

# The Transformative Power of Trees: Landscape Restoration for Carbon and Water

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# CONFLICTING VIEWS ON FORESTS AND WATER



Forestation reduces water yields

Deforestation dries up streams

Deforestation increases water yields

Forests maintain dry season flows



**“REDD ...contribute towards gradual restoration and sustainance of water flows...averting the looming water stress in East Africa.”**

*Kimbowwa et al. 2011. REDD Net*



Carbon with Biological

The Economist

Topics

Research into Use: Policy Brief No. 3

# Forests, flows and water harvesting: replacing myths in watershed management



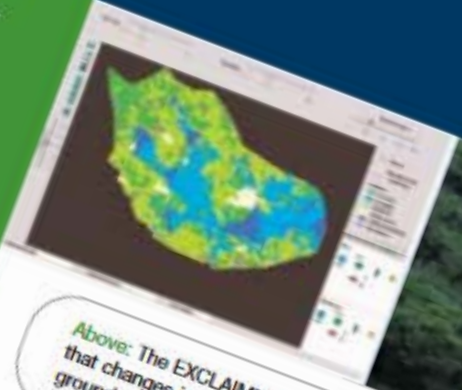
Watershed-development projects have often been based on a set of common misbeliefs. This has all too often led to less water for those who need it most. Instead, evidence-based, pro-poor and integrated land and water management policies are needed. New tools are available to help.

## Common water-related myths exposed

Better ways of measuring water, better models and powerful new geographic information systems (GIS) have exposed some fatal flaws in 'conventional wisdom'. It is a myth, for example, that trees always improve water availability by increasing local rainfall and runoff.

Other common myths are that water harvesting is totally benign, and that drops in flows from catchments are always caused by a decrease in rainfall. Capturing and using water upstream through terracing fields, planting and building water-storage structures is of

New thinking



Above: The EXCLAIM viewer allows easy assessment of the effects that changes in rainfall, water harvesting and land use have on groundwater and surface water flows.

## What can policy makers do?

- Policy makers need to:
- Recognise that many forests providing simple



Climate change



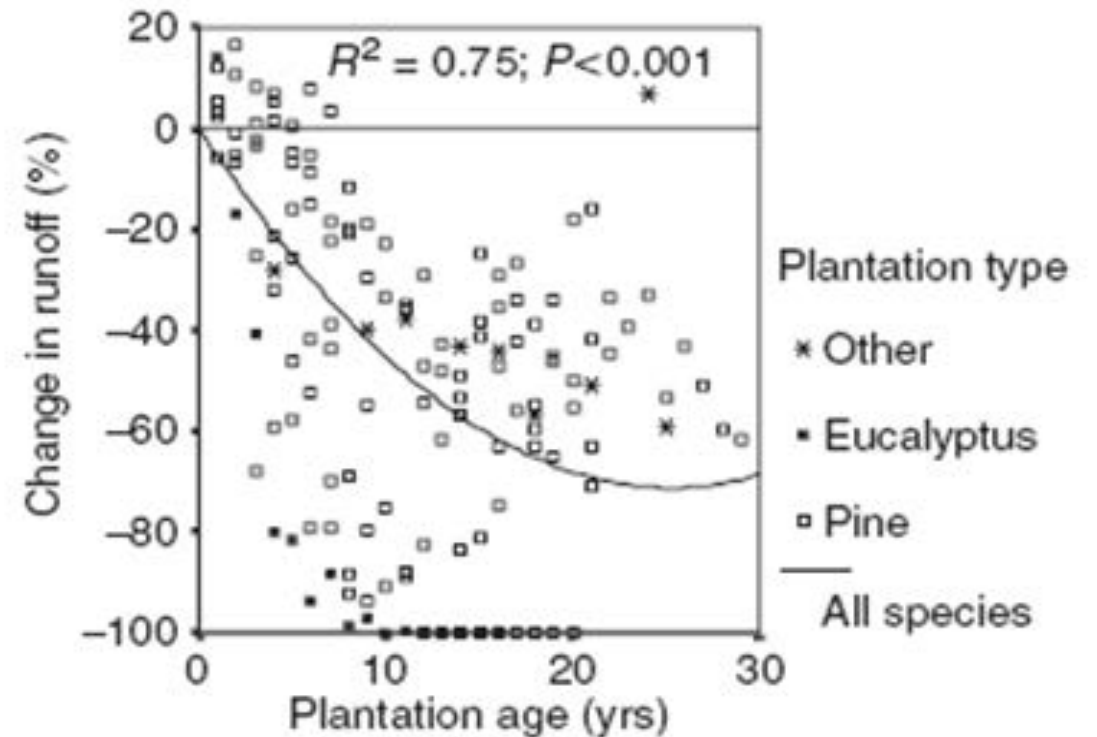
# Trading Water for Carbon with Biological Carbon Sequestration

Robert B. Jackson, *et al.*  
*Science* **310**, 1944 (2005);

## 506 afforestation observations 'globally'

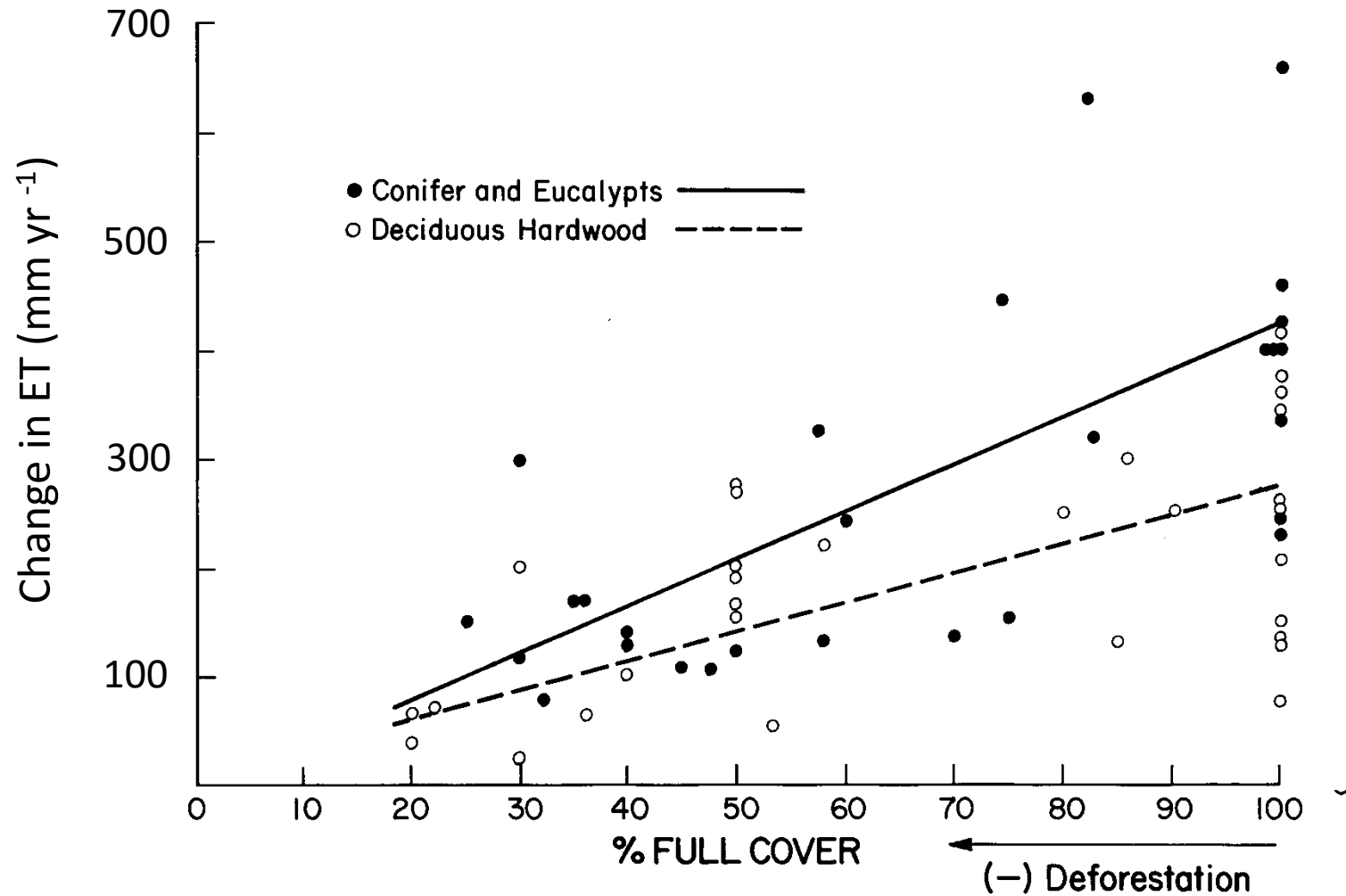
- Annual stream flow decrease 33-44%
- Proportionally worse at dry sites
- Larger reductions in dry season

