Linking salts, groundwater, and vegetation in the (hyper)plains of South America

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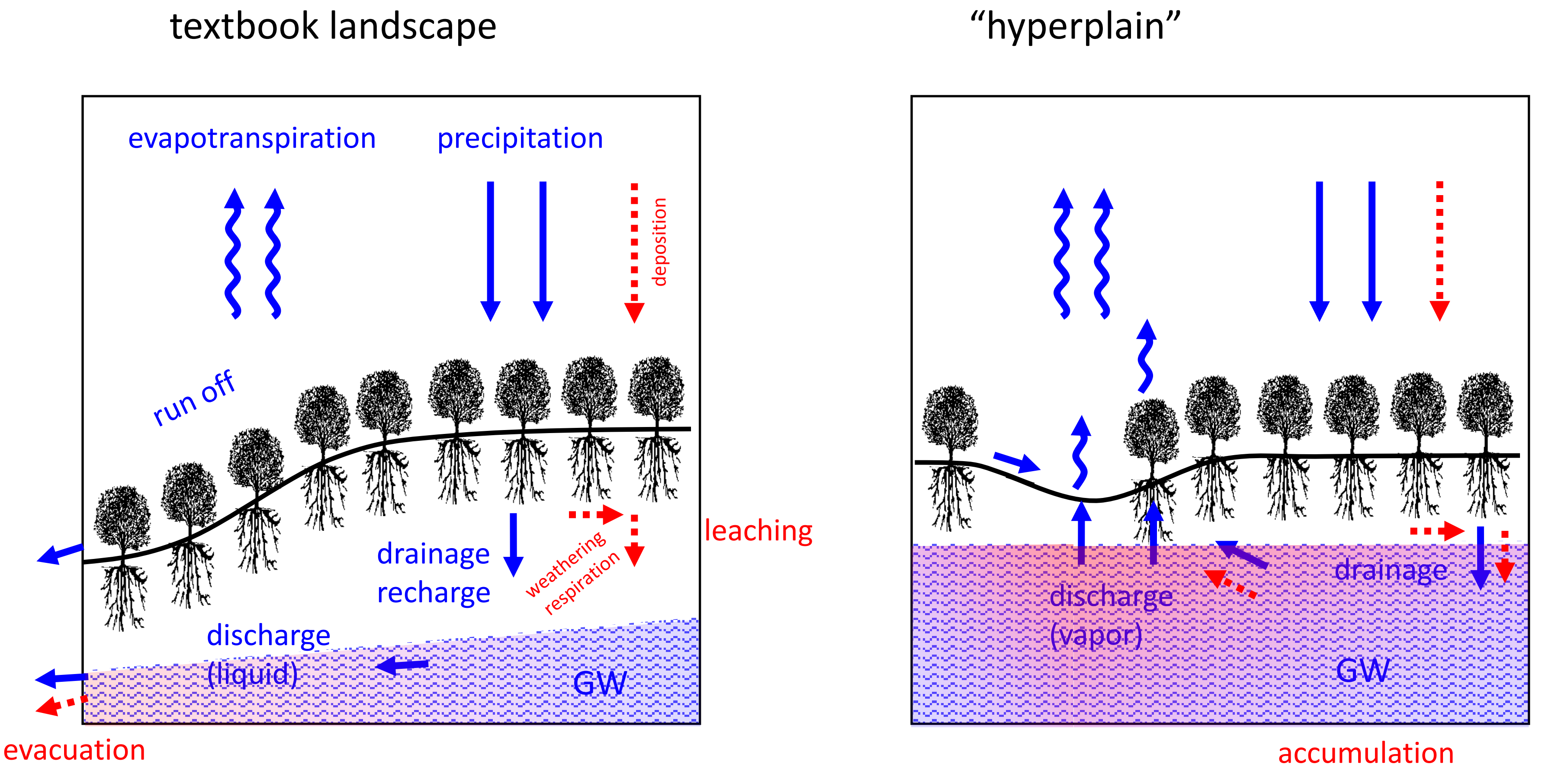
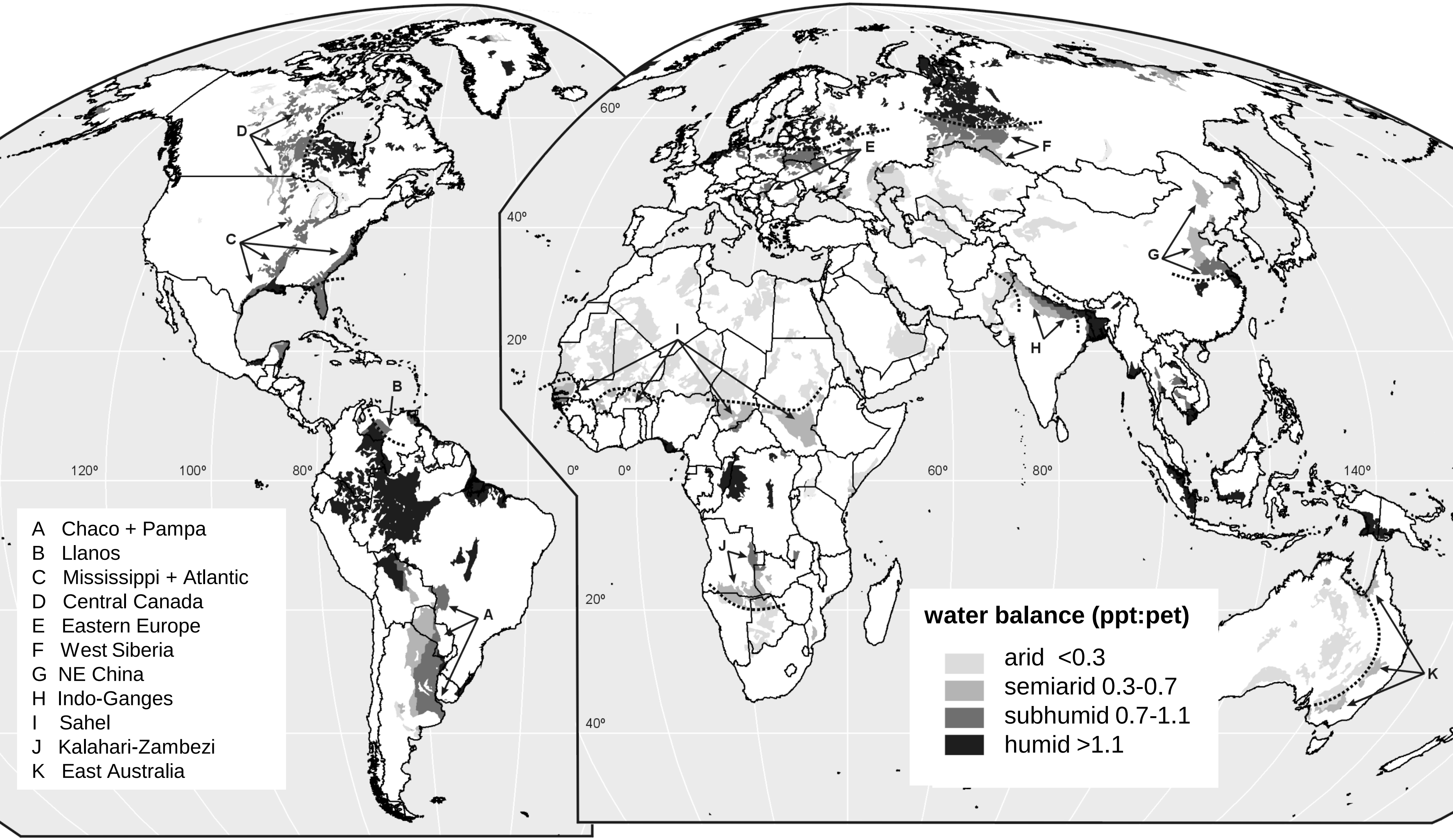
RISSAC (Hungary) - Tibor Tóth
Duke University (US) - Rob Jackson, Vic Engel, Dush Jayawickreme


textbook landscape
evapotranspiration
precipitation
deposition
run off
leaching
drainage
recharge
weathering
respiration
discharge
(liquid)
GW
evacuation
"hyperplain"
discharge
(vapor)
drainage
GW
accumulation

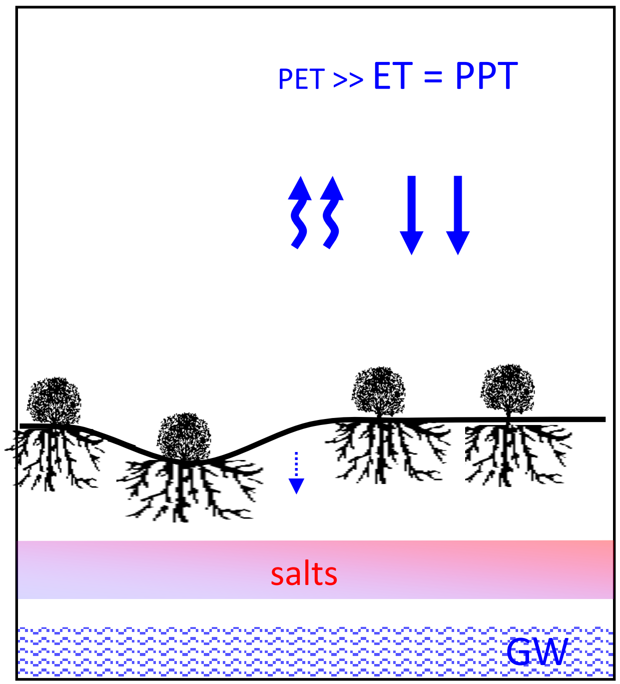


hyperplains (regional slope < 0.1 % - based on Space Shuttle DEM, 8km^2 kernel)

