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El algarrobo: Sobreviviendo al ENSO a través del tiempo

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Universidad de Córdoba
IFEA
Innóvate Perú
PERÚ Ministerio de la Producción
Programa Nacional de Innovación para la Competitividad y Productividad

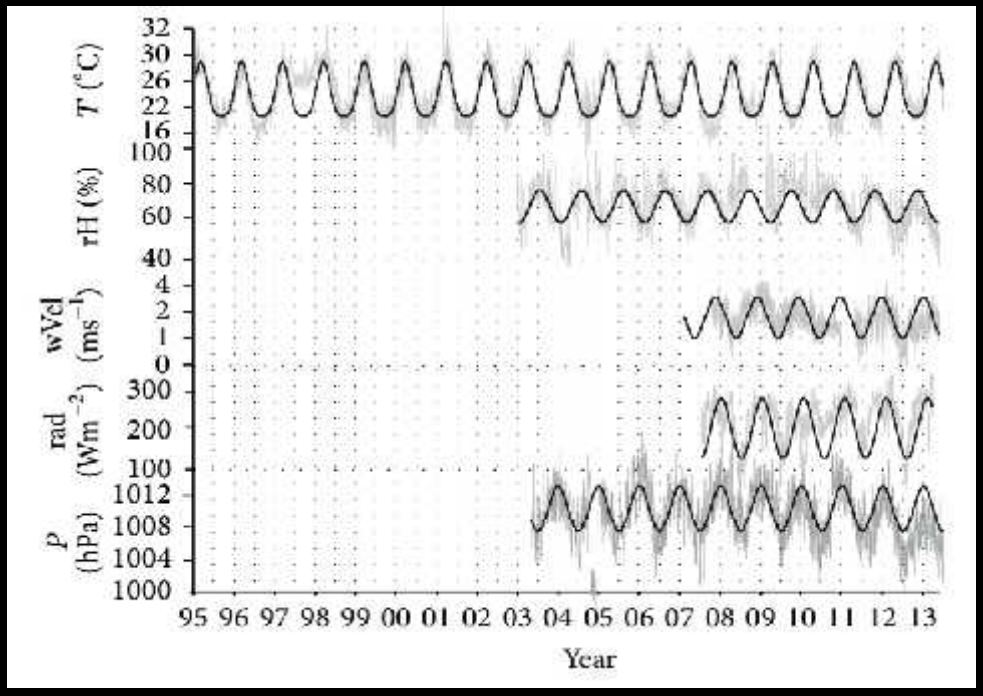
The dryland coast of South America

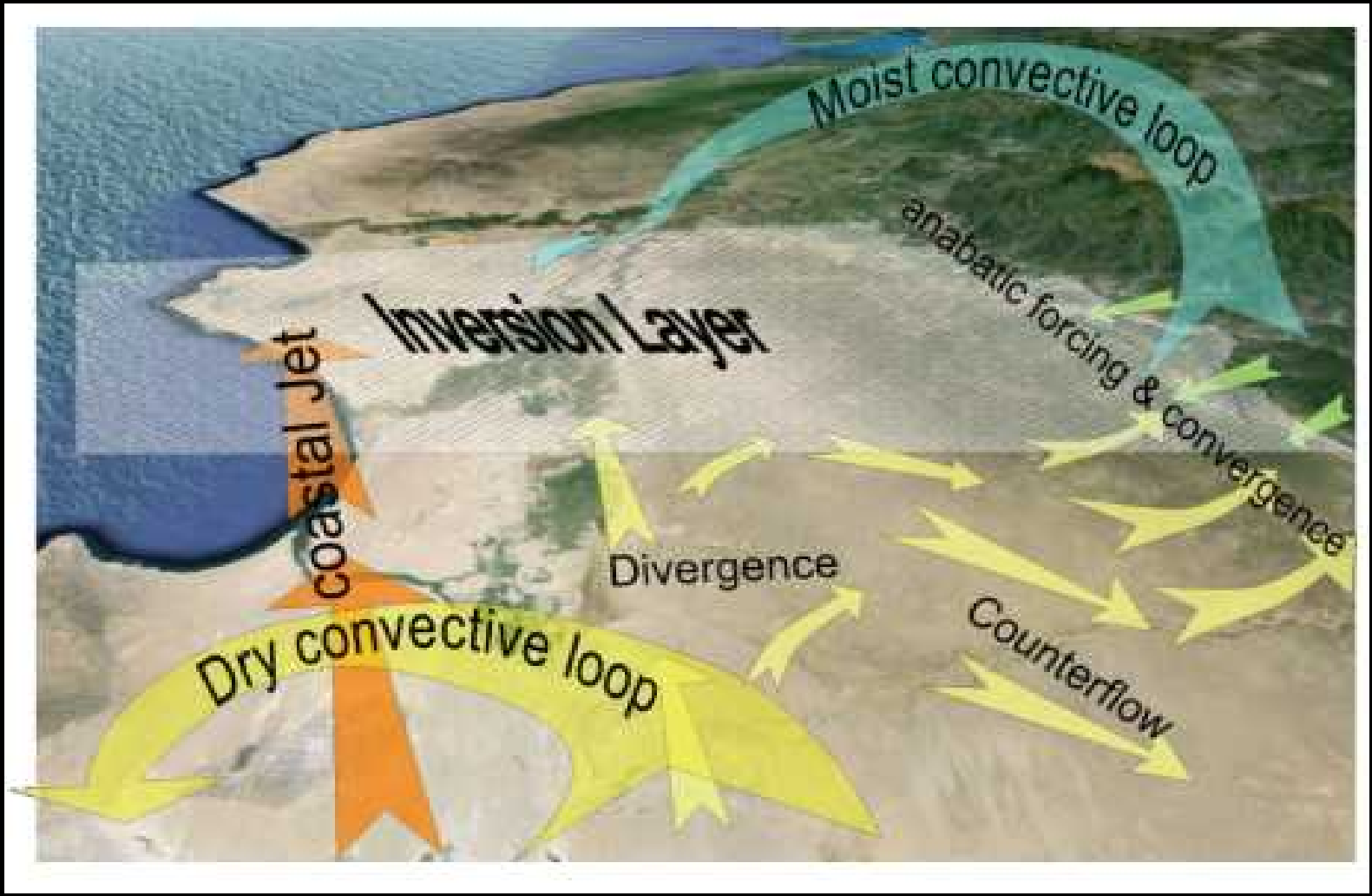
- 600mm ↓
- Clay ↓
- Radiation ↑
- Temperature ↑

- Plant cover ↓

Humboldt Current

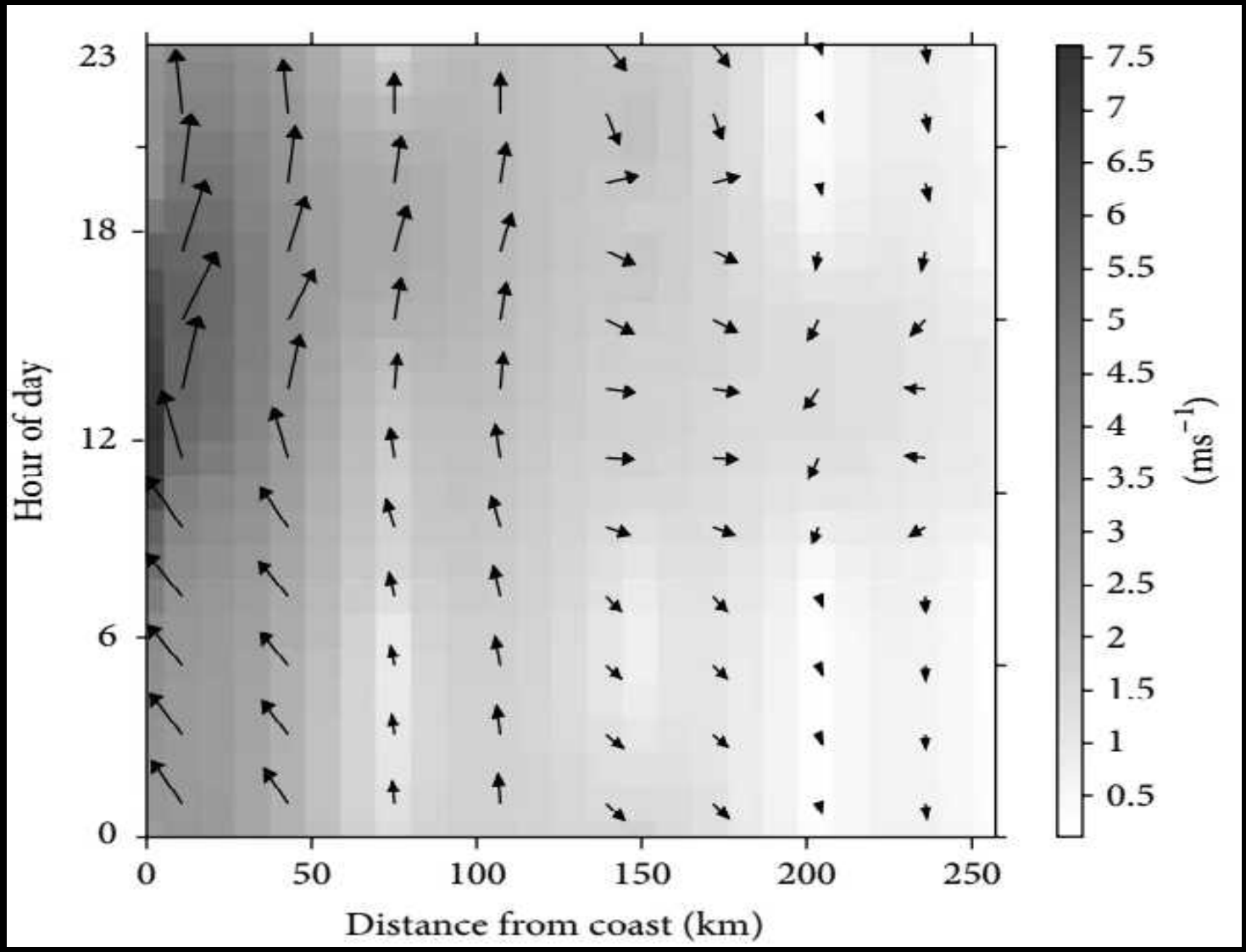
- Sea Temperature
- Rainfall





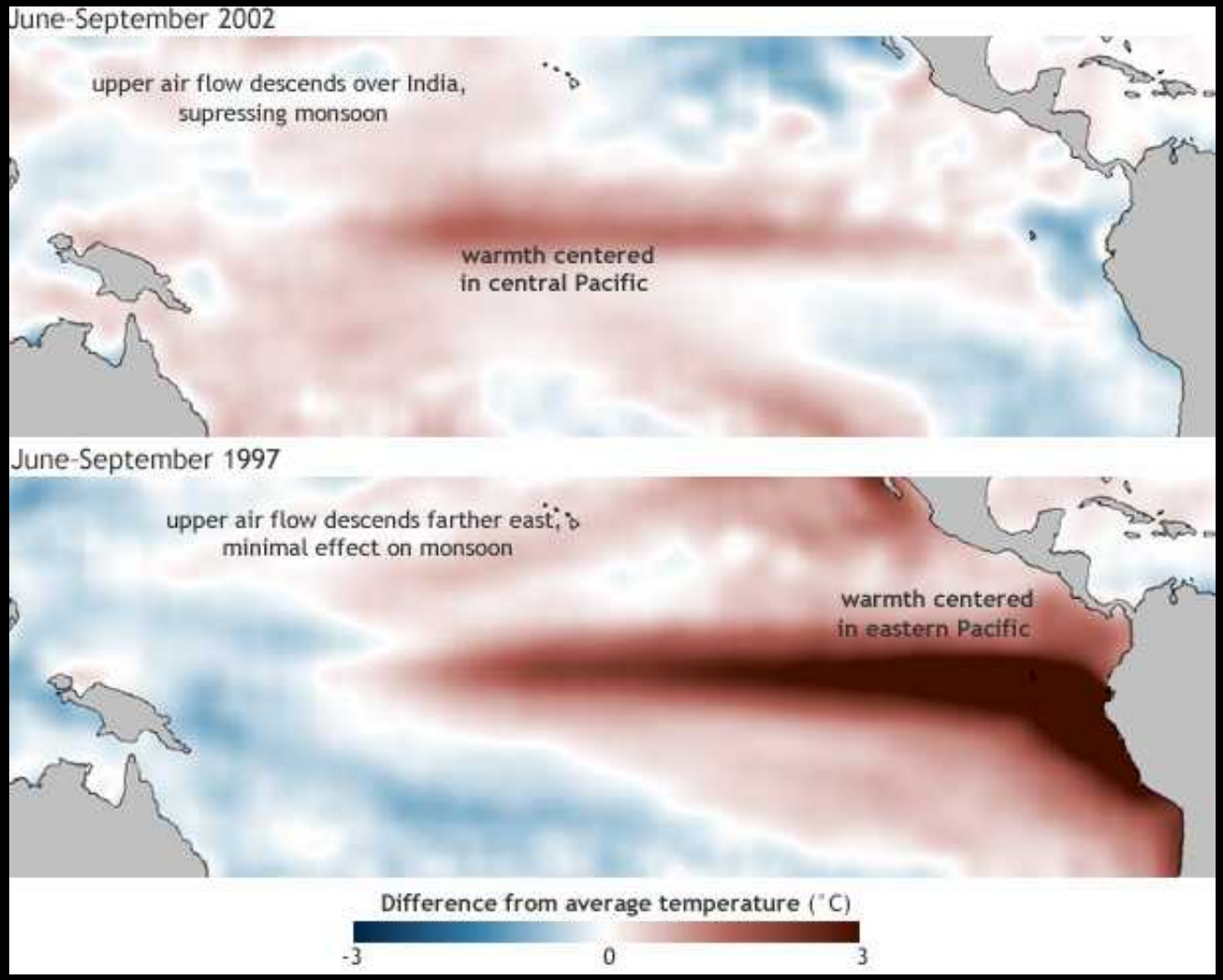
Rollenbeck et al. Advances in meteorology (2015)

Wind and moist dynamic in the North Peruvian coast



Rollenbeck et al. Advances in meteorology (2015)

