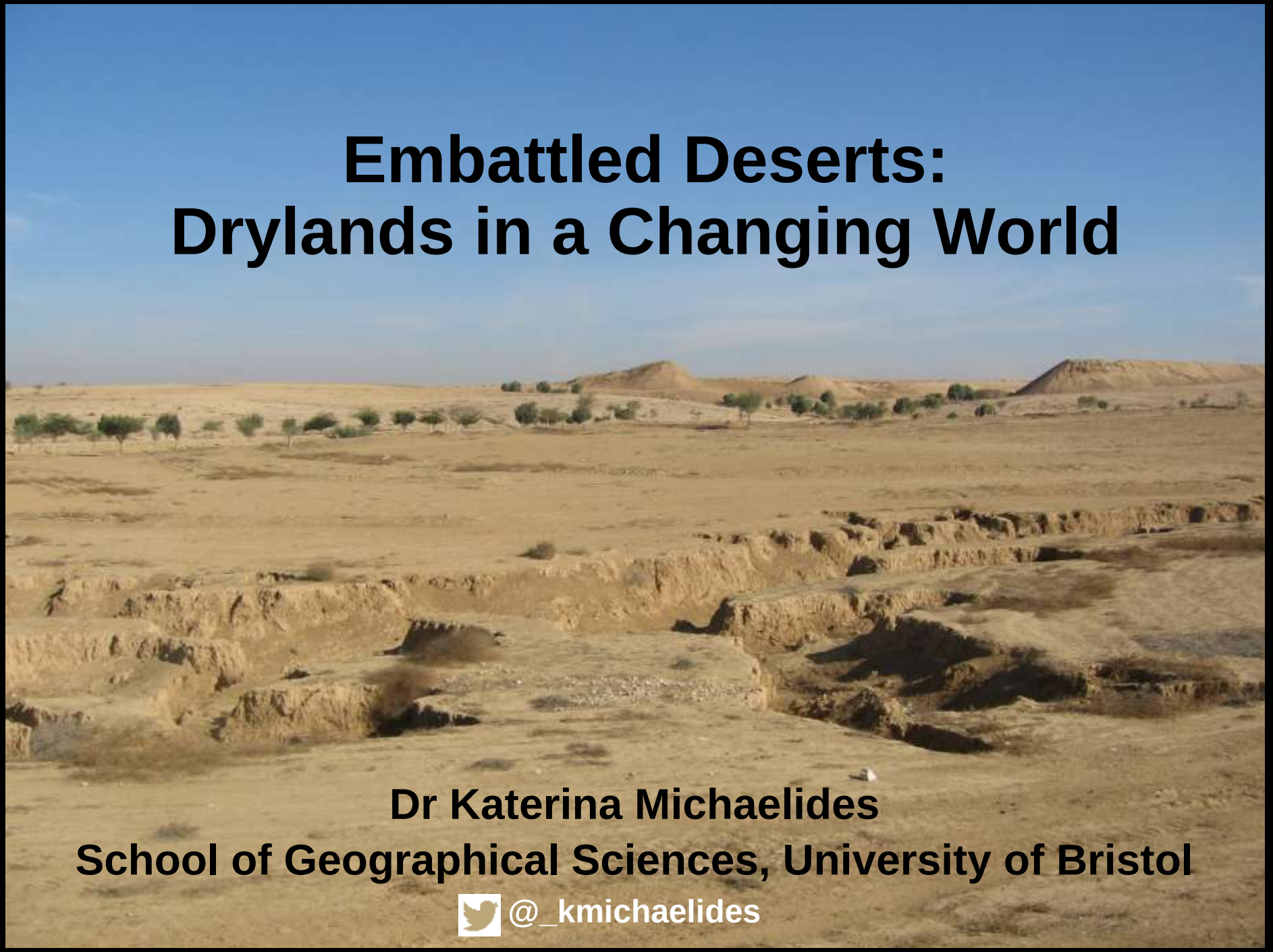
Embattled Deserts: Drylands in a Changing World



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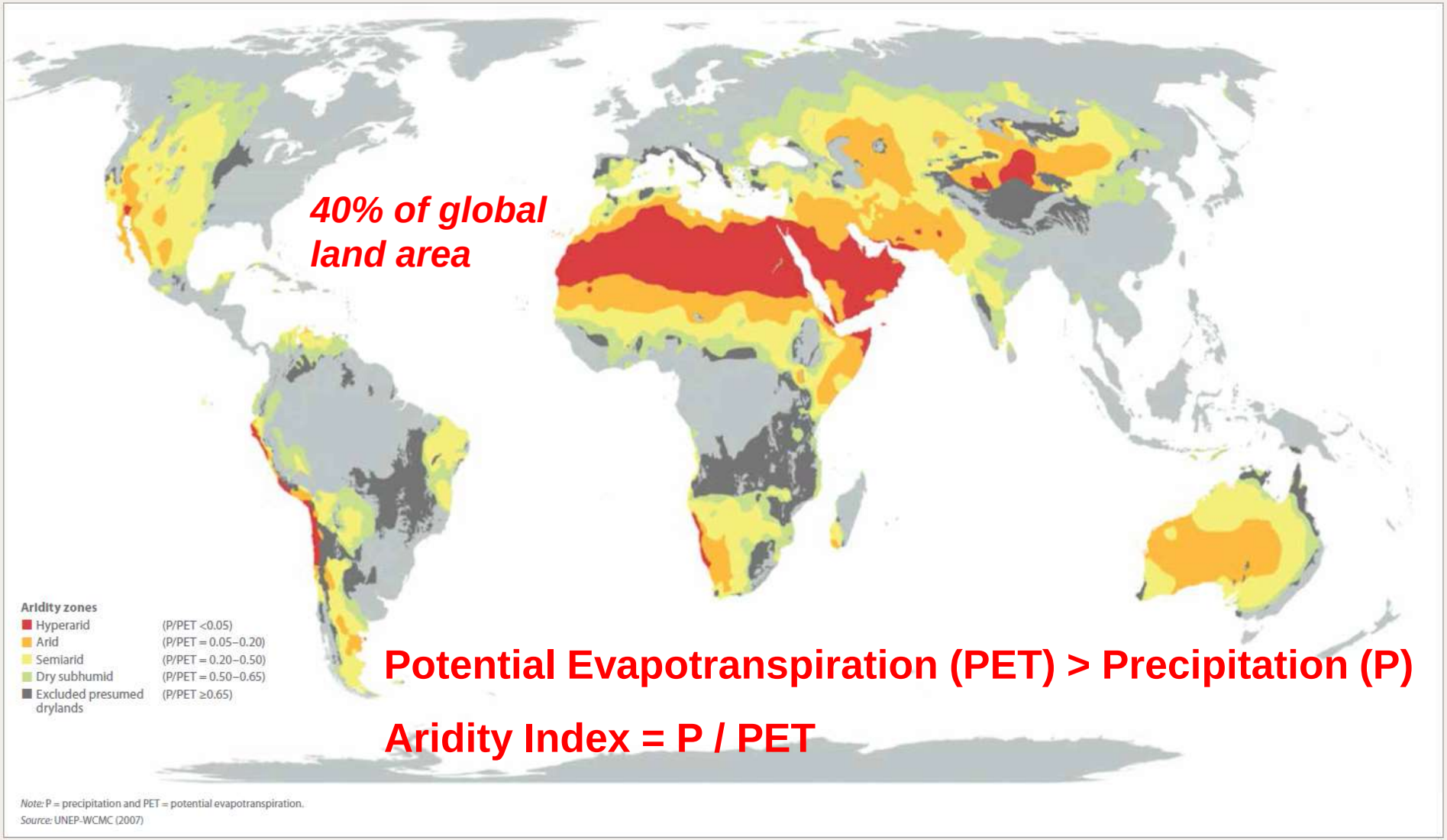
Distribution of Global Drylands



Why are drylands important?

- Drylands support 38% of the world's population (~2.5Bn people), 90% of whom live in developing countries.
- The biodiversity of drylands provides ecosystem services which benefit local communities.
- Dryland carbon storage (soil carbon) accounts for more than one third of the global stock.
- Dryland degradation costs developing countries an estimated 4–8% of their national gross domestic product (GDP) each year.
- *Resilient yet fragile ecosystems*
- *Prone to change once perturbed*

Dispelling myths about drylands

1. Drylands are quiescent, static environments

Drylands are dynamic!

Climatic characteristics

- Temporally and spatially discontinuous rainfall
- Typically rainfall concentrated in a brief season (semi-arid)
- Dry spells for most of the year
- Rainfall distribution tends to be skewed due to overabundance of subnormal years and long term average inflated by a few years with exceedingly high rainfall
- Annual totals are determined by small number of high intensity, low duration rain events

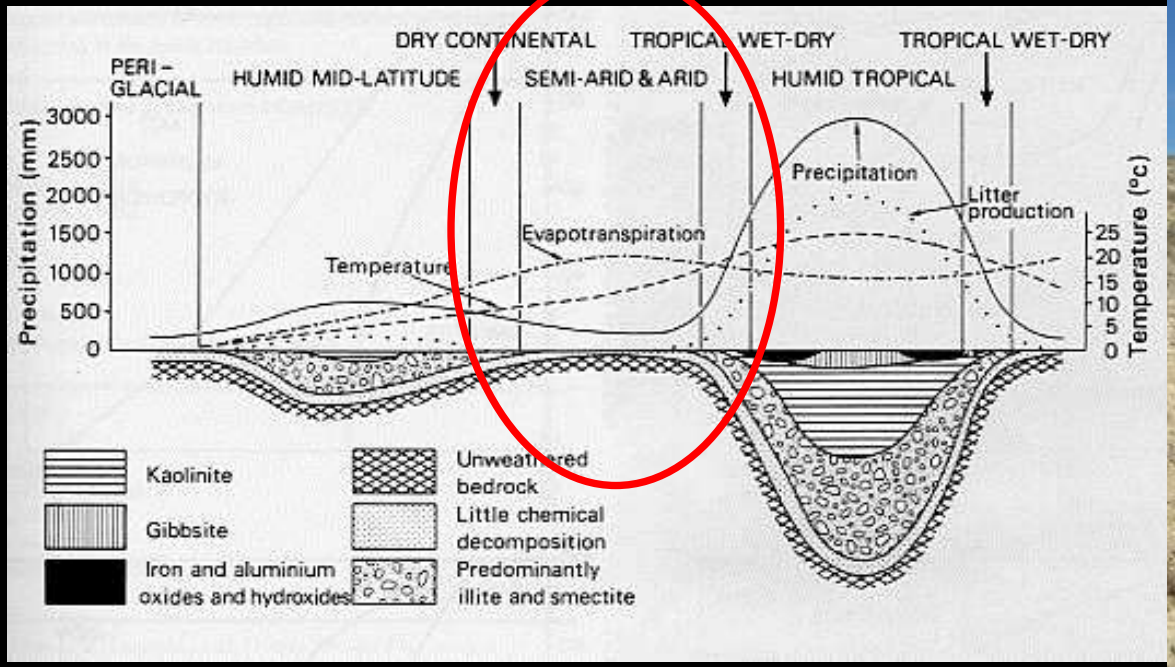
Hyper-arid: < 25mm
Arid: 25 – 200 mm
Semi-arid: 200 – 500mm