Jobbágy et al 2008 – Ecología Austral

ARID

No excess
Deep water tables

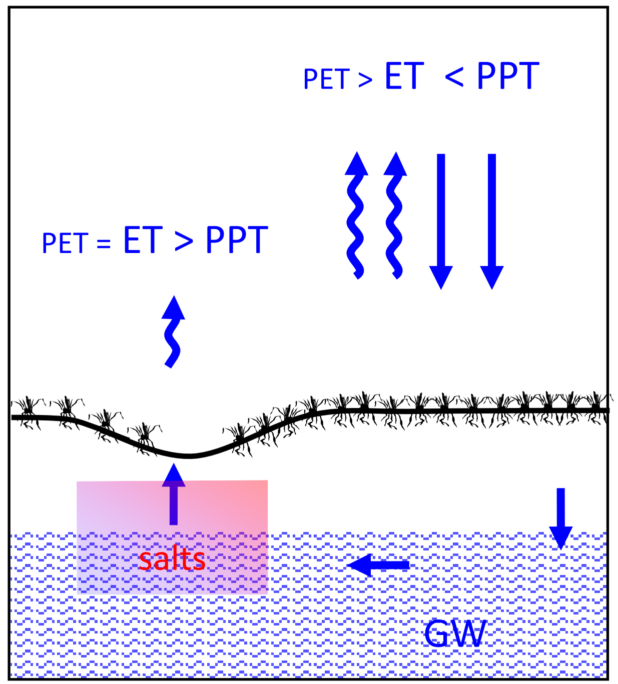


Widespread
Subsoil and vadose zone

CHACO – AUSTRALIA
SAHEL – High plains USA

SEMIARID-SUBHUMID

Small excess in uplands
Shallow water tables
Groundwater use in lowlands

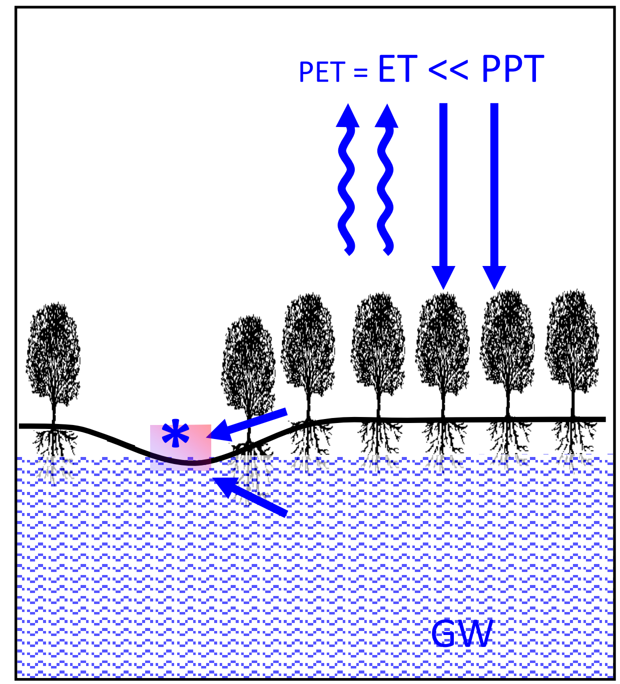


Lowlands
Surface and capillary zone

PAMPAS – WESTERN SIBERIA
HUNGARY – CANADA – N Caspian

HUMID

Large excess
Shallow water tables
Widespread flooding and net loss (*)



Surface and ground water
remove salts

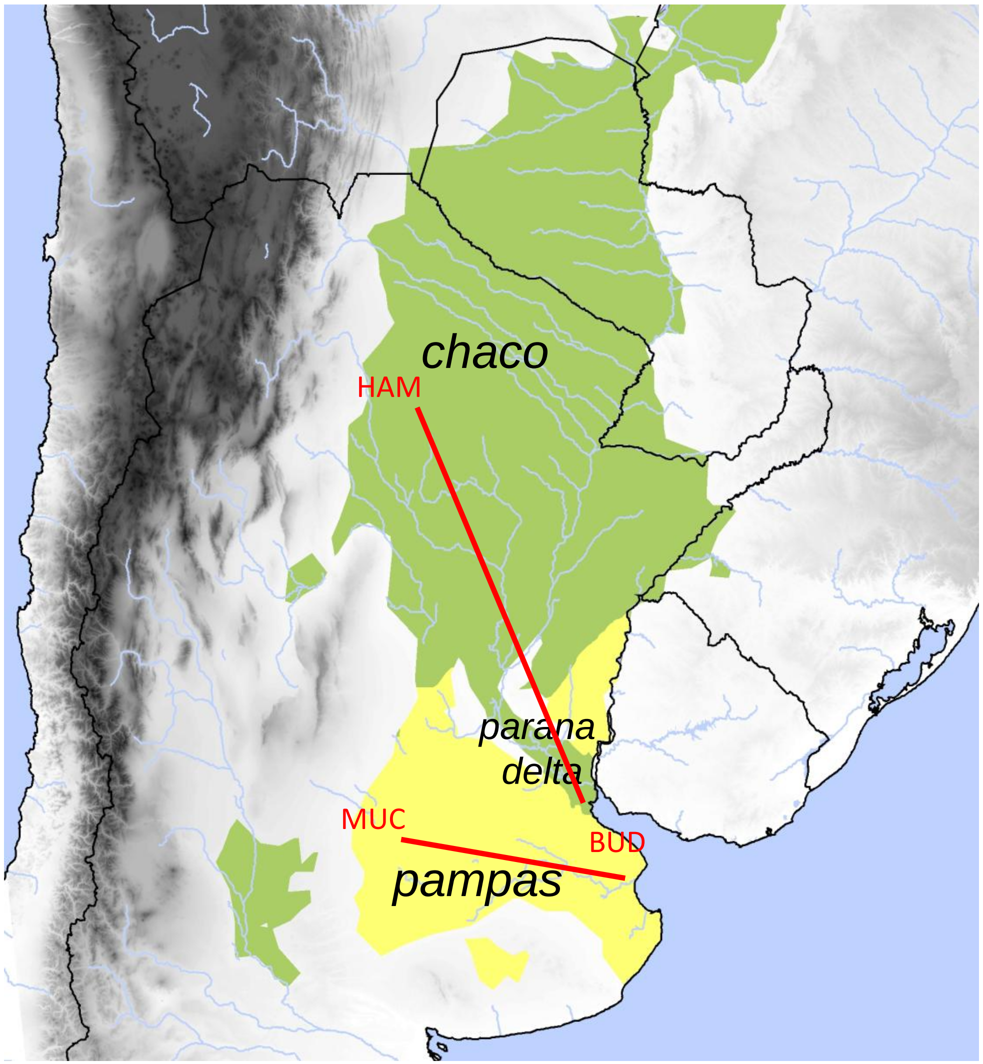
AMAZON – CAMPOS - LLANOS

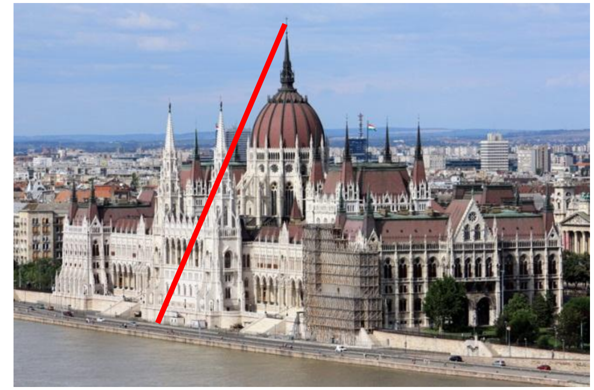
Guiding hypotheses

The reciprocal interactions between **salts**, **groundwater** and **vegetation** are a central organizer of the ecology of **hyperplains**

Their **coupling** offers keys to manage and articulate
three critical (and often competing) **ecosystem services** in these regions:
Food/Timber Production – Hydrological regulation – Natural habitat provision

