

N:P imbalance effects on the seasonal C cycle in a Mediterranean Tree-Grass Ecosystem

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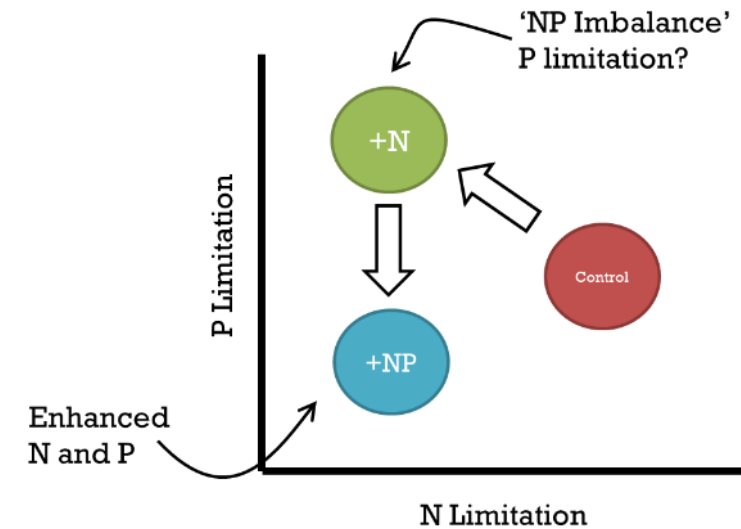


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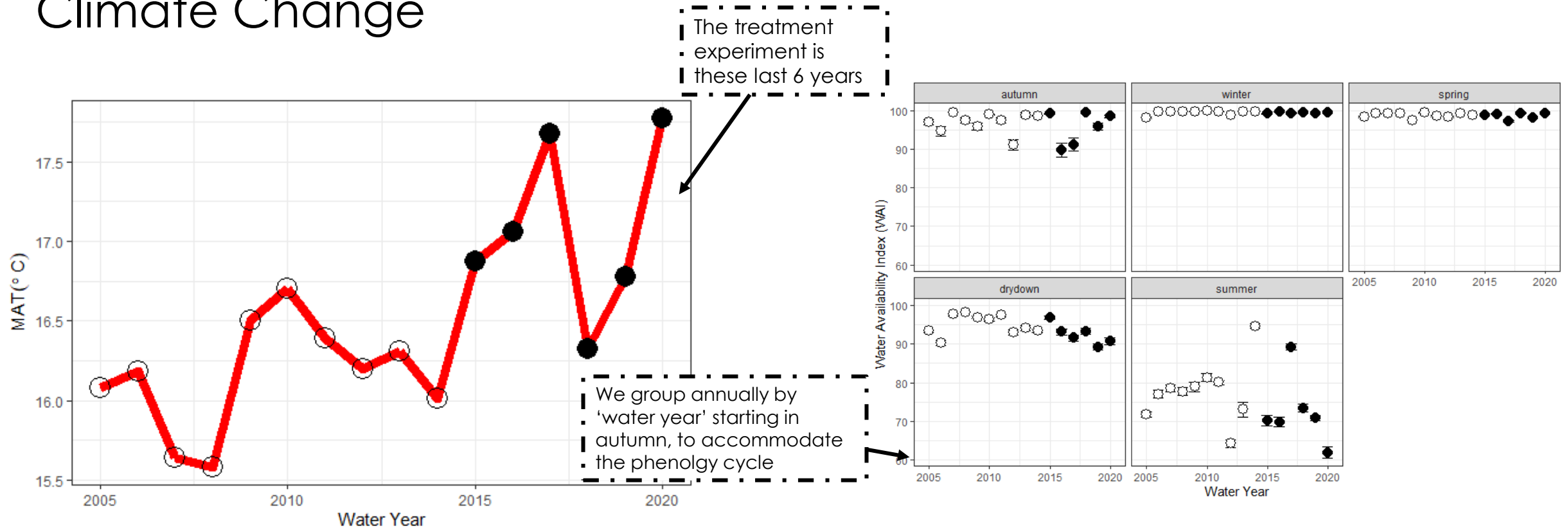
Our field site (Majadas del Tietar) – a typical Spanish dehesa with a strong bimodal phenological cycle, a complex (trees and grasses) structure, and a vulnerability to multiple global change drivers.