### Grasslands



# Watershed studies

(Bosch and Hewlett 1982)



# FAO Forestry Paper 155

“...there is no question that even partial forest removal increases downstream water yields.” (Hamilton 2008)

# **“Forests reduce dry-season flows...**

...as much as or more than they reduce annual water yields. “

Calder et al 2007 (<http://www.fao.org/docrep/010/a1598e/a1598e02.htm>)



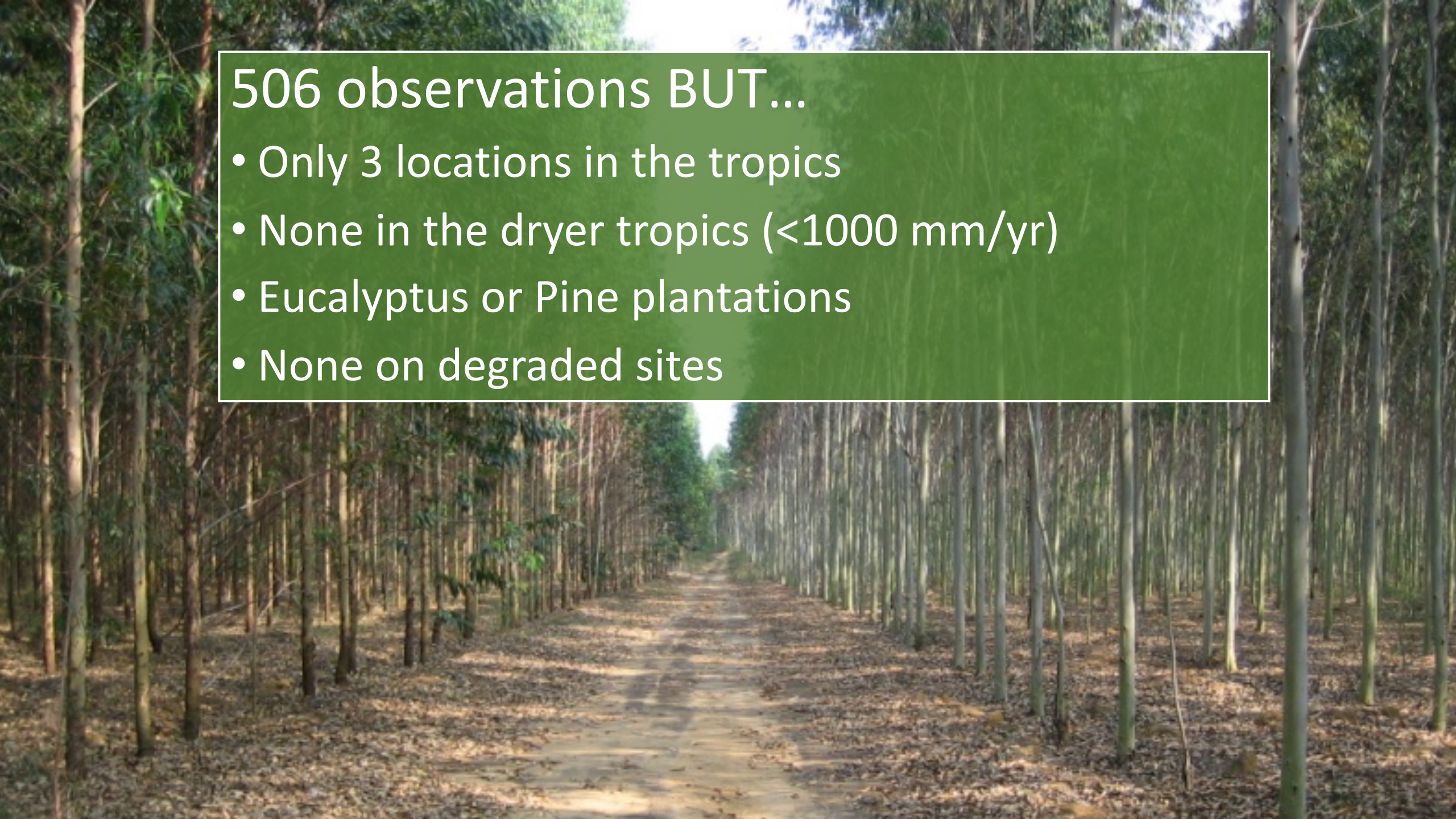
It is **theoretically possible** that in **degraded agricultural** catchments the extra infiltration associated with afforested land might outweigh the extra evaporation loss from forests...