Hyperplains
in Southern South America



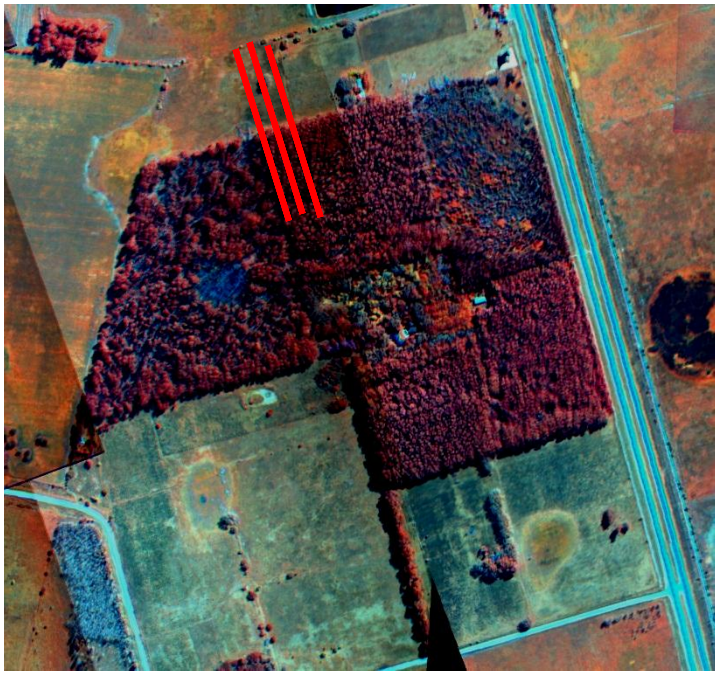


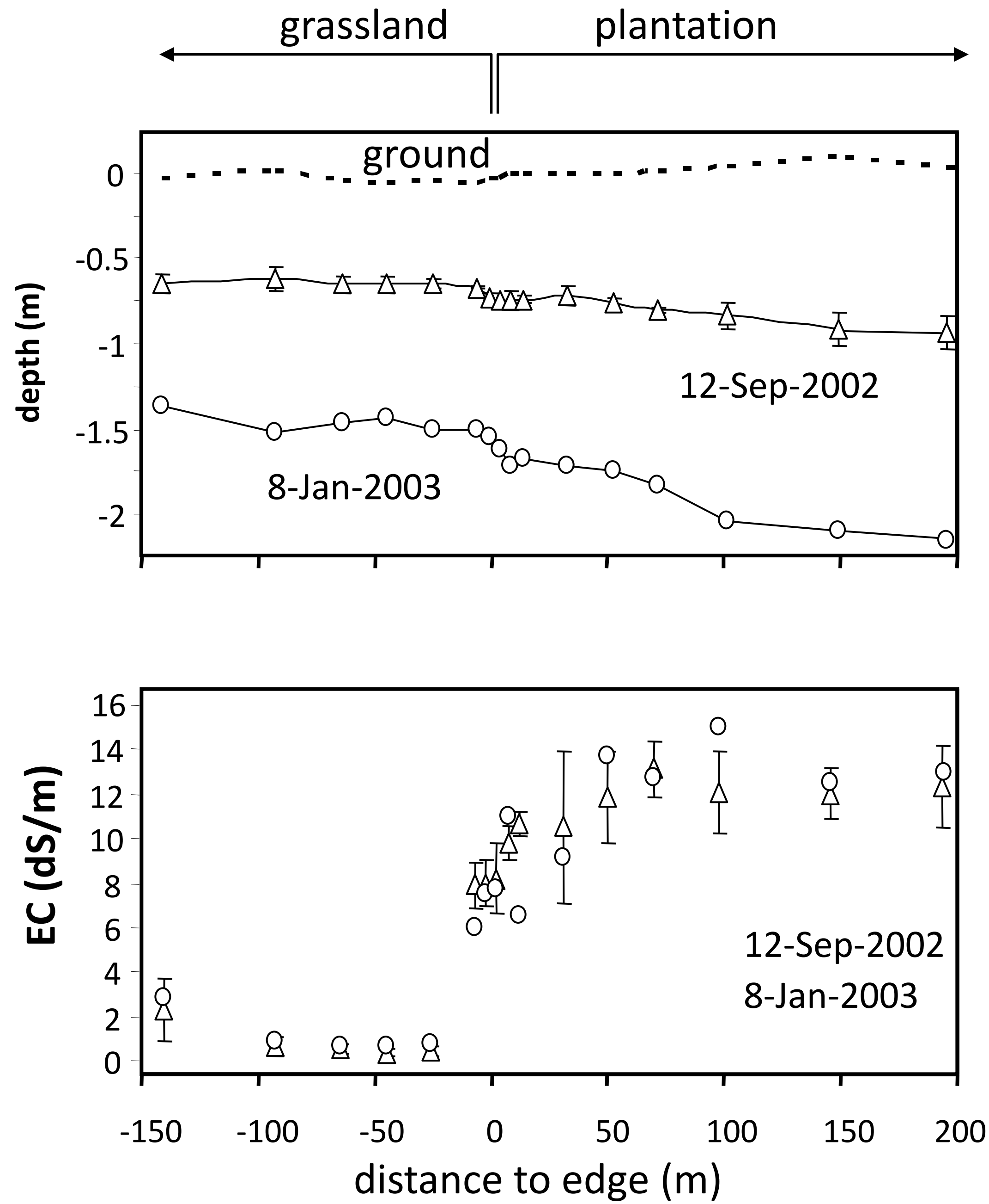
Stop 1

Stop 2

Stop 3

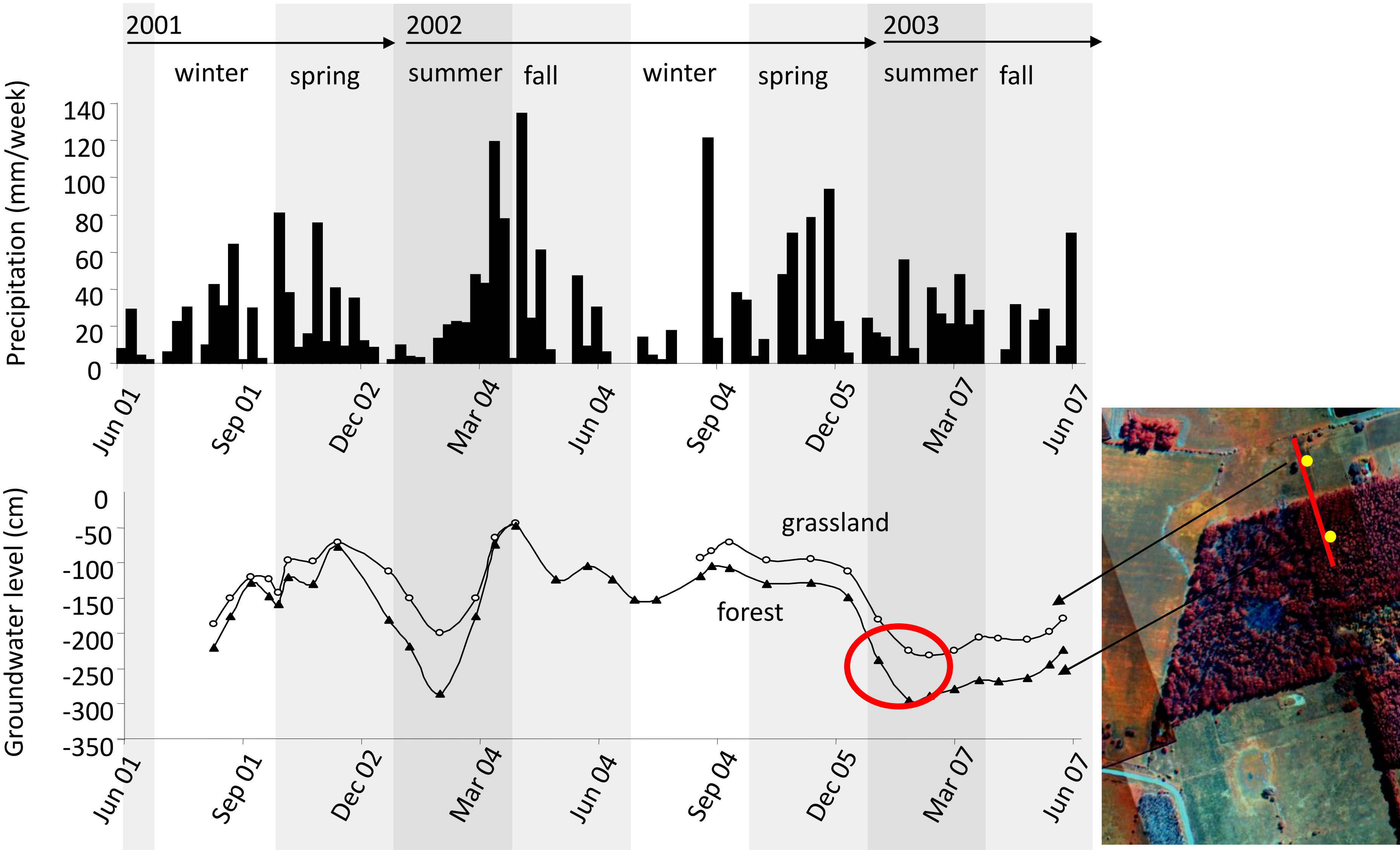

STOP 1
tree plantations
in subhumid
grasslands



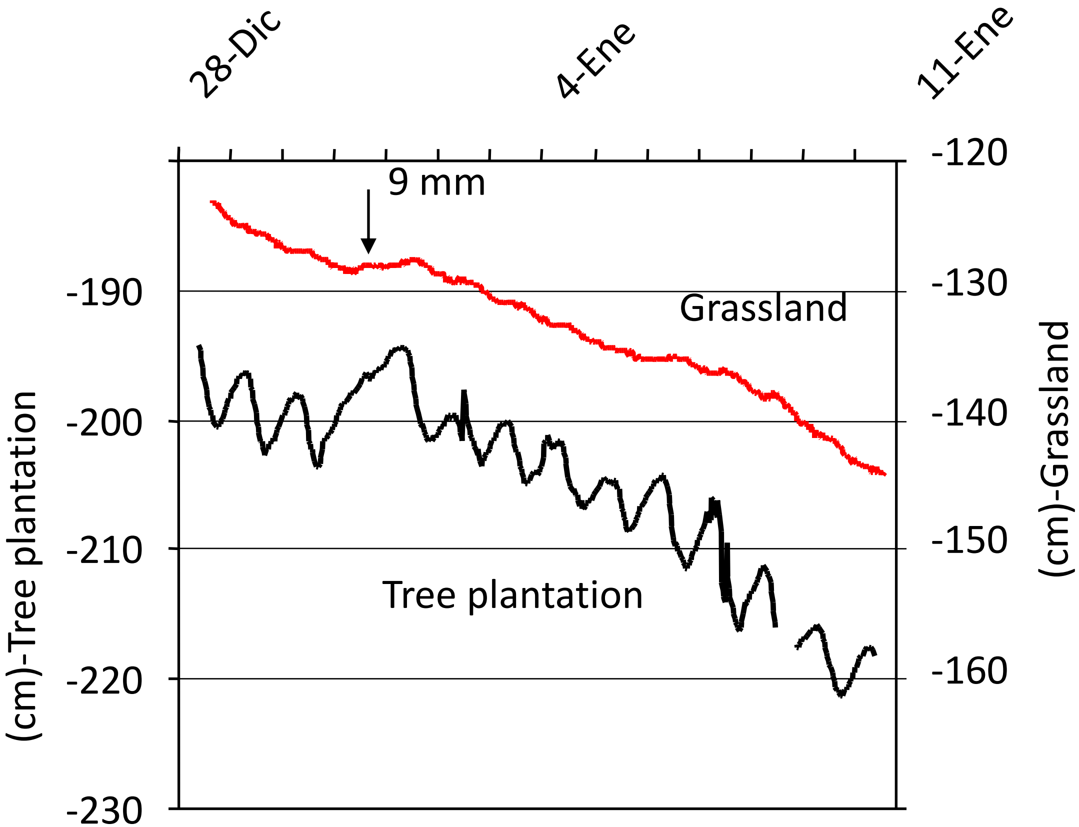


Eucalyptus camaldulensis plantation
50 y/o, 40 Ha
Surrounded by grasslands & pastures
45 observation wells

Jobbagy & Jackson 2004 – Global Change Biology



Jobbagy & Jackson 2004 – Global Change Biology



<u>Other evidence</u>
Drier soils in plantation
Lack of recharge after large rain events
Sap flow data (ET > PPT)
Tree productivity too high for PPT
Salt balance