In 2014/2015, we added a +N and +NP treatment, each measured with its own ecosystem-scale Eddy Covariance installation. Footprints were highly comparable pre-treatment. We alter the ecosystem in 'NP Balanced' (+NP) and 'NP imbalanced' (+N) treatments compared to an unfertilized **control**. We follow the fate of ecosystem functioning for 6 years (as of now!)



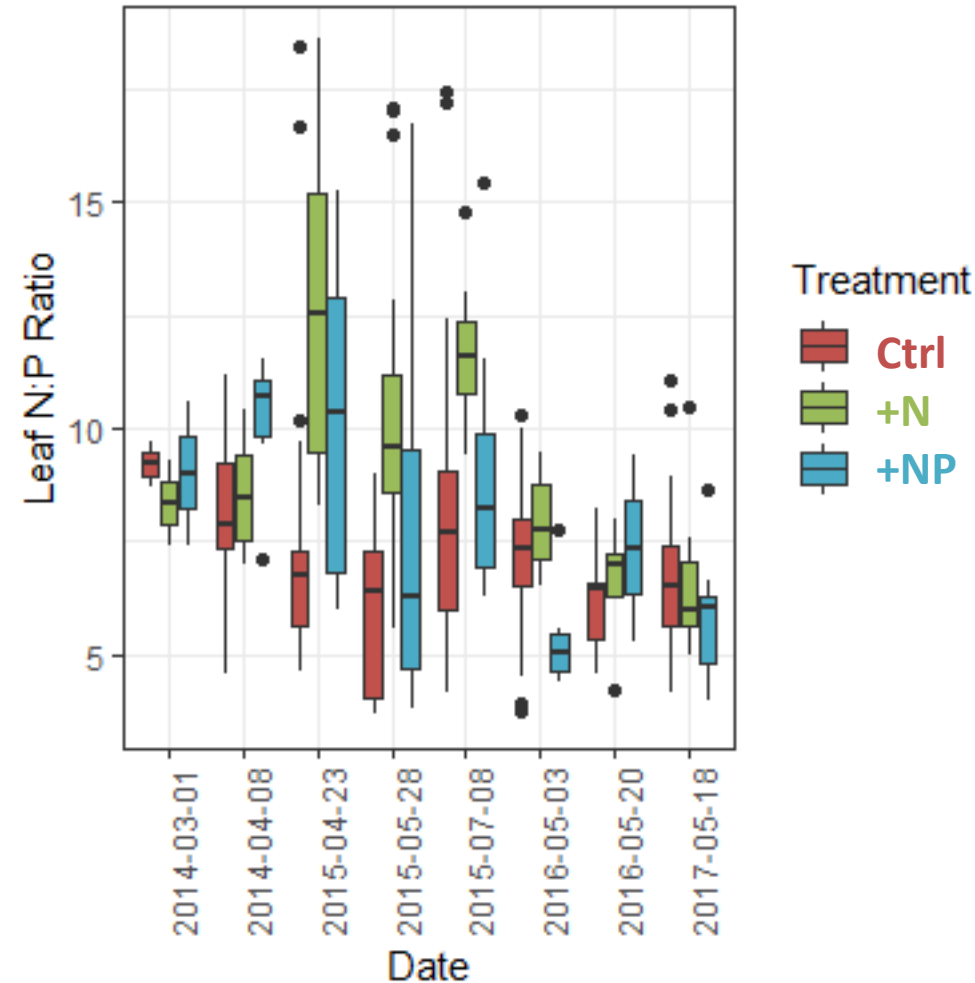
Multiple drivers = multiple trends

Climate Change



Multiple drivers = multiple trends

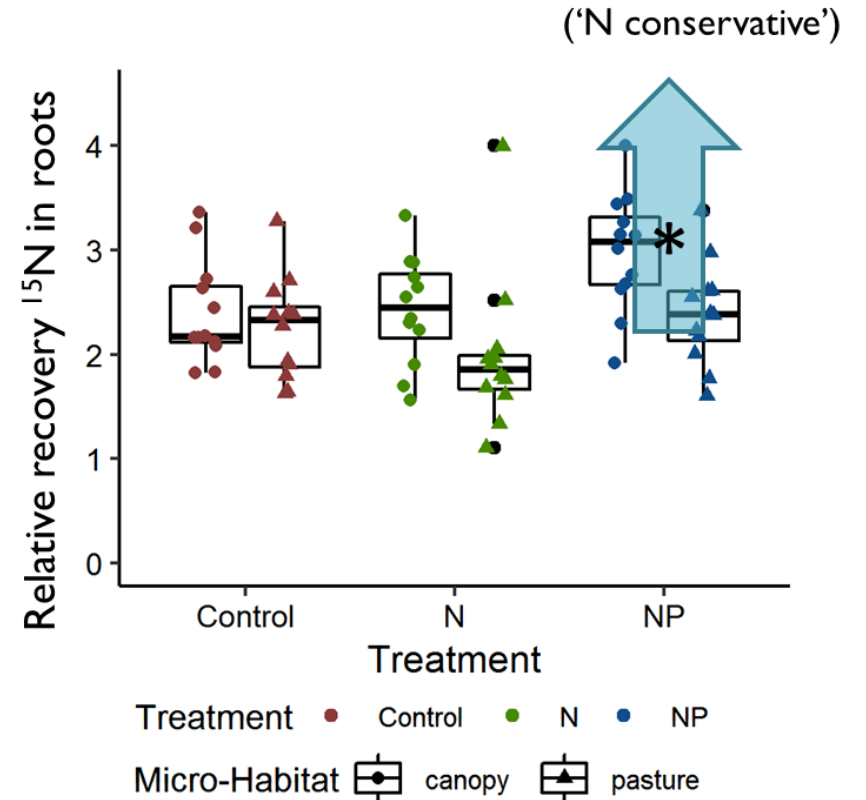
Declining Nutrient Effects?



Nutrient effects will eventually become diluted or leaching from the system.

Initial changes in leaf level nutrient contents may have disappeared by 2017 (left). Similar declines in relative differences in N:P ratio occurred in soil and roots ([Nair et al. 2019](#))

Isotope tracer experiments at this time also showed that *at the individual plant level*, the NP treatment was able to recover more litter ^{15}N nitrogen, indicating a tightening of the N cycle, potentially as N losses were faster than P losses.



What we show here:

In our semi-arid tree grass ecosystems, how **NUTRIENT EFFECTS** on **Resource Use Efficiencies** are effected by:

1) long term time trends

2) phenology

3) (short term) temperature and water anomalies

Calculated from Eddy
Covariance products

We are working on this but just show seasonal trends in this display

We already know the nutrient treatments affect carbon phenology (see [Luo 2019](#)) and expect seasonal variation due to the bimodal, annual nature of our study ecosystem