...**increased** rather than reduced **dry-season flows**  
– **but this has rarely been seen.**”

Calder et al 2007 (<http://www.fao.org/docrep/010/a1598e/a1598e02.htm>)

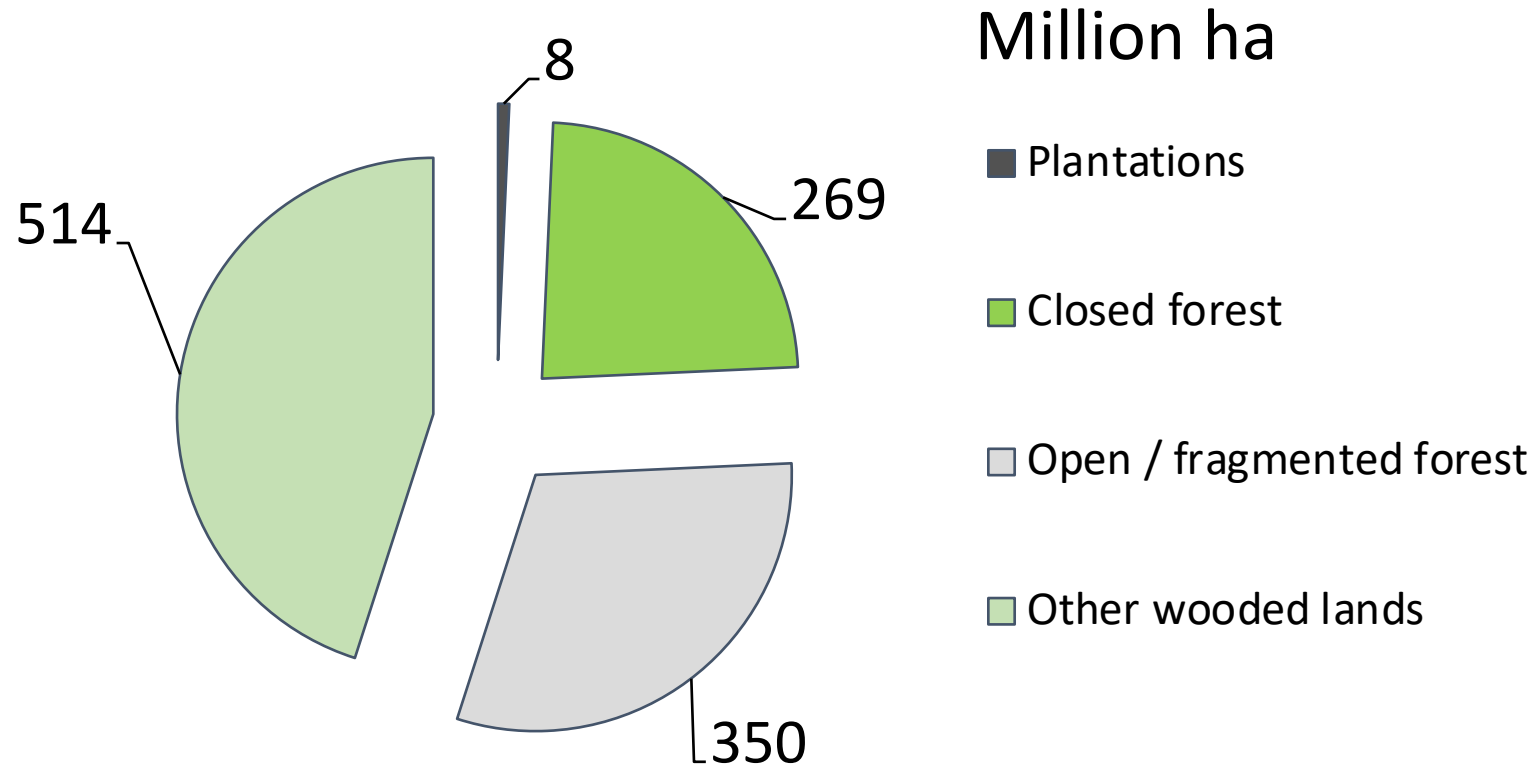
## 506 observations BUT...

- Only 3 locations in the tropics
- None in the dryer tropics (<1000 mm/yr)
- Eucalyptus or Pine plantations
- None on degraded sites





# Closed vs. open forest - Africa



...extra infiltration ... outweigh the extra evaporation... ???



# The effect of afforestation on water infiltration in the tropics: A systematic review and meta-analysis

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<sup>b</sup> Department of Forest Ecology and Management, Swedish University of Agricultural Sciences, SE 901 83 Umeå, Sweden

<sup>c</sup> Center for International Forestry Research (CIFOR), 06 BP 9478 Ouagadougou 06, Burkina Faso

2-5 times larger infiltrability with trees

# Soil infiltration capacity Burkina



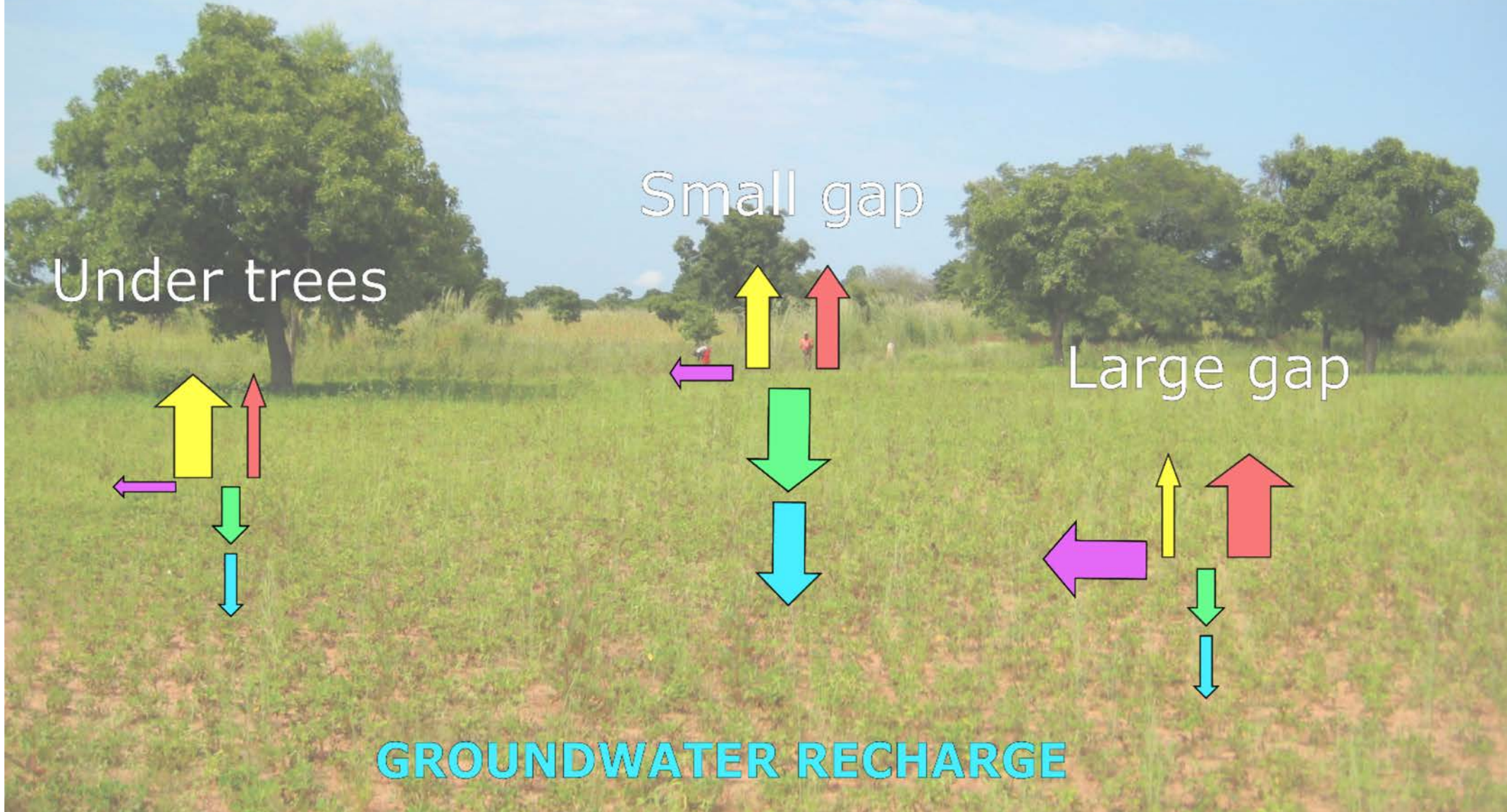
(Ilstedt et al, 2016)

