UCDAVIS

INRA SCIENCE & IMPACT

13th Dahlia Greidinger International Symposium 2019

Dynamics of carbohydrate storage in trees

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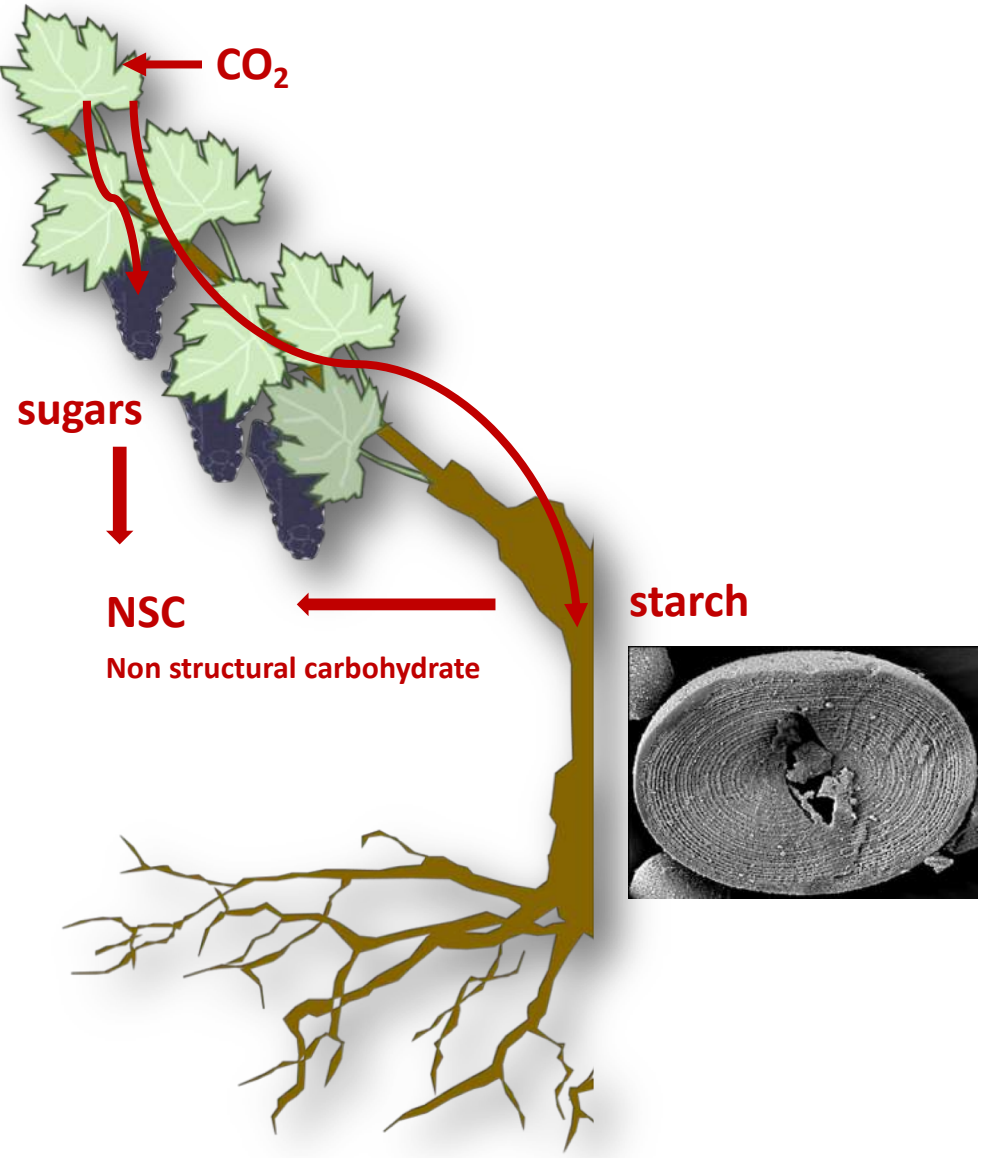
NON STRUCTURAL CARBOHYDRATES ARE CRUCIAL FOR PLANTS

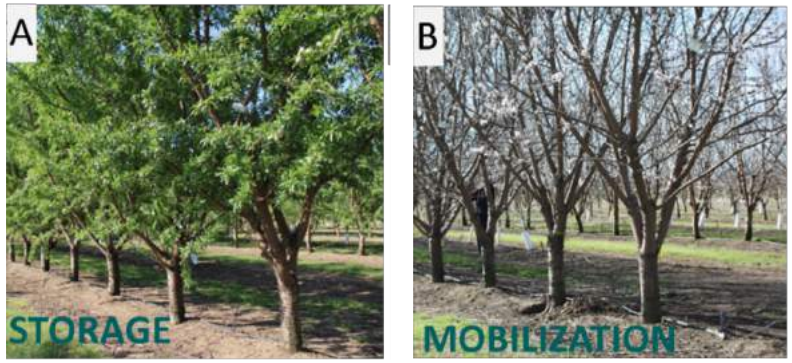
"At the whole-plant level, NSC storage buffers the asynchrony of supply and demand on diel, seasonal or decadal temporal scales "