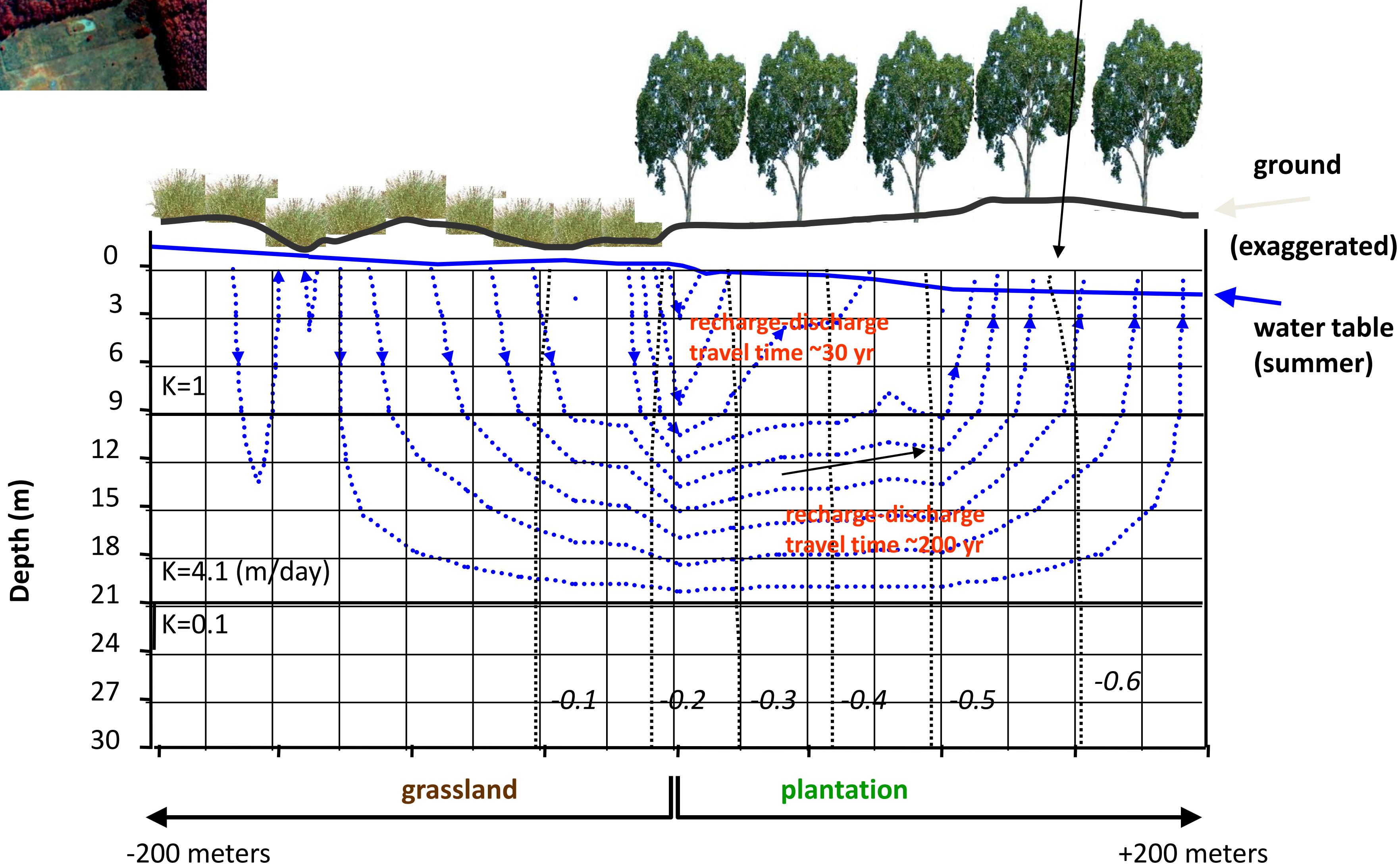
Net GW use
300 mm/yr

Engel et al. 2005 - WRR
Nosetto et al. 2007 – Oecologia (HUNGARIAN CASE ..!)
Jobbagy & Jackson 2004 – Global Change Biology

Flux reconstruction

Jobbagy & Jackson 2007 – JGR - Biogeochemistry

Saturated conductivity measurements
(well tests, existing data)
Simulation with FLOWNET



^3H = tritium

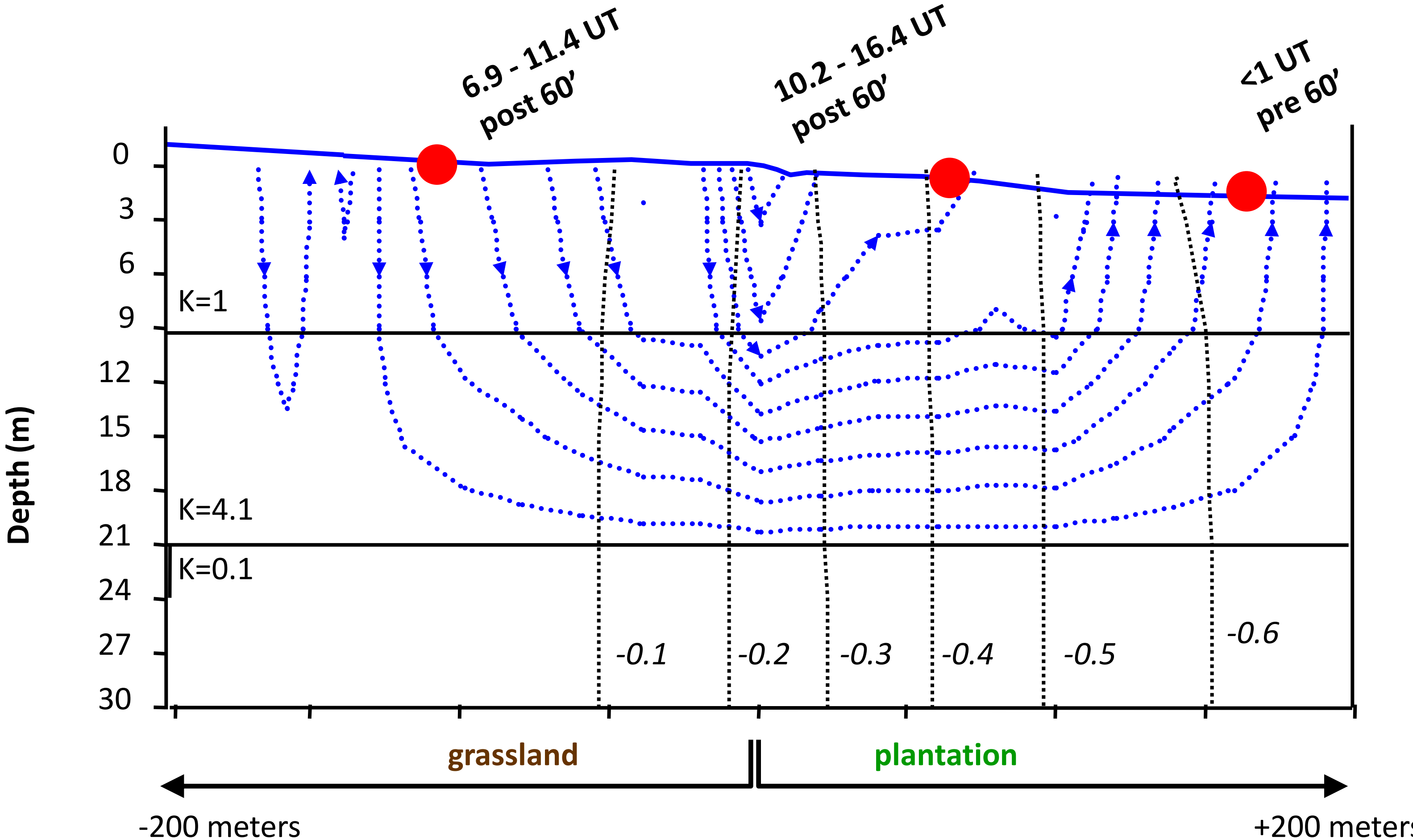
half life 12.34 yrs

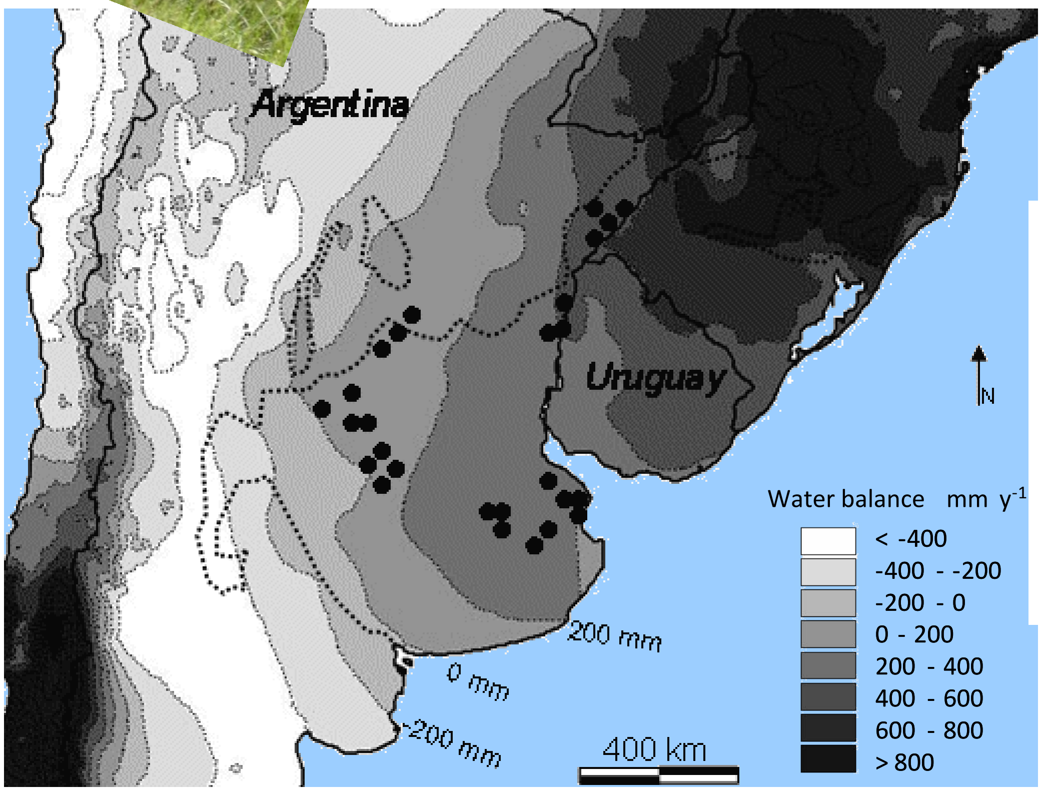
Concentration in precipitation

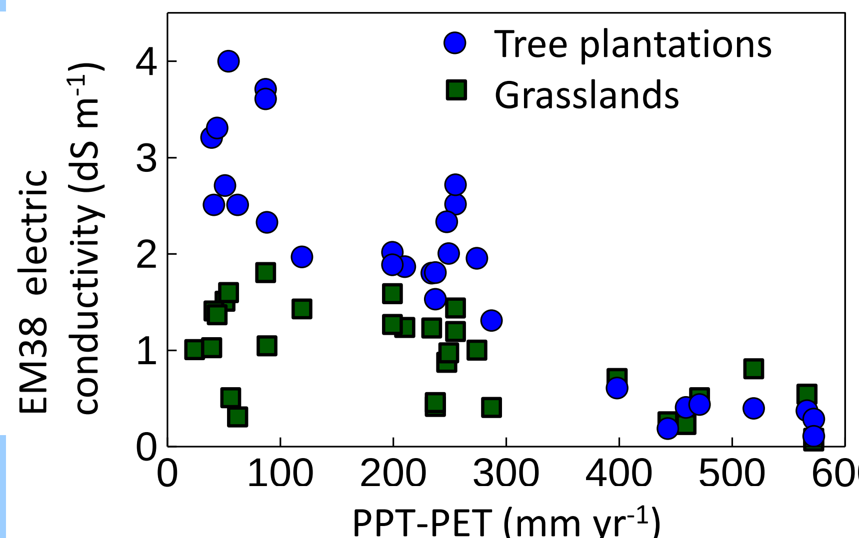
Before 1950 = < 1 TU

1962-1967 = > 50 TU

Today (BA) = 5-10 TU (1UT = [^3H2O] 10^{-18})



