes that alter SMB and seedlings are no longer drowned

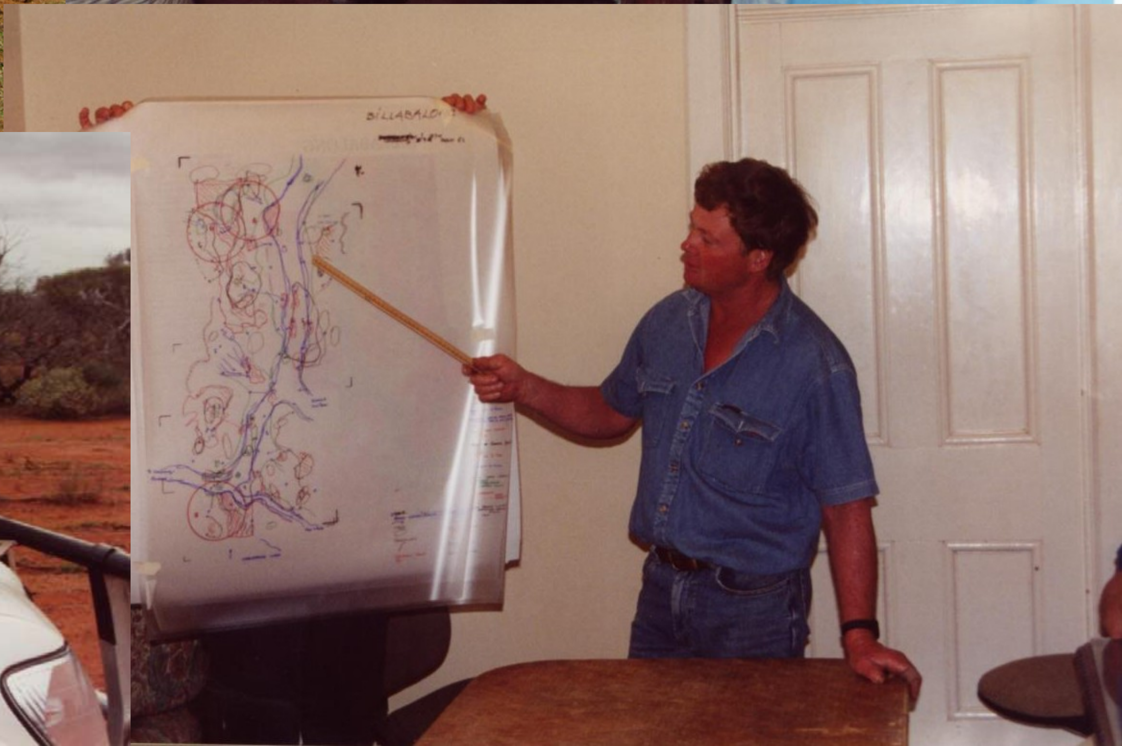
Next:

- Repairing dehydrating catchments and their key, inter-linked components
- Monitoring rangelands as hierarchical, complex catchment-ecosystems

Fundamentals for catchment repair

- What are the primary causes?
- Where are the critical control points - CCPs- (base-levels, key-lines)
  - Are any CCPs under urgent threat and need reinforcement immediately?
  - What needs to be done up-slope (calming at tributary confluences) to enable effective restoration of CCPs?
  - What needs to be done downslope (eg headward gully insions)



Putting the plug back in the bath

- Incised catchments…like running a bath without the plug in.

- Maintaining ground cover is not enough ….and is more difficult in unplugged landscapes

- **Rain use efficiency**: the plug in and fine patterning of resource control

- Local and **multi-property (catchment)** issue

Gascoyne Headwaters Restoration Project

- Pastoralist, Mining company, Local Aboriginal community, EMU Team
- Gullies destroying grassy floodplains and wetlands (Cattle pads)

“Rakes” across rock bars higher in the catchment

Then down to stabilise the gully heads eating floodplain

And now fencing off the floodplains and introducing rest-based grazing

Work completed recently

- Numerous new sets of rake filters, 3 rows, 1m apart to calm flow onto floodplain
- Banks to return water to swamp and out of track creek back into the river

….but that's just in arid Australia!!!!

- Ord River catchment across to Mt Isa, down to Ethabuka and Craven Peak Reserves
- Todd River’s Emily Plain at Alice Springs
- From Namibia through to Mozambique, the Karoo in South Africa
- New Mexico to California (e.g. Cooke and Reeve)

It’s a **global** rangeland phenomenon

Londolozi gulley repair 1980s

- Base-level incision
- Headward gully erosion
- Lateral sheeting

- Dehydration, impoverishment and homogenisation

Key parts of catchments and landscapes are disintegrating

Illius and O'Connor say these are critical equlibrial landscape components in Africa

But why isn't this an issue?......

LIMITED INTELLIGENCE !!!!!!

Limited intelligence….