Low annual total rainfall

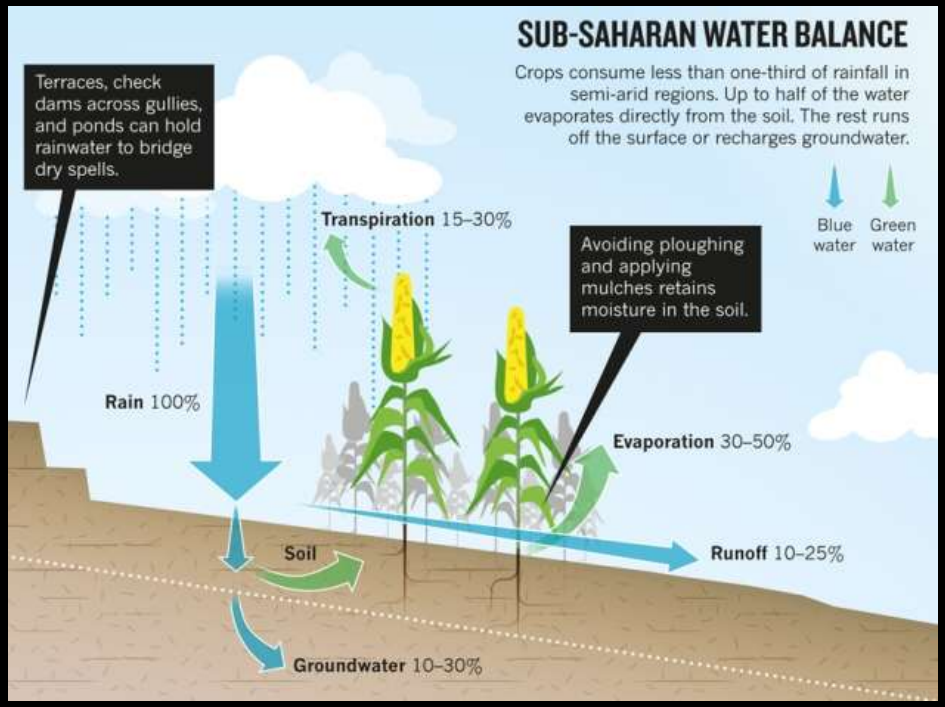
but

Delivered as discrete storms, typically high intensity, short duration

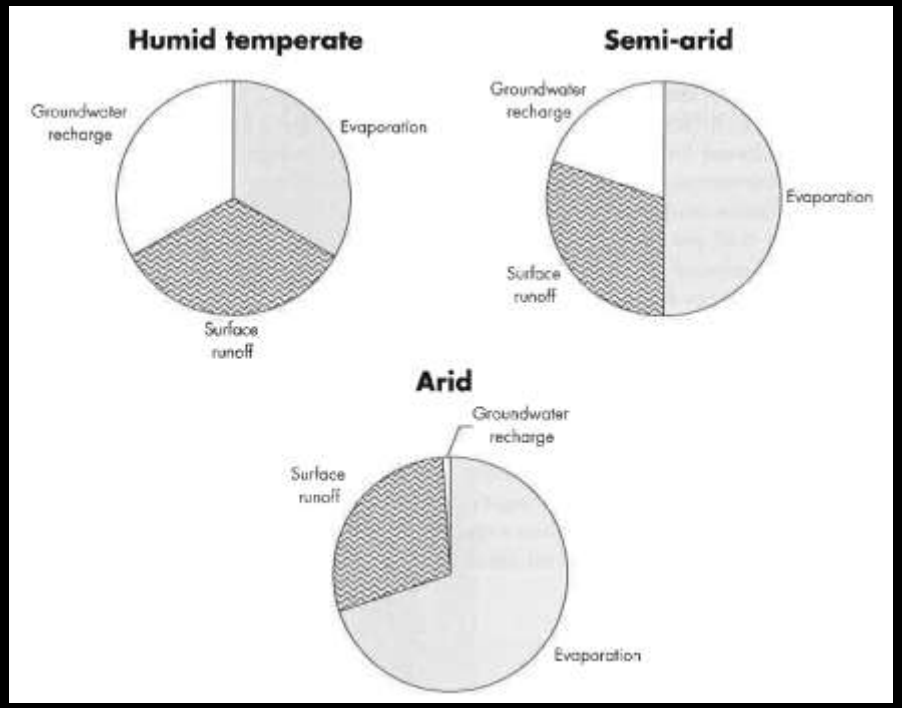
Dryland soils



Water Balance in Drylands

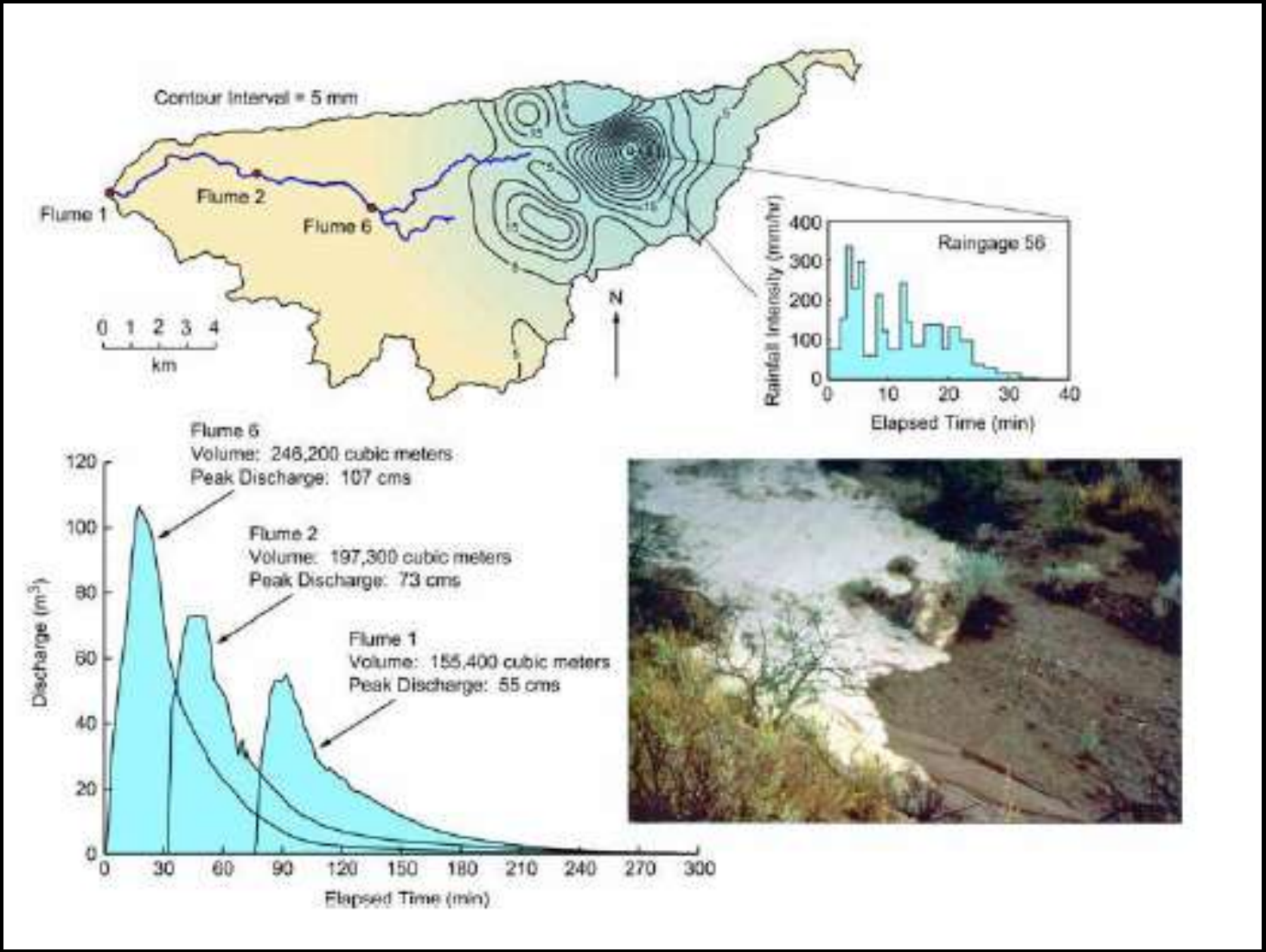


Rockstrom & Falkenmark 2015



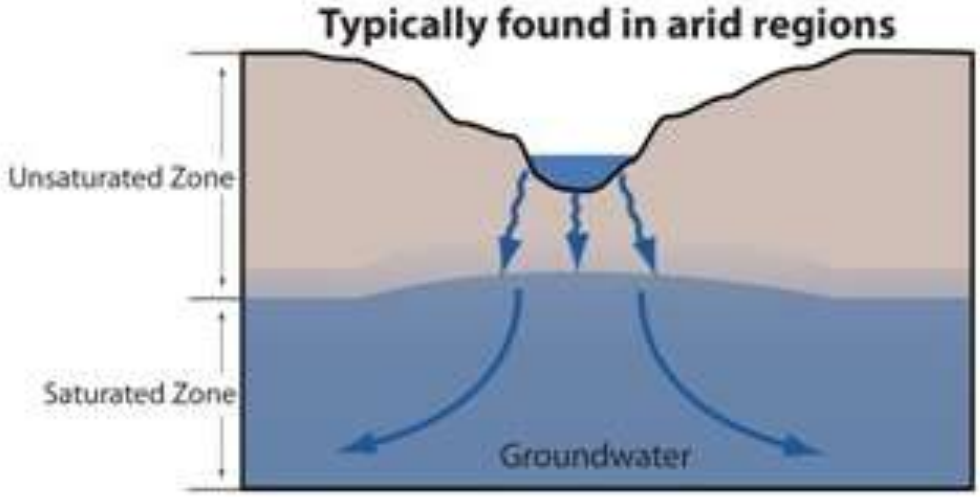
Davie 2008 (from UNESCO, 2006)