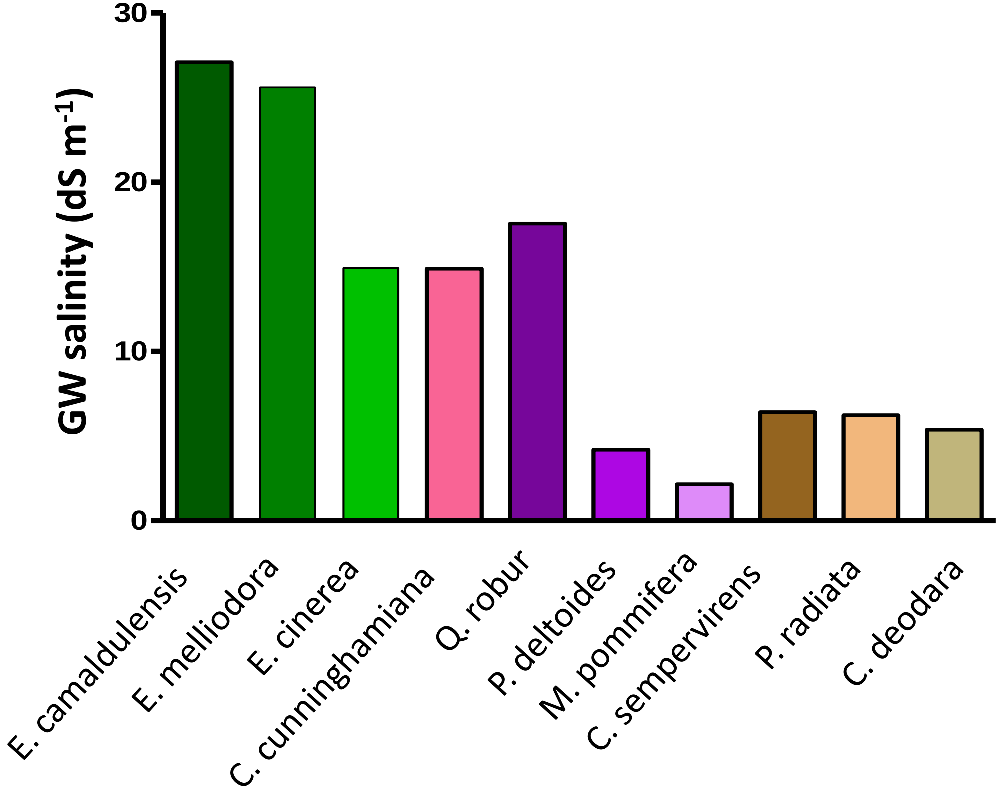


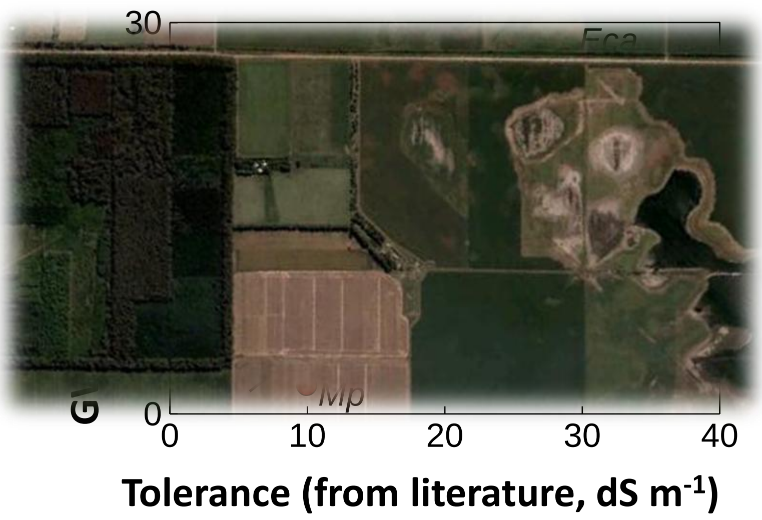


Nosetto et al. 2008 – Global Biogeochemical Cycles



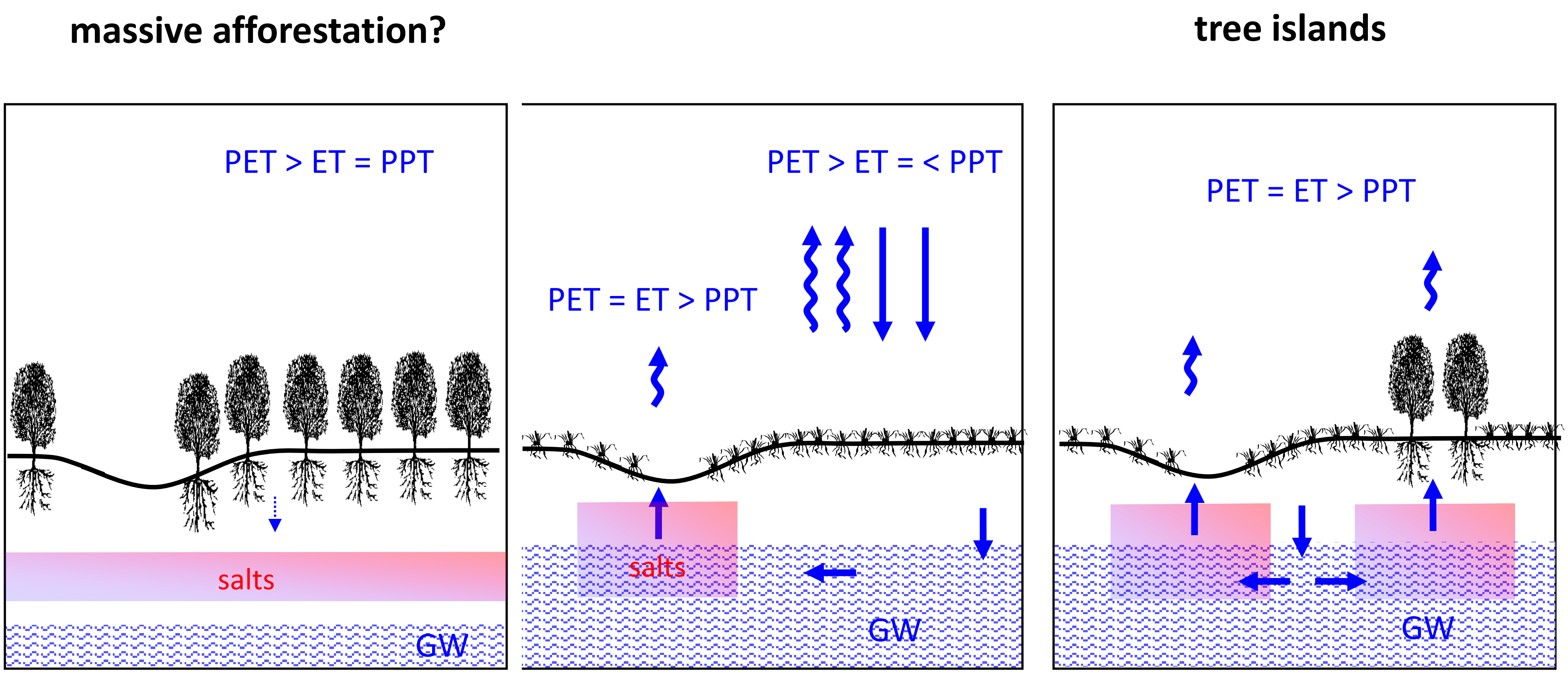




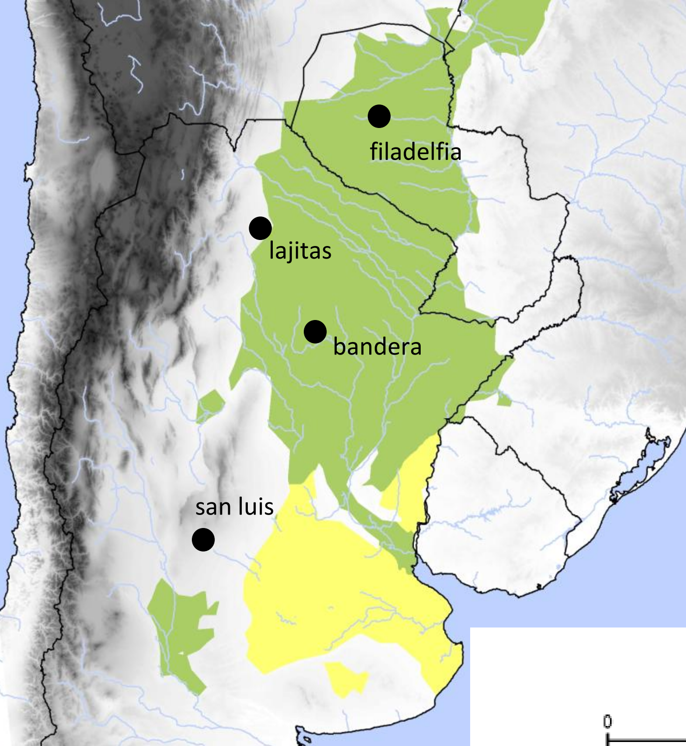
Nosetto et al. 2008 – Global Biogeochemical Cycles

SEMIARID-SUBHUMID

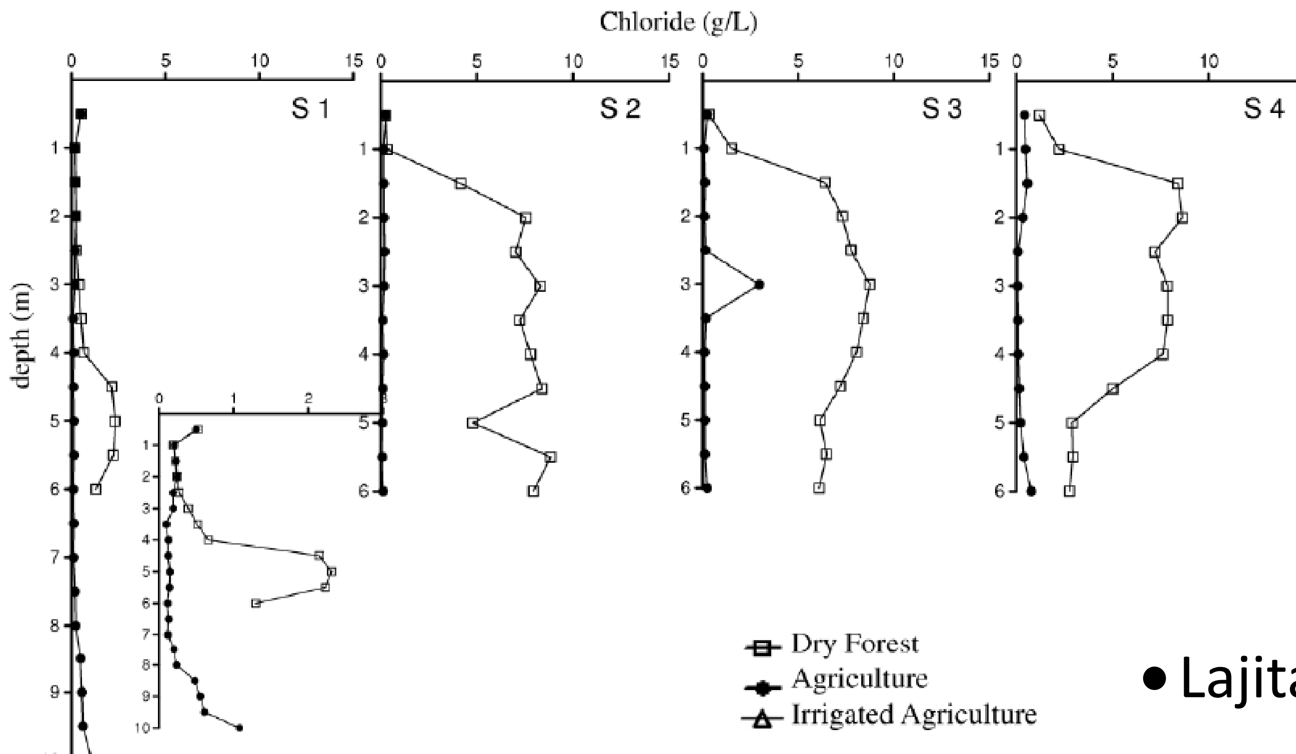



STOP 2
crops
in semiarid
forests

Santoni et al. 2010 – WRR
Jayawickreme et al. 2011 – Ecological Applications
Contreras et al. 2012 – Ecohydrology
Amdan et al. in review – WRR
Gimenez et al. in preparation