Wind Field Along the coast

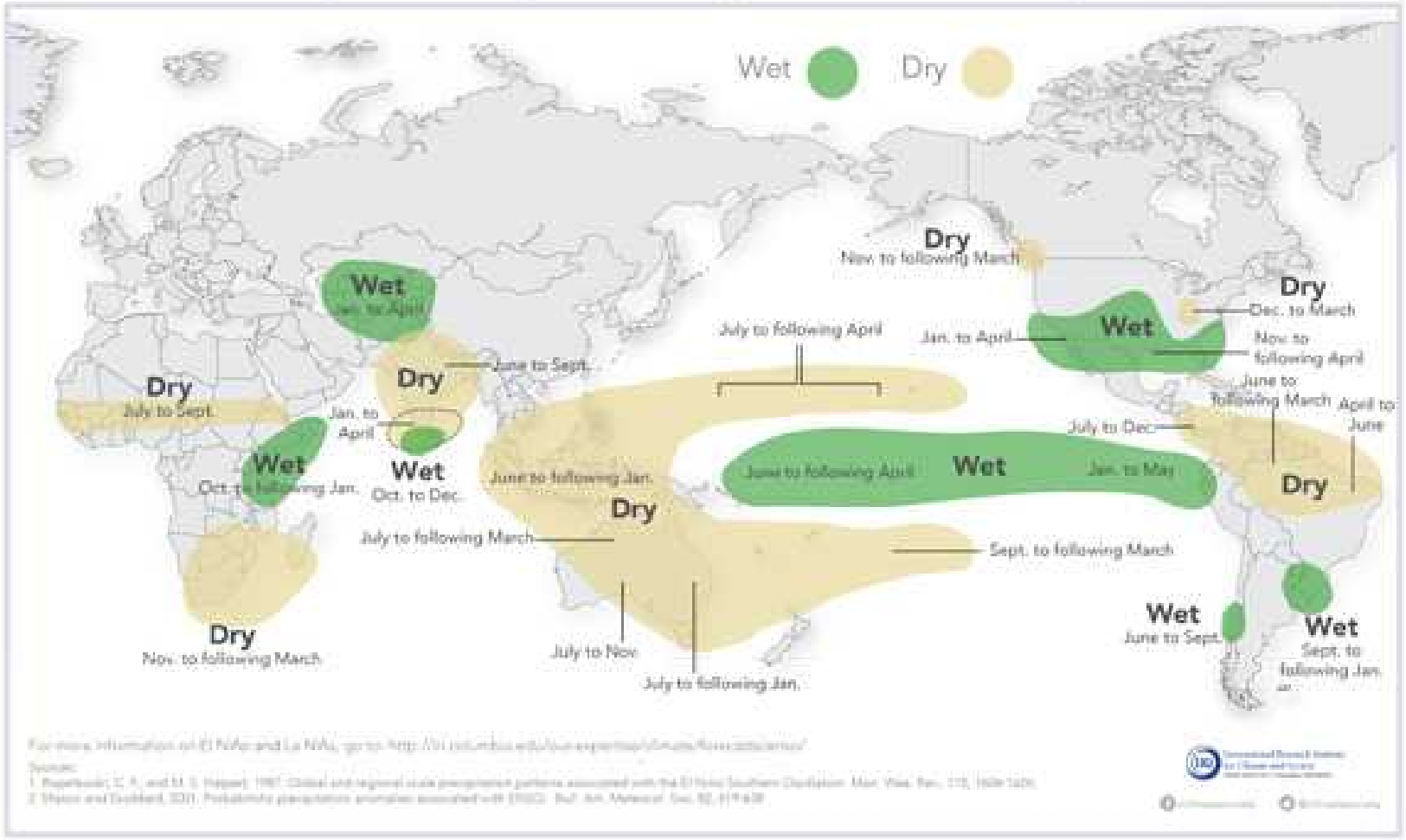


www.pmel.noaa.gov (01/07/2017)

A temperature gradient on the Central Pacific Ocean controls the rain and the wind direction

El Niño and Rainfall

El Niño conditions in the tropical Pacific are known to shift rainfall patterns in many different parts of the world. Although they vary somewhat from one El Niño to the next, the strongest shifts remain fairly consistent in the regions and seasons shown on the map below.



www.pmel.noaa.gov (01/07/2017)

The climatic cycle

- Unstable climatic conditions
- Germination burst
- High competition

Game over

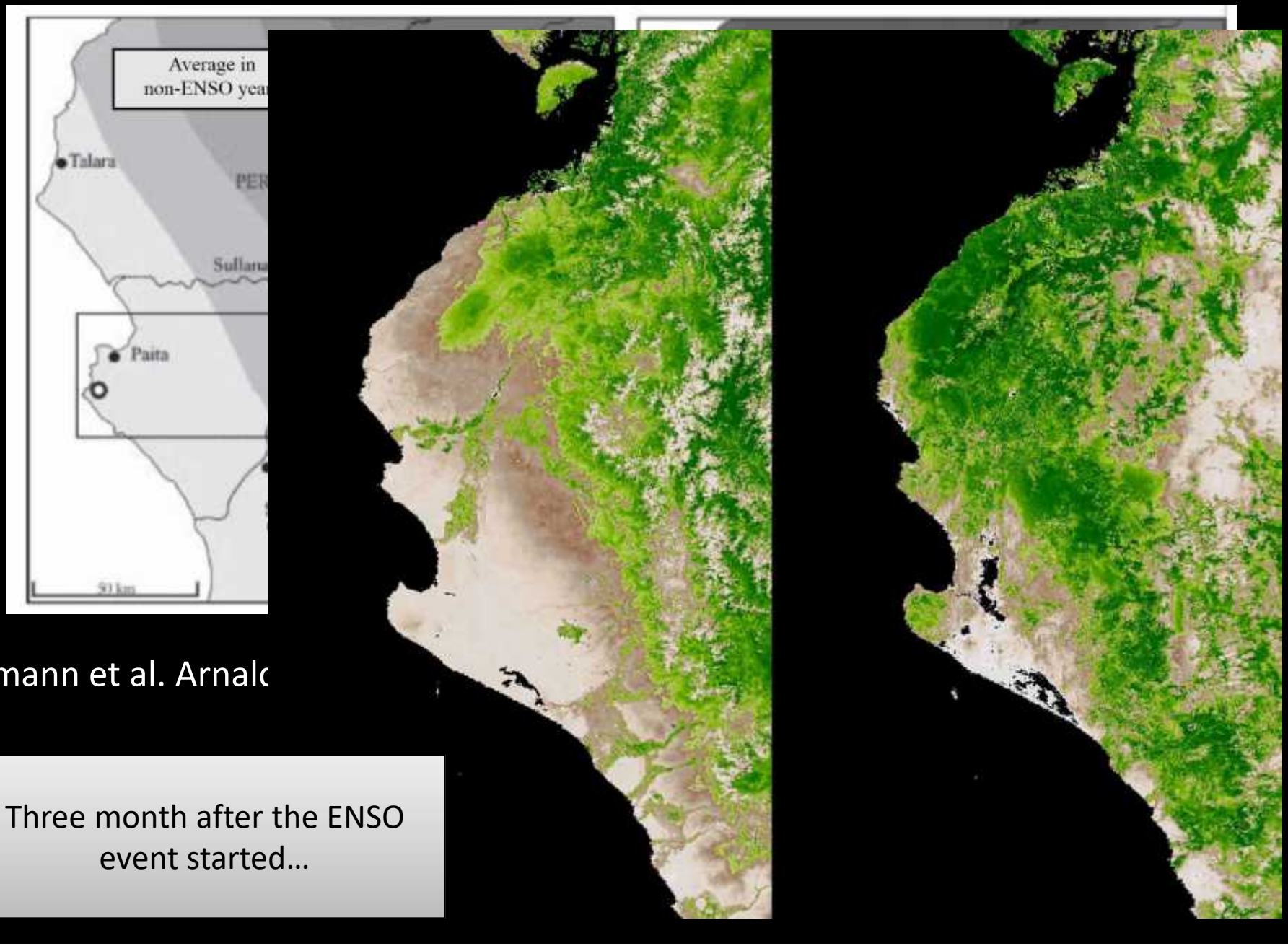
Insert Coin

- High stable climatic conditions
- Slow and steady growth
- Survival mechanism

Ready?

Go!

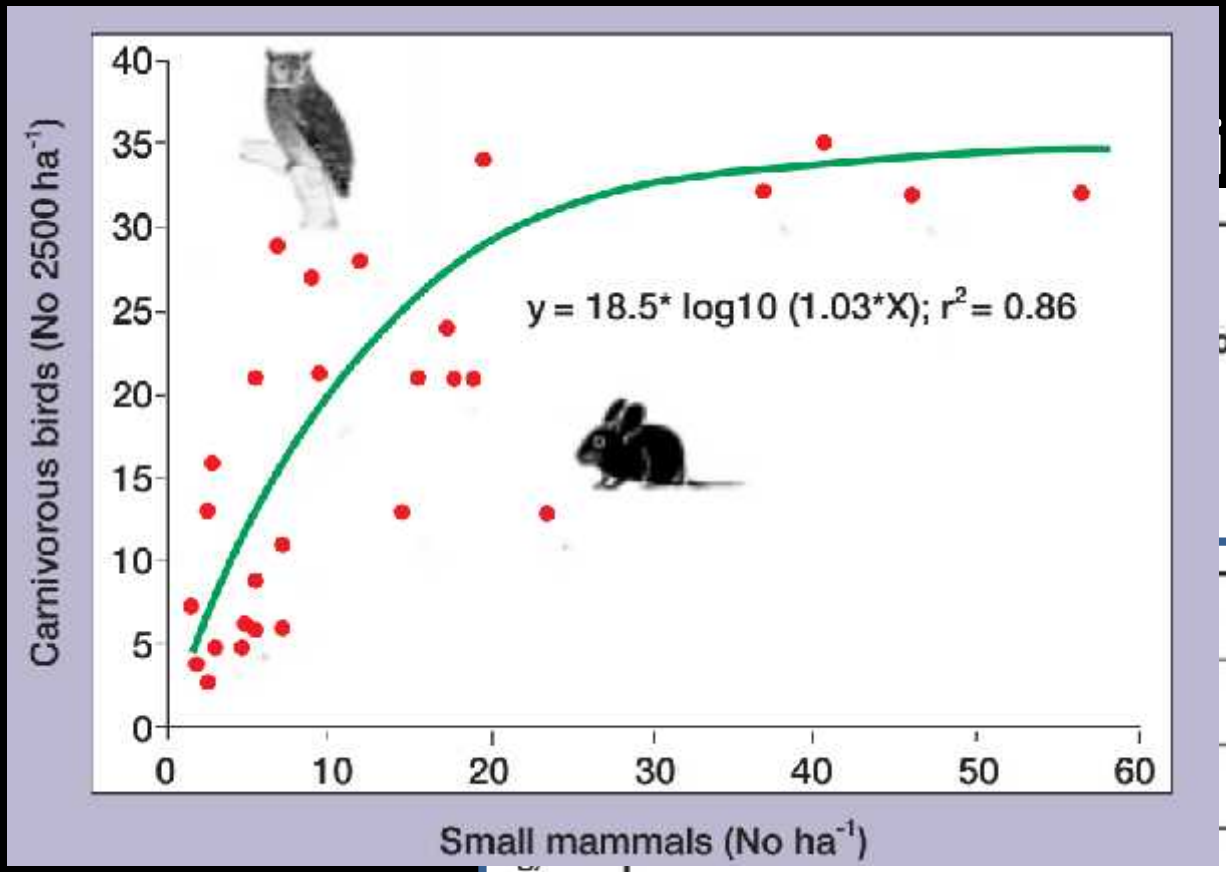
ENSO No-ENSO ENSO

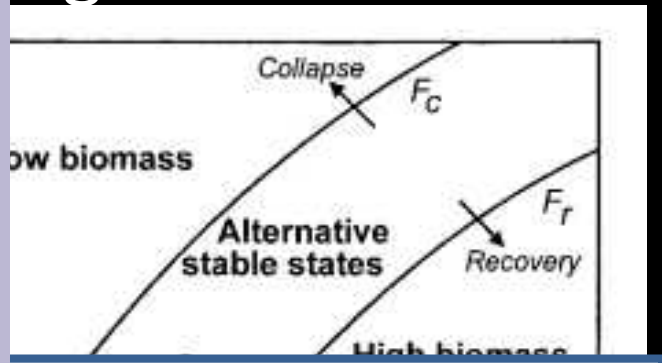


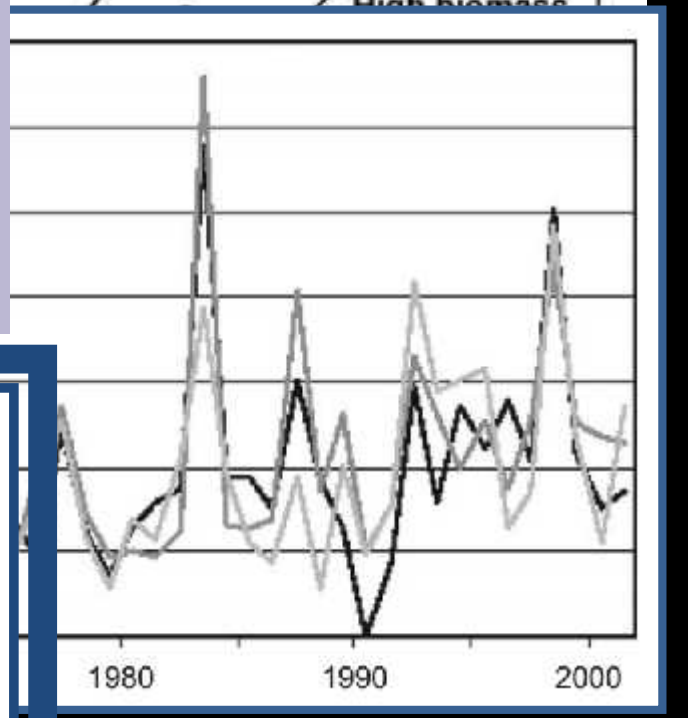
Erdmann et al. Arnalc

Three month after the ENSO event started…

ing the ENSO







Short Communication

Distribution of geckos in northern Peru: Long-term effect of strong ENSO events?