Transmission losses

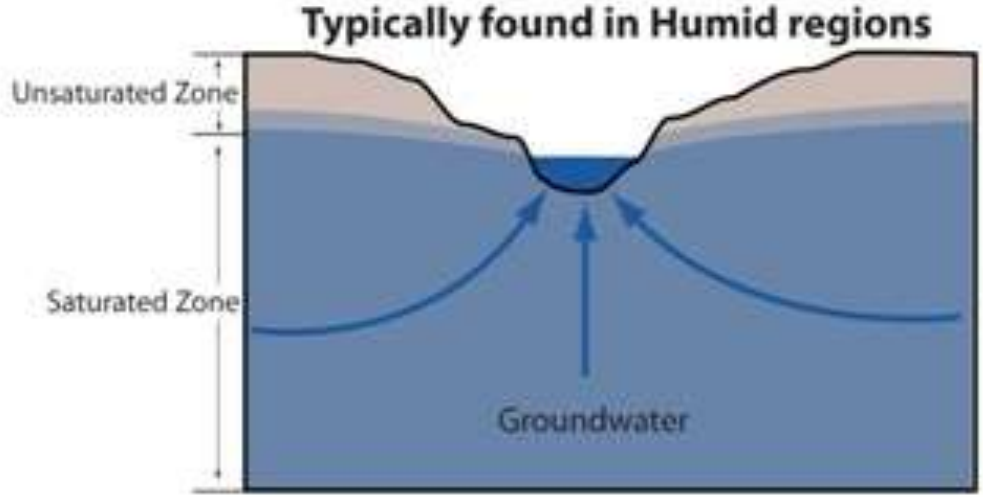


Walnut Gulch Brochure, Tombstone, Arizona
http://www.ars.usda.gov/SP2UserFiles/Place/20221000/WGBrochure.pdf

Groundwater Recharge

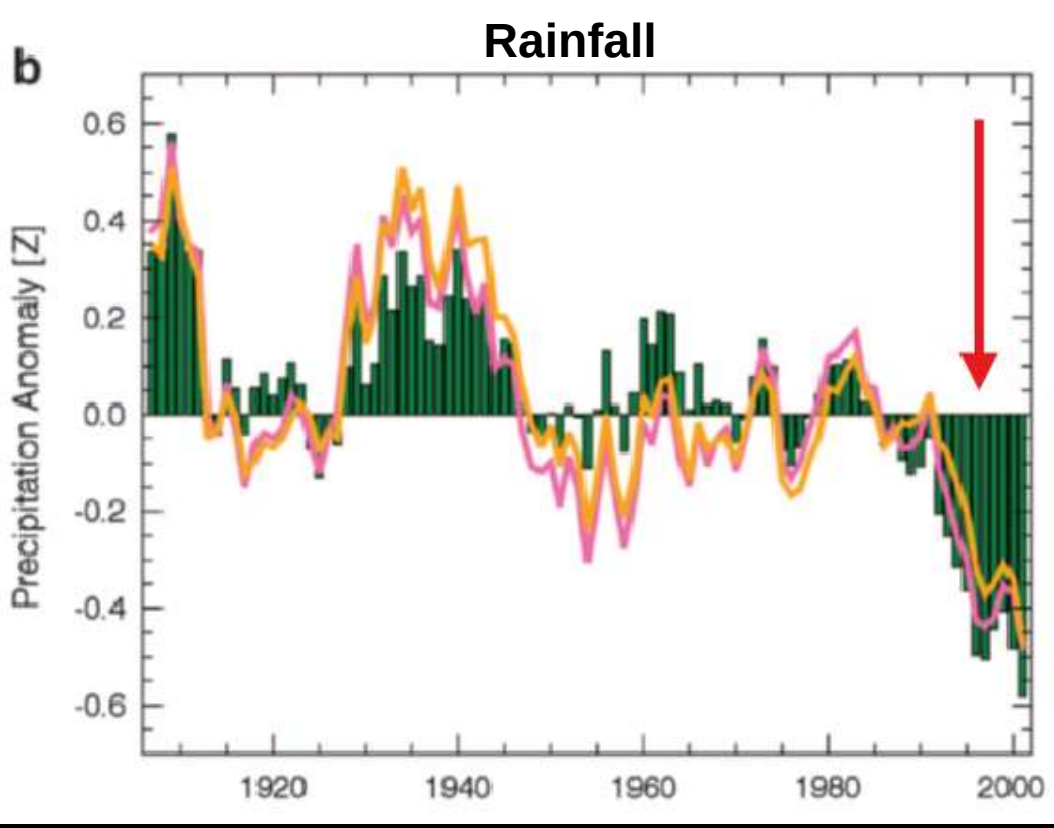


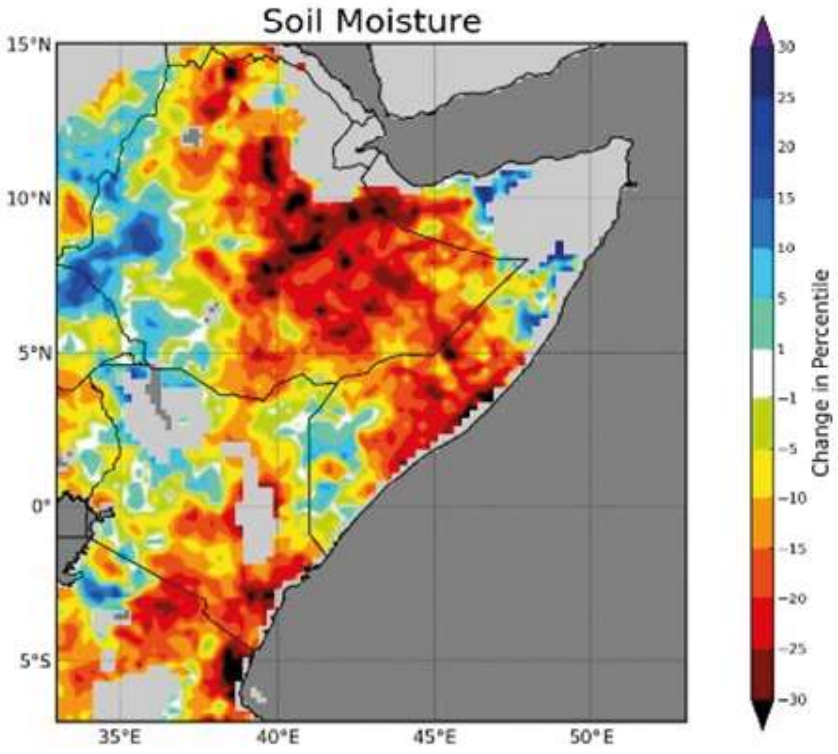
Losing Stream:
In arid regions, streambeds are usually dry. When storm flows fill the channel, water infiltrates through the bed recharging the aquifer below.



Gaining Stream:
In humid regions, streambeds are usually wet. Groundwater, recharged by frequent rainfall, flows into the stream maintaining baseflow.