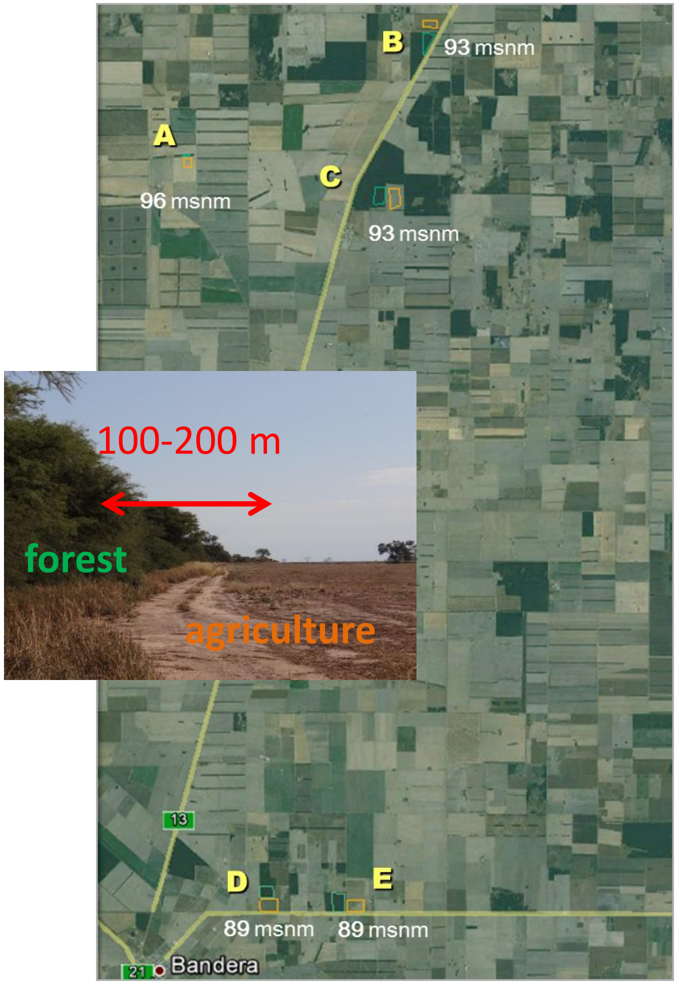
	Rainfall (mm/yr)	GW depth (m)	natural chloride stock (kg/m^2)	Recharge rate with cultivation (mm/yr)
San Luis	600	> 20	0.2-9 Kg/m2	5 to 20
Filadelfia	800	> 10	> 10 Kg/m2	unknown
Lajitas	850	> 20	6-13 Kg/m2	30 to 50
Bandera	950	> 8	10-12 Kg/m2	30 to 50