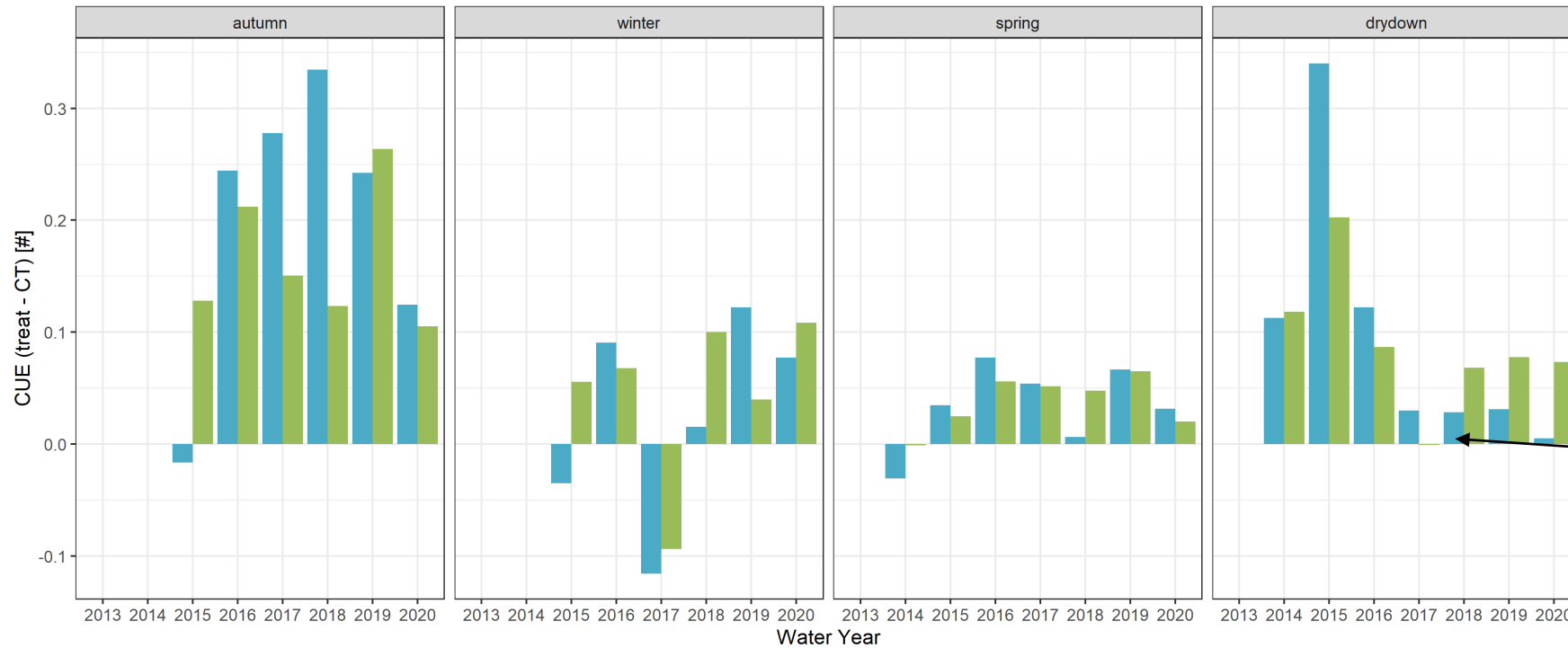
Some other things we already know:

- A much more in depth analysis of WUE effects: [El Madany et al. \(2021\)](#)
- Root distribution changes ([Nair et al. 2019](#)) and indicators of declining treatment-N fertility ([Nair et al 2020](#))
- Short term partitioning of ^{15}N additions (and lack of P effect on N fertilizer partitioning) ([Morris et al. 2019](#))

Mean CUE effect of Treatments

By 'season' (variable length, defined by phenocam-sensed vegetation period)

Calculated from Eddy
Covariance products
7 day averages
CUE = NEP / GPP
Effect = **Treatment** - **Ctrl**



Summer omitted
overall fluxes are
small/effects confusing
due to ecosystem
dormancy (also space
constraints)

nb. inversion in
relative CUE
effect in drydown
after 2017

Carbon Use Efficiency (CUE) increased in fertilized treatments... except in some winters.