Hartmann &Trumbore, 2016

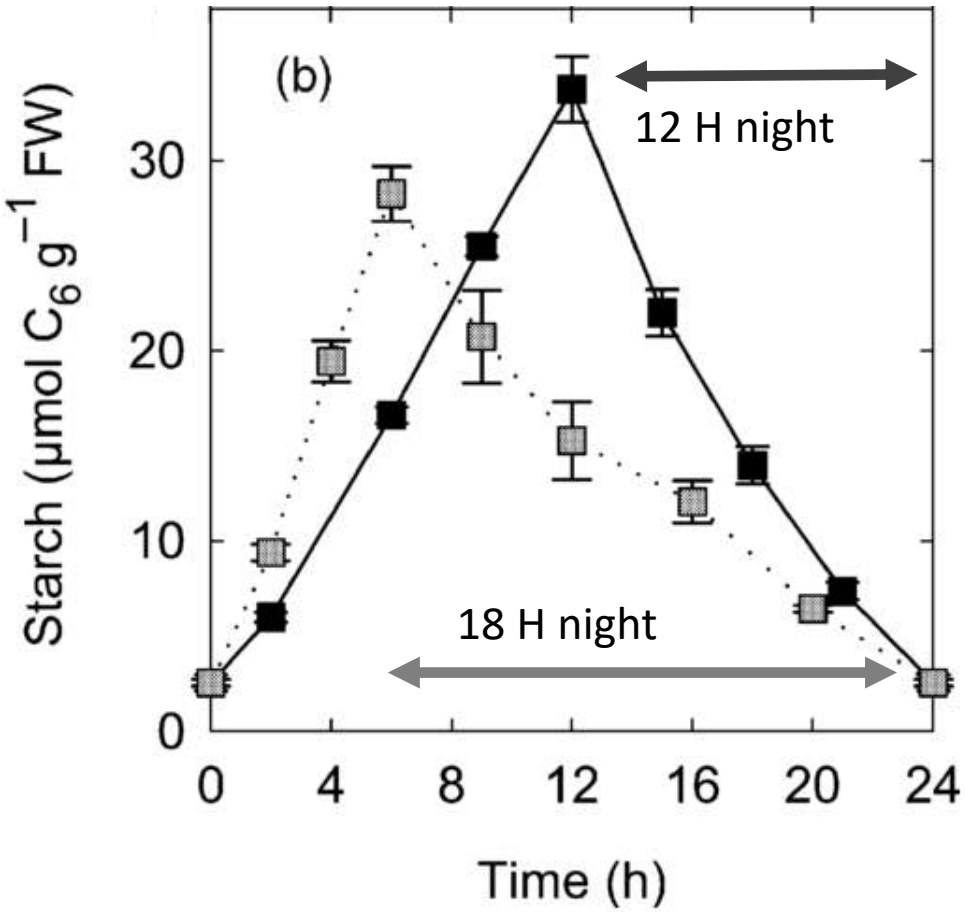


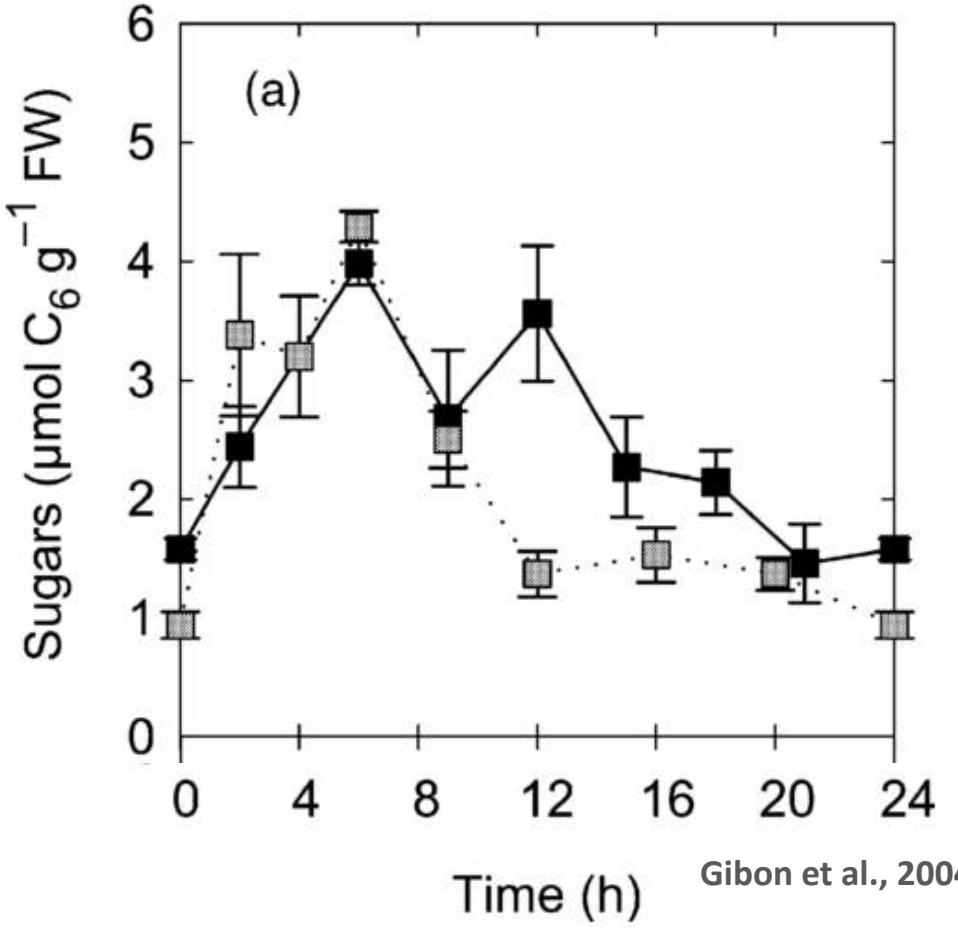
NSC allocation has to be balanced

Requirement for storage in the form of starch



The transitory starch accumulation in leaves during day-time provides substrate for respiration and sugar translocation during night-time