Transpiration and interception

Soil evaporation

Surface runoff

Infiltration



Under trees

Small gap

Large gap

**GROUNDWATER RECHARGE**



# The agroforestry parklands of Saponé, Burkina Faso

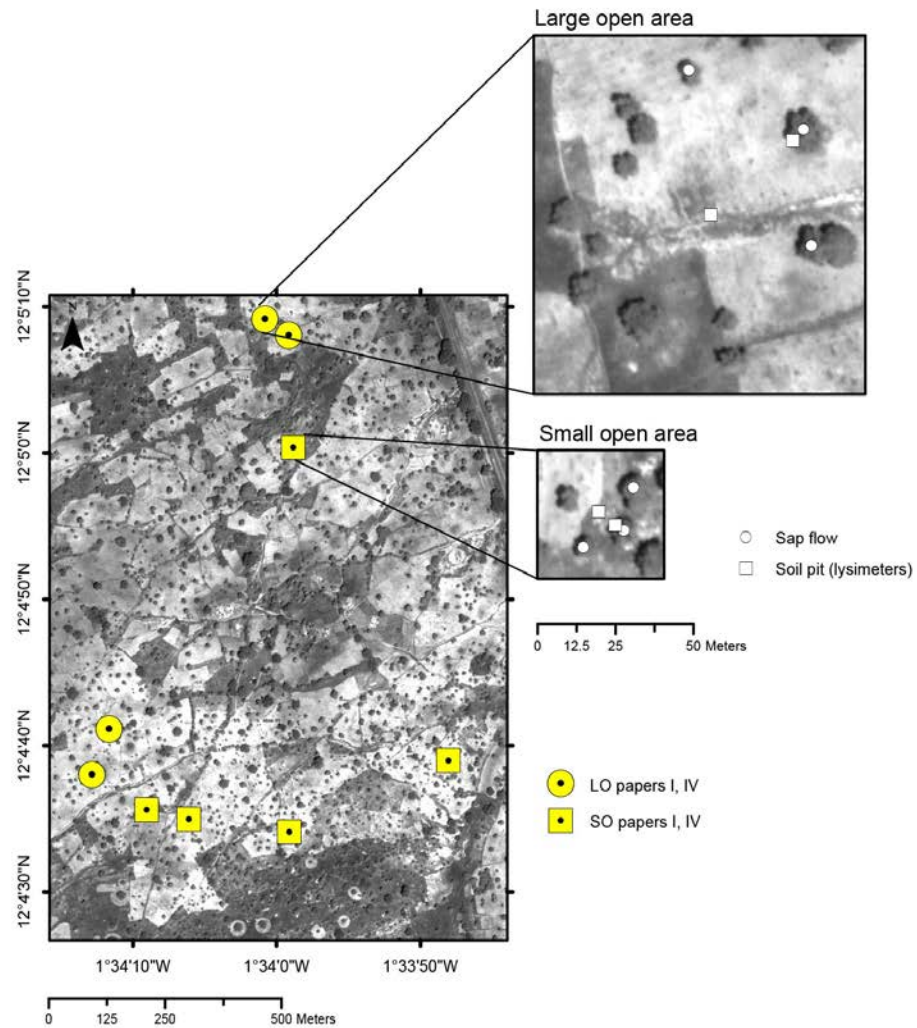


Photo: Maria Ölund



Photo: Maria Ölund

# Measurements – agroforestry parkland



Soil pits under tree – open



Soil pit with lysimeters



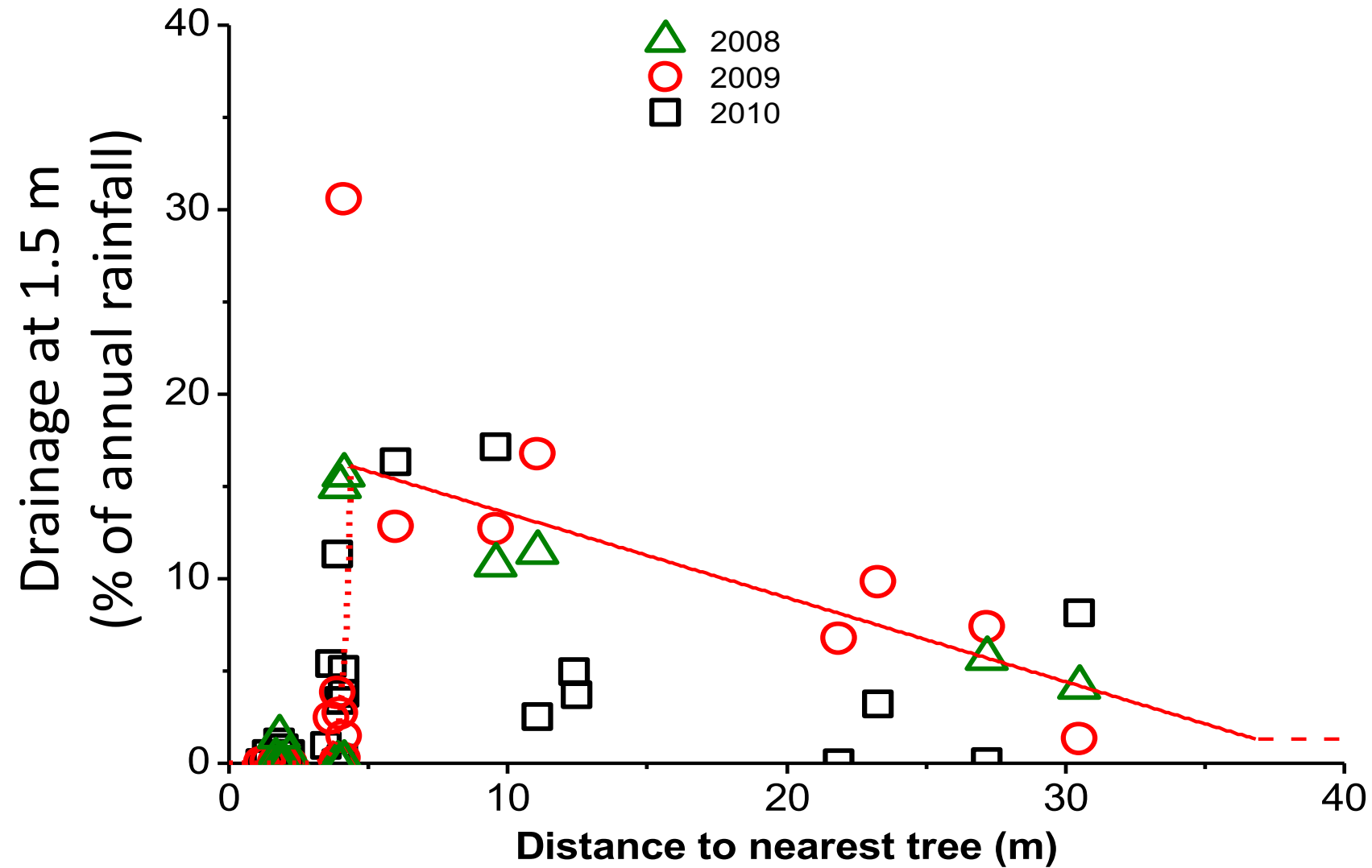
Passive fiberglass wick lysimeter