Climate Change and Drought

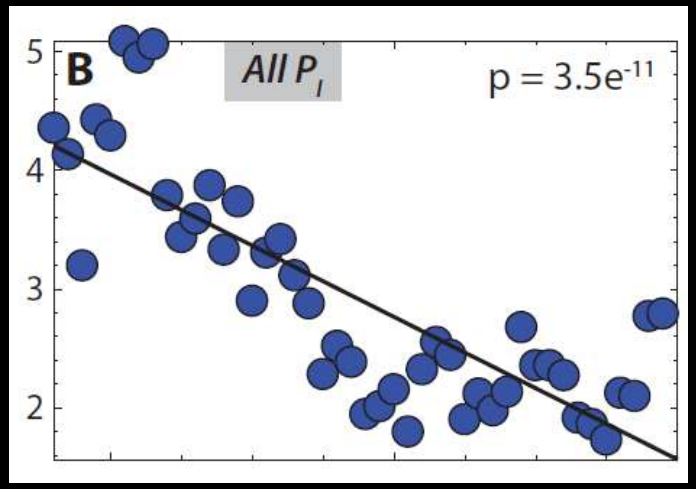




Source: Funk et al 2015

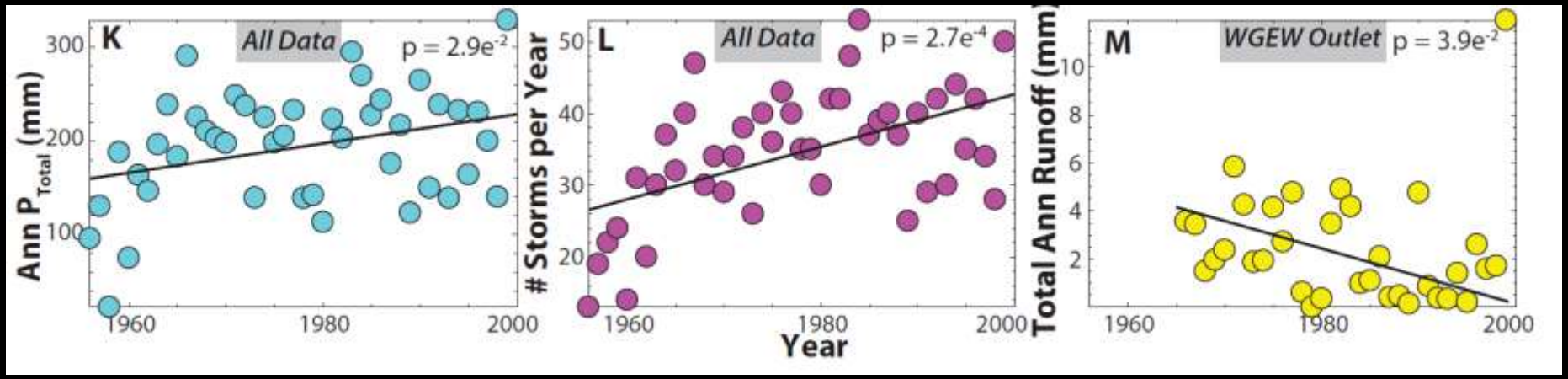
East Africa

Climate Change and Rainfall



Declining rainfall intensity and declining runoff

SE Arizona, USA



Singer & Michaelides, 2017

But increase in annual rainfall and number of storms per year

Dispelling myths about drylands

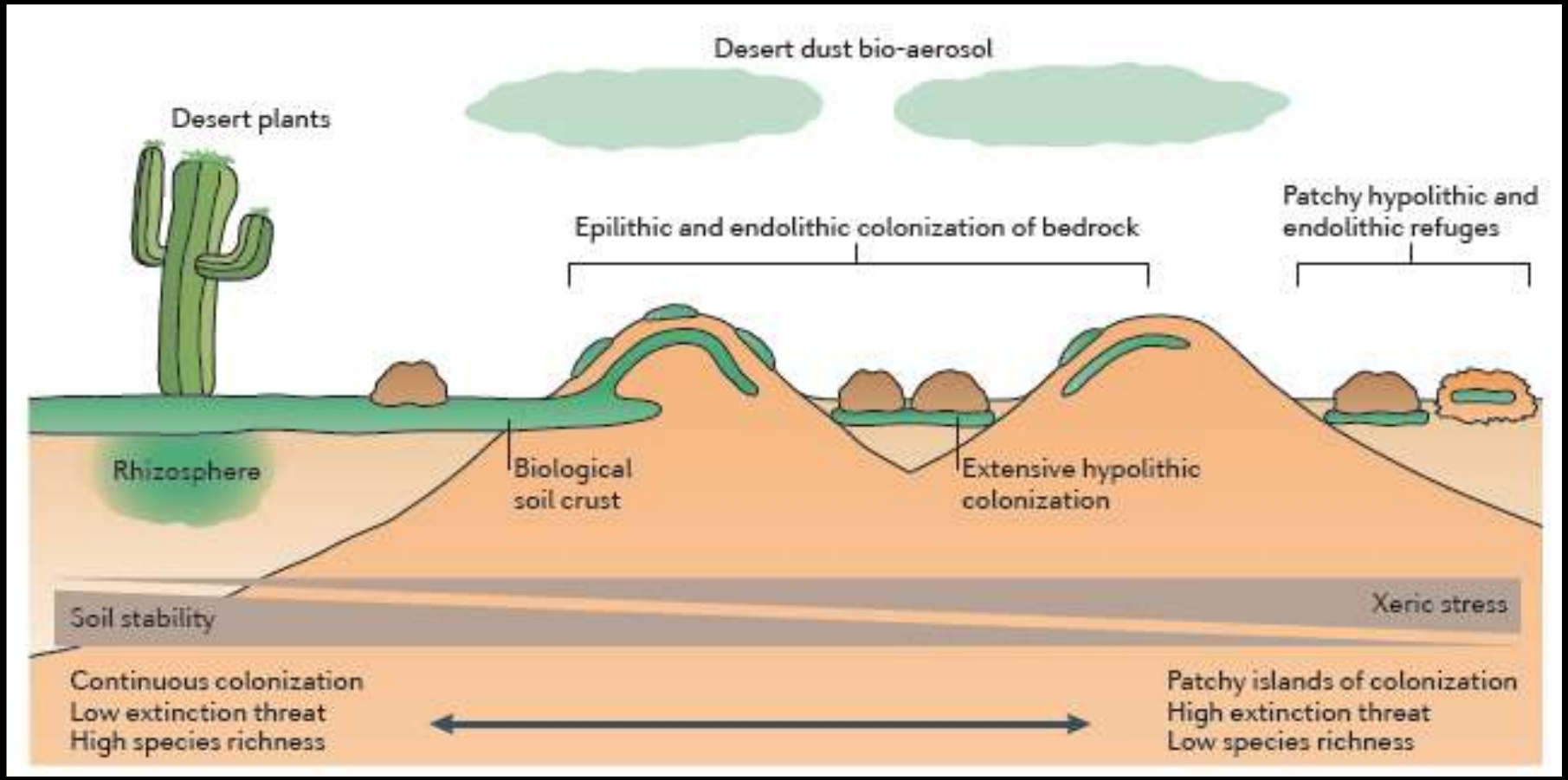
2. Drylands are rare, barren, lifeless places




Ecological resilience strategies

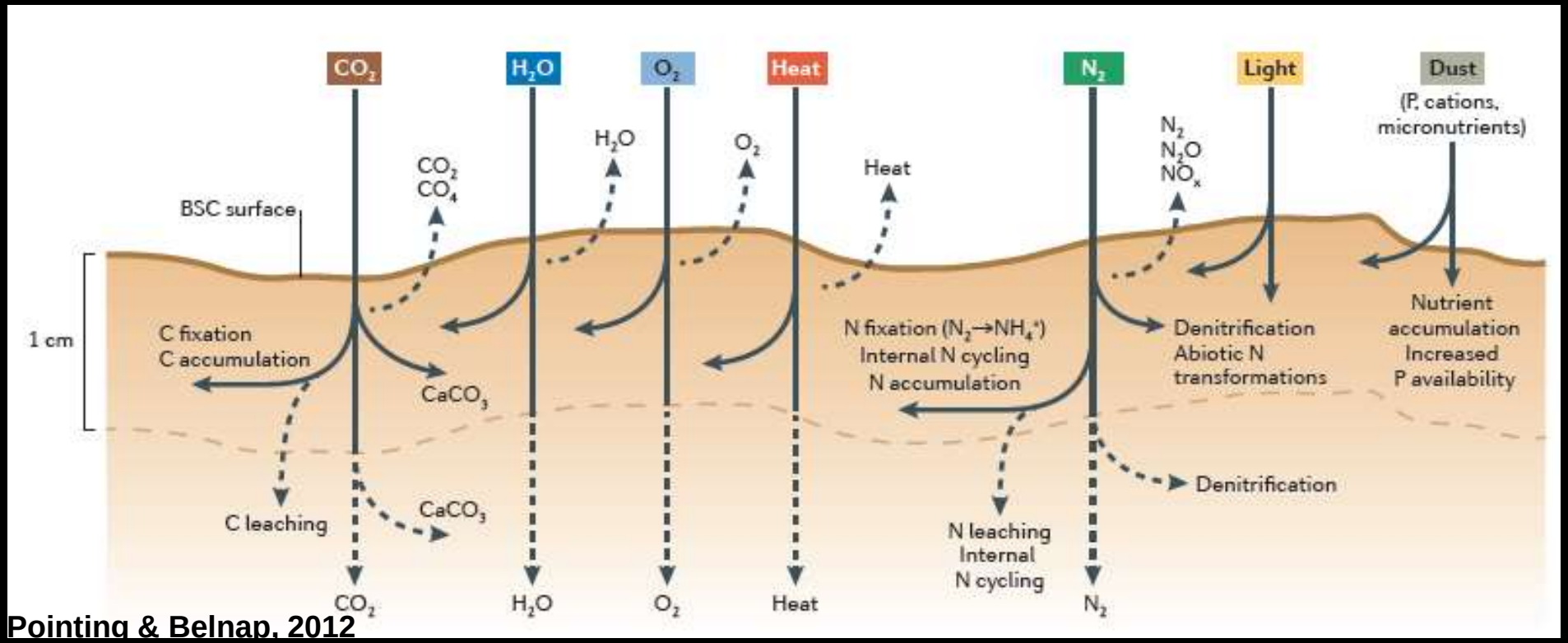
Drought resistant vegetation
Vegetation re-growth after dry or drought periods

Drylands are biodiverse



Pointing & Belnap, 2012

Dryland biodiversity is skin deep



Pointing & Belnap, 2012

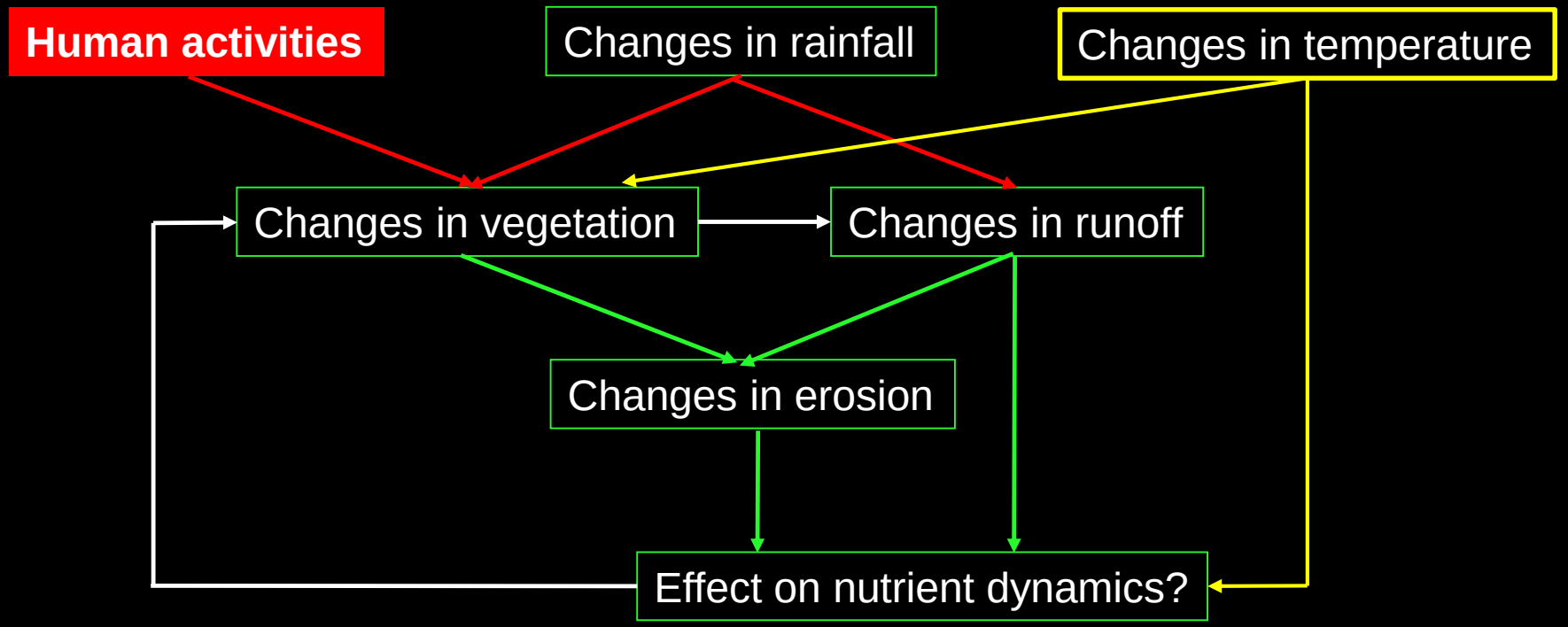
Biological soil crusts

Land Degradation (desertification)