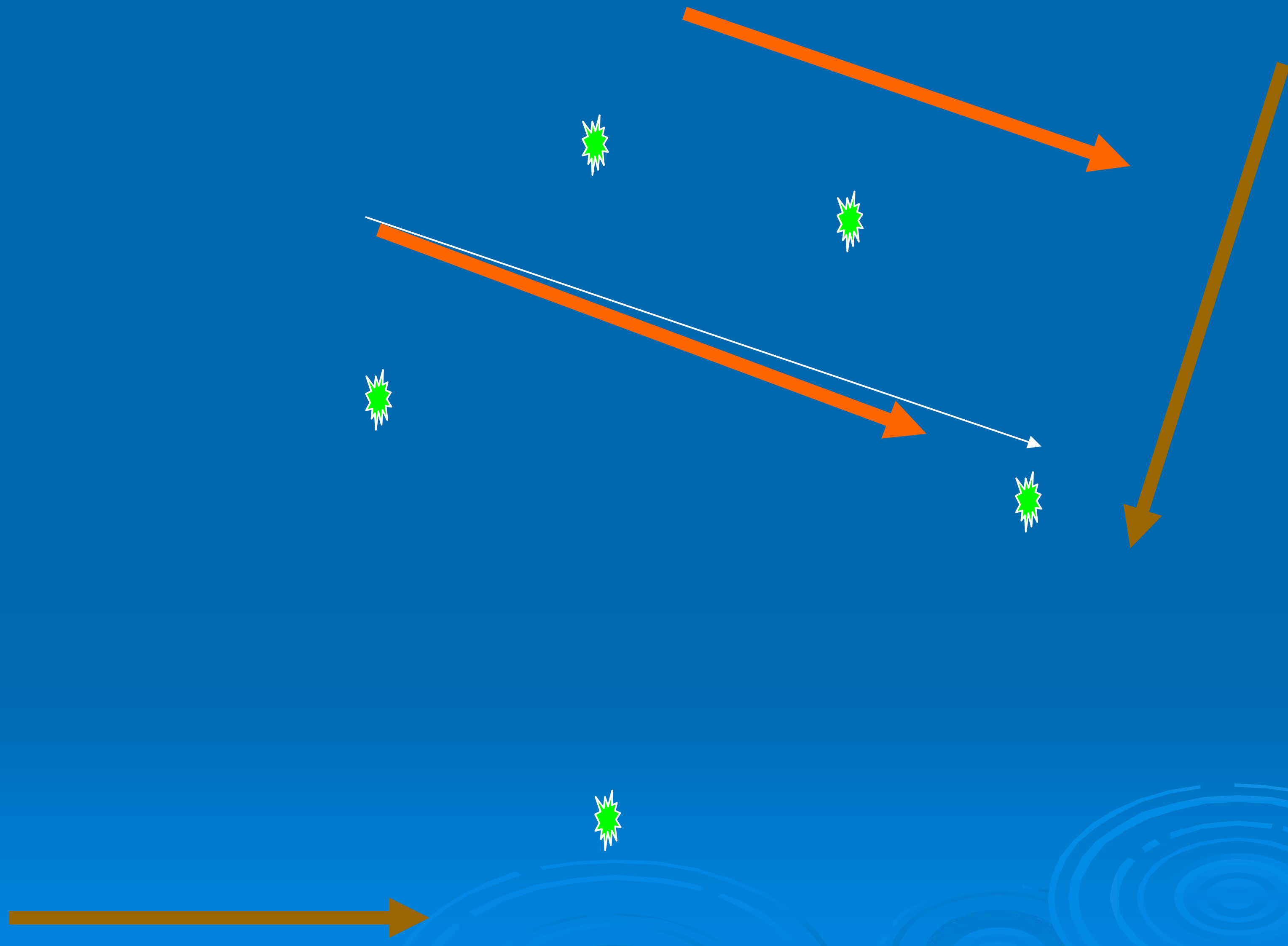
- Monitoring the *big toe nail* instead of the *pulse*