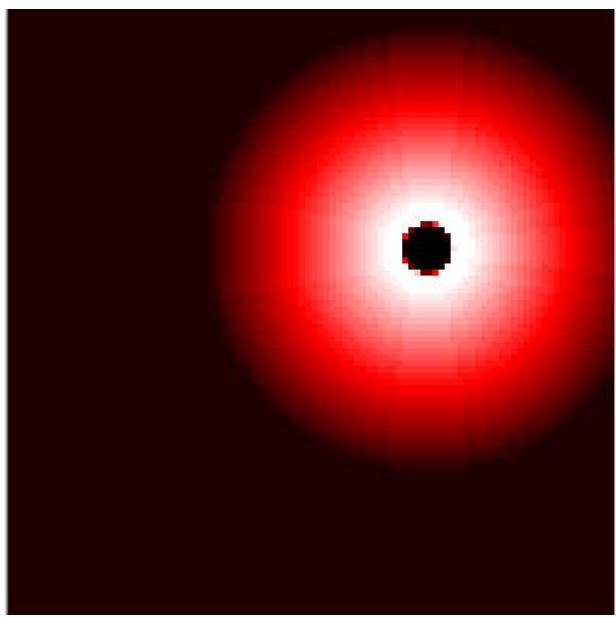


Sap flow measurements– HRM

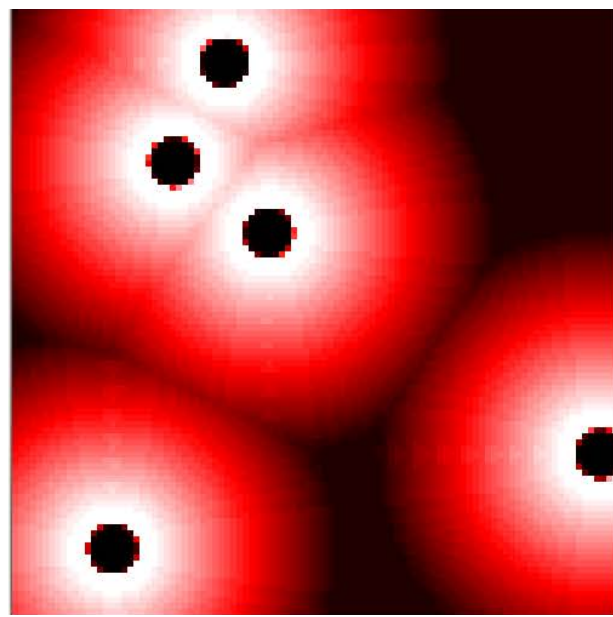


# SOIL WATER DRAINAGE AT 1.5 m DEPTH

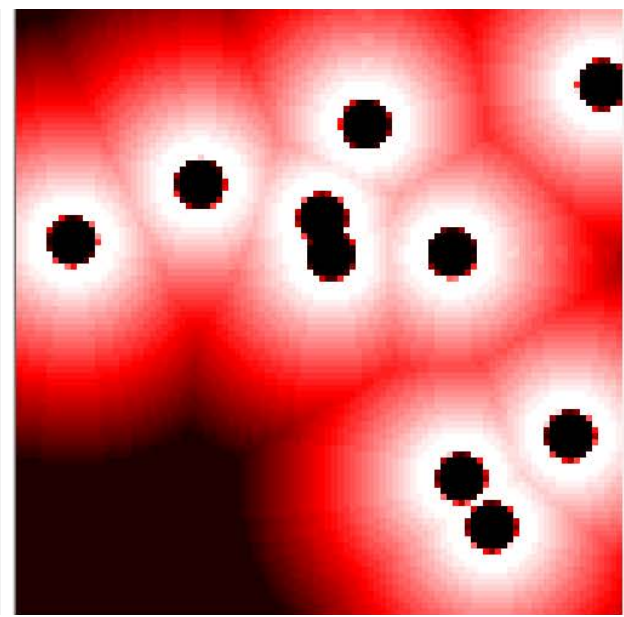




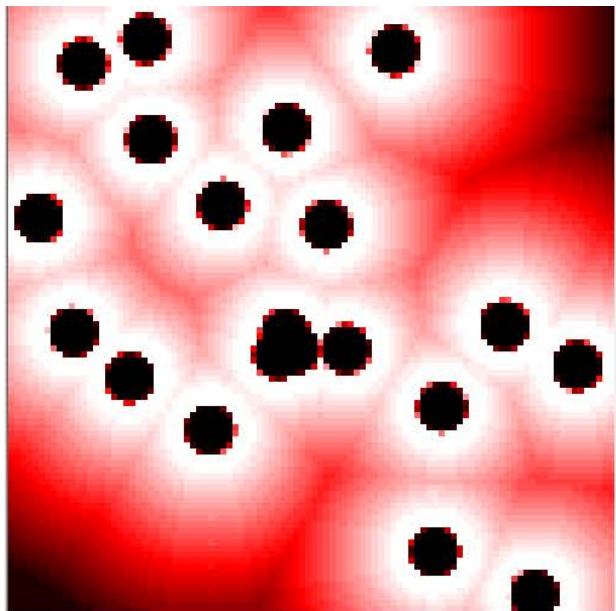
1 tree ha<sup>-1</sup> ; 25 mm



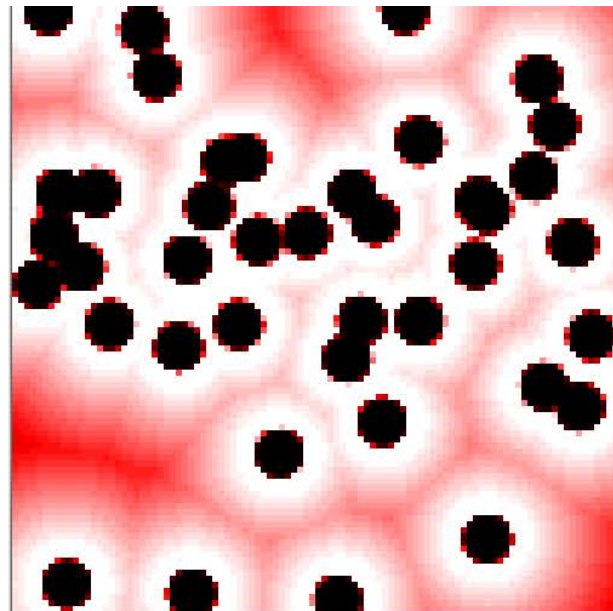
5 tree ha<sup>-1</sup> ; 53 mm



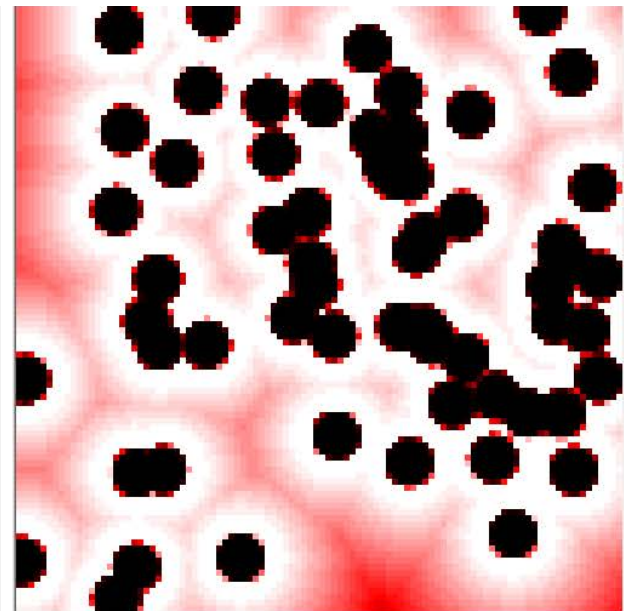
10 tree ha<sup>-1</sup> ; 66 mm