- Loss of soil productivity / fertility
- Decline in soil quality
- Loss of organic matter
- Physical, chemical and biological deterioration

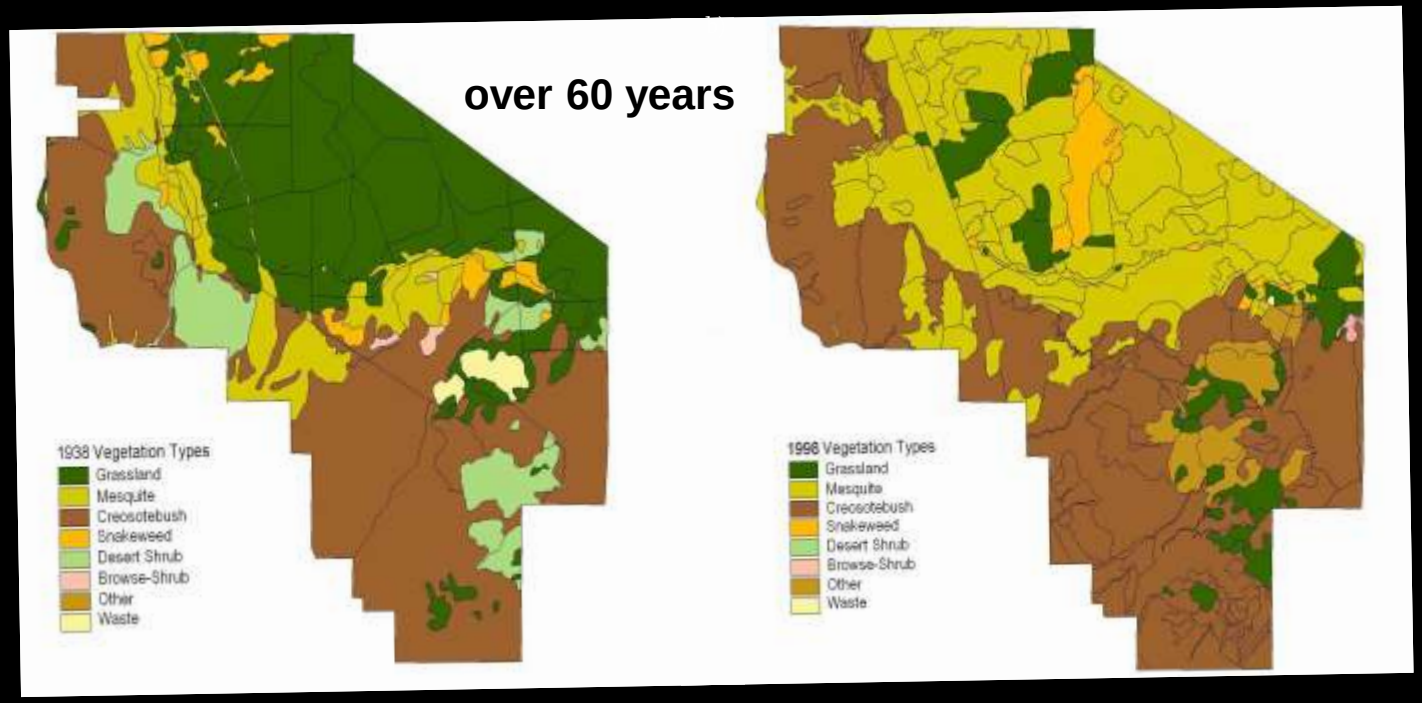
- Reduction in biomass
- Decrease in biodiversity
- Decline in quality in terms of the nutritional value for wildlife
- (Quasi) permanent change in ecosystem

Interacting processes



Dryland Degradation

(Jornada LTER, New Mexico, USA)