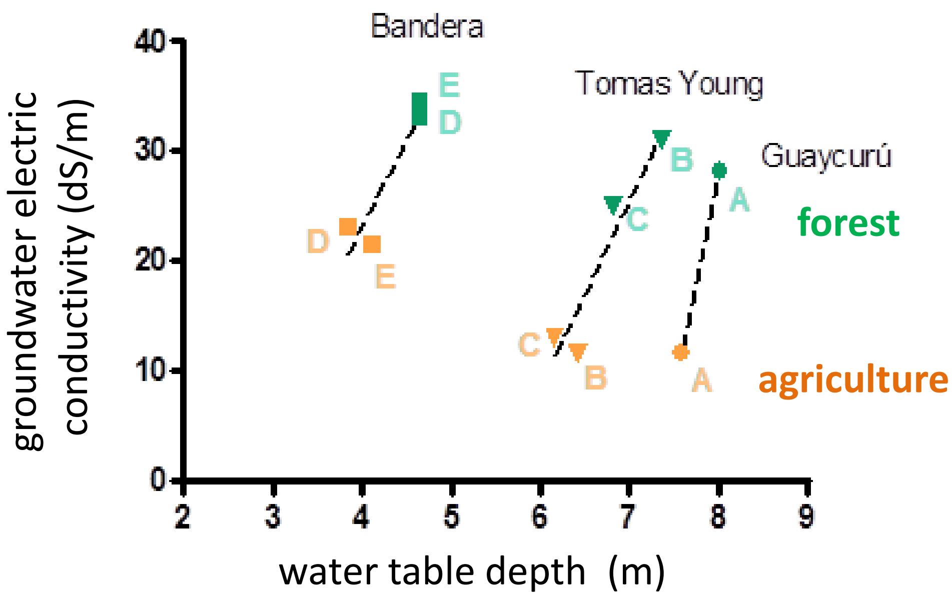


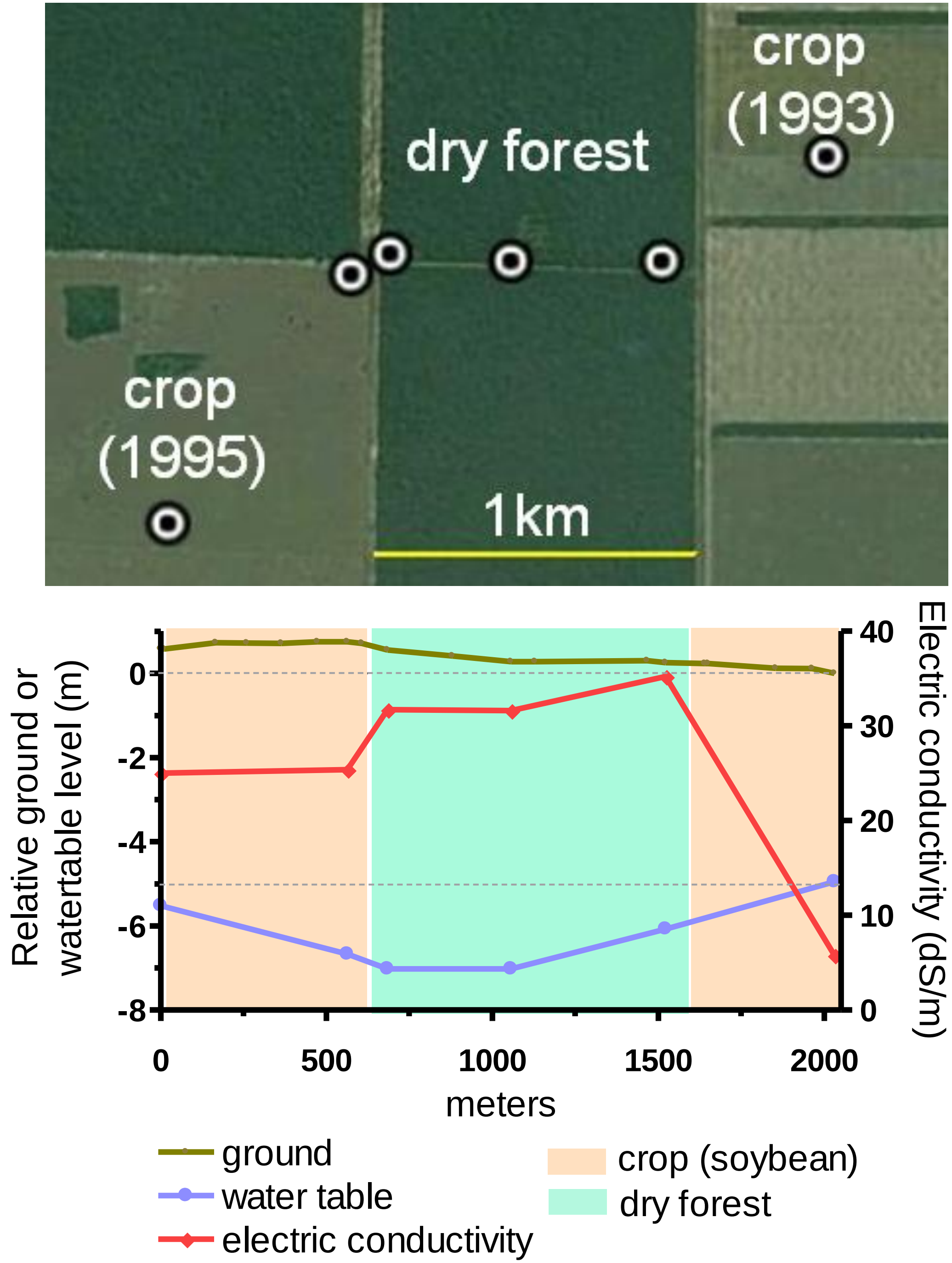
• Lajitas

Gimenez et al. in preparation

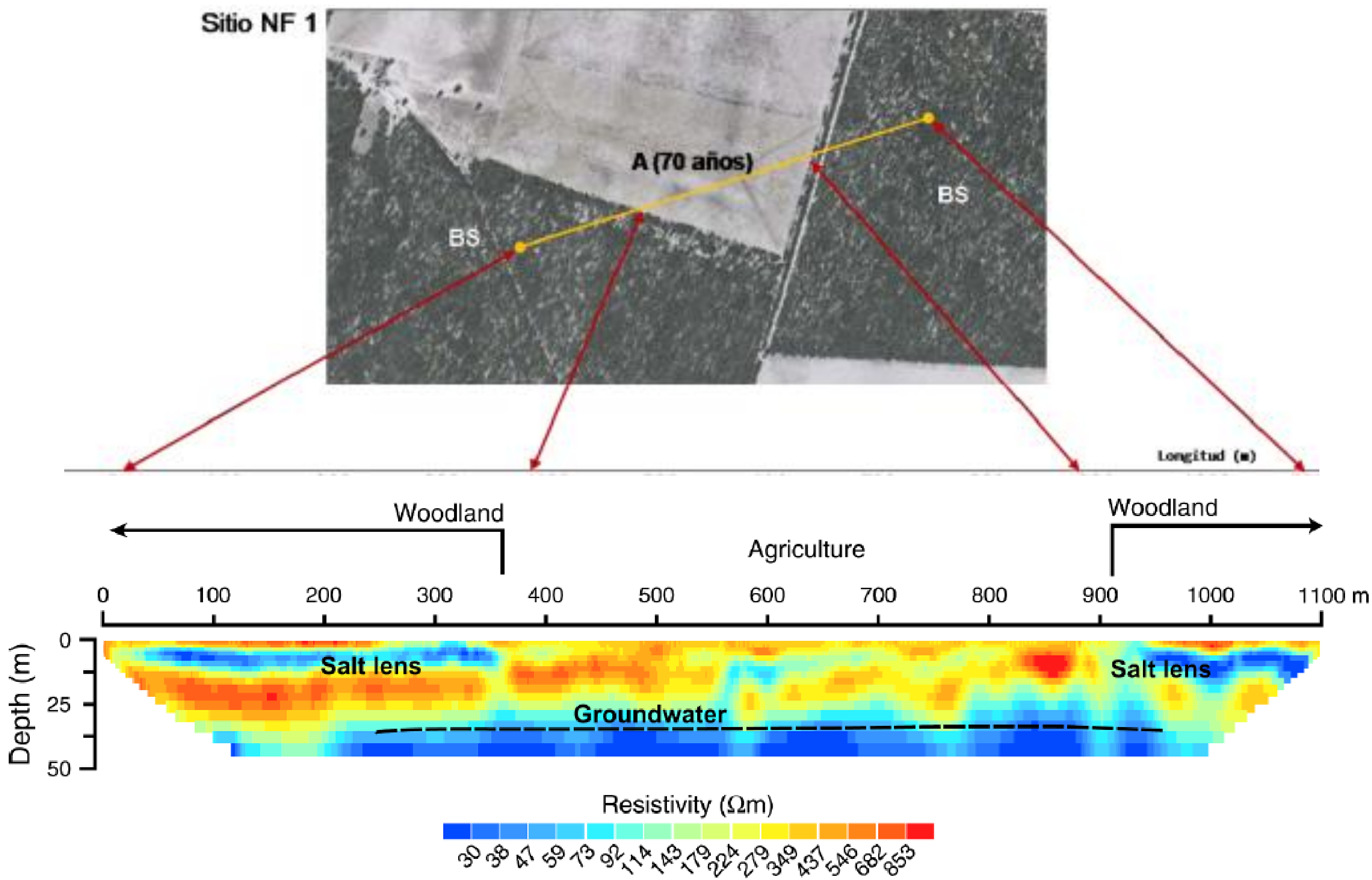
- Bandera






crop
(1993)
dry forest
crop
(1995)
1km
Relative ground or
watertable level (m)
Electric conductivity (dS/m)
0
-2
-4
-6
-8
40
30
20
10
0
0
500
1000
1500
2000
meters
ground
water table
electric conductivity
crop (soybean)
dry forest

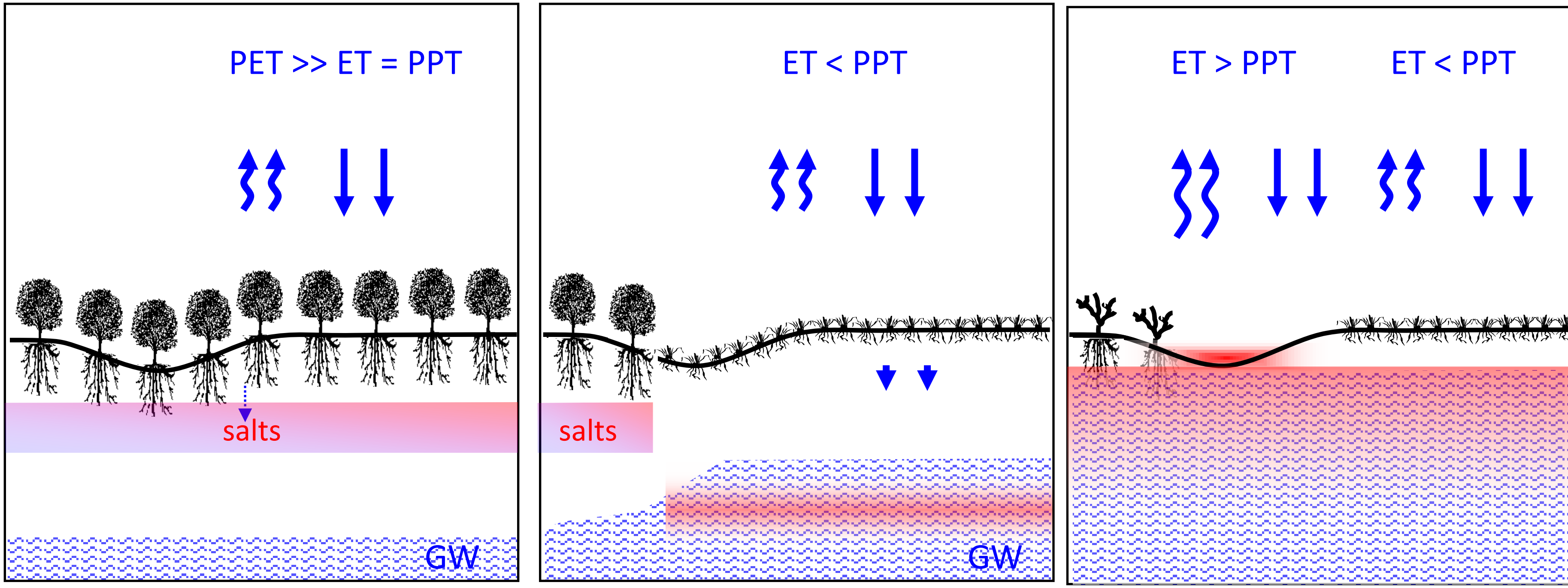
- San Luis



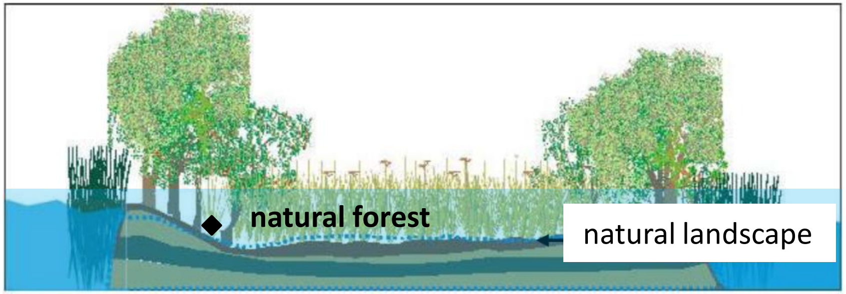
more conductive

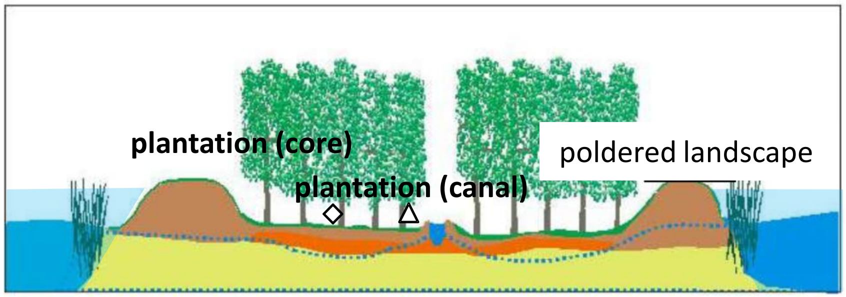
less conductive

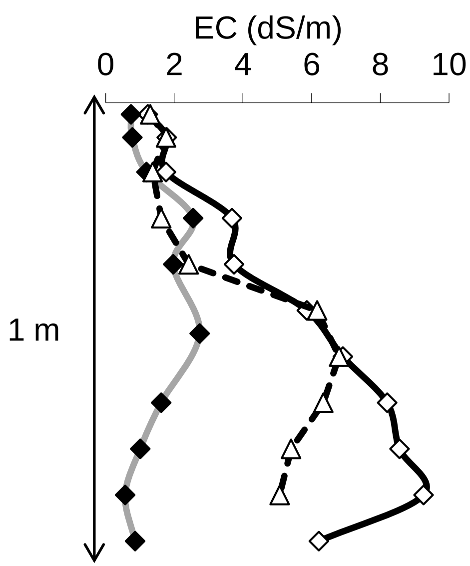
SEMIARID FOREST SEMIARID CROPLAND FUTURE?