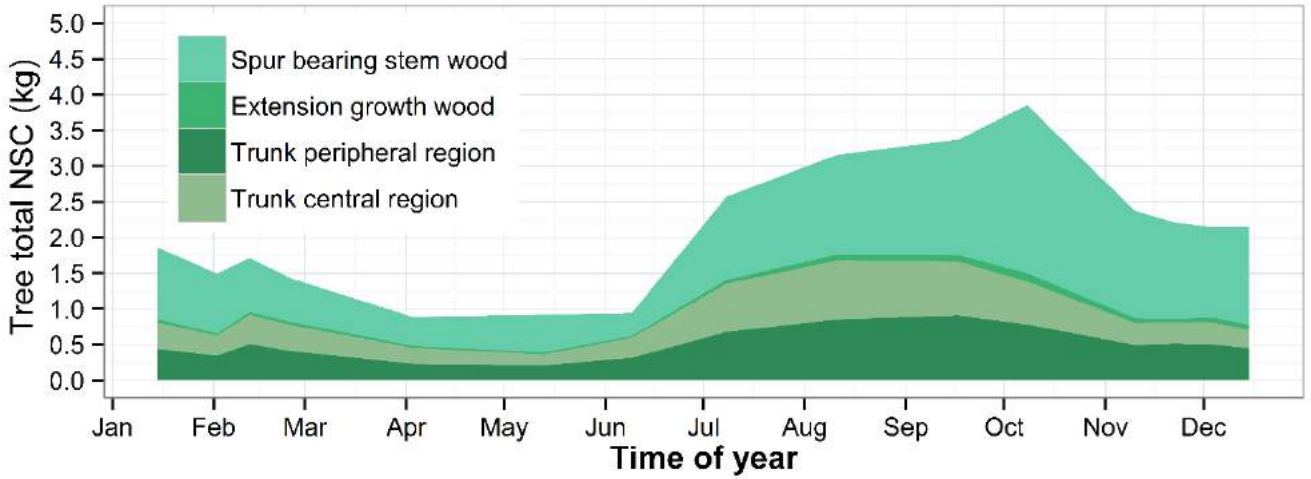
Gibon et al., 2004

~ 50 % of photoassimilates during day time is partitioned into starch

Arabidopsis thaliana

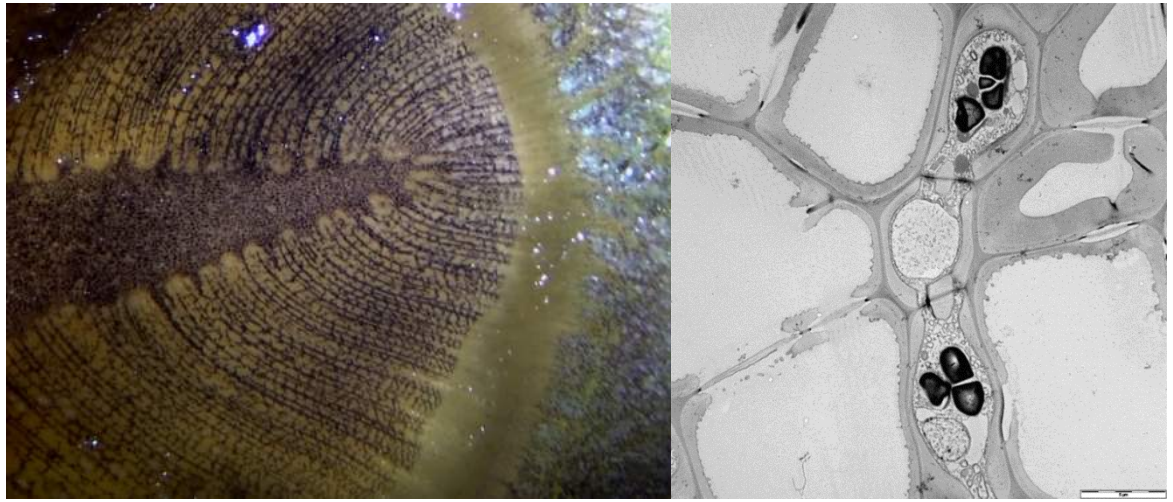
CAN WE TRANSPOSE OBSERVATIONS IN ARABIDOPSIS TO WOODY PERENNIALS ?