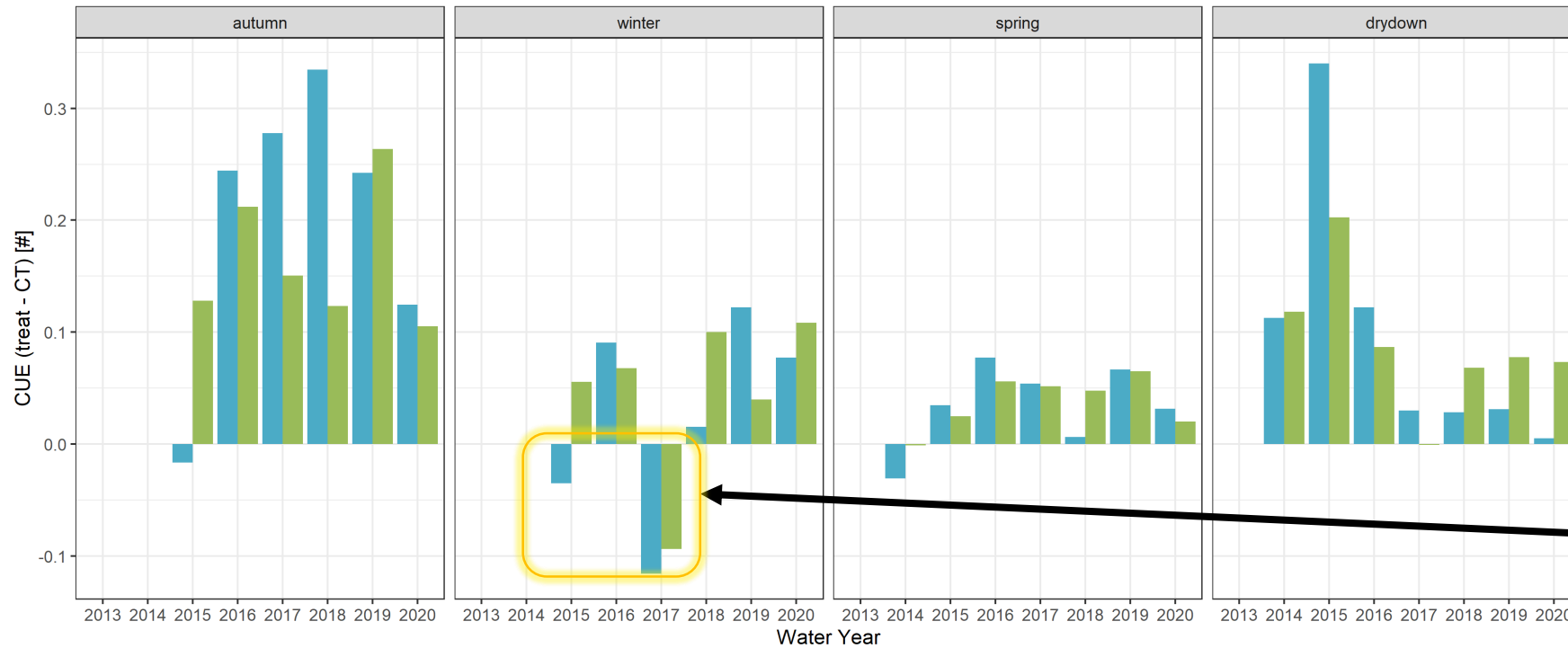
CUE is consistently higher in autumn in NP (faster leaf phenology? See [Luo 2019](#))

+NP fertilization effect on CUE in drydown at first STRONGER than **+N**, then WEAKER

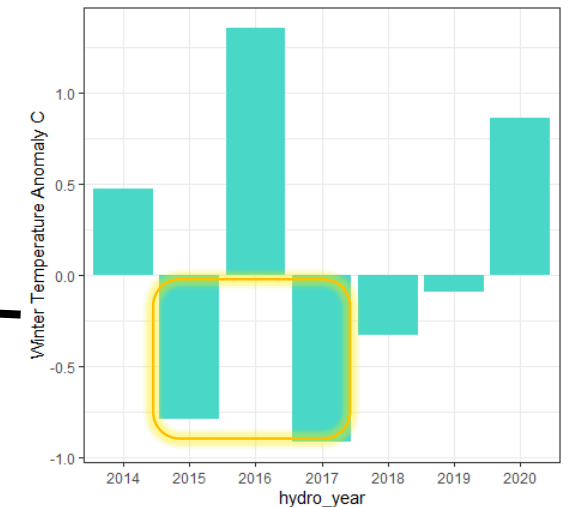
Mean CUE effect of Treatments

By 'season' (variable length, defined by phenocam-sensed vegetation period)