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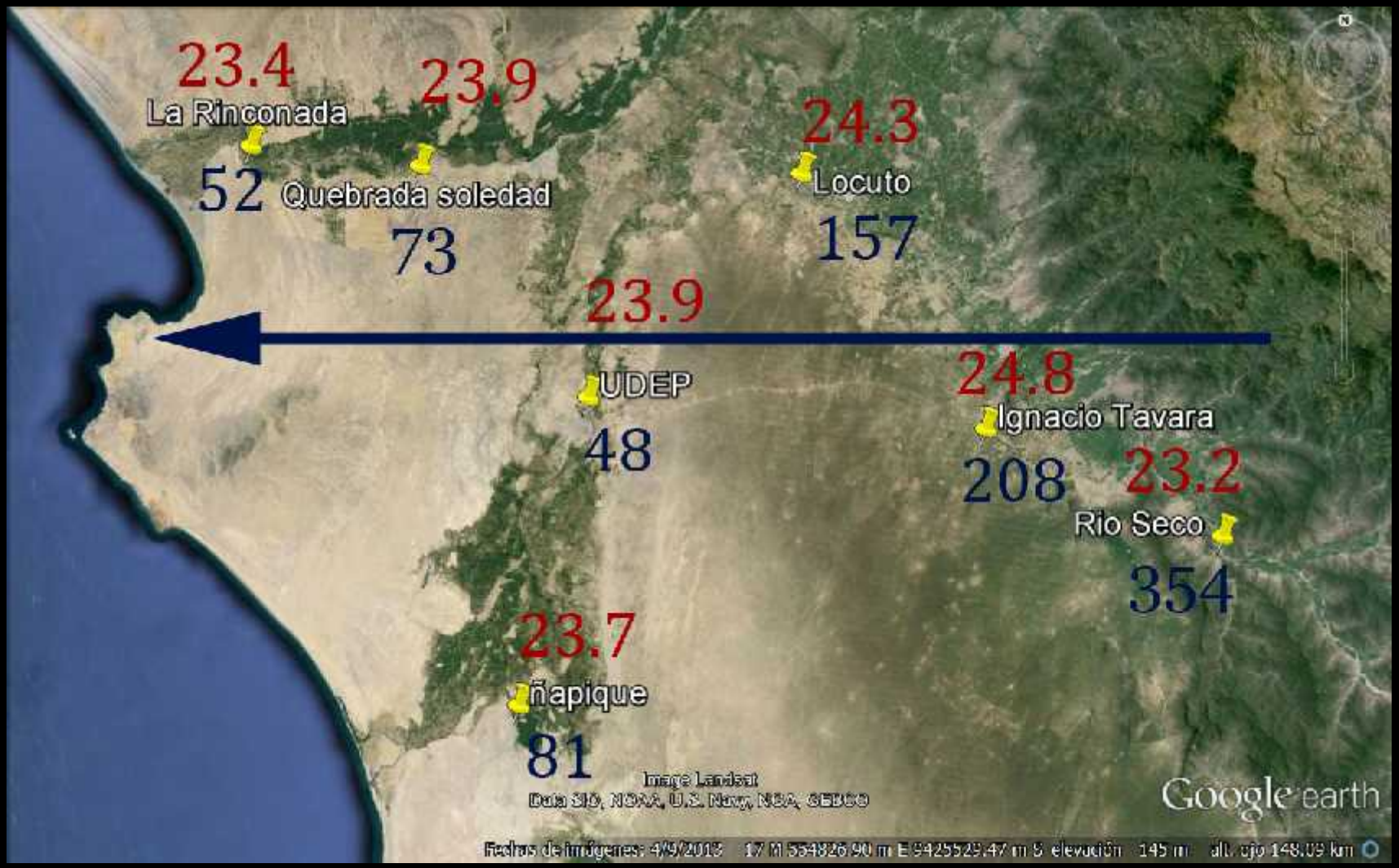
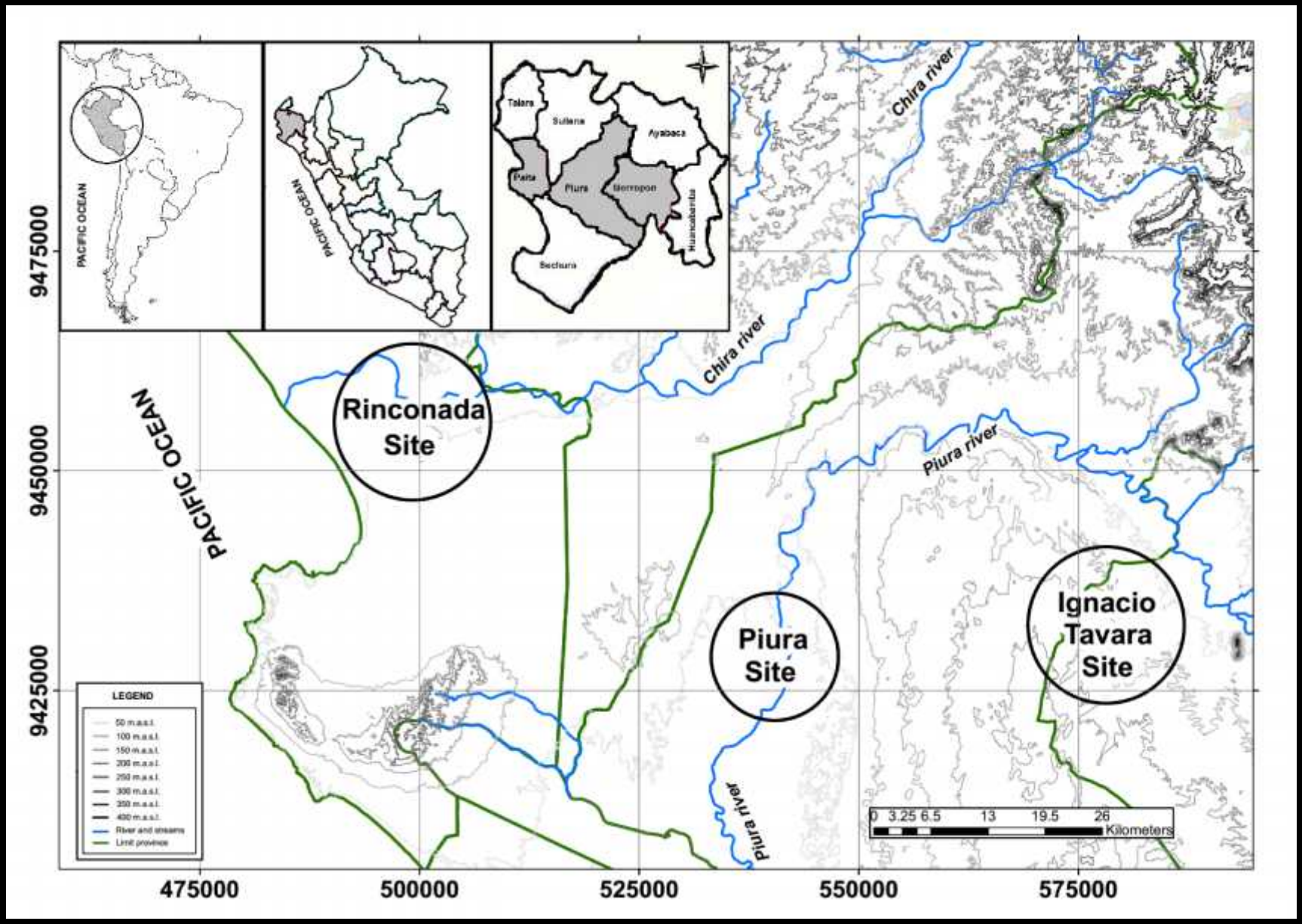
Received 14 February 2007; received in revised form 14 April 2007; accepted 4 May 2007
Available online 27 June 2007

López et al. (Global Change Biology (2006)

STUDY SITE LOCATION (near the 1+2 region)





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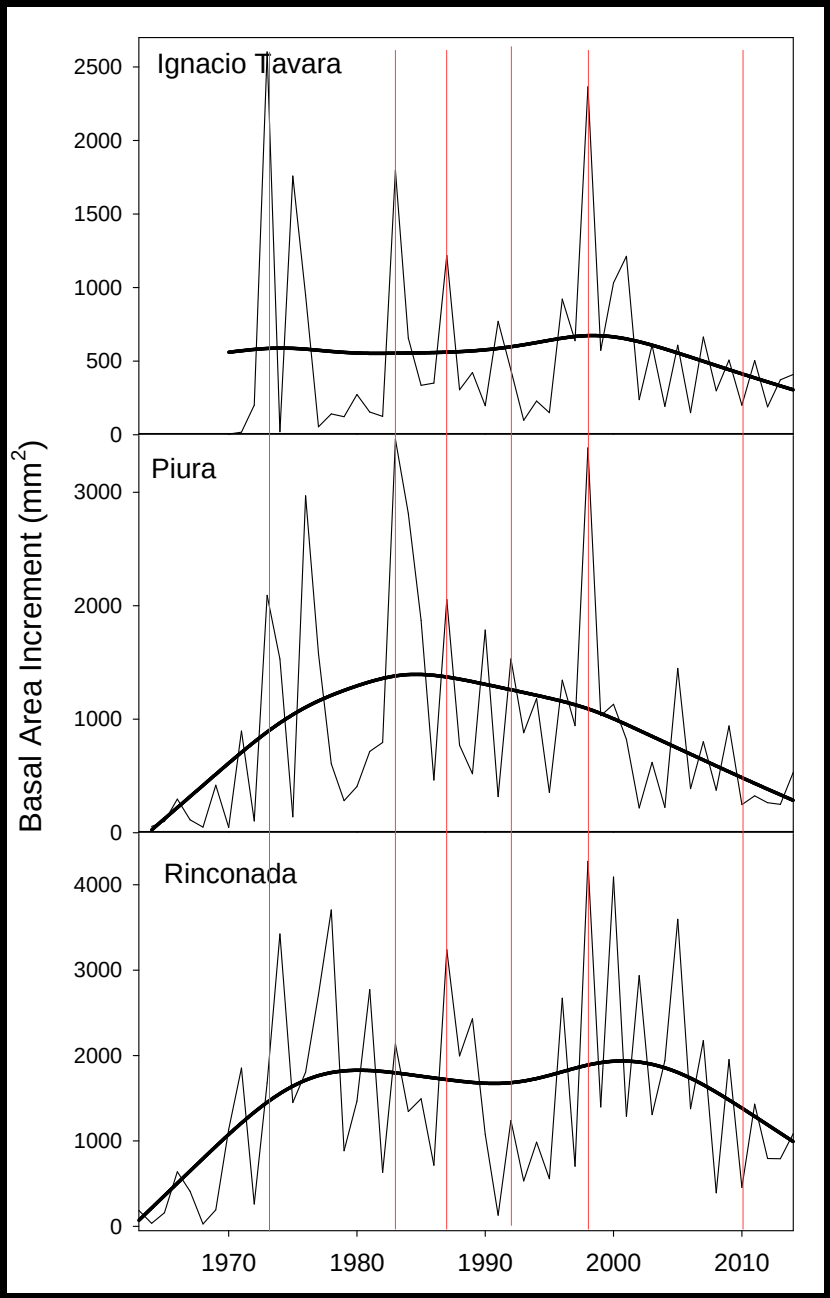
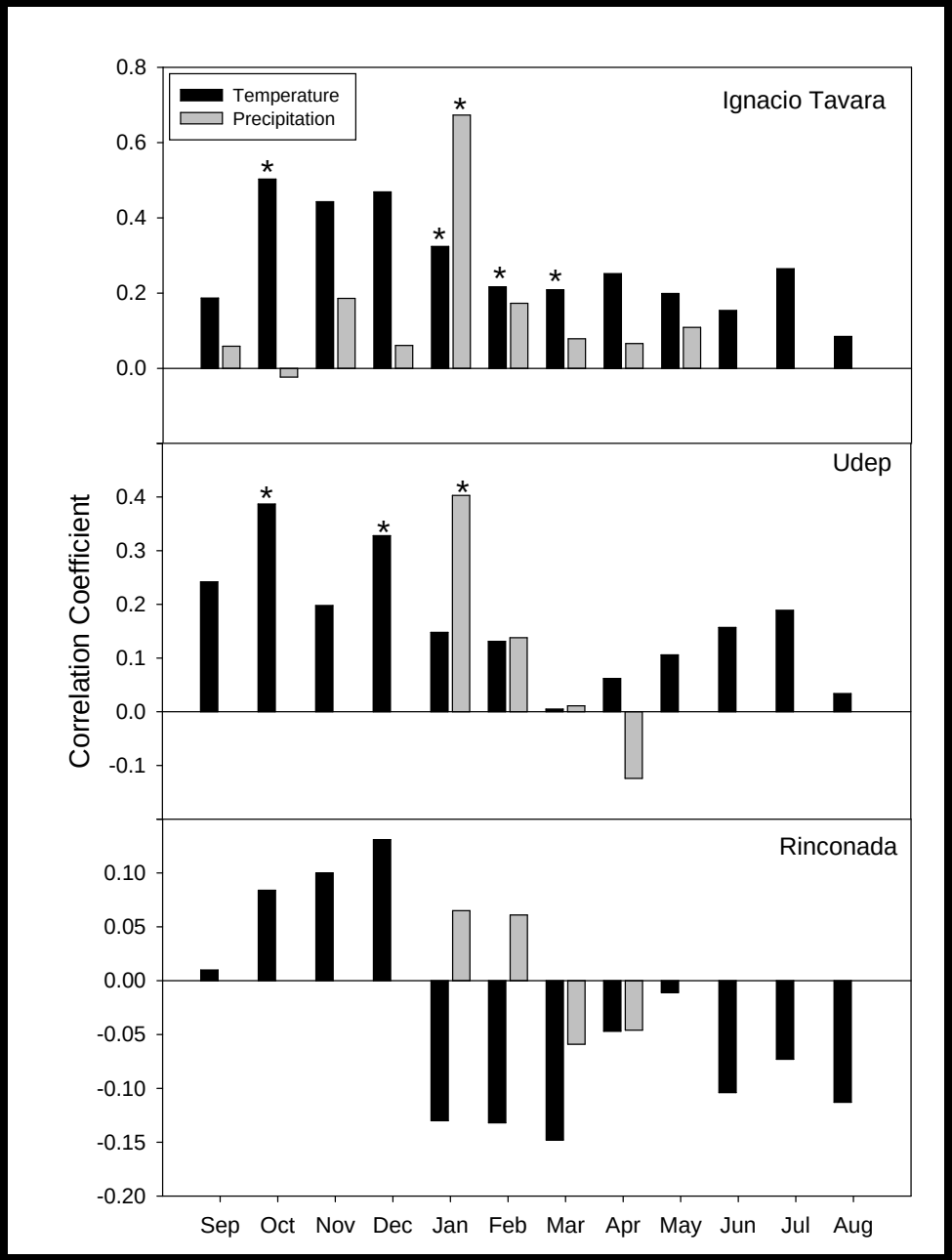


Inland populations are more ENSO-dependant than coastal locations

Dendrochronological results shows a high temporal and spatial variation of the ENSO