DIFFERENCE IN LIFE HABITS



Perennial need accumulation of carbohydrates in storage tissues for winter

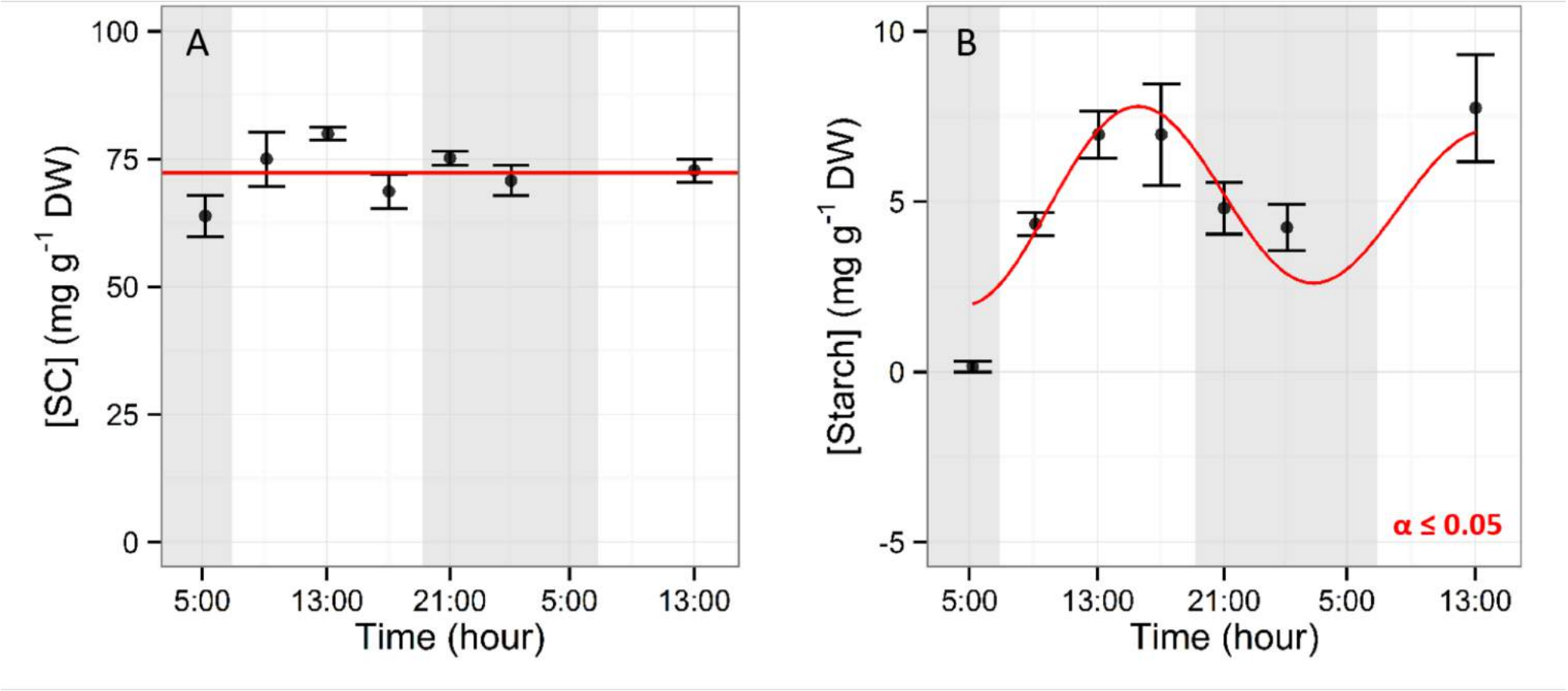
DIFFERENCE IN STORAGE TISSUES



Woody plant store starch in the parenchyma cells of xylem

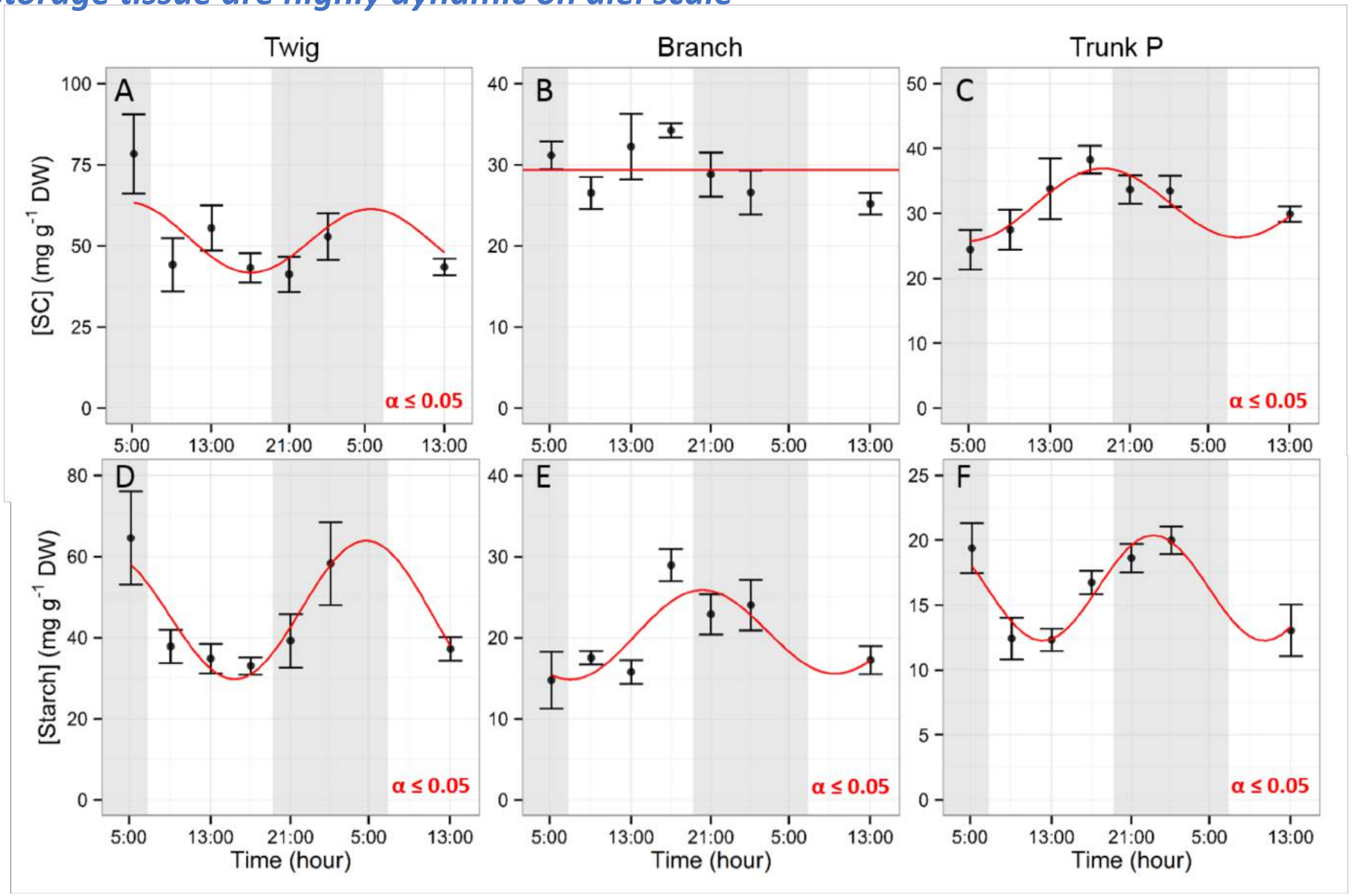
(SIZE)

LEAVES of Almond trees show similar trends as Arabidopsis



100 % of starch stored during the day is remobilized during night

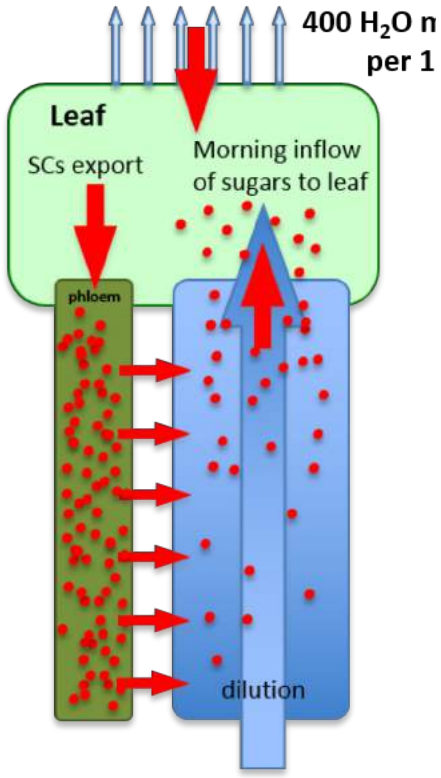
WOOD storage tissue are highly dynamic on diel scale



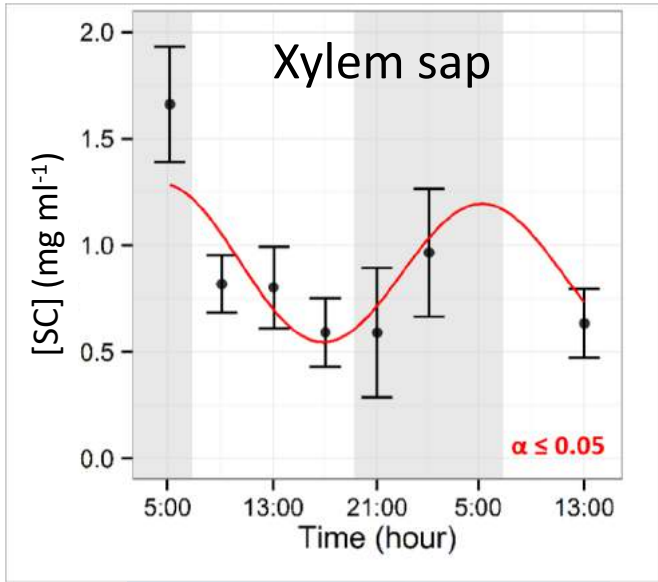
Recirculation of sugars via xylem ?