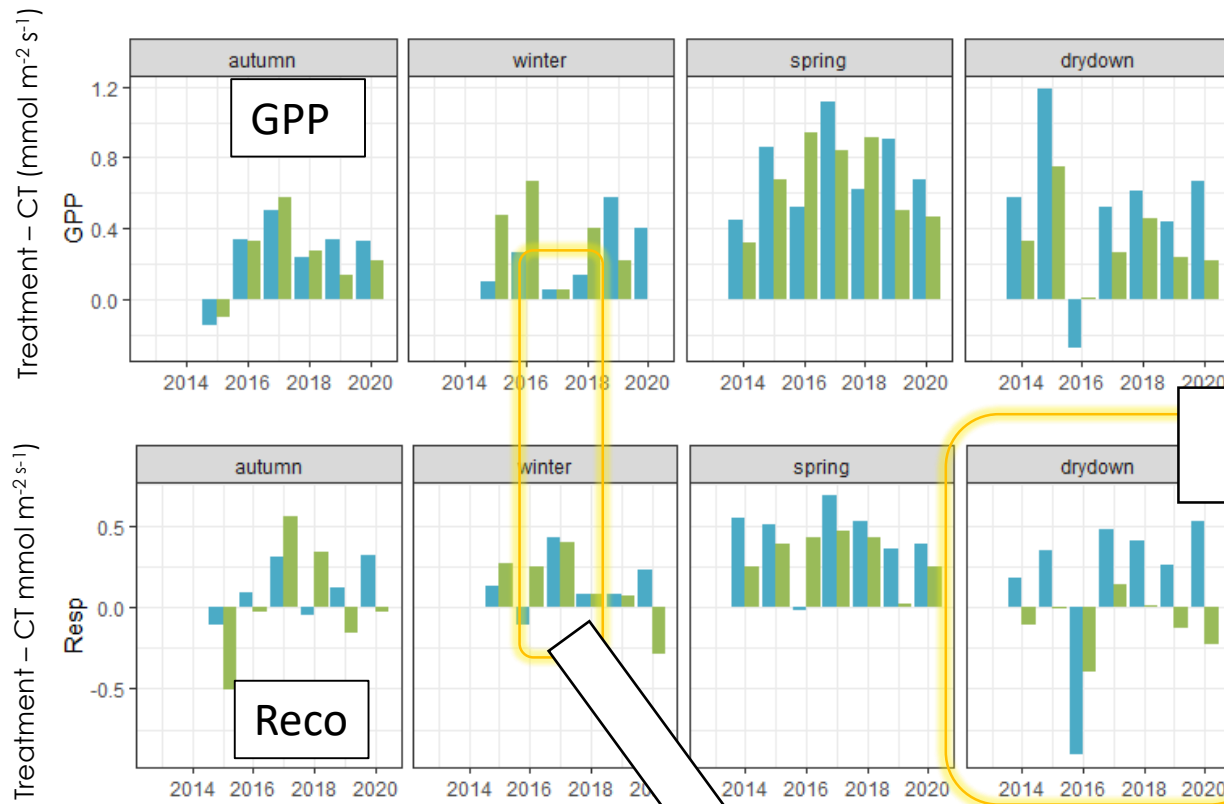
Calculated from Eddy
Covariance products
7 day averages
CUE = NEP / GPP
Effect = **Treatment** - **Ctrl**



Winter 2015 and
2017 were COLD!



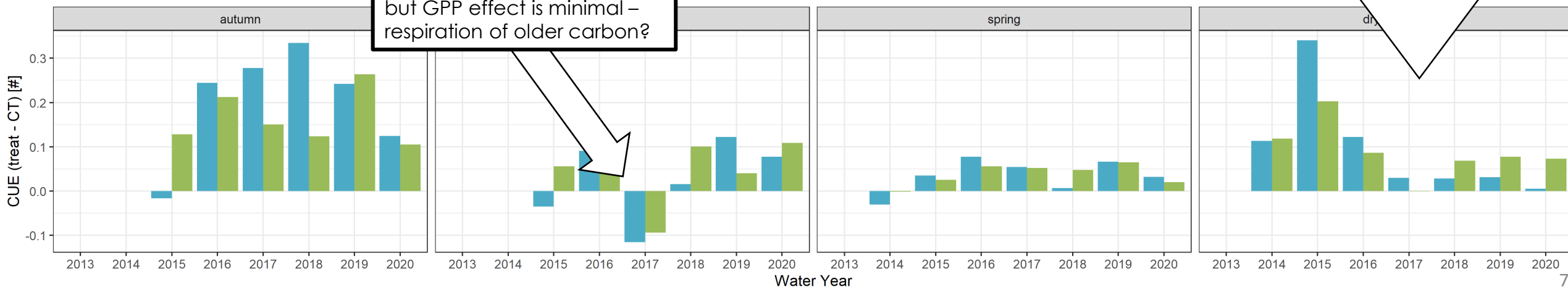
Cold winter temperatures mean the **fertilized treatments** are *less* carbon use efficient than the **control**



Difference between ecosystem scale **respiration** and **photosynthesis** explain cold winter response and drydown inversion in CUE

drydown respiration is suppressed in **+N** treatment (due to water depletion? see next slide) later in the experiment, relative to **+NPT** where respiratory fluxes are high and remain high

In this cold winter, **treatment** effect on respiration is strong but GPP effect is minimal – respiration of older carbon?