- Using "old" ecology and sometimes new technology…same paradigm, more coverage

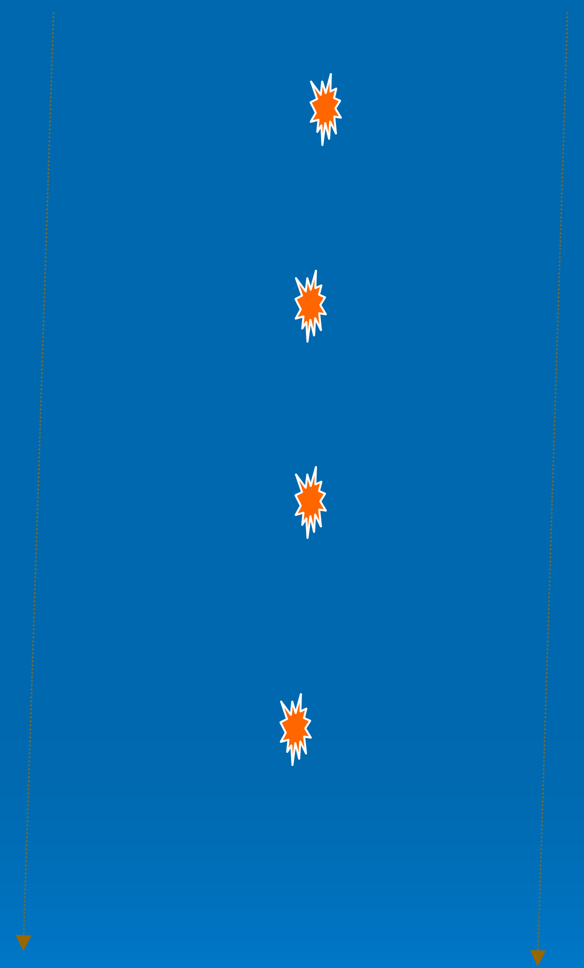
- Scale issues addressed….but not ***hierarchical ecological organisation***

Monitoring big toe nails

From Pringle et al. (2006) Landscape Ecology



Land system and it's local alleys



monitoring site (typically)

From Pringle et al. (2006) Landscape Ecology

Q1: Are WARMS sites representative of areas of more concentrated flow

- Not by productivity or importance at a catchment scale and not at all at a land system scale:
  - 2 of 10 sites in the catchment alley, but both in calm parts
  - 10 of 10 sites *outside* the local alley

So, ditch monitoring sites?

Absolutely not, sparse sites representing most extensive landscape types

BUT COMPLIMENT IT WITH *INTELLIGENT* REMOTE SENSING

Without remote sensing we will continue to have little understanding of the ‘health’ of our rangelands as complex, valued ecosystems

Remote sensing and hierarchical patch dynamics

- Use remote sensing to test hypotheses
- Be led by ecological insights of salient patterns and processes interacting between levels of ecosystem organisation
- Map the landscape and catchment scale succession processes

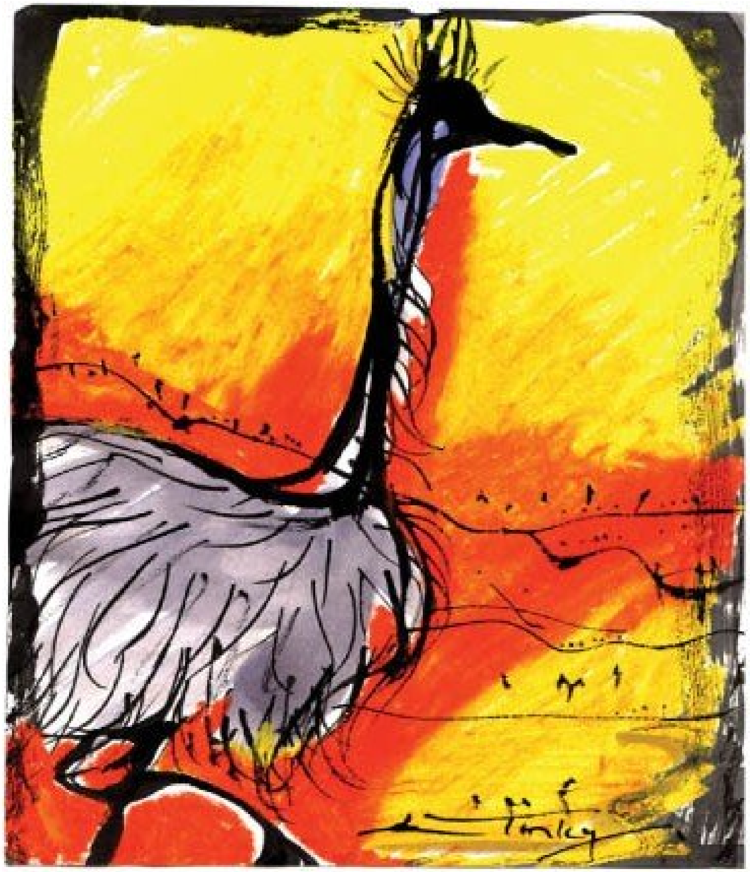
(Pringle, Watson & Tinley 2006; Landscape Ecology)

Two contrasting paradigms

- The current “flat earth” model
  - **Rangelands as mosaics of veld types**
  - **That are independent ecological units**
  - **And should be managed (and monitored) accordingly**

- **Hierarchical catchment-ecosytstems**
  - **Levels of ecological organisation**
  - **Highly interactive across and between levels**
  - **Systems, holistic management (and monitoring)**

Re-covering the Red
using local knowledge



E.M.U. Ecosystem Management Understanding

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A project of the WA Rangelands NRM Co-ordinating Group, supported by the National Hertitage Trust

Let’s halt desiccation and homogenisation!