20 tree ha<sup>-1</sup> ; 76 mm



40 tree ha<sup>-1</sup> ; 79 mm



60 tree ha<sup>-1</sup> ; 74 mm



# Intermediate tree cover can maximize groundwater recharge

www.nature.com/scientificreports

SCIENTIFIC REPORTS

Ilstedt *et al.* 2016

<https://www.nature.com/articles/srep21930>



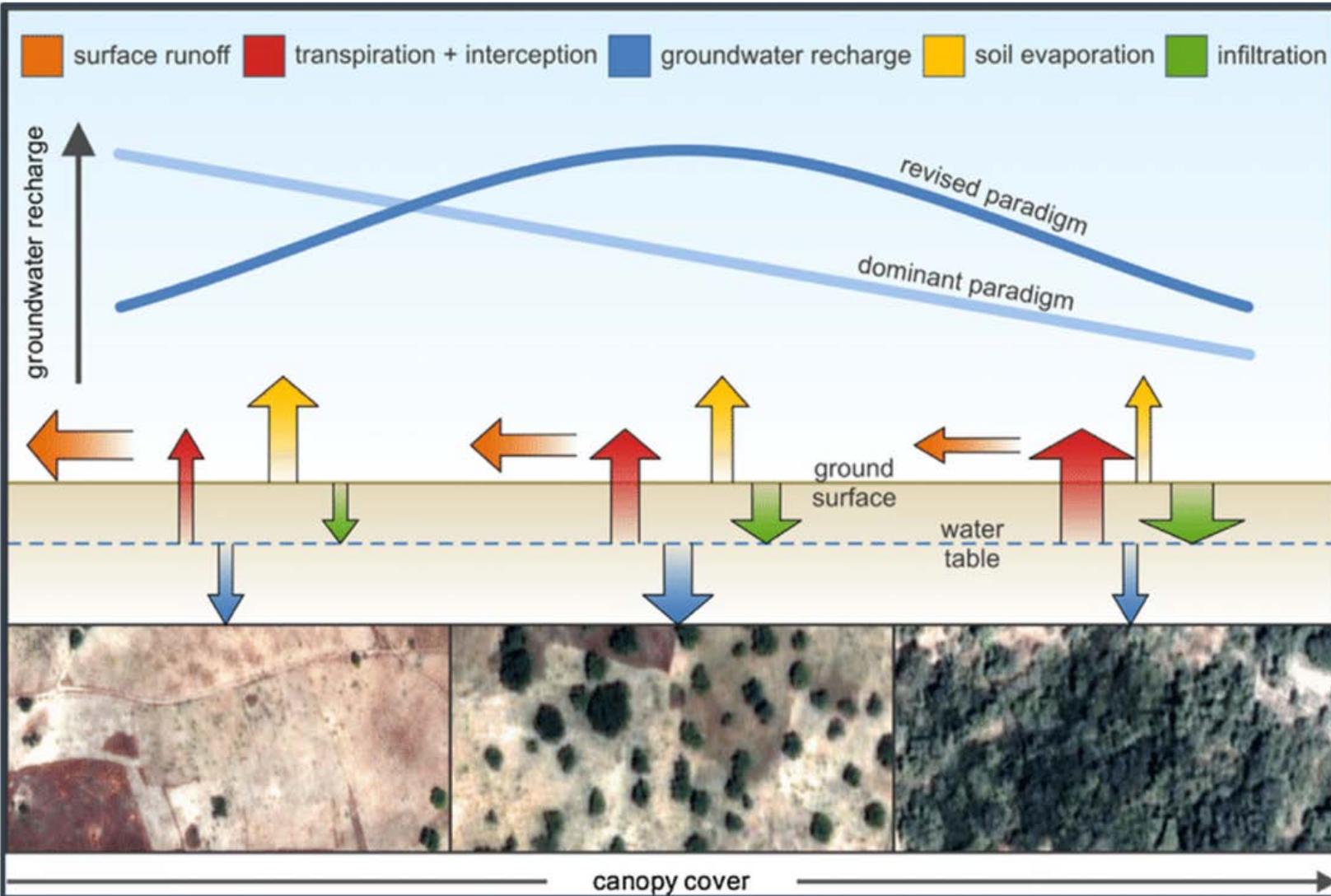
Global Environmental Change

journal homepage: [www.elsevier.com/locate/gloenvch](http://www.elsevier.com/locate/gloenvch)