Mean WUE effect of Treatments

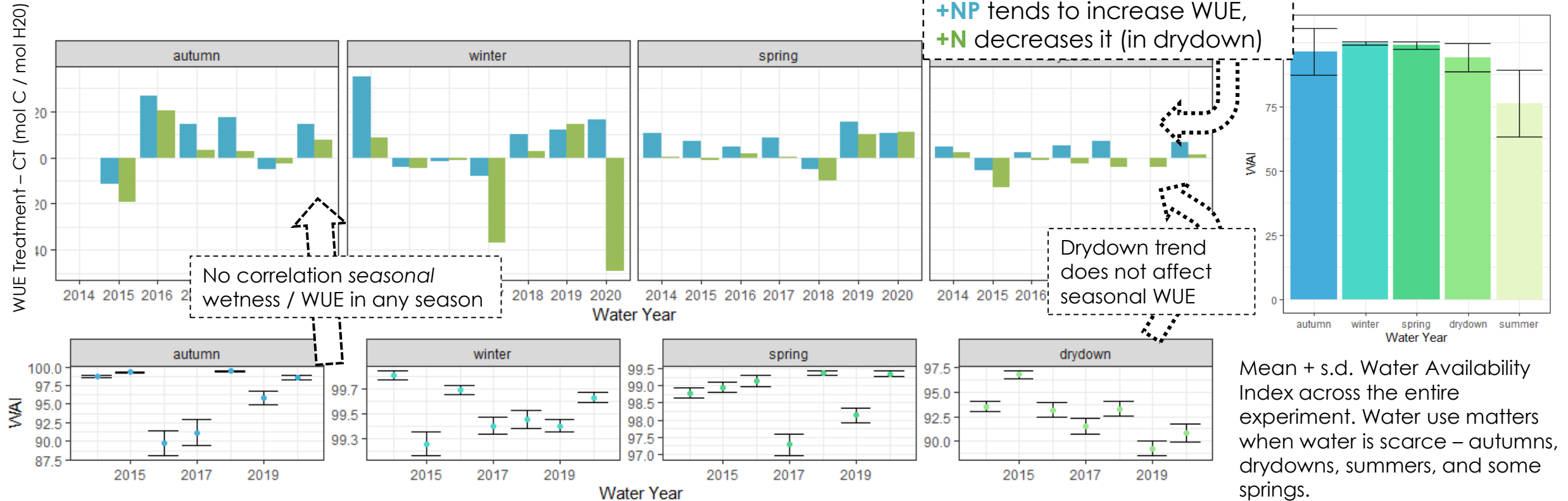
(on days when it has not rained for 3 days...)

By 'season' (variable length, defined by phenocam-sensed vegetation period)