Winter temperature is a reliable indicator of ENSO intensity

Salazar et al. unpublished



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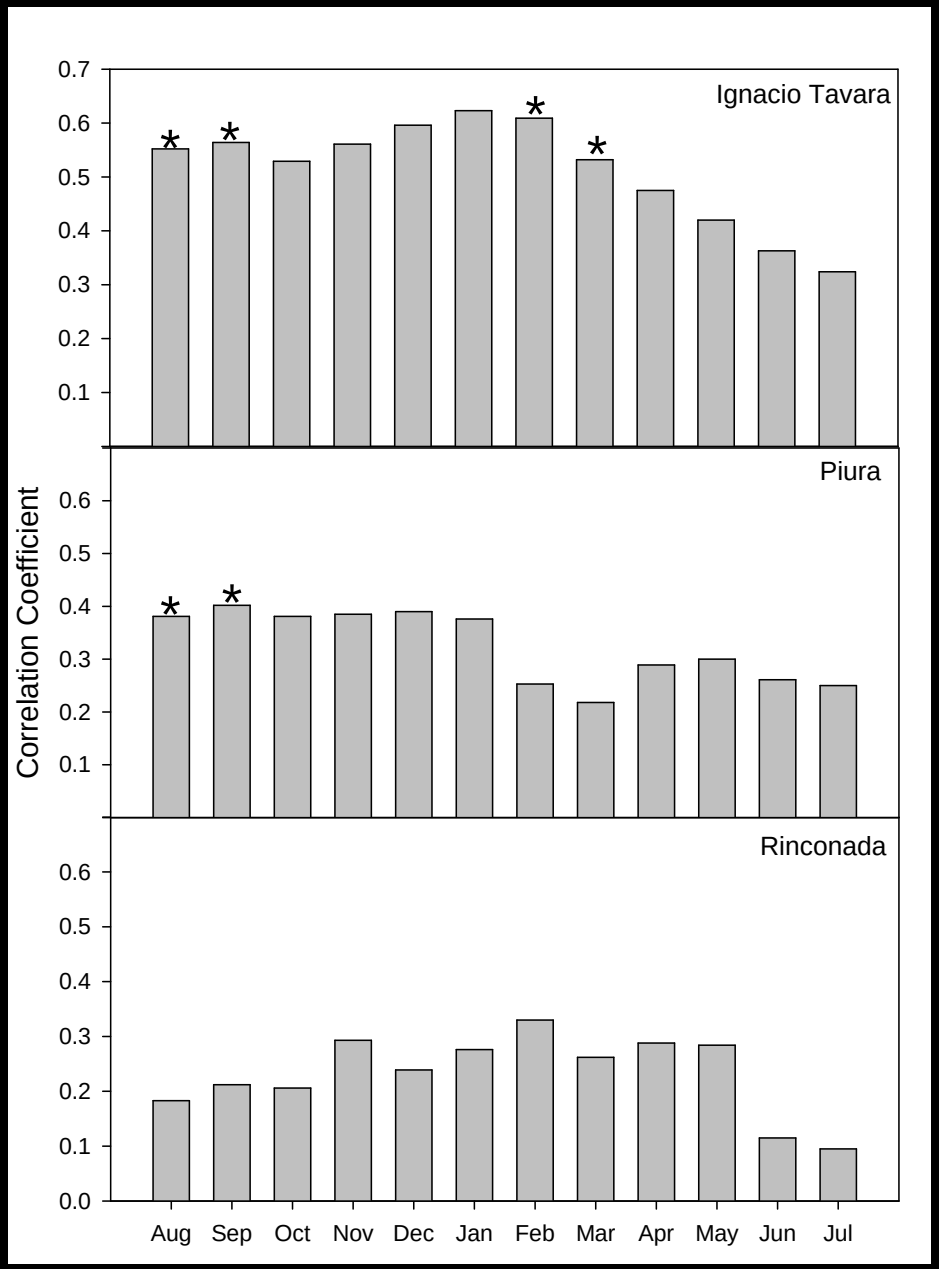

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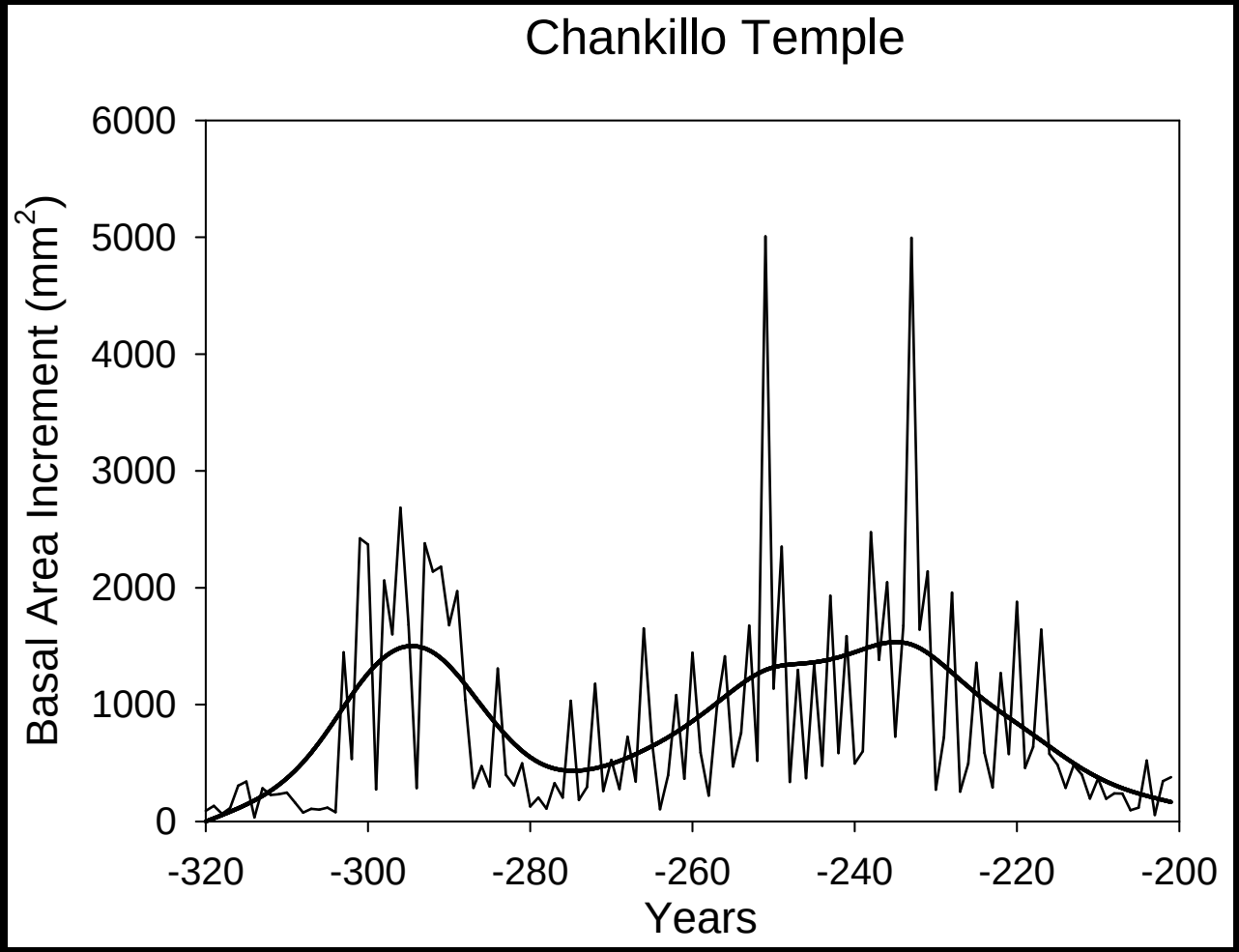
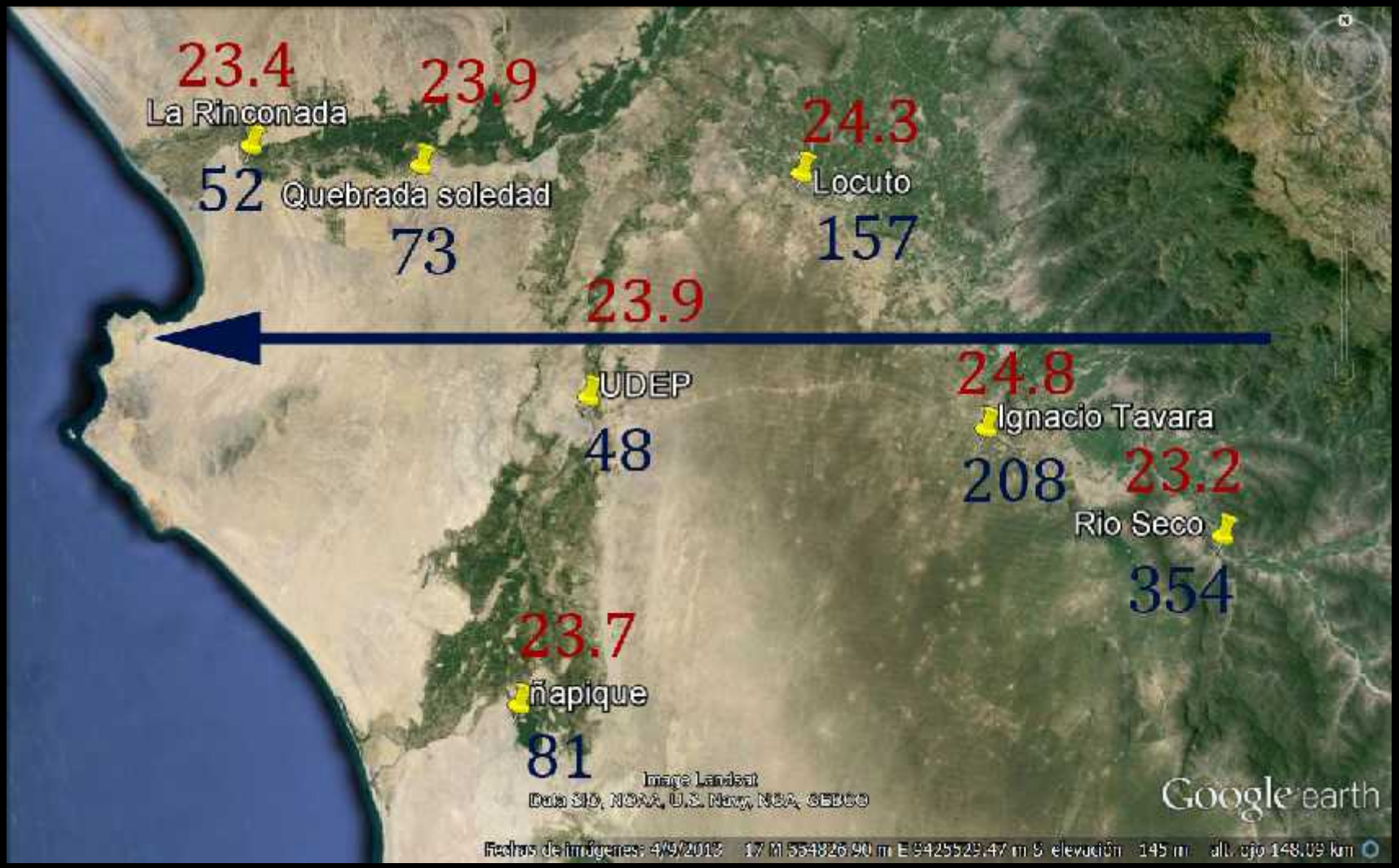


Ghezzi et al. unpublished

Prosopis pallida Dendrochronological reconstruction 2000 years ago

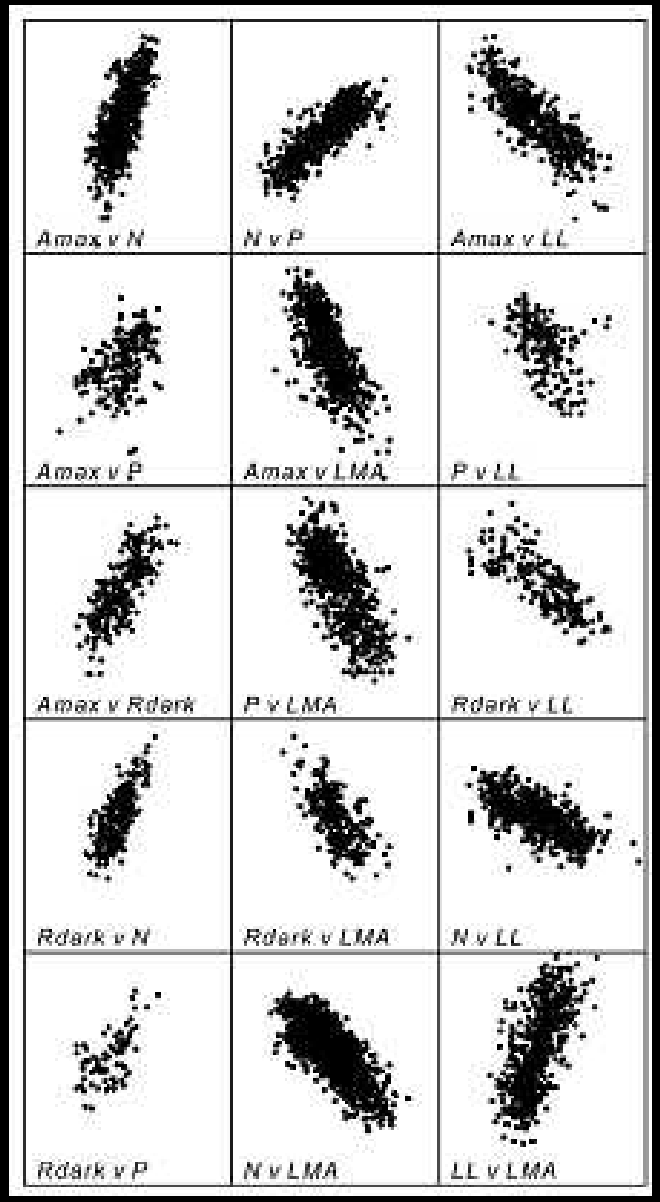
Growth and Survival during the dry phase