Research paper

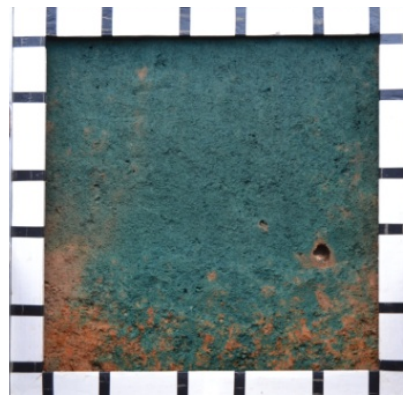
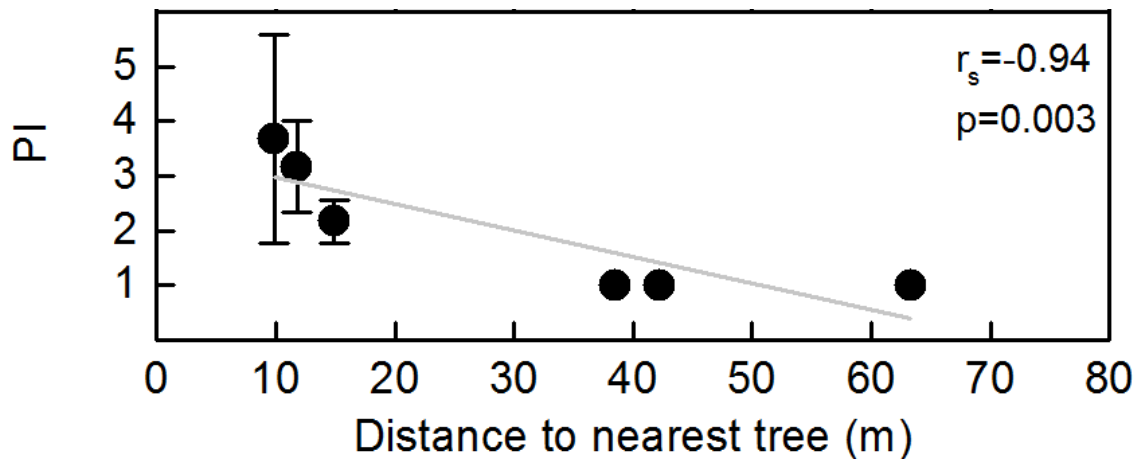
Trees, forests and water: Cool insights for a hot world

Ellison *et al.* 2017



# THE POWER OF TREES EXTENDS BEYOND THE CANOPY EDGE

## Degree of preferential flow

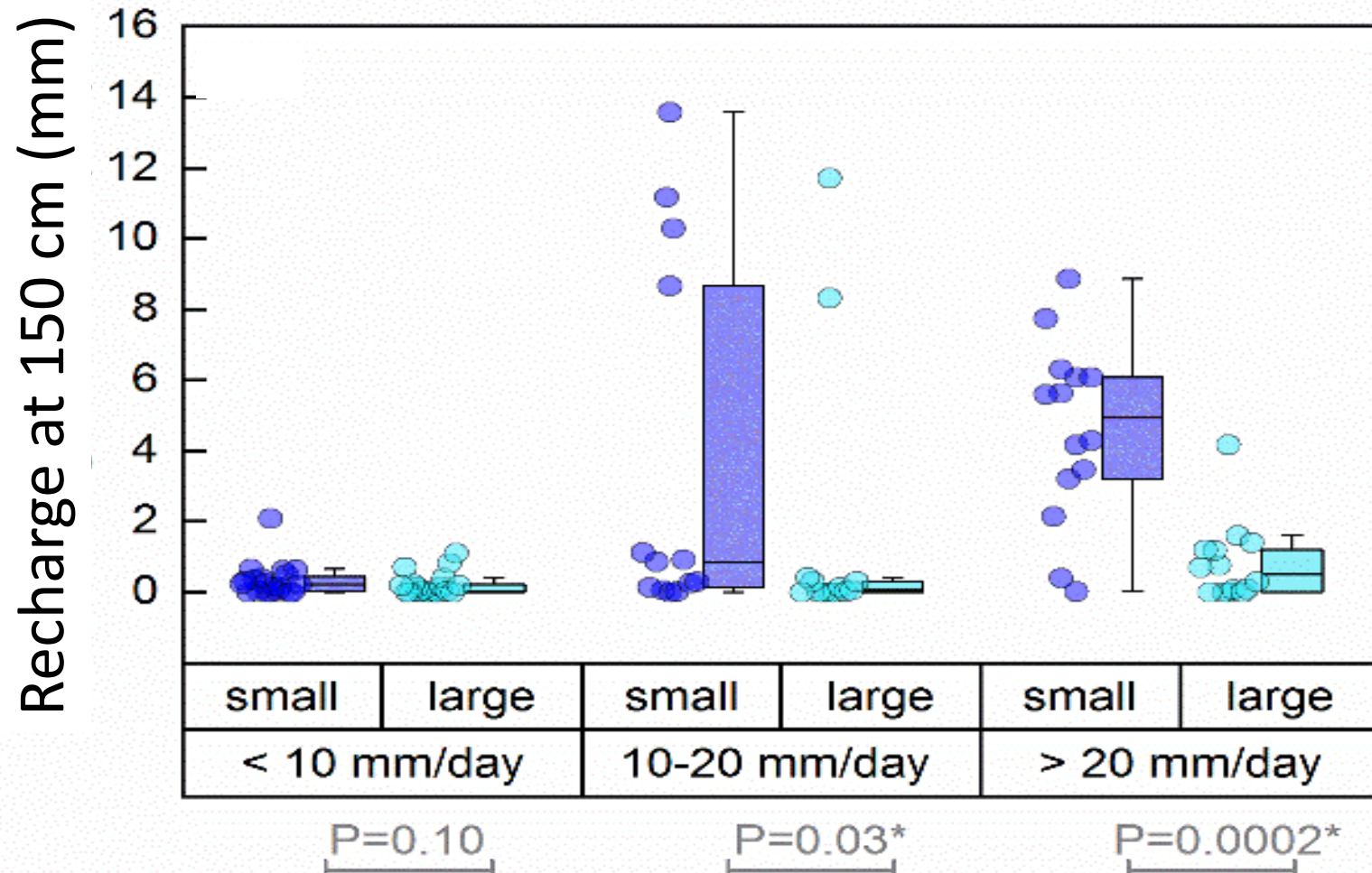


## Vitellaria paradoxa (Shea tree) roots



# Implications for climate change:

At high rain intensity x13 recharge in small gaps

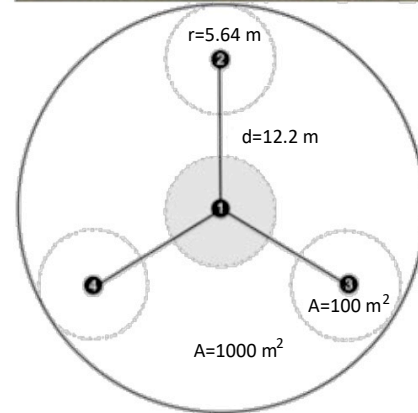
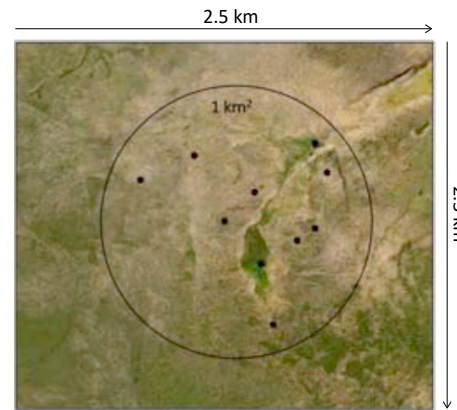
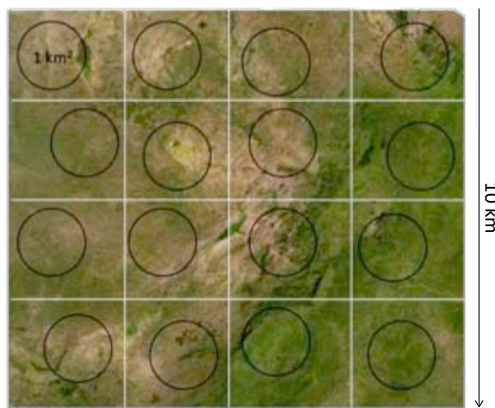