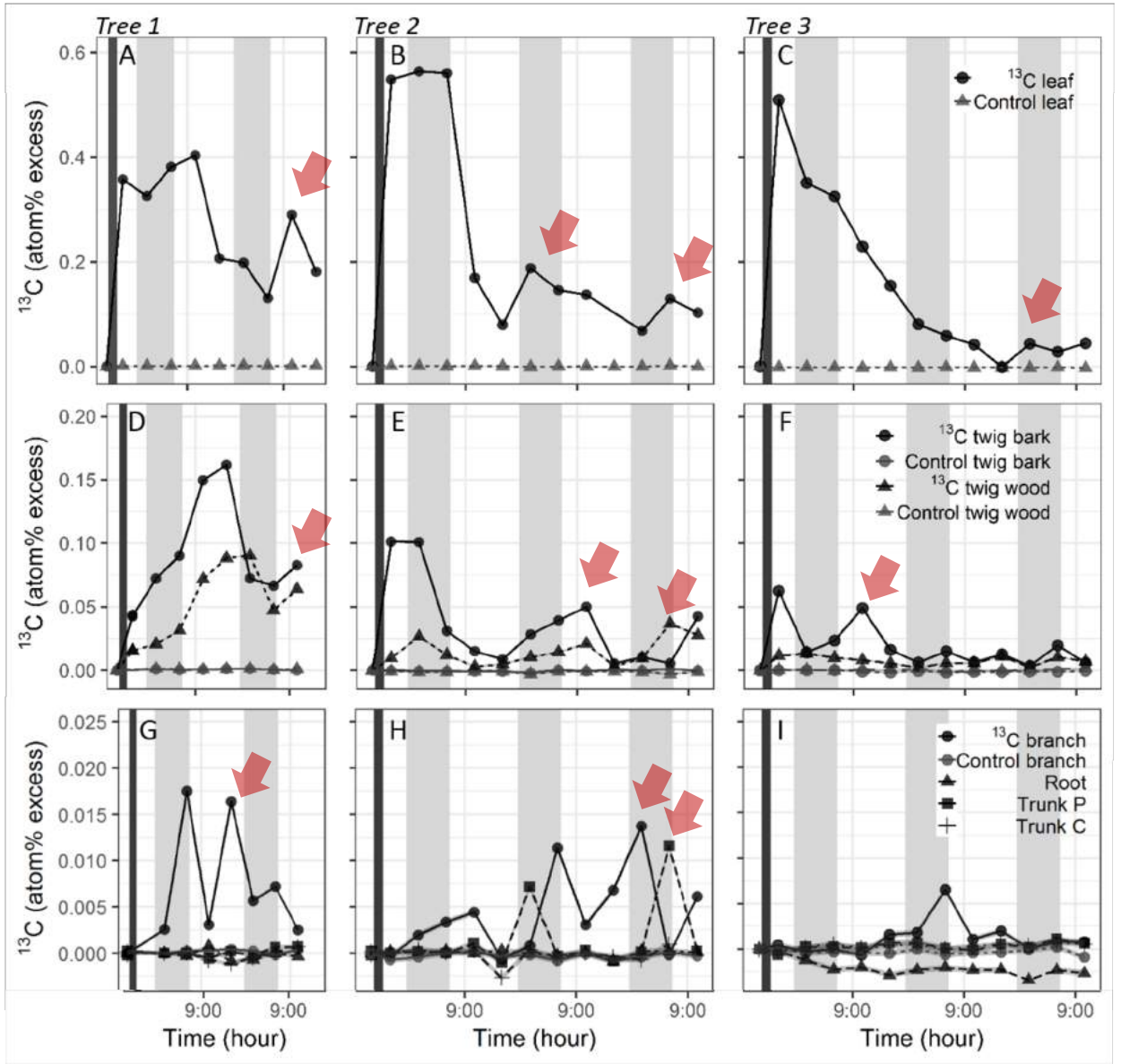
Morning (transpiration)

In the morning for two carbons from photosynthesis one carbon comes with xylem sap (~33 % of leaf 'new' NSCs comes from stem).



2 [mg_{sugars}/mL_{H2O}] or
~1 C atom per 800 H_2O molecules



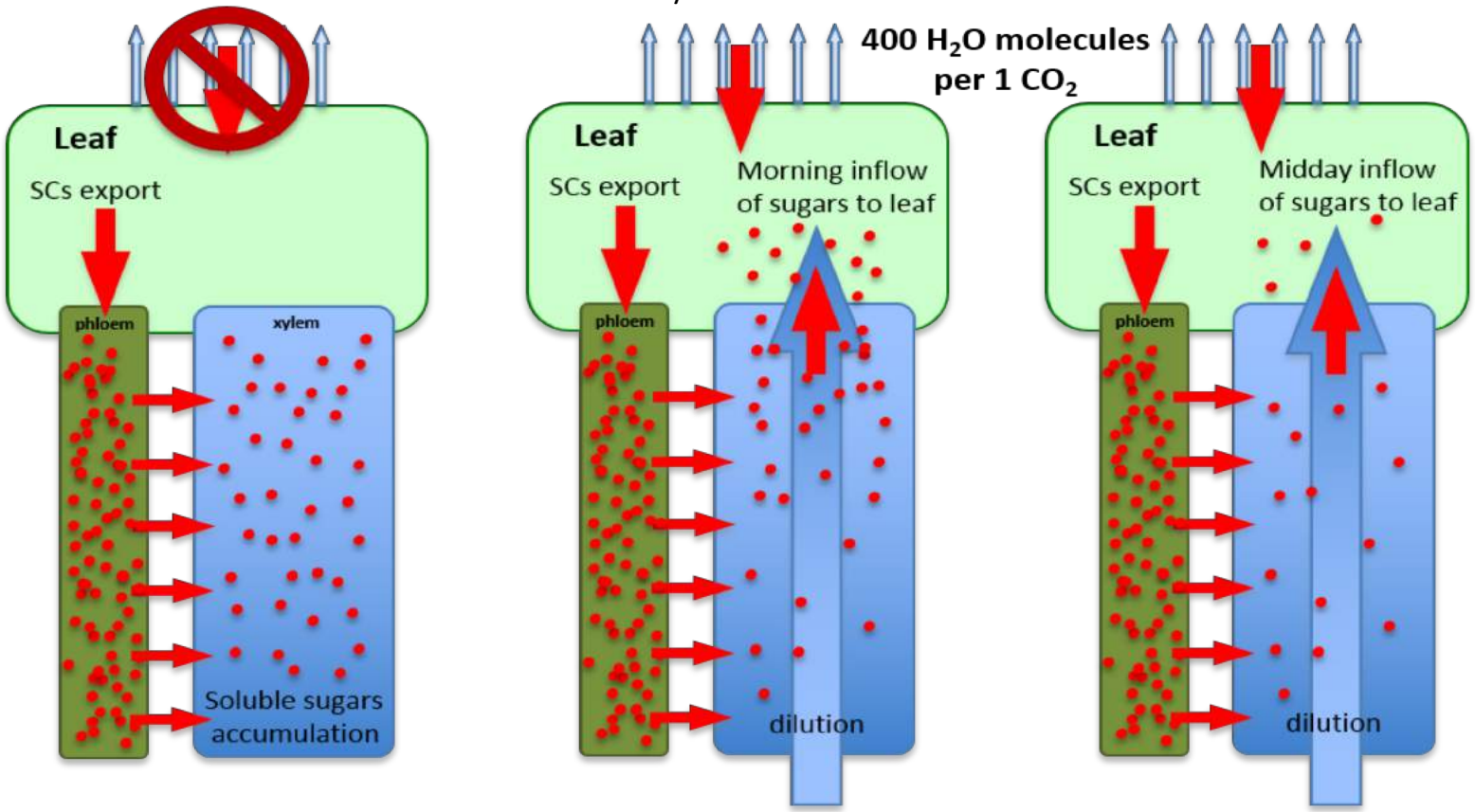


Recirculation of sugars via xylem, vertical mixing ?