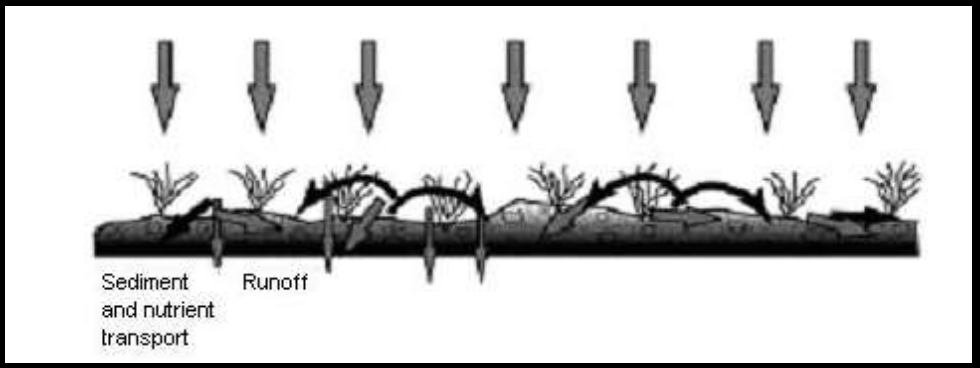


Grassland → Shrubland

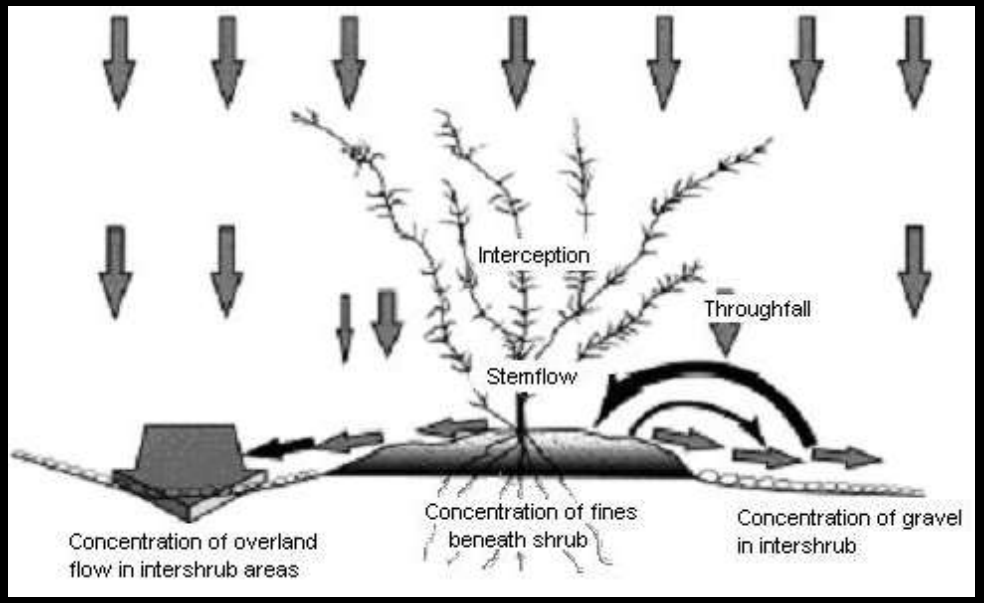
Overgrazing

Time grazing the same area more significant that herd size

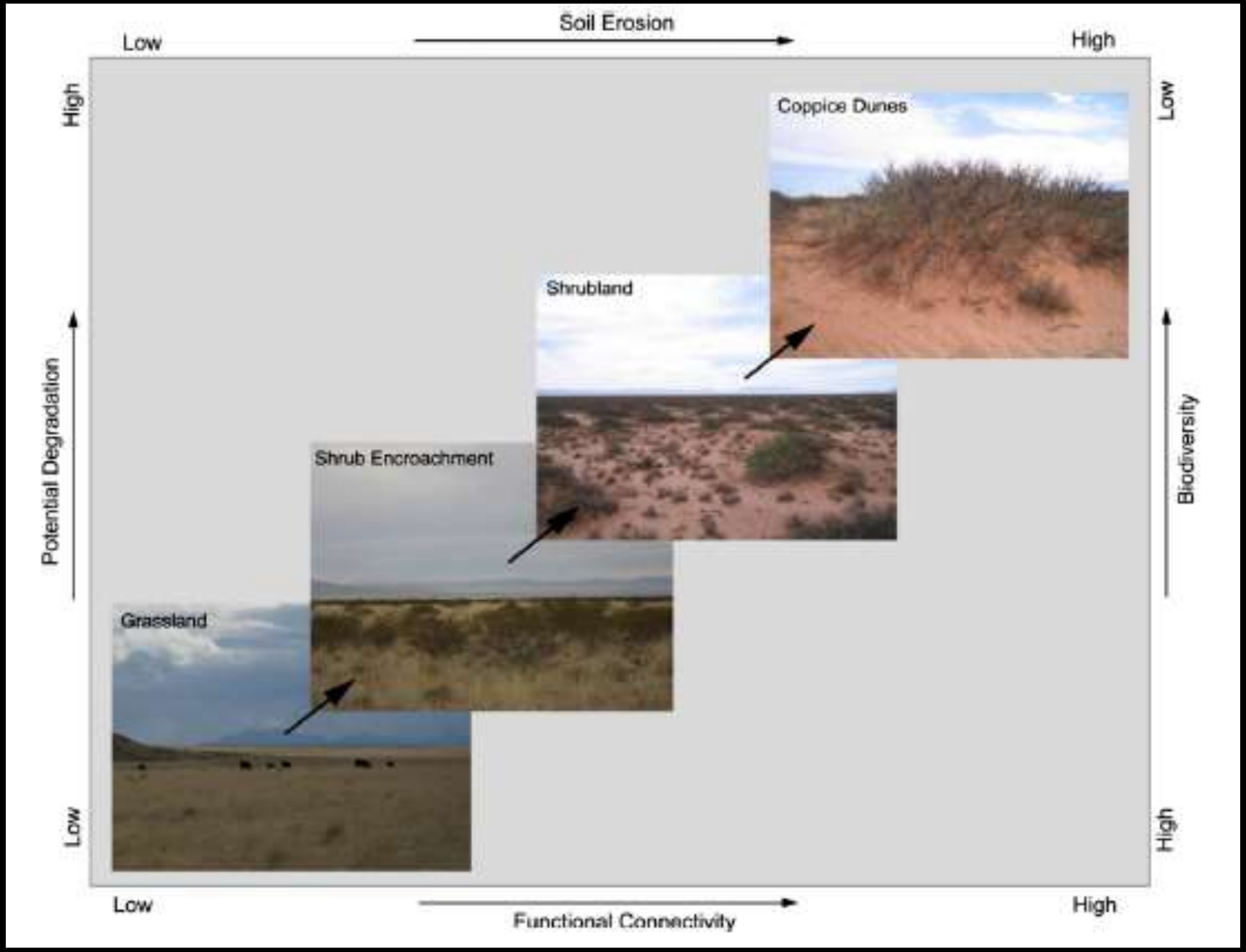
Grassland



Shrubland

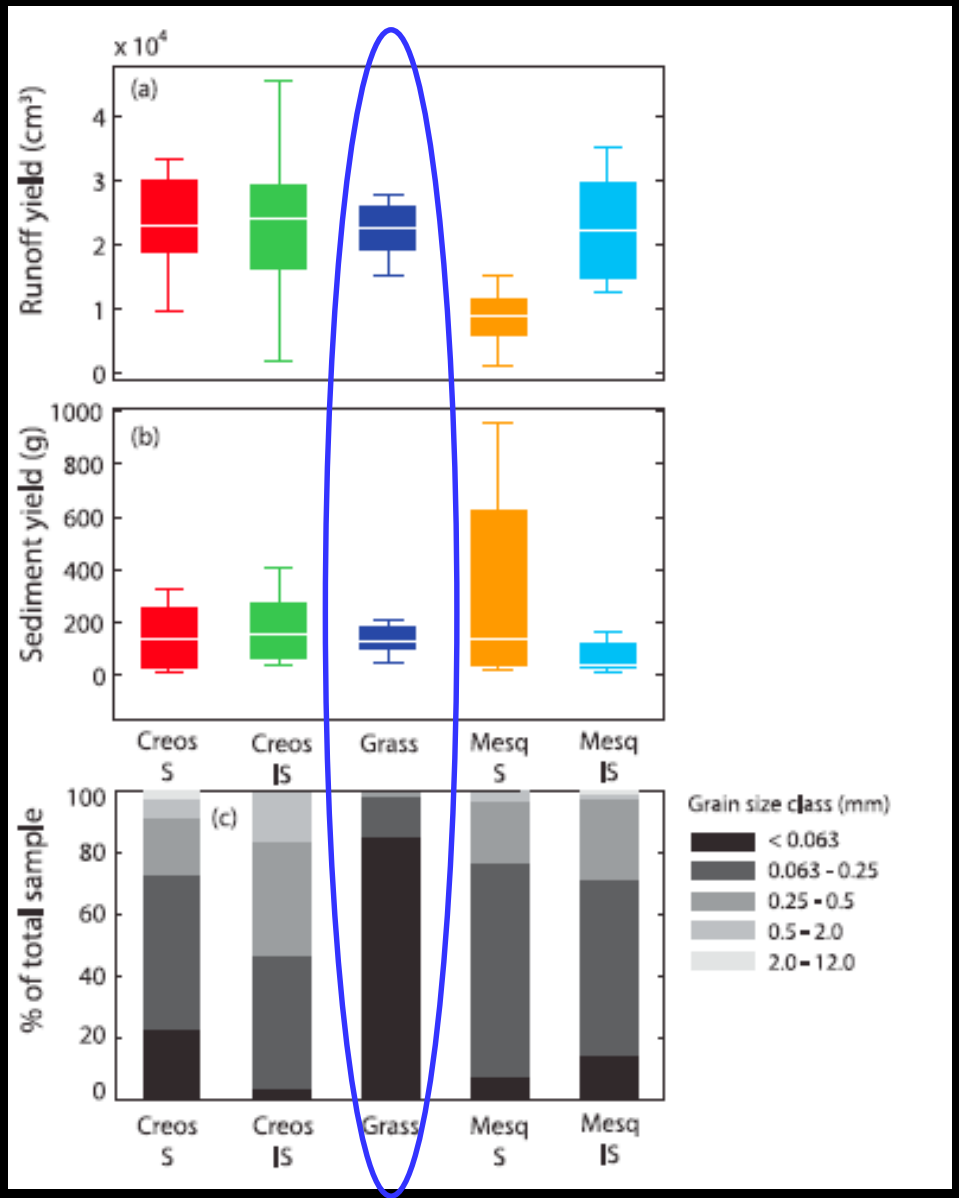


Increases heterogeneity and resource redistribution



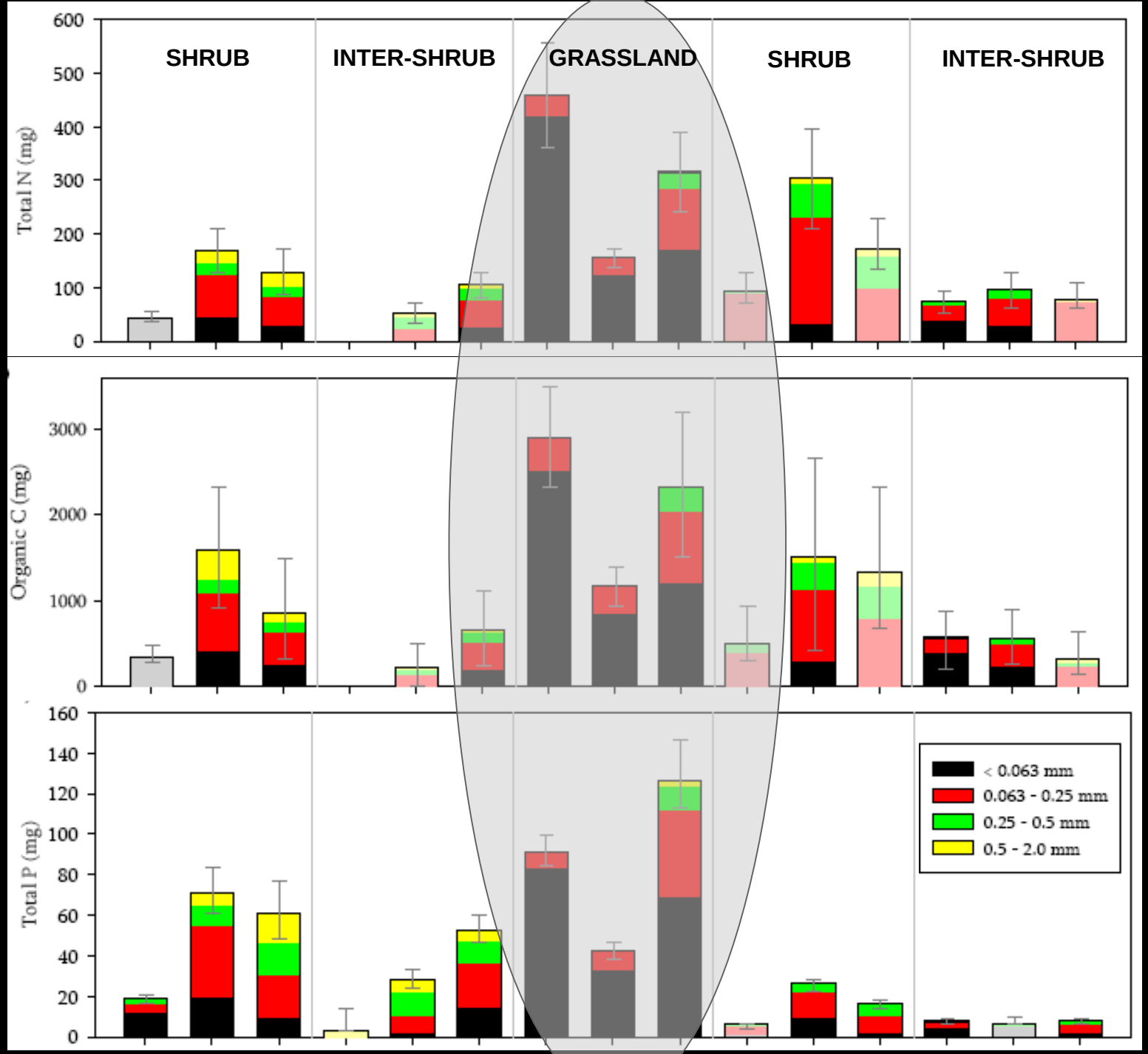
Ravi et al., 2010

Plants, runoff, erosion, nutrients