Leaf functional traits as indicators of plant functioning

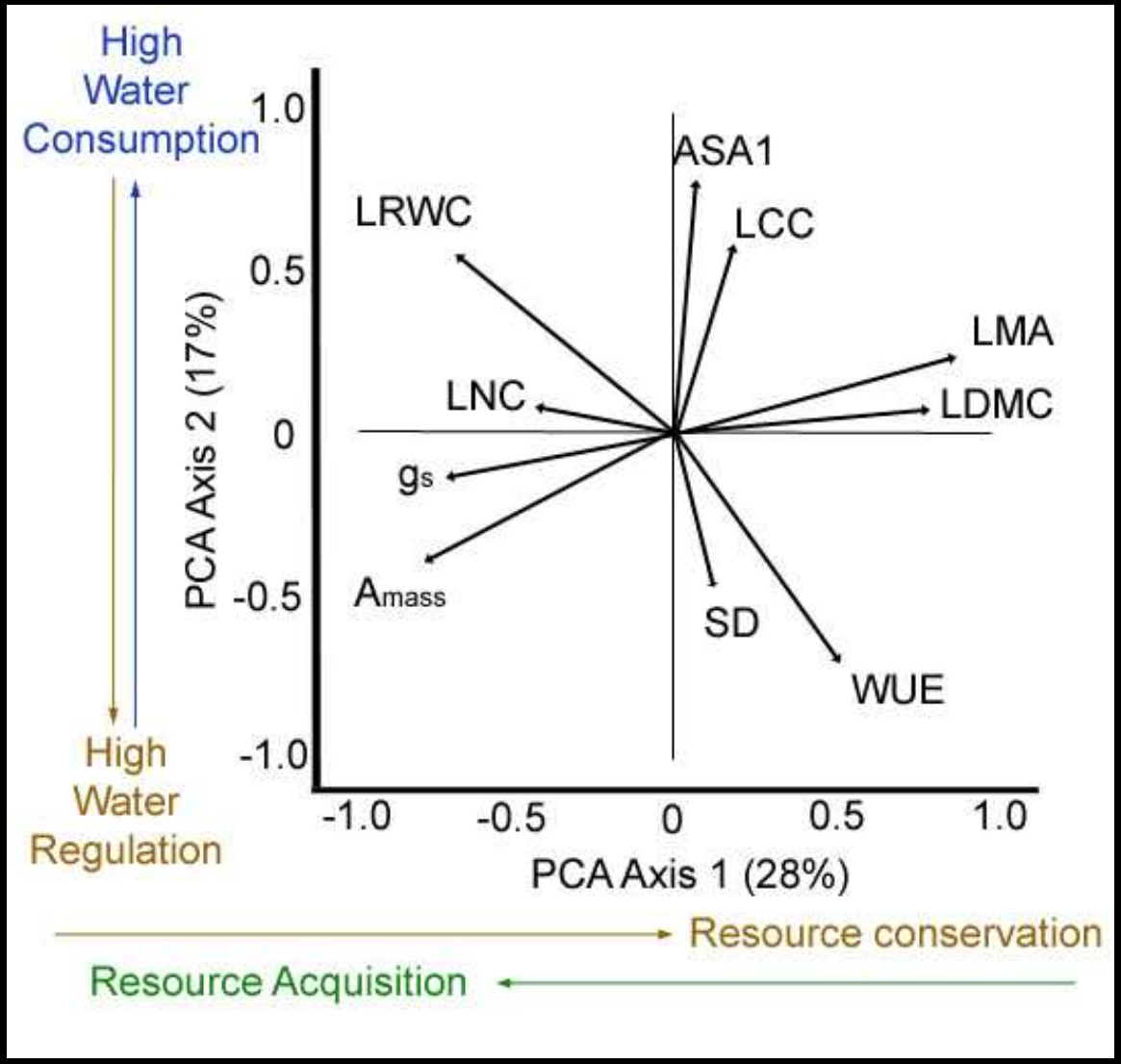
- Net photosynthesis
- LMA
- Leaf nutrient content
- LRWC
- Leaf stomatal size

- Soil measurements

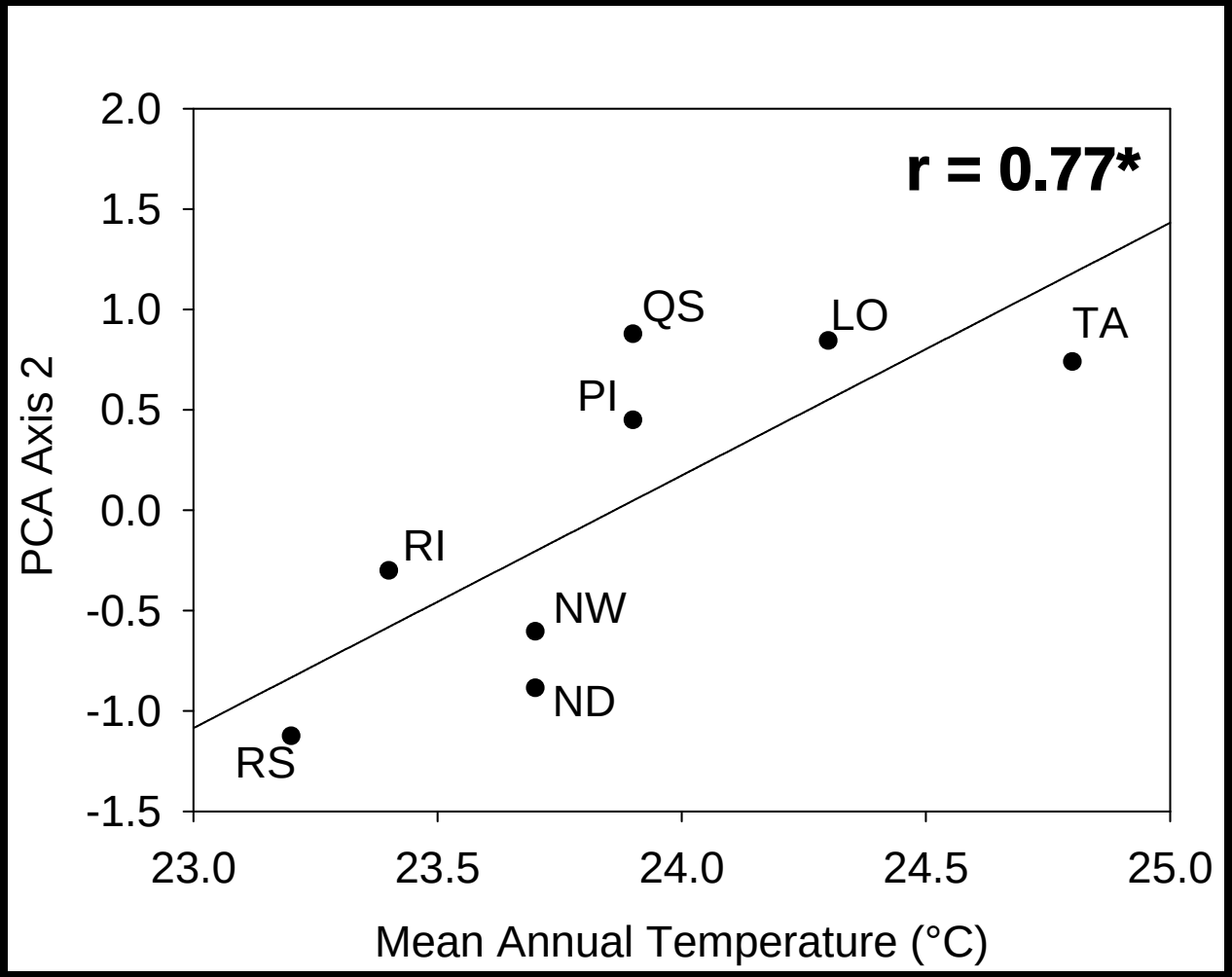


Osnas et al. Science (2013)

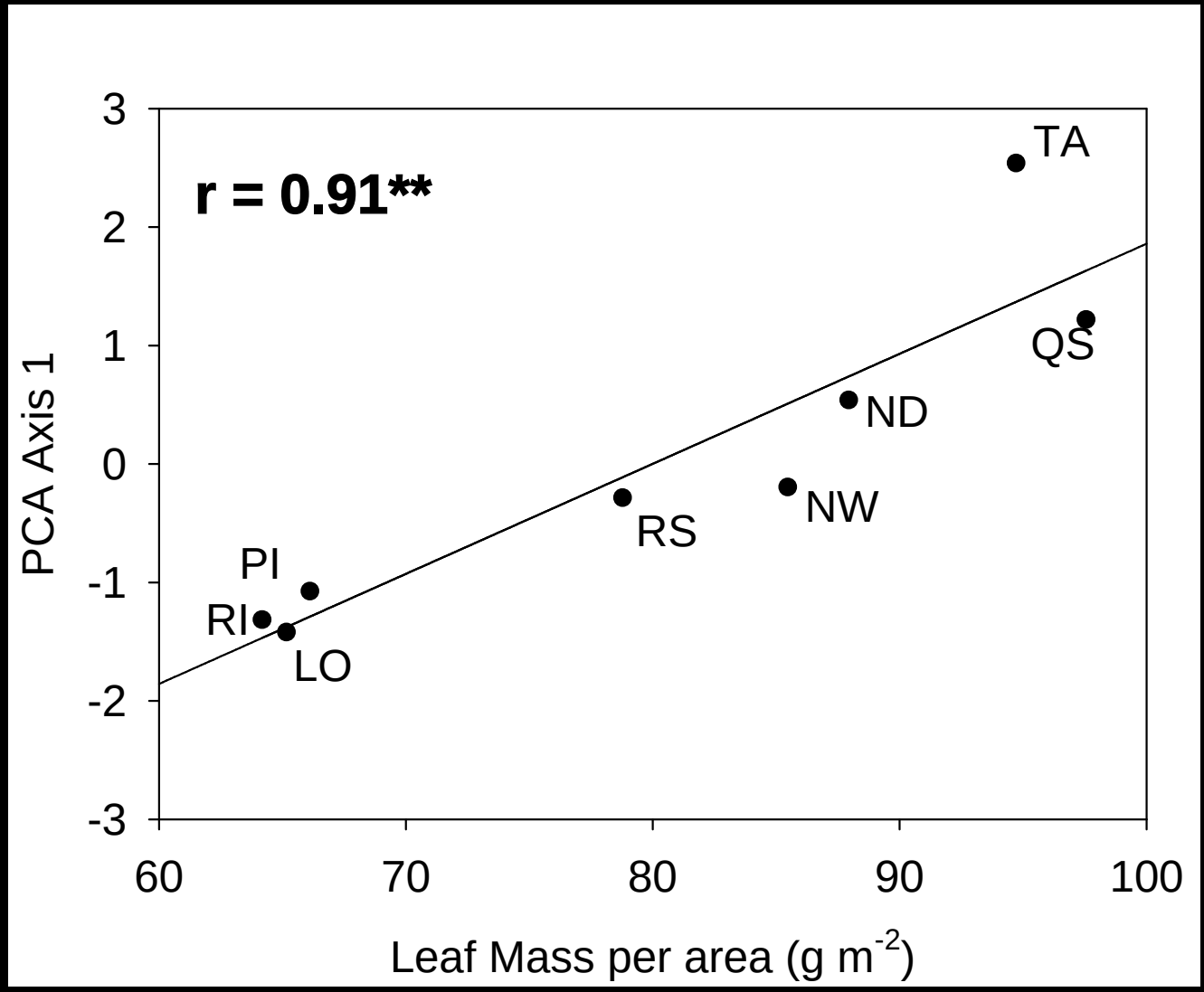
Principal component analysis



Temperature plays an important role in plant functioning during the dry season



Leaf morphology is the main driver

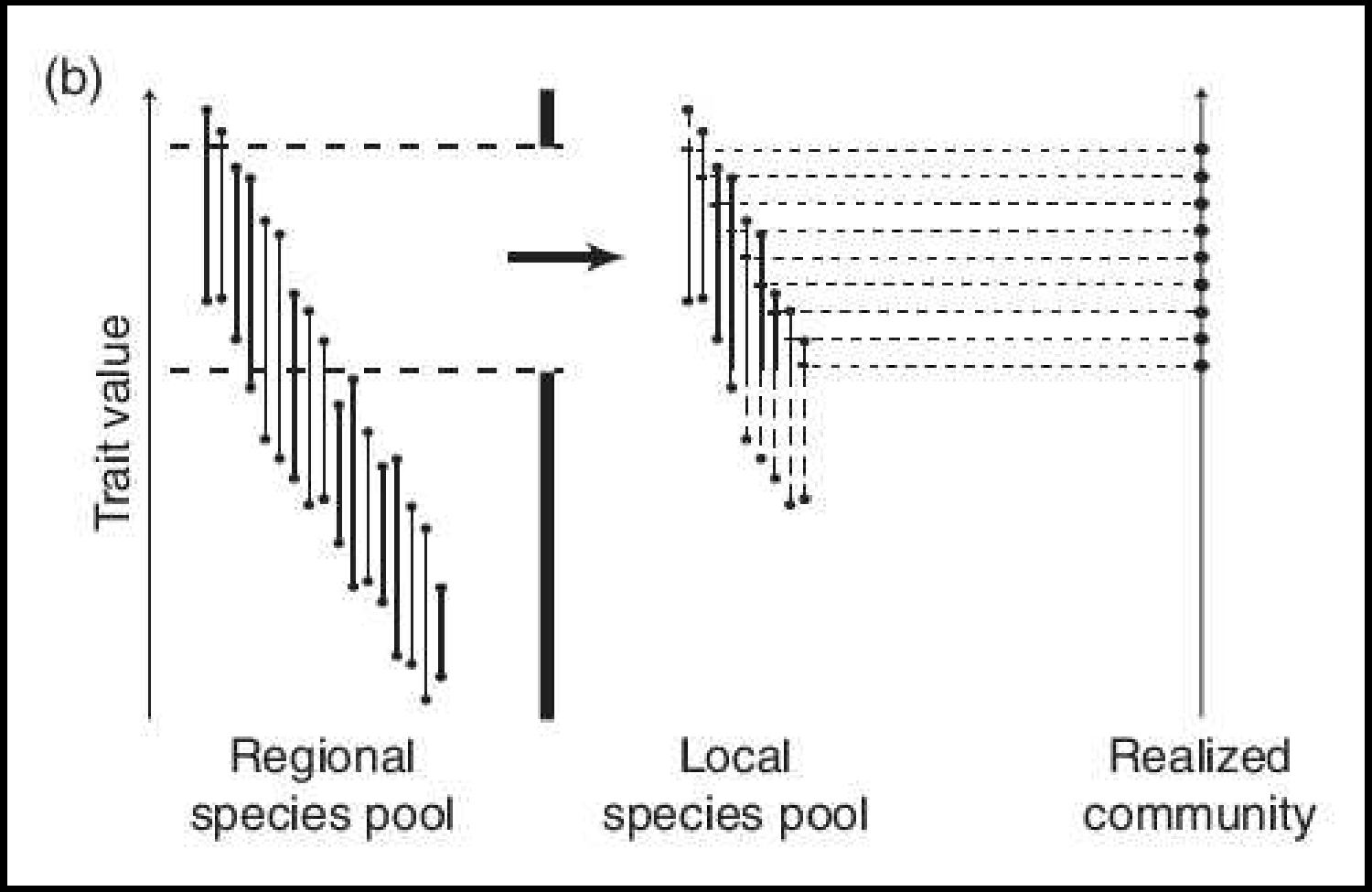


- The *P. pallida* forest have a high functional variability at macro and micro scale depending of the trait
- Nutrient consumption and water regulation are the most important factors in this ecosystem
- Functional variability is controlled by mean temperature and leaf morphology