Night
No transpiration
No photosynthesis

Morning
1000 H_2O
2 CO_2
1/6 Glucose

Day
High transpiration
Low sugar concentration



Tixier et al. 2018

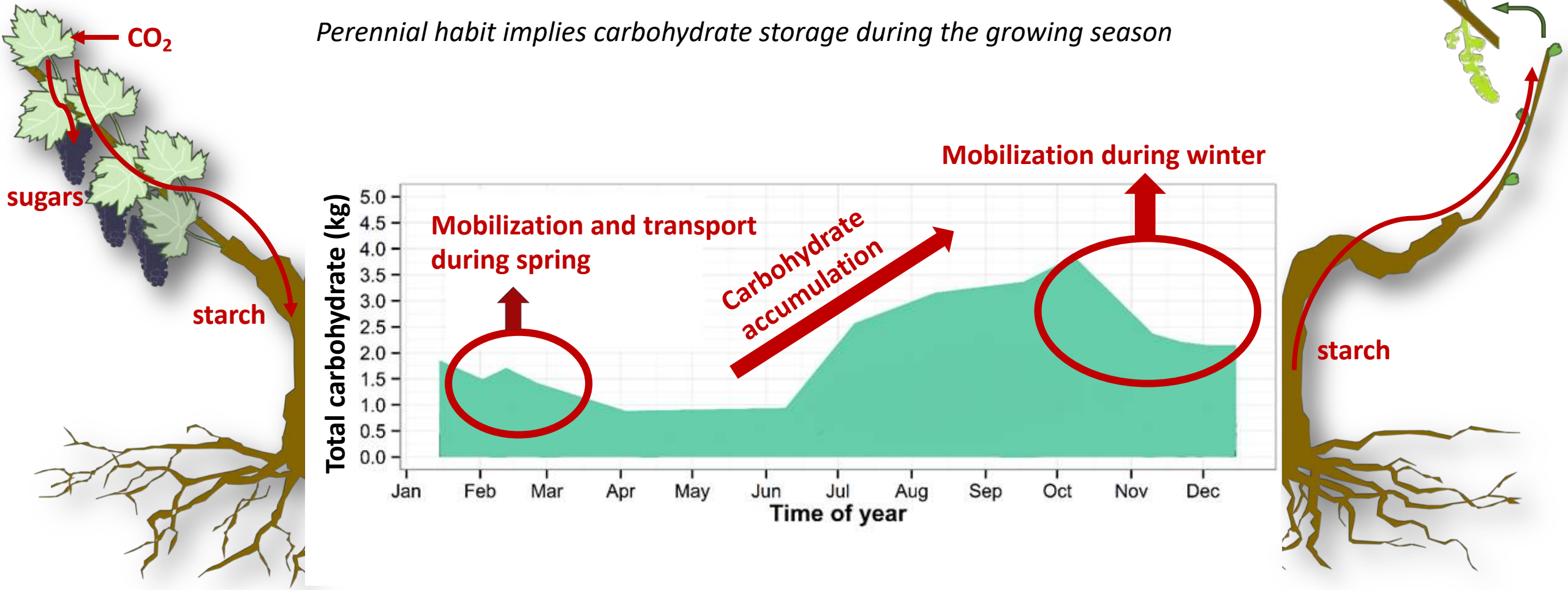
BALANCING SUPPLY AND DEMAND ON SEASONAL TIME SCALE

"At the whole-plant level, NSC storage buffers the asynchrony of supply and demand on diel, seasonal or decadal temporal scales "