Michaelides *et al*., 2009; 2012

Nutrient Losses by Erosion

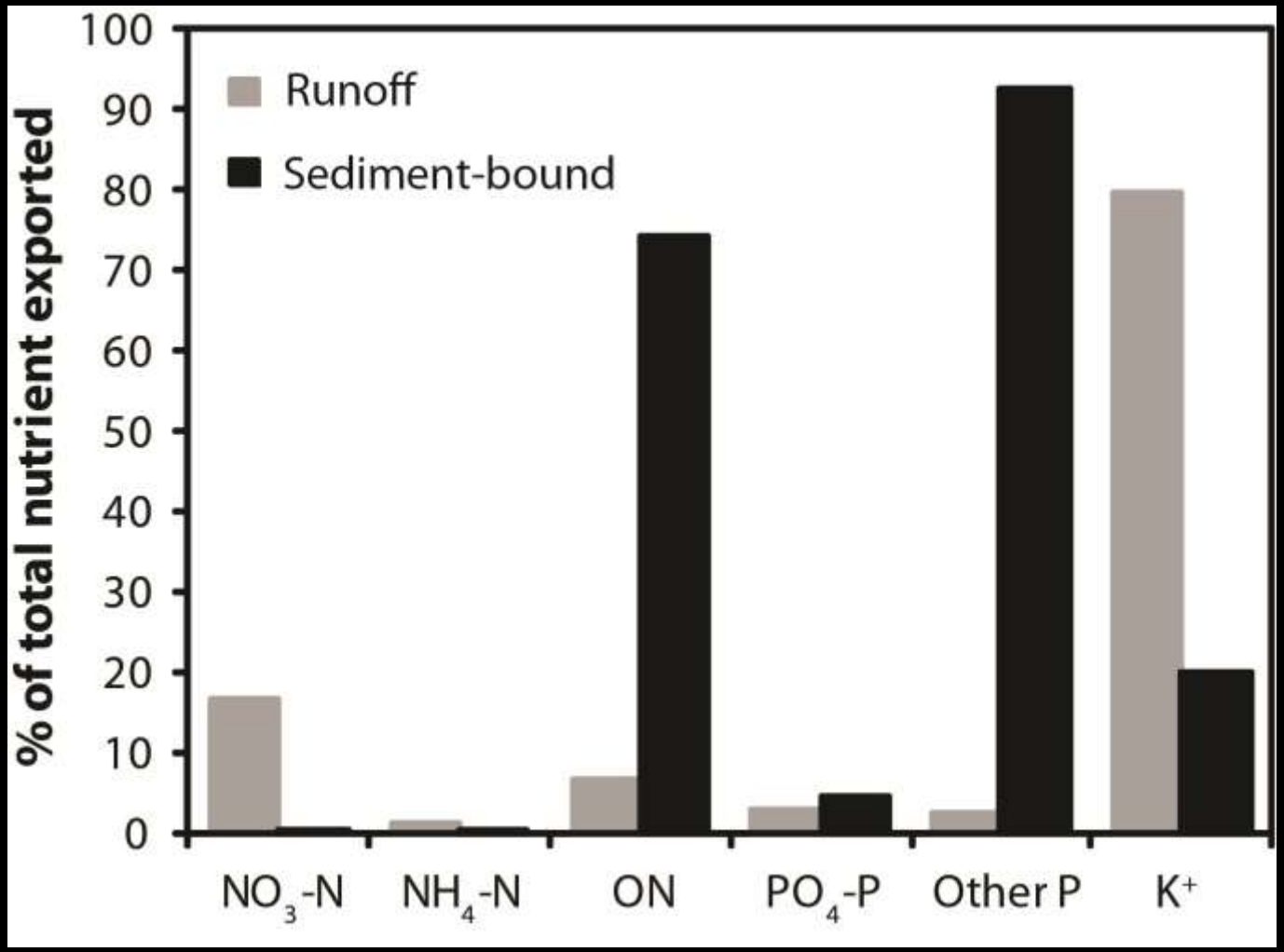


Nitrogen

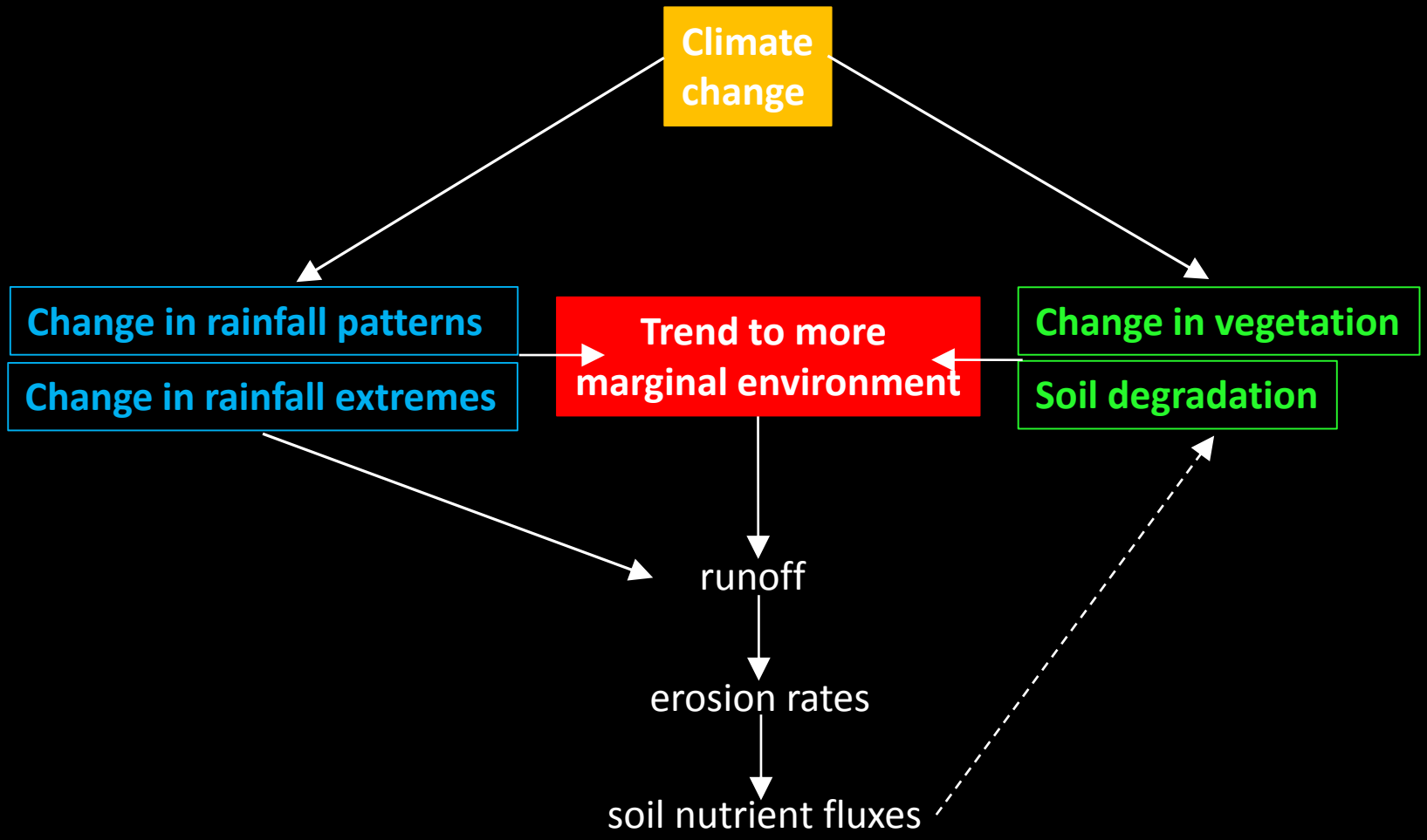
Organic Carbon

Phosphorus

Total Nutrient Export



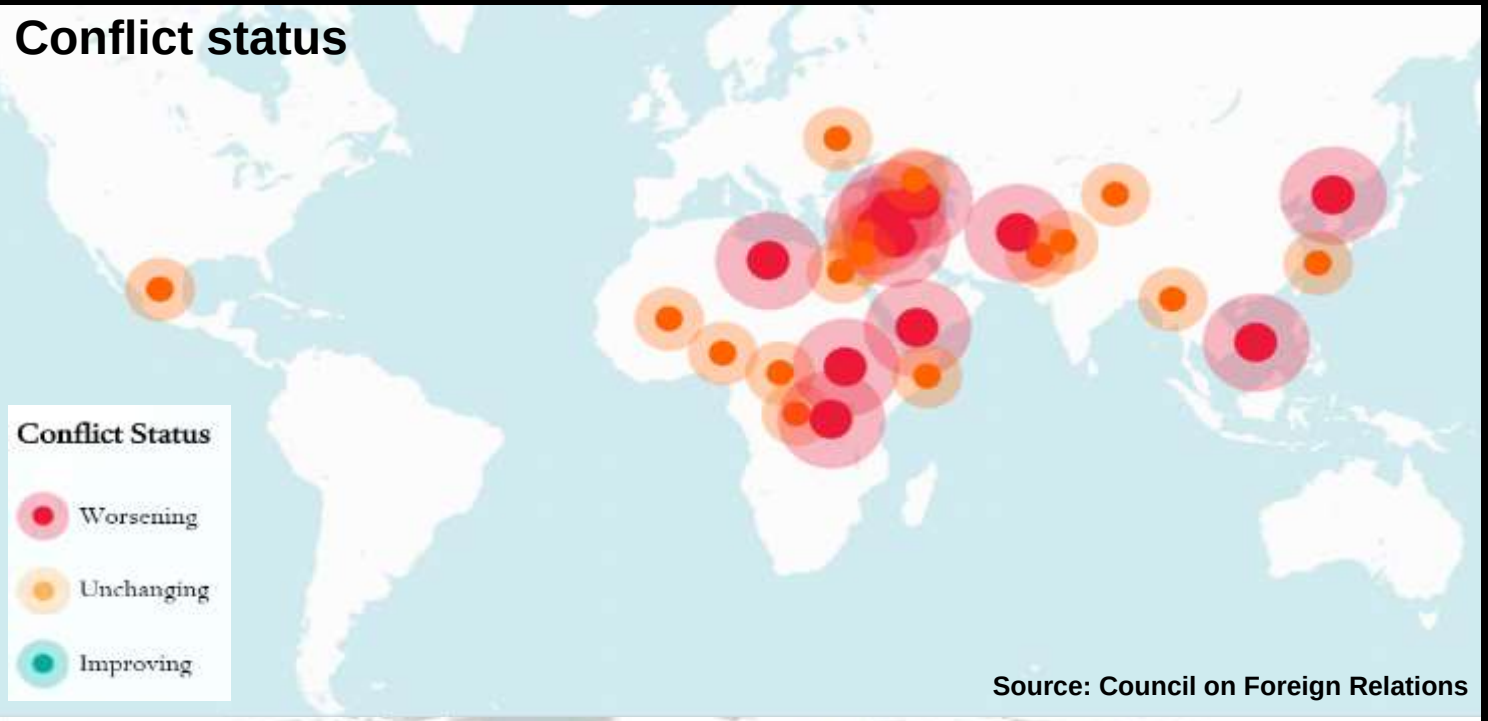
Michaelides *et al.*, 2012


Climate change
Change in rainfall patterns
Change in rainfall extremes
Trend to more marginal environment
Change in vegetation
Soil degradation
runoff
erosion rates
soil nutrient fluxes