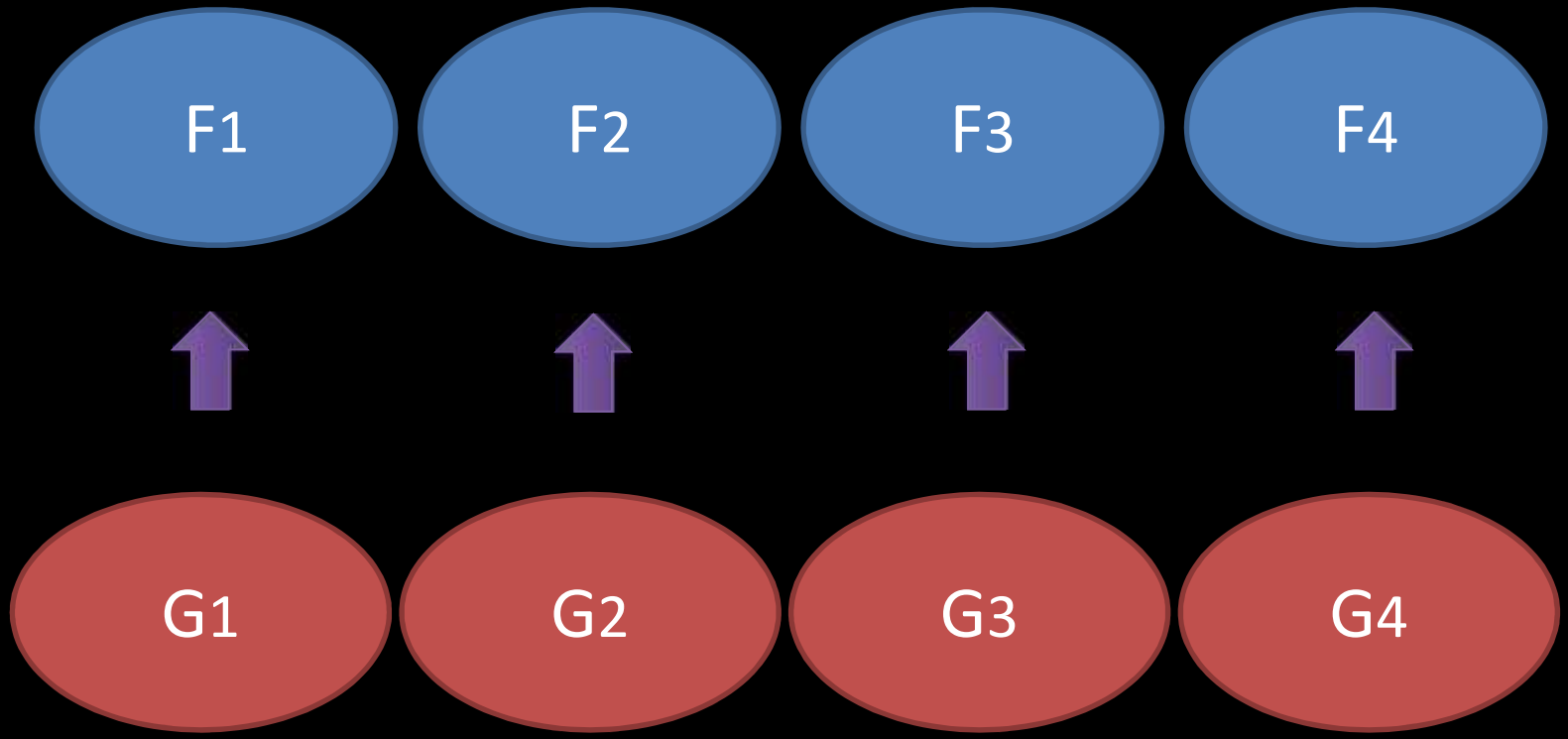
- But what about the rain??

La variabilidad poblacional esta mediada por factores de alta cobertura geográfica

Jung et al Journal of Ecology 2010

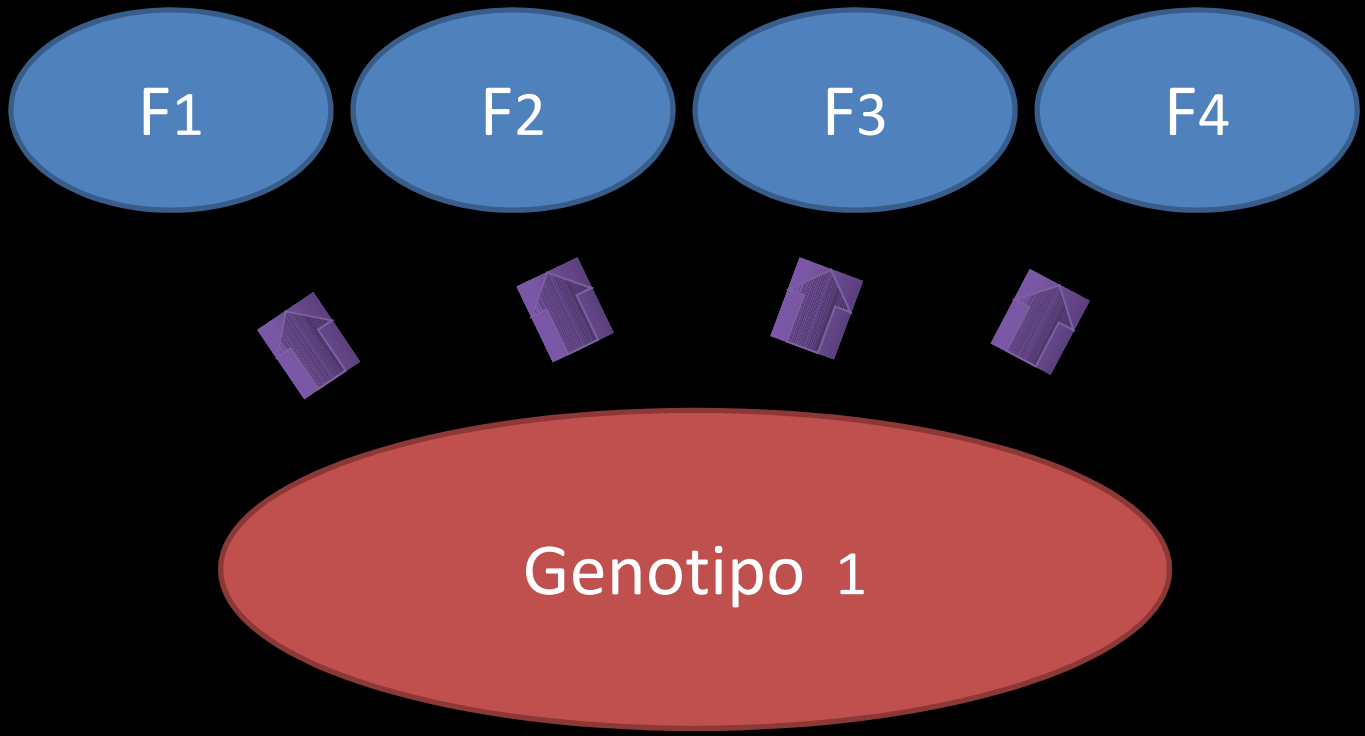


Instrapecific variability



La **variabilidad intraespecífica** depende de la variabilidad genetica y de la plasticidad fenotipica.

Phenotypic plasticity



Es la capacidad de un genotipo para expresar fenotipos diferentes bajo condiciones externas diferentes (Valladares et al. 2006).

Greenhouse experiment

- Tratamiento hidrico
  - R0 = 40% CC
  - R1 = 80% CC
- Tratamiento poblacional
  - 7 poblaciones
- 8 replicas por tratamiento
- N = 112

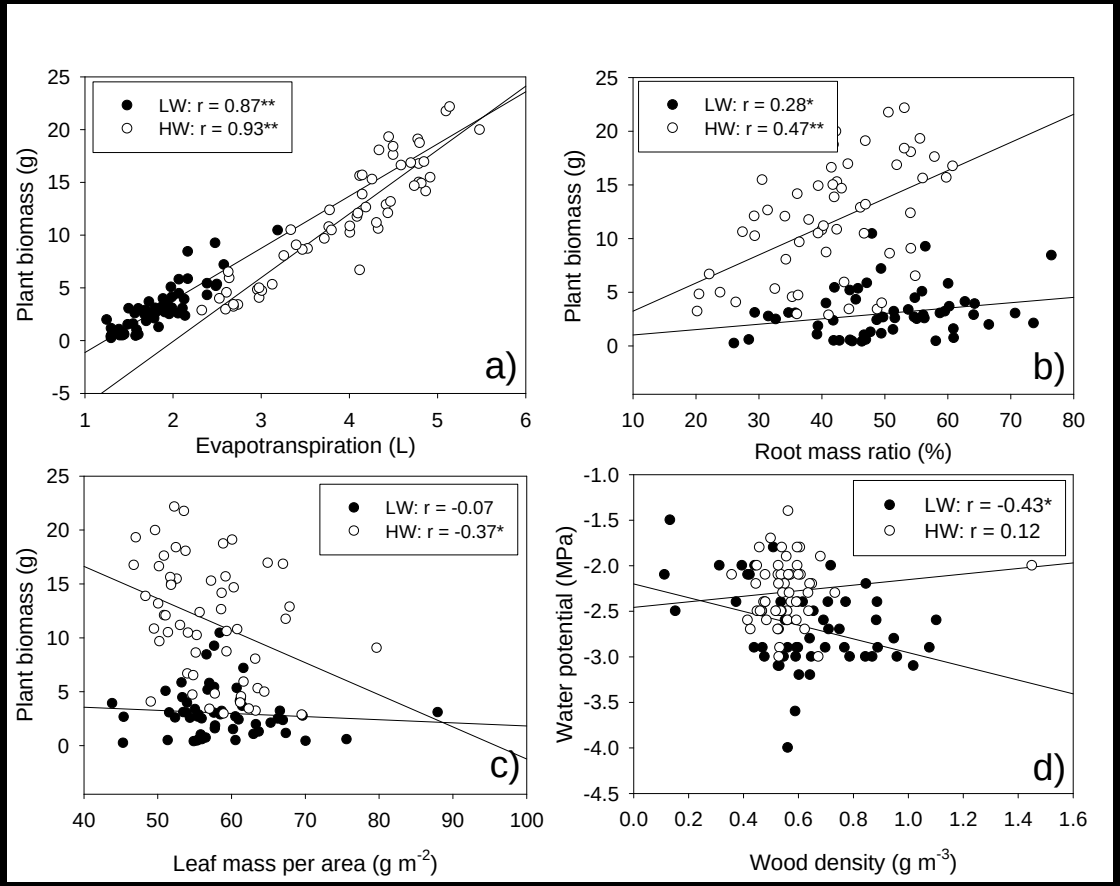
Low vs High water availability

Just like another grass species, an increase in water availability will water consumption and plant biomass