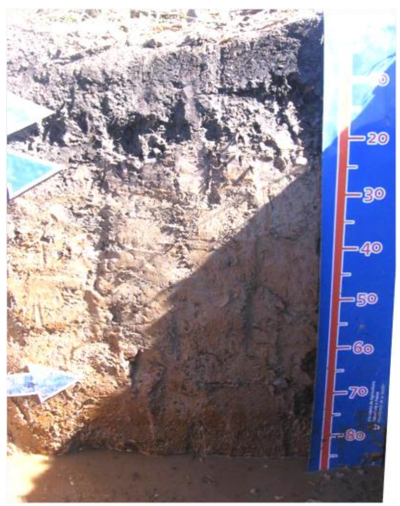


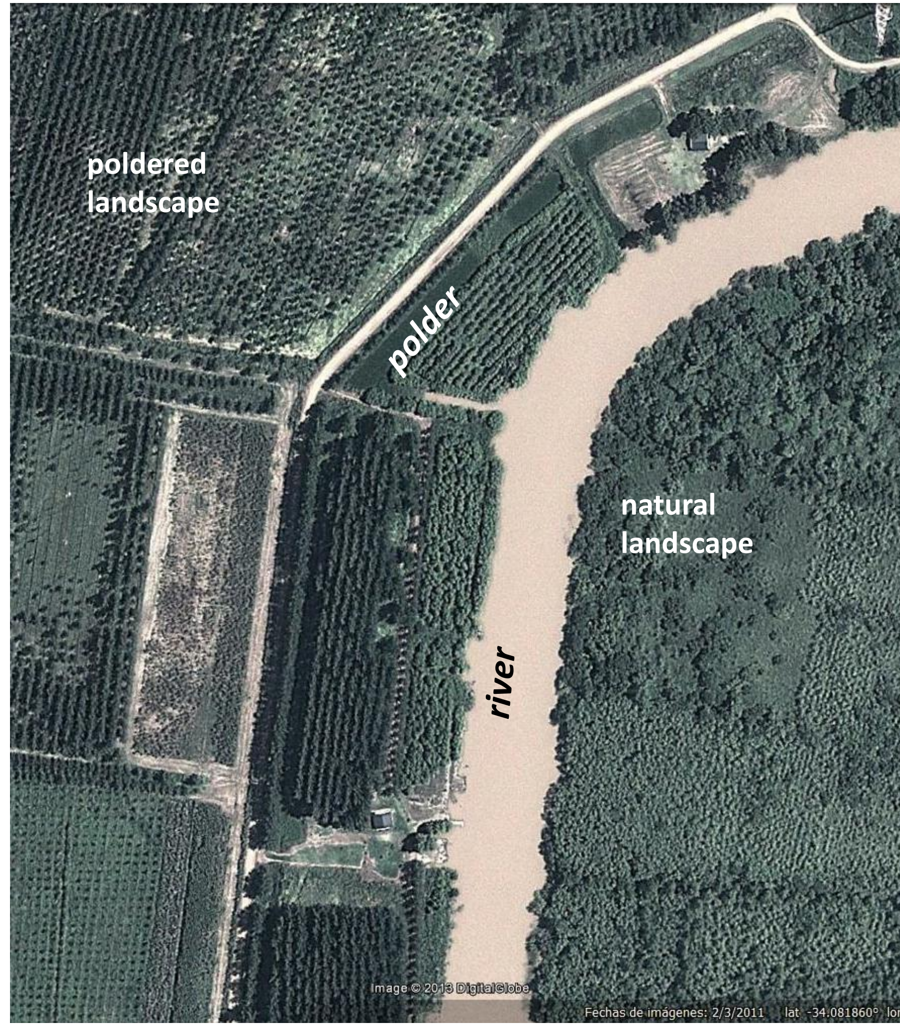

STOP 3
poldering
and tree planting
in humid delta









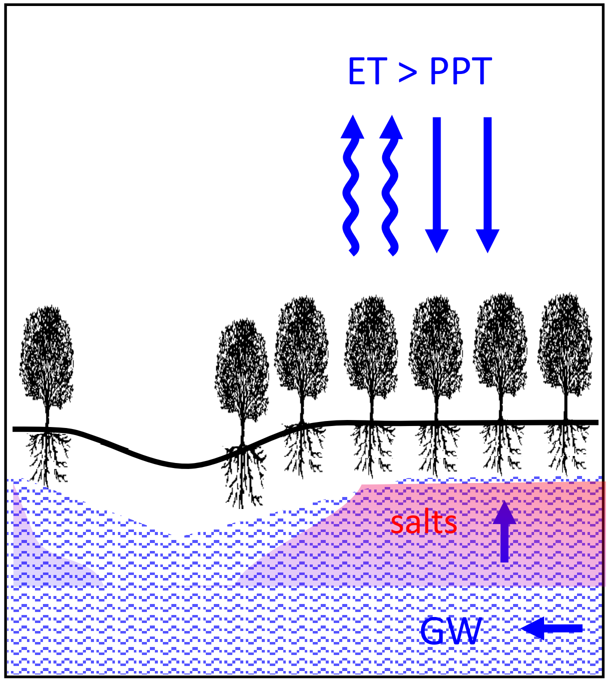


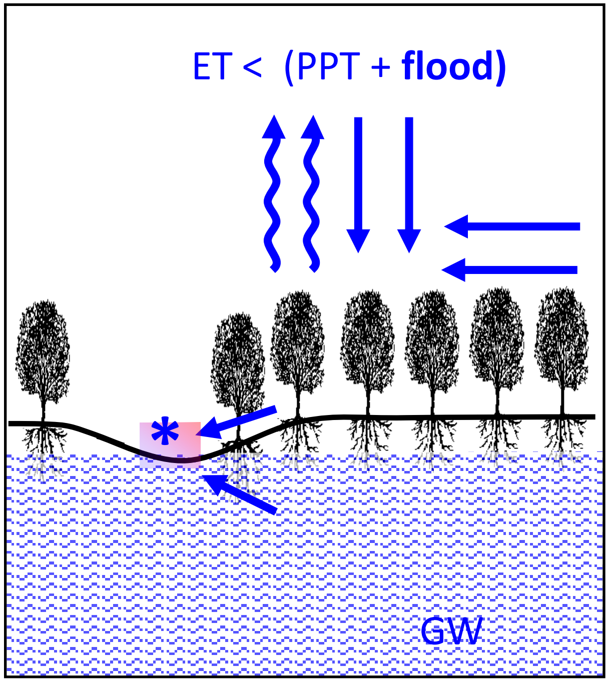
Ceballos et al – 2012, Biogeochemistry

Ceballos et al – in preparation

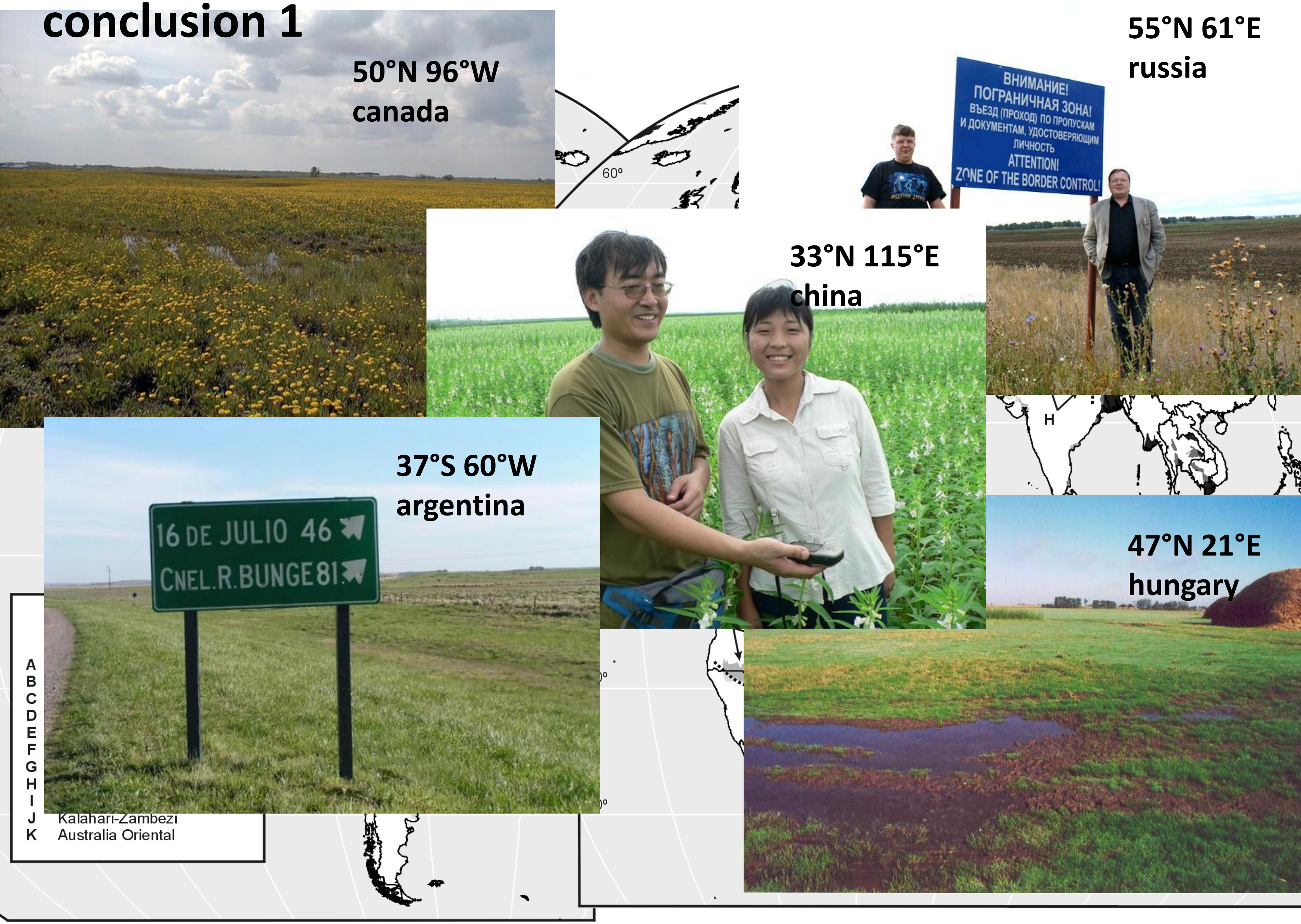
Poldering cuts flood

SUBHUMID but flooded = HUMID





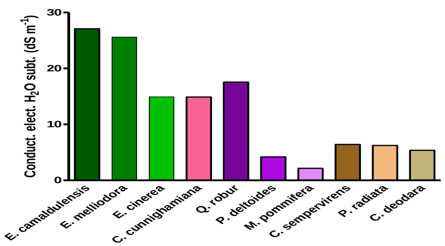
conclusion 1

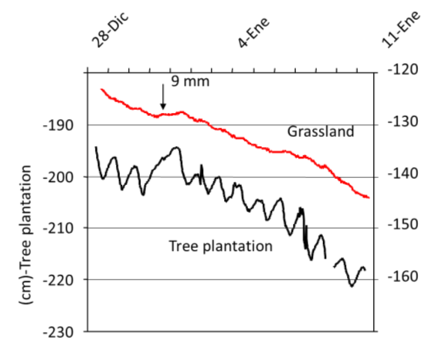


conclusion 2

people

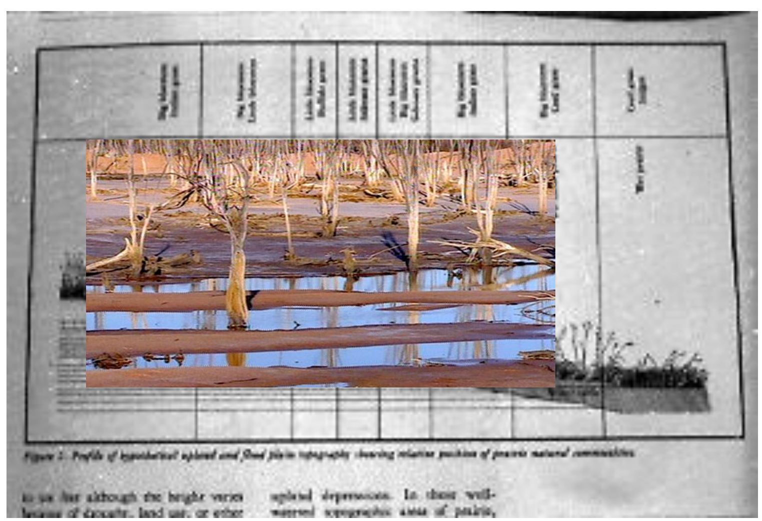
vegetation





salt

groundwater

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köszönöm !!