Calculated from Eddy
Covariance products
7 day averages

$$\text{WUE} = \text{GPP} / \text{ET}$$

$$\text{Effect} = \text{Treatment} - \text{Ctrl}$$



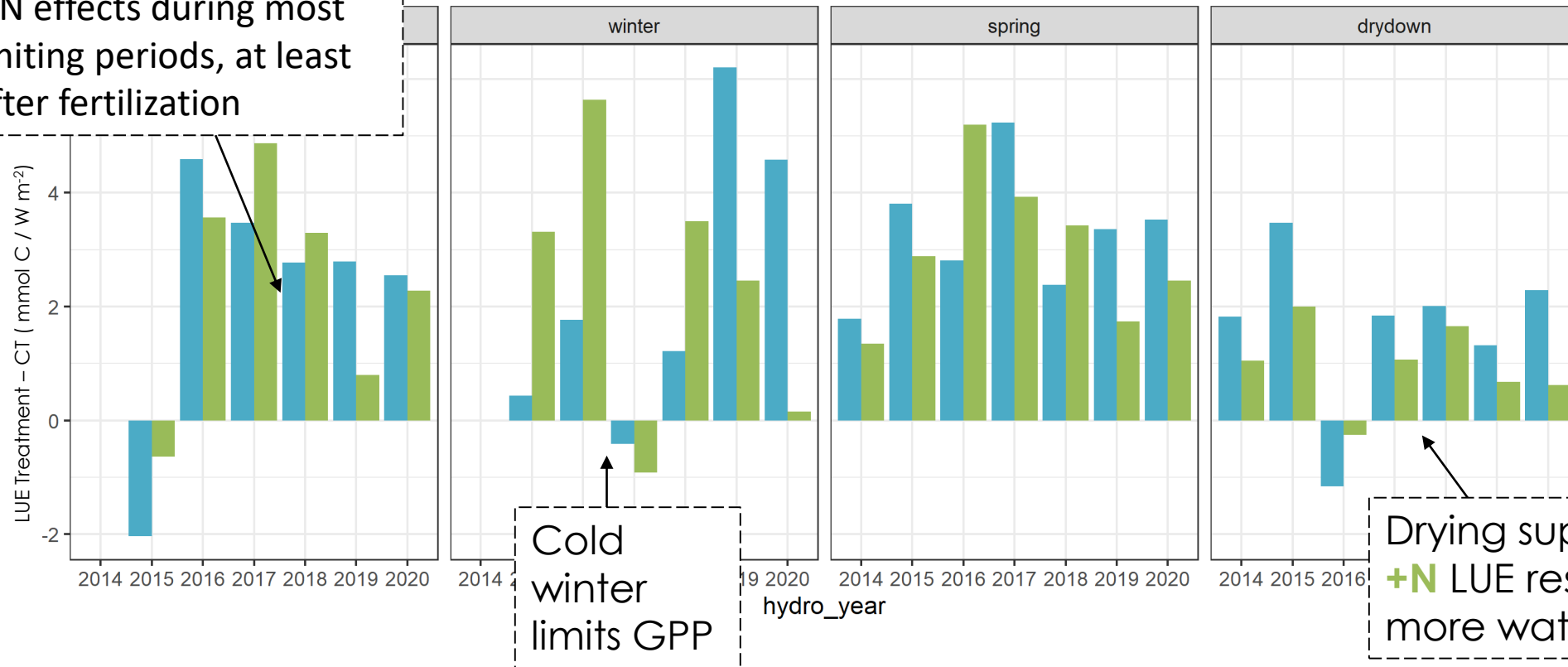
+N lower WUE in periods of water stress (drydown), generally quite unstable in other periods
 +NP generally higher WUE. Water metrics on the *seasonal* scale do not explain seasonal WUE
 (this is a very crude summary of a crude WUE calculation – for a much more in depth look, see [El Madany 2021](#))

Mean LUE Effect of Treatments

Calculated from Eddy
Covariance products
7 day averages
LUE = GPP / Rad
Effect = **Treatment** - **Ctrl**

By 'season' (variable length defined by phenocam-sensed vegetation period)

Strong N effects during most
light limiting periods, at least
soon after fertilization



LUE effect declines through the year (Light only limiting at the start of the year) or is potentially confused by LAI changes (not shown)

Excess N in +N may be useful in the winter to achieve more photosynthesis in low light conditions (enhanced LUE shortly after fertilization / when stoichiometric effects are evident)

Outlook (i)

Ecosystem level resource use efficiency increases from +N/+NP are sustained for the entire 6 year period.

Treatment effects on RUE are different in 'stoichiometric effect' period and afterwards

Exception are poor conditions midyear where more biomass = more resp.

Tissue stoichiometric effect early -> community (or allocation) change later?

Carbon use efficiency has reversed in +N/+NP comparison during drydown period

- more drought adapted community in +N? Or more respiration in +NP due to less water constraints

Outlook (ii)

Seasonal effects are coarse, difficult to relate quantitatively to environmental conditions, and probably heavily influenced by biomass phenology.

At finer timescales, we aim to look at underlying sensitivity of RUEs to environmental conditions independent of phenological trends. But that's not ready yet...

Many people are involved in the MANIP experiment, the presenter is thankful for the hard work expert knowledge and scientific insight of many others. ...



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