RMR is crucial to increase plant biomass in both scenarios

LMA variability is more relevant under high water conditions

Water transport is related to wood morphology under dry conditions



Population differences to water availability

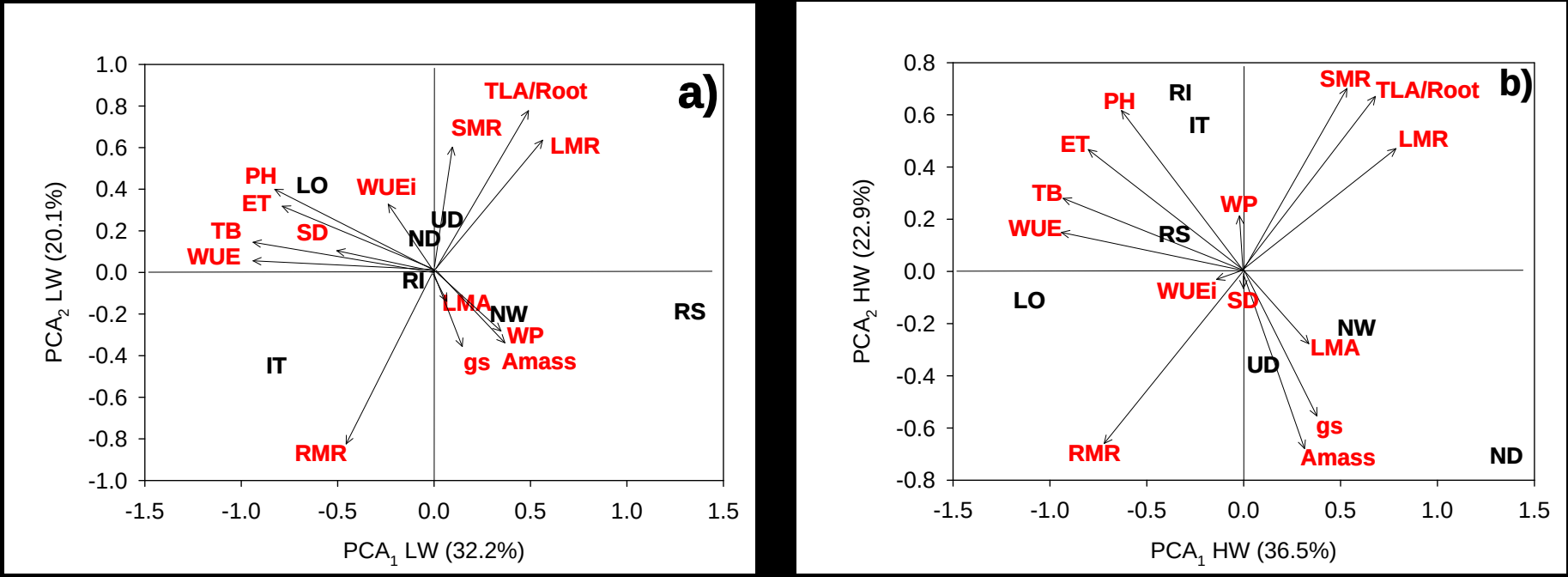


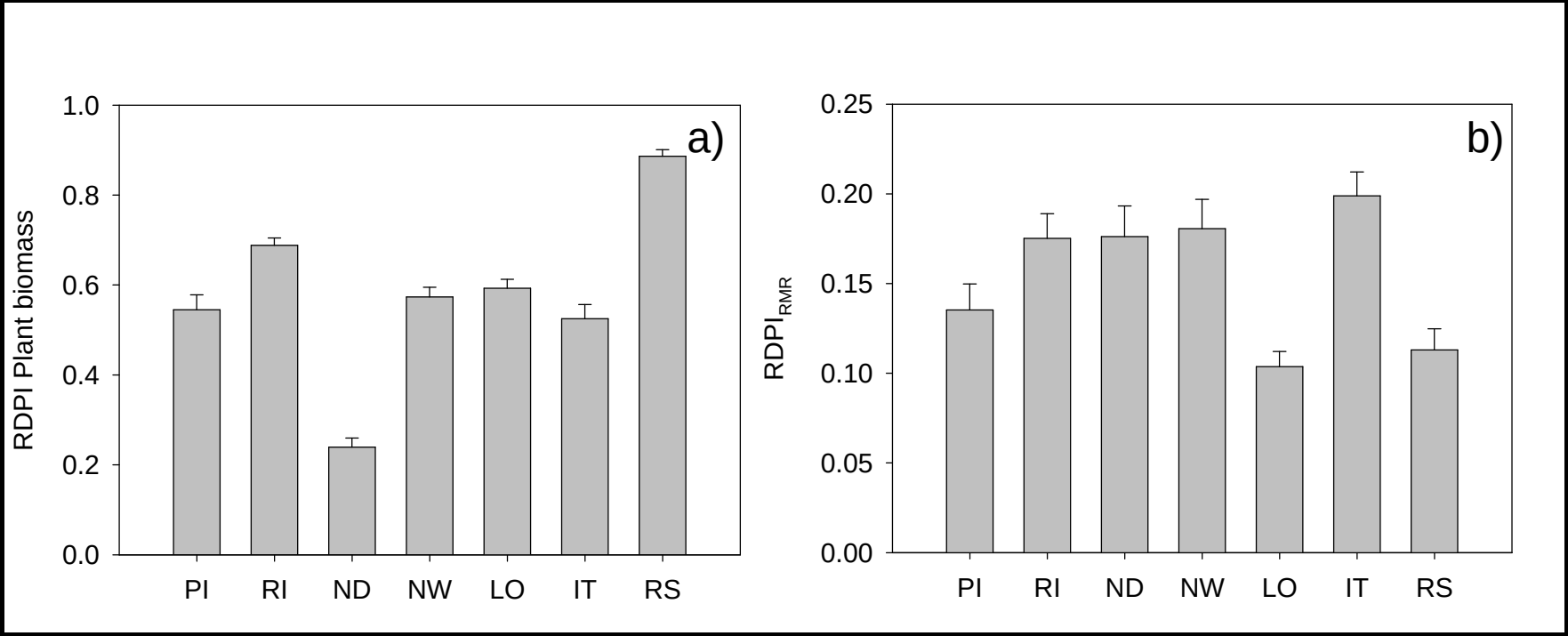
Figure 4. Principal component analysis (PCA) of all traits studied under low (LW) and high (HW) water availability. Mean population score is shown in each case. TB : Plant Biomass, PH: Plant height, WD: wood density, A_{mass}: Net photosynthetic rate per unit leaf mass, g_s: Stomatal conductance, WUEi: Instant water use efficiency, ET: Evapotranspiration, LMR: Leaf mass ratio, SMR: Stem mass ratio, RMR: Root mass ratio, TLA/Root: Total leaf area/root biomass, WP: Water potential, WUE: Water use efficiency, and LMA: Leaf mass per area

Measuring phenotyplic plasticity

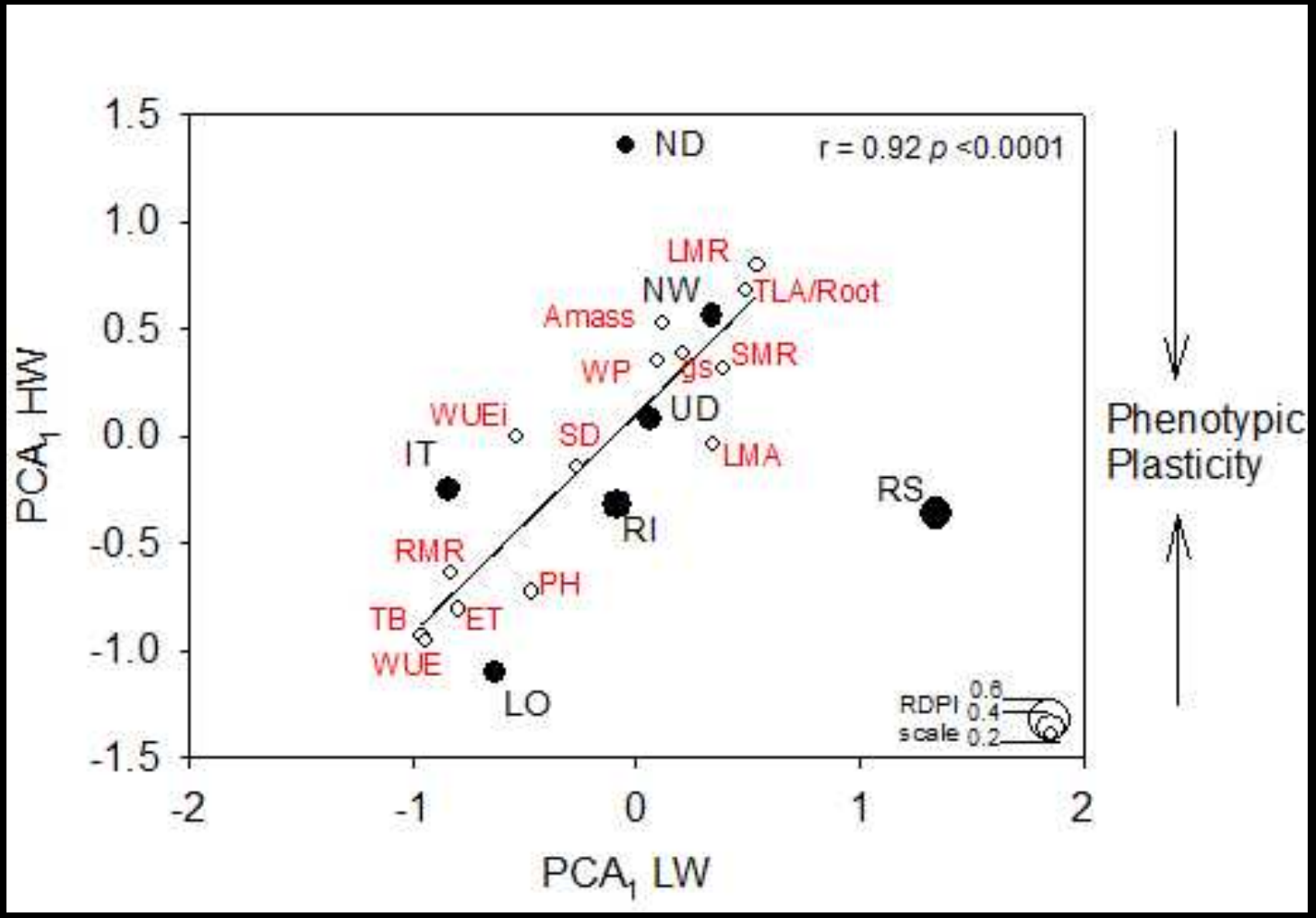
- RDPI = relative distance plasticity index

It is the mean value between the distance of each replicate of treatment 1 an treatment 2 divided by its sum

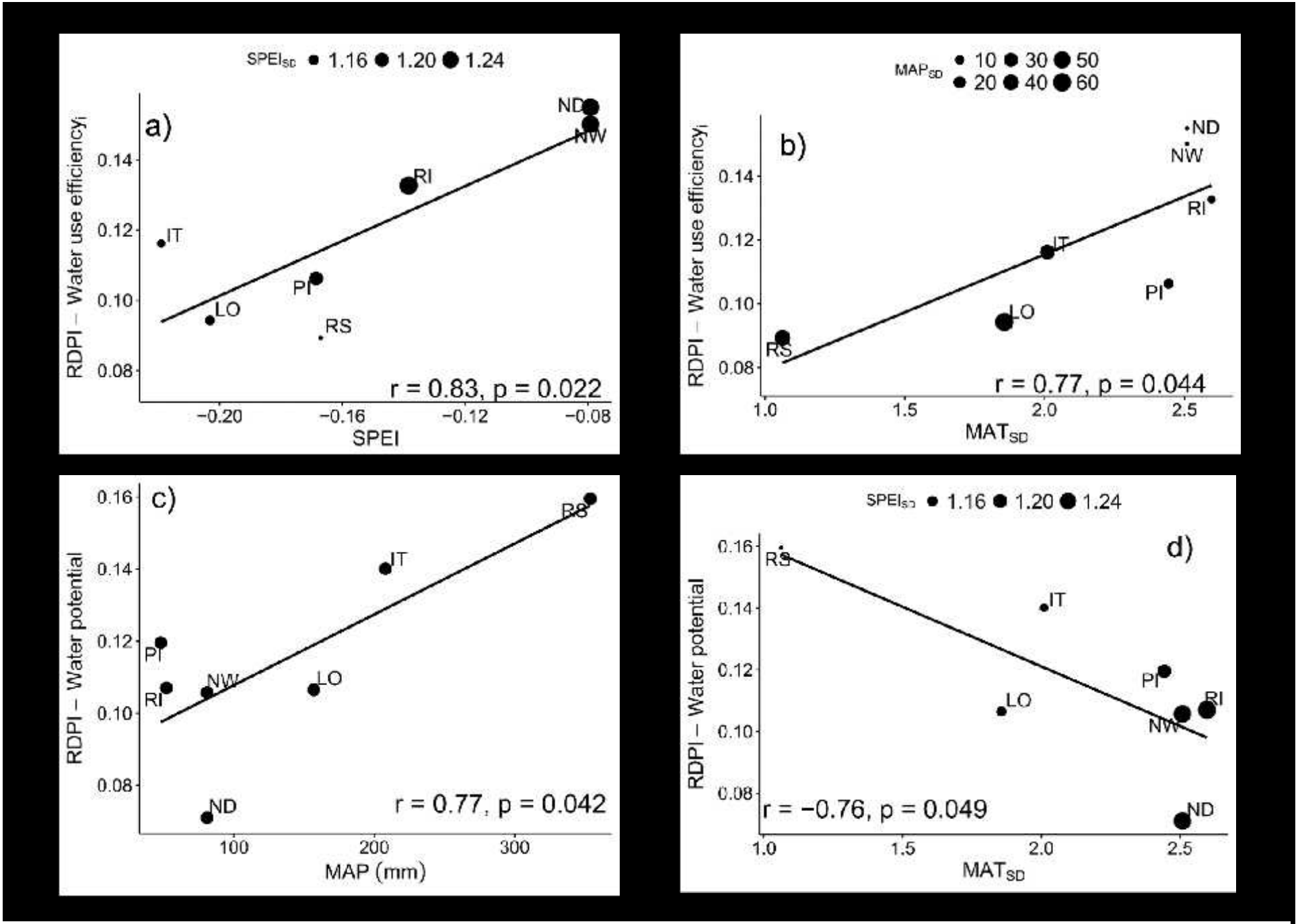
$$RDPI = \sum [\frac{(d_{ij} \rightarrow i'j')}{x_{ij} + x_{i'j'}}] /n$$

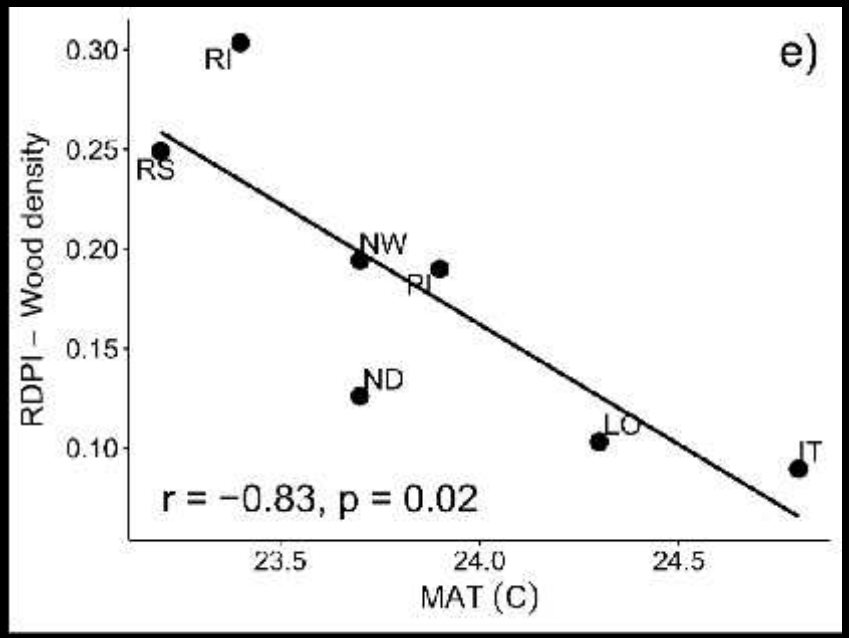


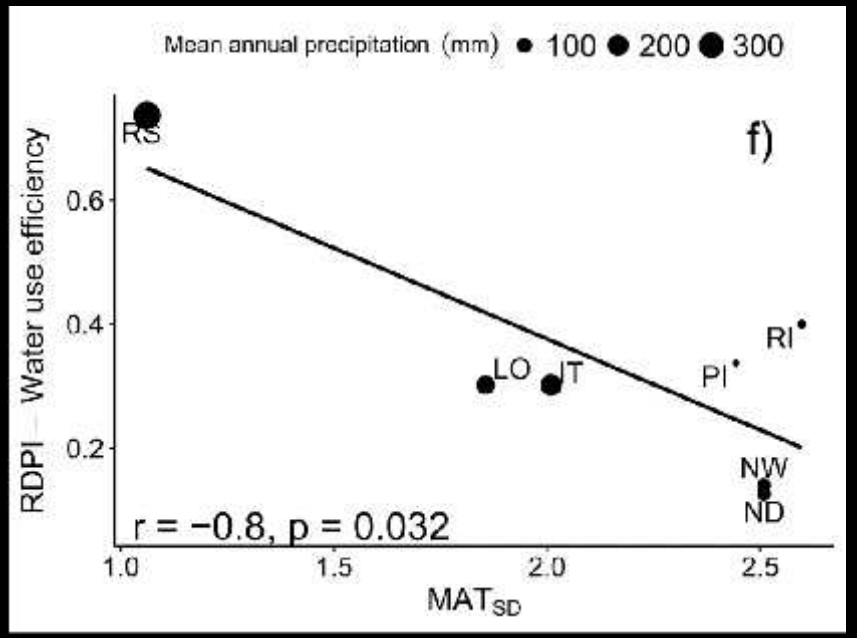
Plasticity index mean values (RDPI) per population. (a) Mean RDPI value of plant biomass per population. (b) Mean RDPI of root mass ratio (RMR) per population. Note the different scales of both figures