Hartmann &Trumbore, 2016

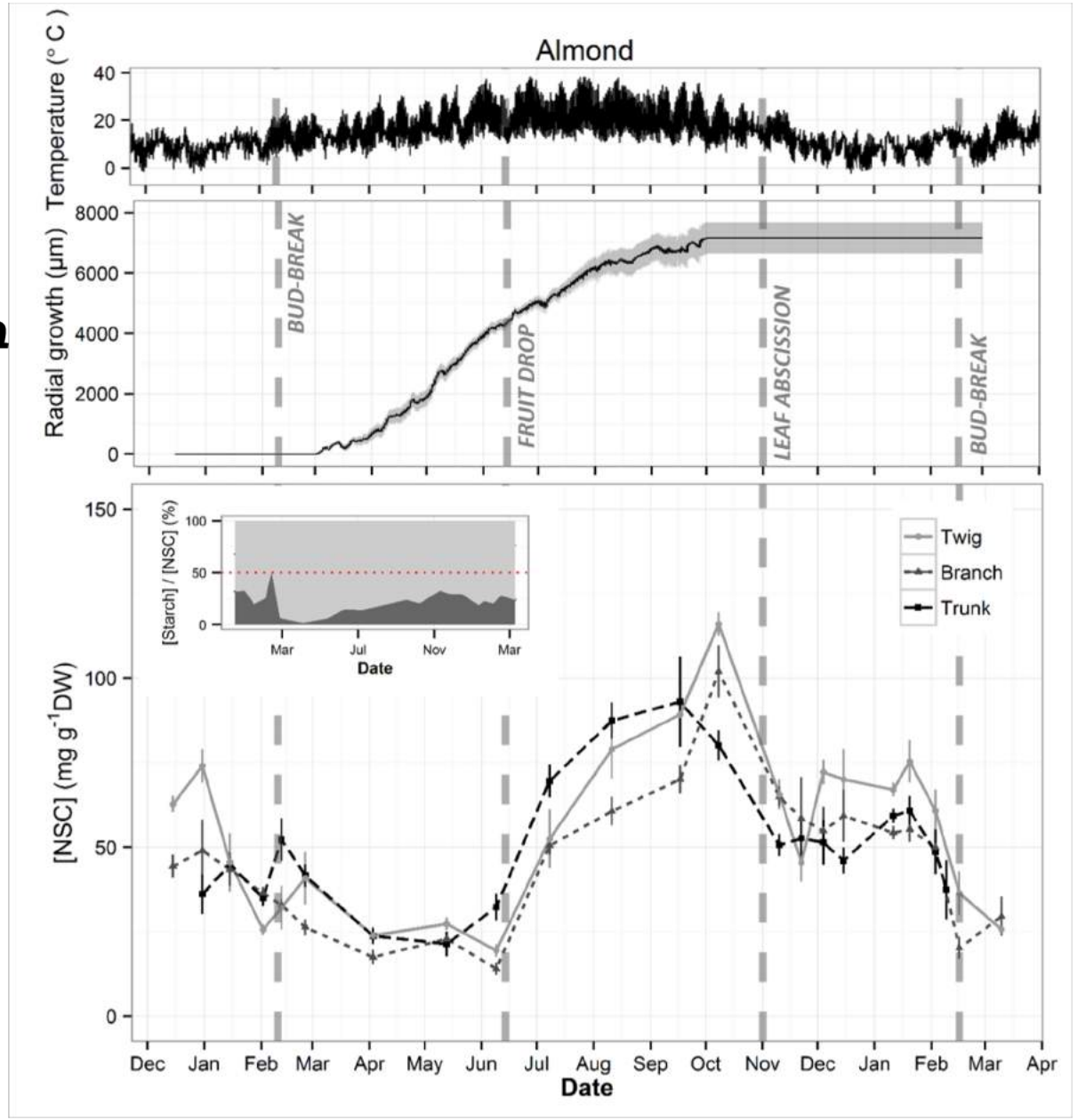
Seasonal time scale

Perennial habit implies carbohydrate storage during the growing season



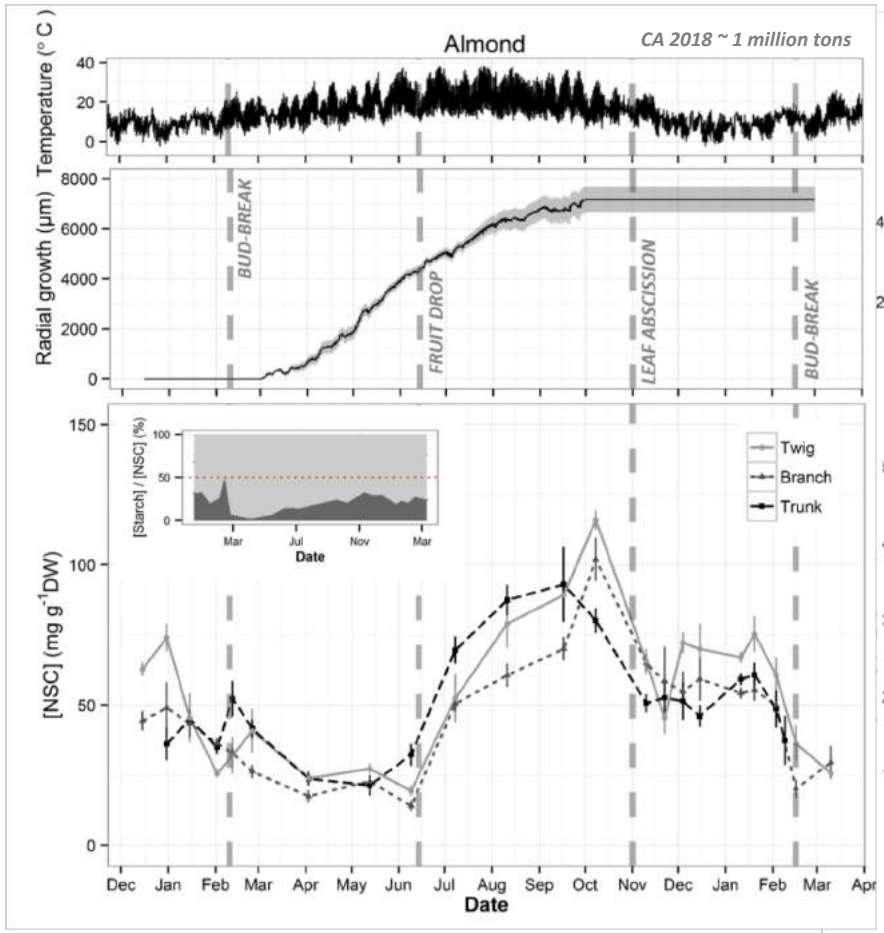
BALANCING SUPPLY AND DEMAND ON SEASONAL TIME SCALE

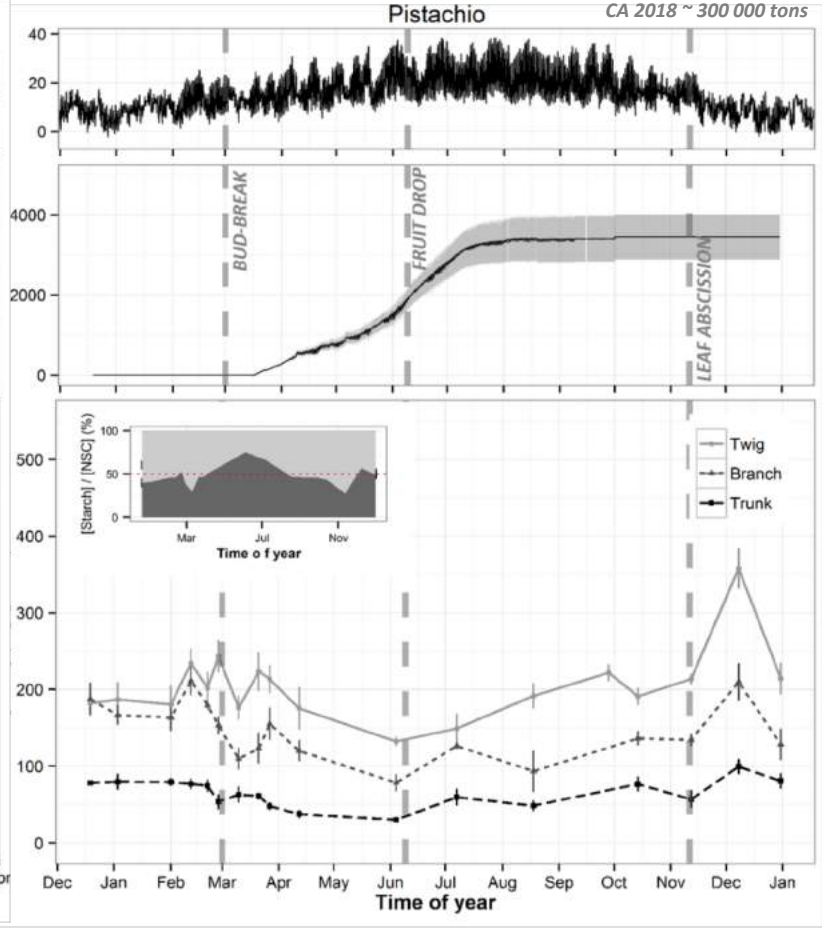