Dispelling myths about drylands

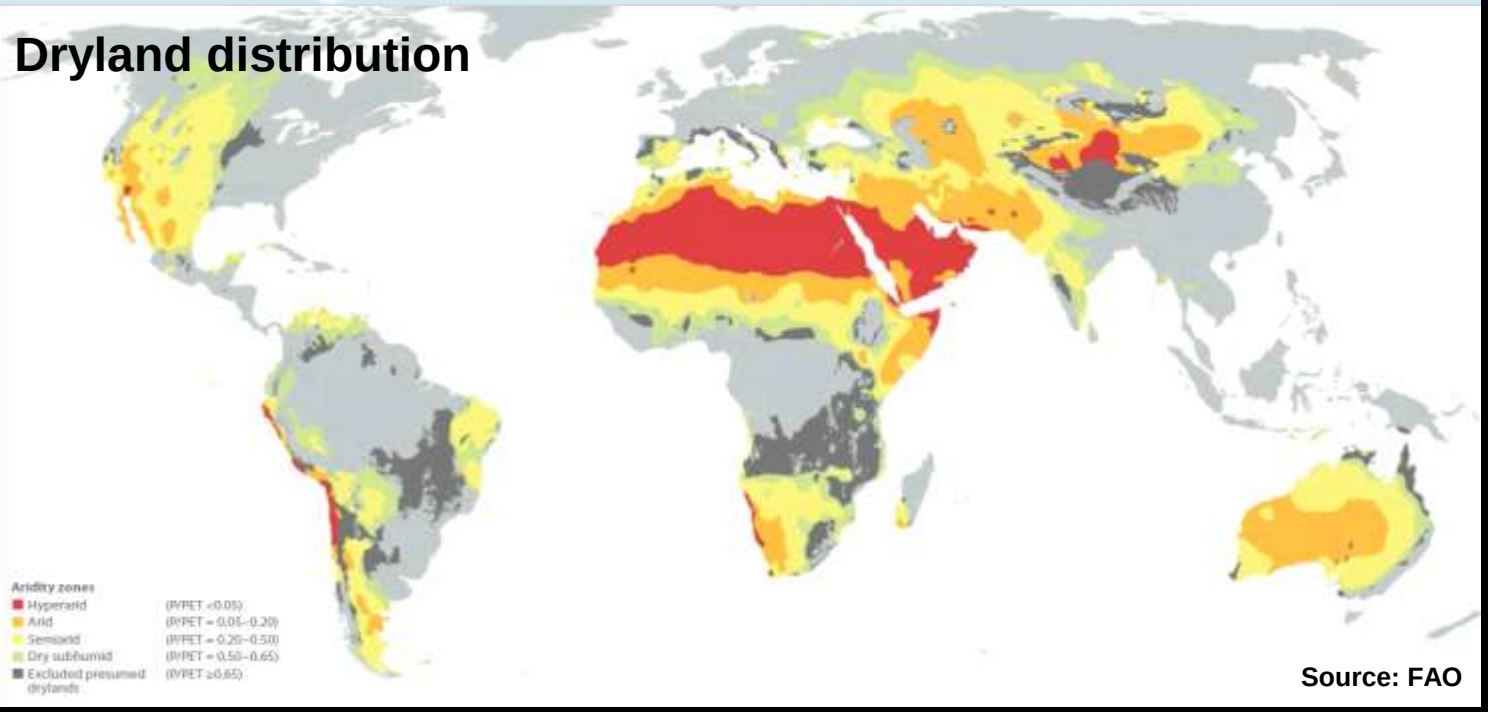
3. Nothing can destroy them any further

Conflict status



Source: Council on Foreign Relations

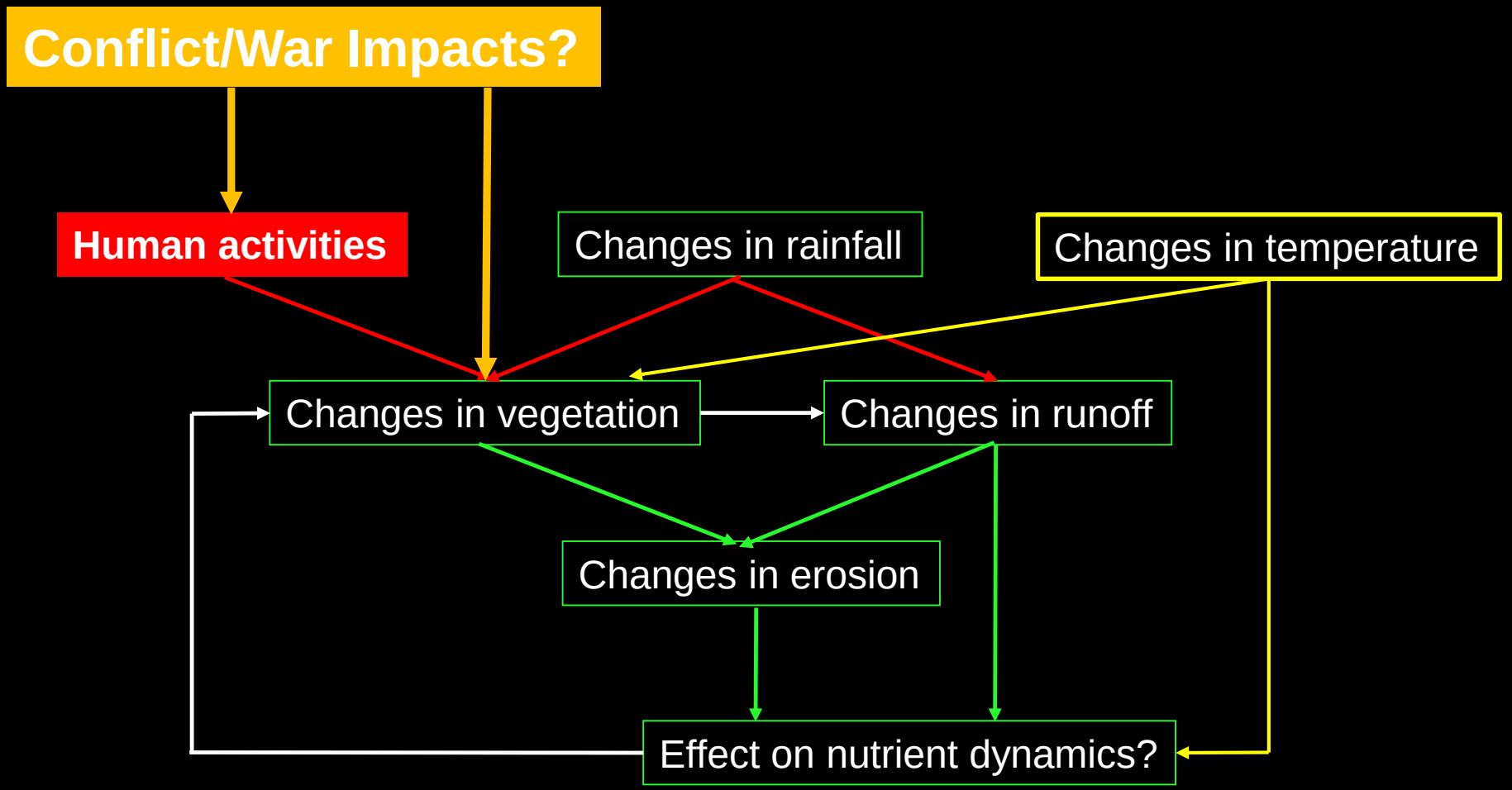
Dryland distribution



Source: FAO


Iraq
trwn.org
Afghanistan
Care2.com
Syria
Spioenkop.blogspot.co.uk
Somalia
Intelligencebriefs.com

Interacting processes



Conflict Impacts?

Direct impacts

- Bombing and explosives
- Troop and heavy vehicle movement
- Mass migration
- Refugee camps

Indirect impacts

- Political instability and lack of governance
- Misuse or overuse of natural resources
- Ignore long-standing ‘resilience’ strategies (lack of trust)

Estimated natural recovery times in years for California desert plant communities subjected to various anthropogenic impacts (Lovich & Bainbridge, 1999)

Impact	Location	$T_{recovery}$	Reference
Tank tracks (military)	eastern Mojave	65,[a] 76[b]	Lathrop (1983a)
Tent areas (military)	eastern Mojave	45,[a] 58[b]	Lathrop (1983a)
Dirt roadways (military)	eastern Mojave	112,[a] 212[b]	Lathrop (1983a)
Tent sites (military)	eastern Mojave	8–112[c]	Prose and Metzger (1985)
Tent roads (military)	eastern Mojave	57–440[c]	Prose and Metzger (1985)
Parking lots (military)	eastern Mojave	35–440[c]	Prose and Metzger (1985)
Main roads (military)	eastern Mojave	100–infinity[c]	Prose and Metzger (1985)
Military	eastern Mojave	1500–3000[d]	Prose and Metzger (1985)
Townsites	northern Mojave	80–110,[e] 20–50,[b] 1000+[f]	Webb and Newman (1982)
Pipeline	southern Mojave	centuries[g]	Vasek et al. (1975a)
Powerline	southern Mojave	33[h]	Vasek et al. (1975b)
Fire	western Colorado Desert	5[b,i]	O'Leary and Minnich (1981)
Off-road vehicle use	western Mojave	probably centuries	Webb et al. (1983)
Pipeline (berm and trench)	Mojave Desert	100[j]	Lathrop and Archbold (1980b)
Pipeline (road edge)	Mojave Desert	98[j]	Lathrop and Archbold (1980b)
Powerline pylons and road edges	Mojave Desert	100[j]	Lathrop and Archbold (1980b)
Under powerline wires	Mojave Desert	20[j]	Lathrop and Archbold (1980b)

Take-home messages

- Drylands are resilient yet fragile environments which cover ~40% of the Earth's land surface and ~2.5 billion people rely on for their livelihoods
- Drylands are on the "front line" in battles with climate change, desertification, and conflict.
  - Changes in rainfall with knock-on consequences for dryland water balance
  - Increase in drought severity and duration
  - Disrupting soil surfaces damage soil fertility and ecosystem functioning, with devastating consequences.
- Dryland degradation (desertification) is a global challenge with serious consequences for ecosystem functioning