(Bargués-Tobella, 2019)

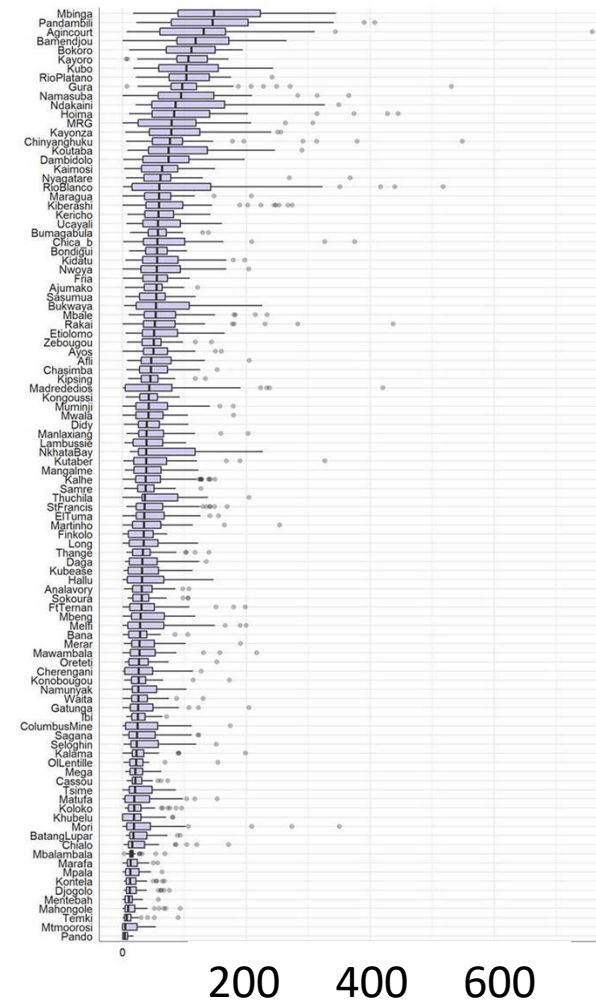
# Effect of trees on water across tropical drylands

Linking tree cover, land use and biodiversity with water

The Land Degradation Surveillance Framework

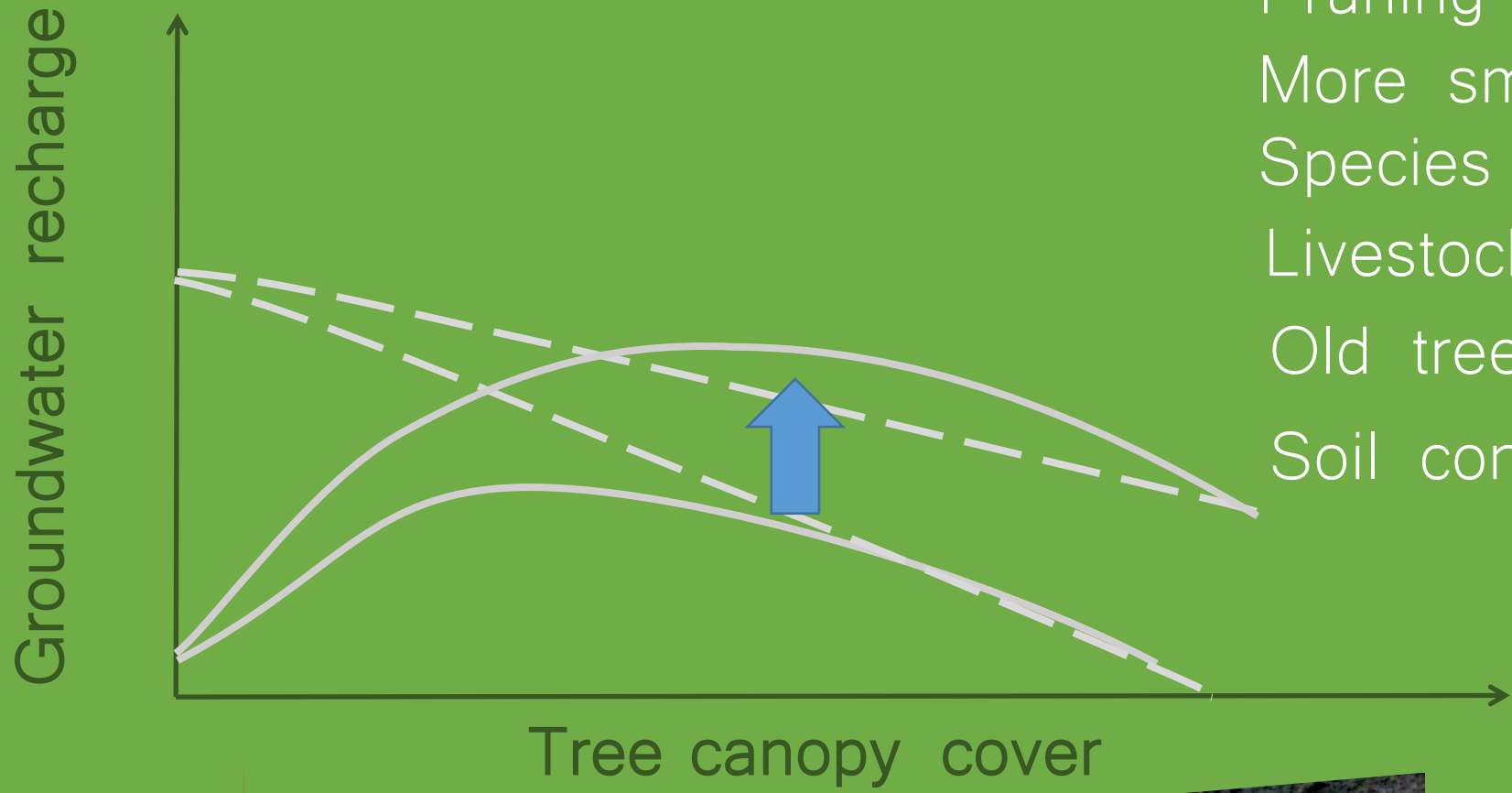


Infiltration capacity (mm h<sup>-1</sup>)





# Managing trees for water



- Pruning
- More small gaps
- Species with low water use
- Livestock control
- Old trees
- Soil conservation





Photo: Jonas Koala