Relationships between the first axis of the principal component analysis (PCA) of traits under low (LW) and high (HW) water availability (PCA_1 HW versus PCA_1 LW). Correlation coefficient and statistical significance is shown. Black dots represent score values of each population, dots size are proportional to their mean RDPI


SPEI$_{SD}$ 1.16 1.20 1.24
a)
RDPI – Water use efficiency$_i$
SPEI
r = 0.83, p = 0.022
ND
NW
RI
IT
PI
LO
RS
b)
MAP$_{SD}$ 10 20 30 40 50 60
MAT$_{SD}$
r = 0.77, p = 0.044
c)
RDPI – Water potential
MAP (mm)
r = 0.77, p = 0.042
d)
r = −0.76, p = 0.049





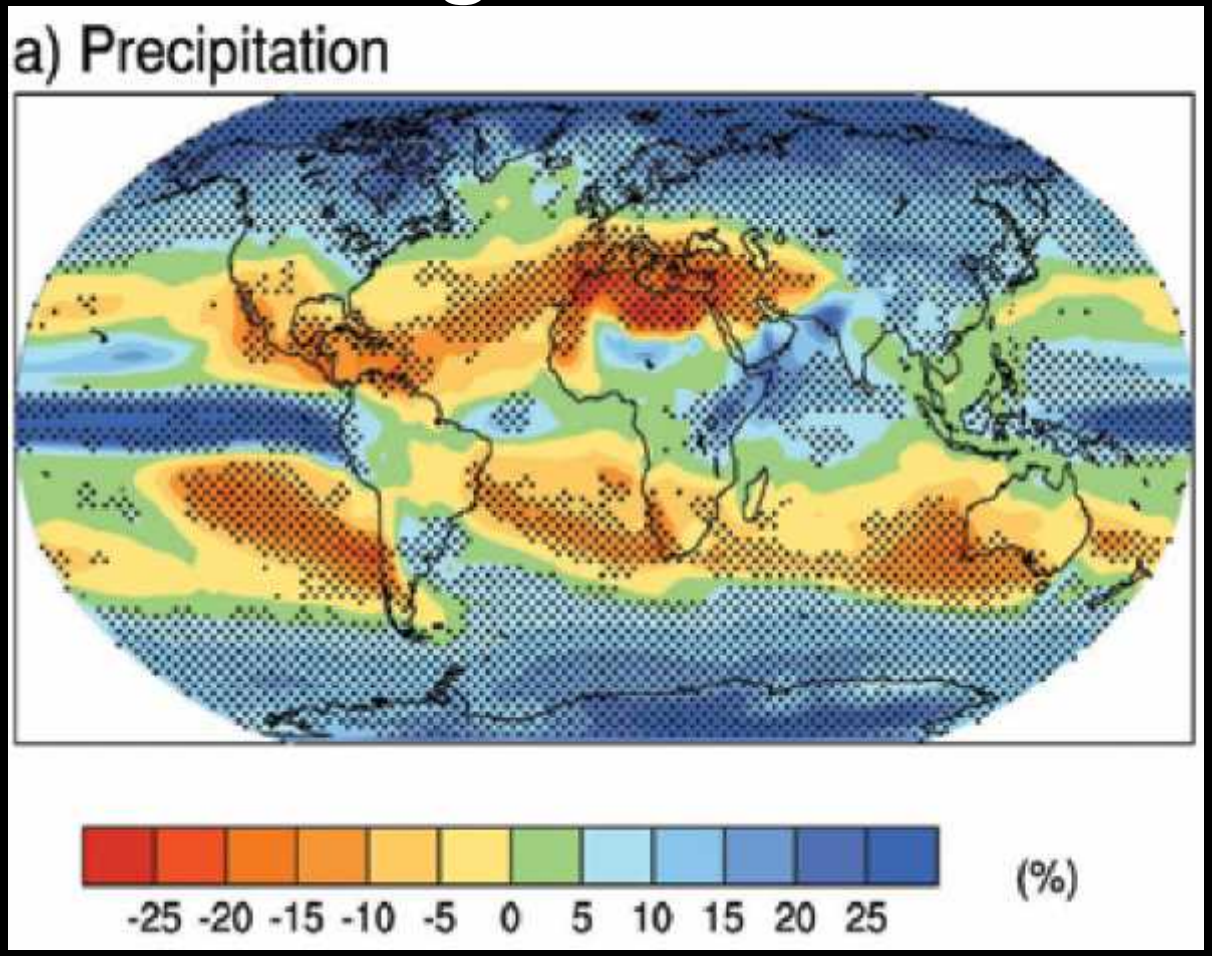
- Climatic factors has a significant effect on plastic plant phyisology, but not in plant growth

- The *P. pallida* forest have a strong response to water availbility, increaseing water consumption and plant biomass

- RMR and LMA are key traits to increase plant biomass under high water availability

- Phenotypic plasticity is limited by co-trait variations

What it is expected under the climate change scenario?



Bates et al. Climate Change and water (2008)

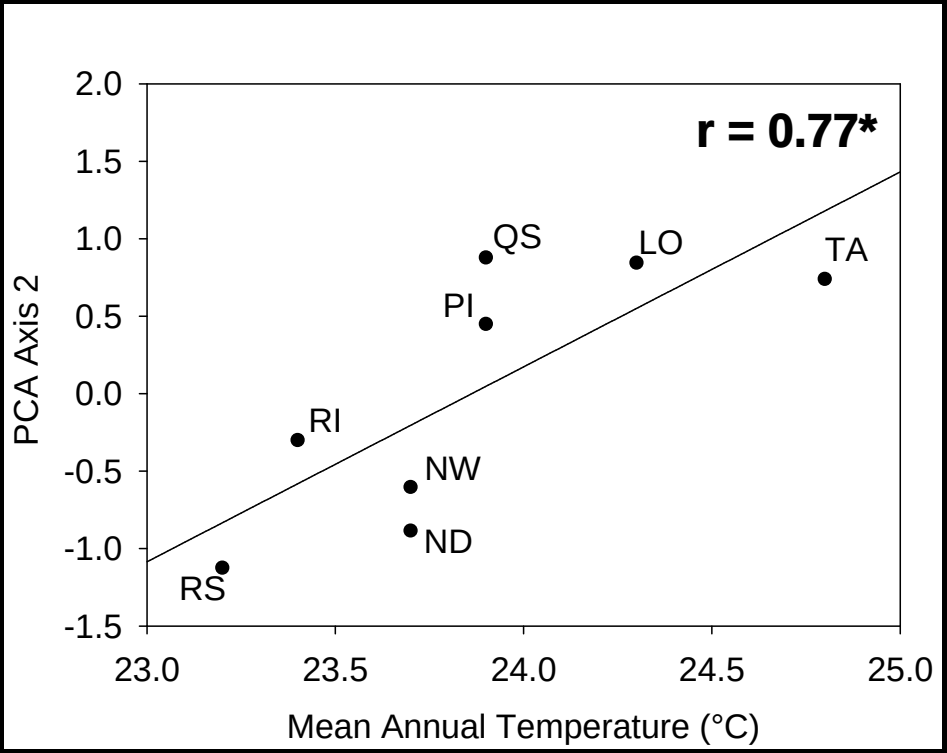
What it is expected under the climate change scenario?

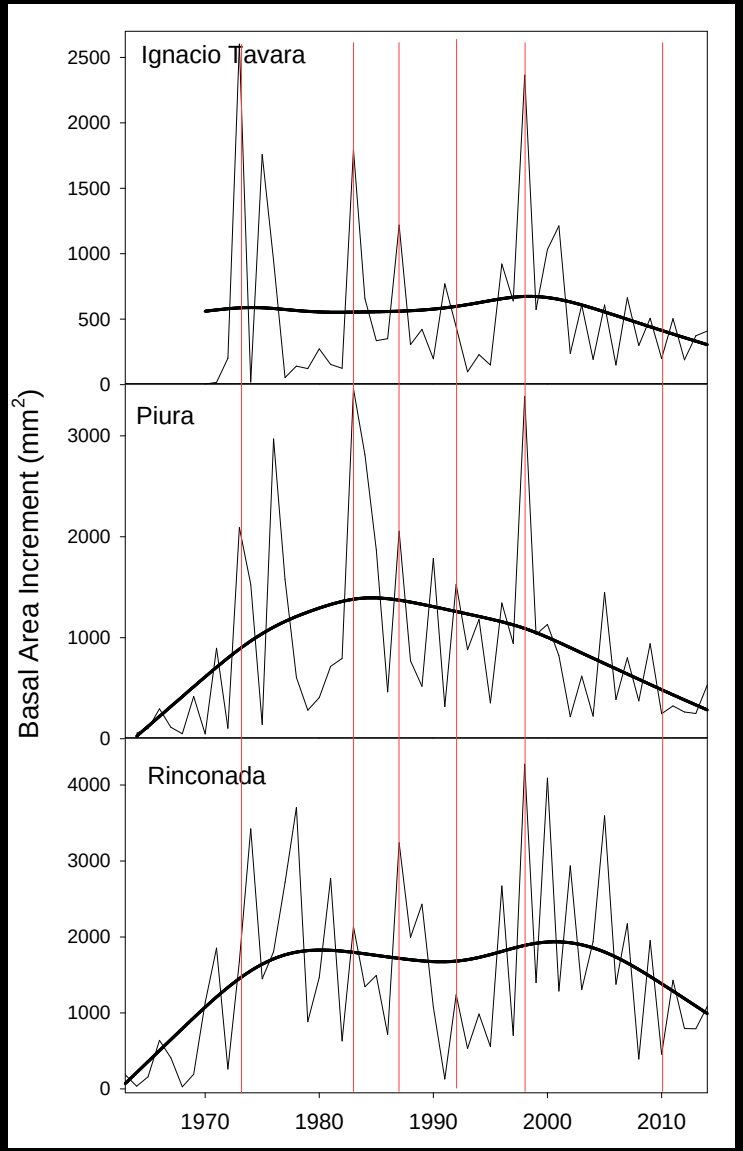
- An increase in sea surface temperature (1.5-2ºC) is expect in the Pacific ocean
- Increase in mean annual rainfall?
- Increase in strong ENSO events
  - From 5 to 10 events each 100 years
- Infrastructural limitation to deal with ENSO

What it is expected under the climate change scenario?

- Infrastructural limitation to deal with ENSO

- What does this mean for the vegetation?
  - ↑Temperature → drier condition
  - ↑temperature → wetter condition





What it is expected under the climate change scenario?

- Increase in grass species during the wet seasons
- How resilient is the vegetation to deal with a fast dry and wet cycle?
- With a 99% sand soil, is runoff a problem?
- Increase in sand whirlwinds?

Referencias

- Holmgren, M., Stapp, P., Dickman, C.R., Gracia, C., Graham, S., Gutiérrez, J.R., Hice, C., Jaksic, F., Kelt, D. a., Letnic, M., Lima, M., López, B.C., Meserve, P.L., Milstead, W.B., Polis, G. a., Previtali, M.A., Richter, M., Sabaté, S., Squeo, F. a., 2006. Extreme climatic events shape arid and semiarid ecosystems. Front. Ecol. Environ. 4, 87–95. doi:10.1890/1540-9295(2006)004[0087:ECESAA]2.0.CO;2
- López, B.C., Rodriguez, R., Gracia, C.A., Sabate, S., 2006. Climatic signals in growth and its relation to ENSO events of two Prosopis species following a latitudinal gradient in South America. Glob. Chang. Biol. 12, 897–906. doi:10.1111/j.1365-2486.2006.01138.x
- Osnas, J.L.D., Lichstein, J.W., Reich, P.B., Pacala, S.W., 2013. Global leaf trait relationships: mass, area, and the leaf economics spectrum. Science 340, 741–4. doi:10.1126/science.1231574
- Rollenbeck, R., Bayer, F., Münchow, J., Richter, M., Rodriguez, R., Atarama, N., 2015. Climatic cycles and gradients of the El Niño core region in North Peru. Adv. Meteorol. 2015, 10. doi:10.1155/2015/750181
- Wright, I.J., Reich, P.B., Westoby, M., Ackerly, D.D., Baruch, Z., Bongers, F., Cavender-Bares, J., Chapin, T., Cornelissen, J.H.C., Diemer, M., Flexas, J., Garnier, E., Groom, P.K., Gulias, J., Hikosaka, K., Lamont, B.B., Lee, T., Lee, W., Lusk, C., Midgley, J.J., Navas, M.-L., Niinemets, U., Oleksyn, J., Osada, N., Poorter, H., Poot, P., Prior, L., Pyankov, V.I., Roumet, C., Thomas, S.C., Tjoelker, M.G., Veneklaas, E.J., Villar, R., 2004. The worldwide leaf economics spectrum. Nature 428, 821–827. doi:10.1038/nature02403
- Catenazzi, A., Donnelly, M. a., 2007. Distribution of geckos in northern Peru: Long-term effect of strong ENSO events? J. Arid Environ. 71, 327–332. doi:10.1016/j.jaridenv.2007.05.003
- Messier, J., McGill, B.J., Lechowicz, M.J., 2010. How do traits vary across ecological scales? A case for trait-based ecology. Ecol. Lett. 13, 838–848. doi:10.1111/j.1461-0248.2010.01476.x
- Jung, V., Violle, C., Mondy, C., Hoffmann, L., Muller, S., 2010. Intraspecific variability and trait-based community assembly. J. Ecol. 98, 1134–1140. doi:10.1111/j.1365-2745.2010.01687.x
- Valladares, F., Gianoli, E., Gómez, J.M., 2007. Ecological limits to plant phenotypic plasticity. New Phytol. 176, 749–63. doi:10.1111/j.1469-8137.2007.02275.x
- Valladares, F., Sanchez-Gomez, D., Zavala, M. a., 2006. Quantitative estimation of phenotypic plasticity: Bridging the gap between the evolutionary concept and its ecological applications. J. Ecol. 94, 1103–1116. doi:10.1111/j.1365-2745.2006.01176.x
- Lambers, H., Hayes, P.E., Laliberté, E., Oliveira, R.S., Turner, B.L., 2015. Leaf manganese accumulation and phosphorus-acquisition efficiency. Trends Plant Sci. 20, 83–90. doi:10.1016/j.tplants.2014.10.007