Phytech

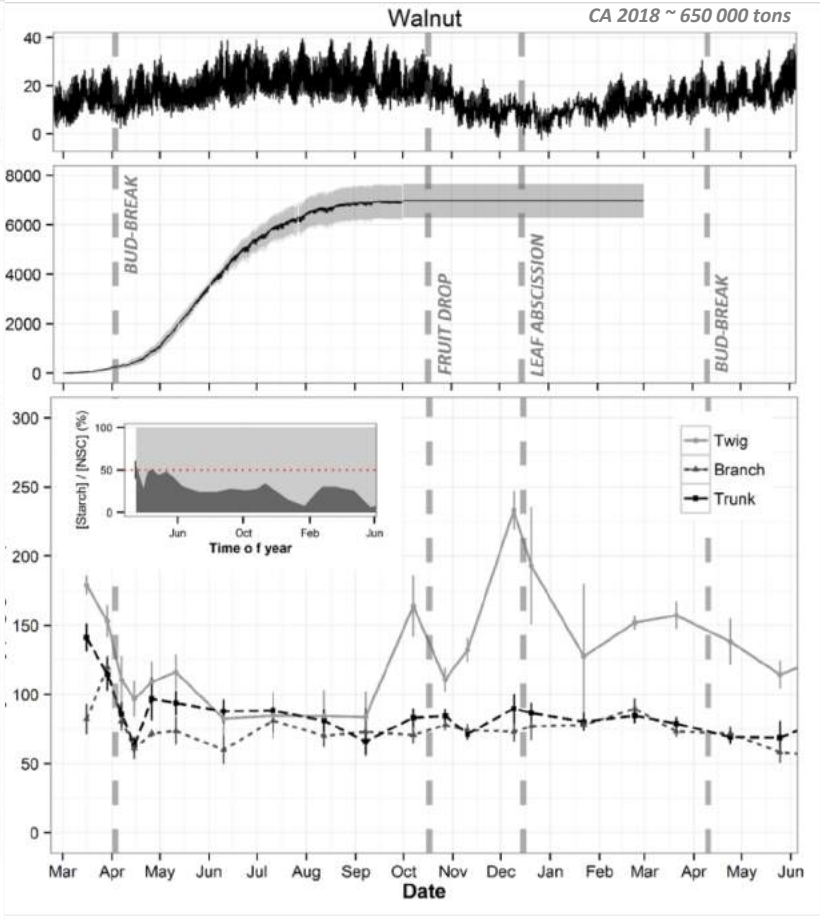


1330 measures of NSC in almond trees

BALANCING SUPPLY AND DEMAND ON SEASONAL TIME SCALE







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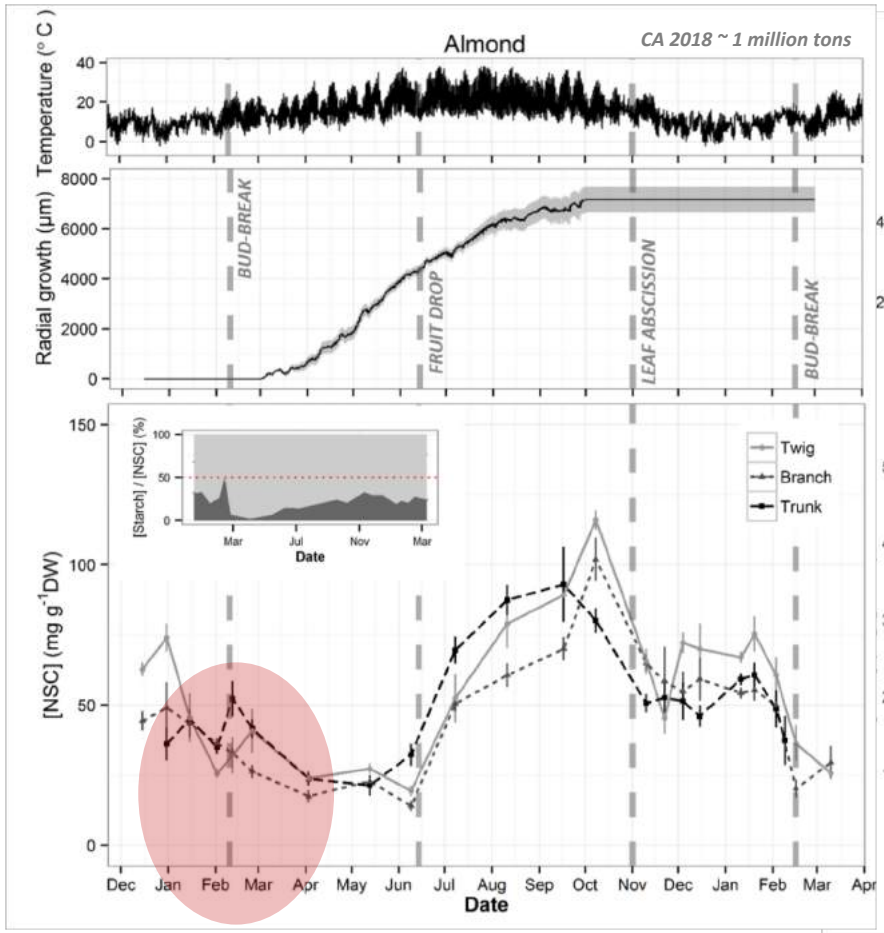
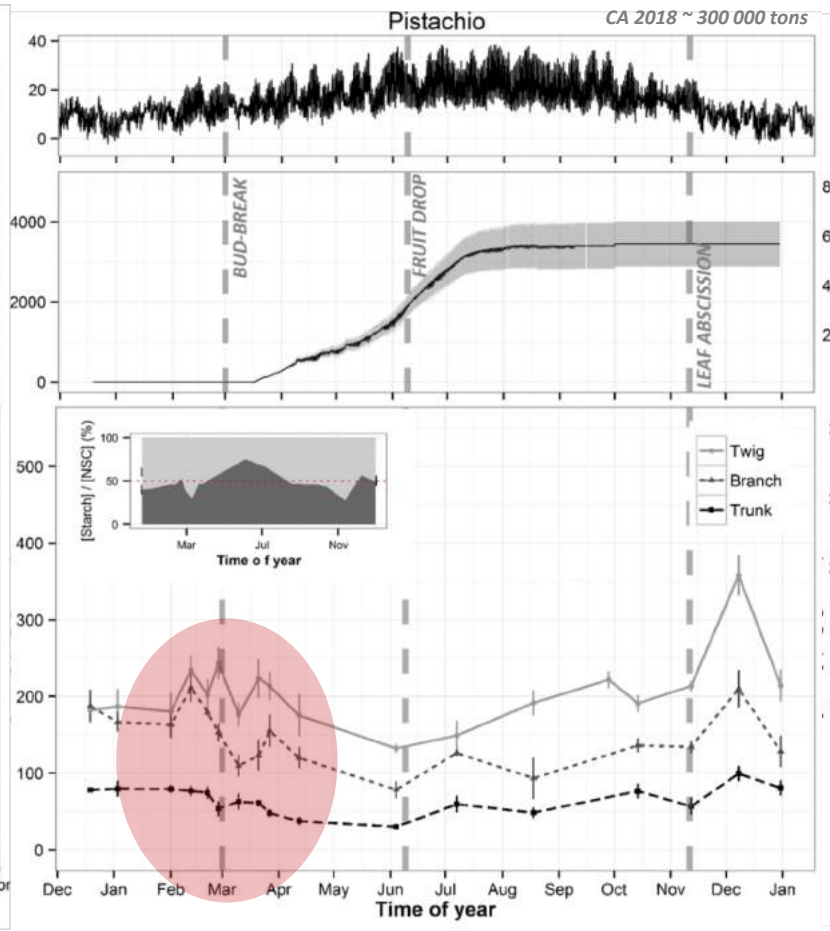
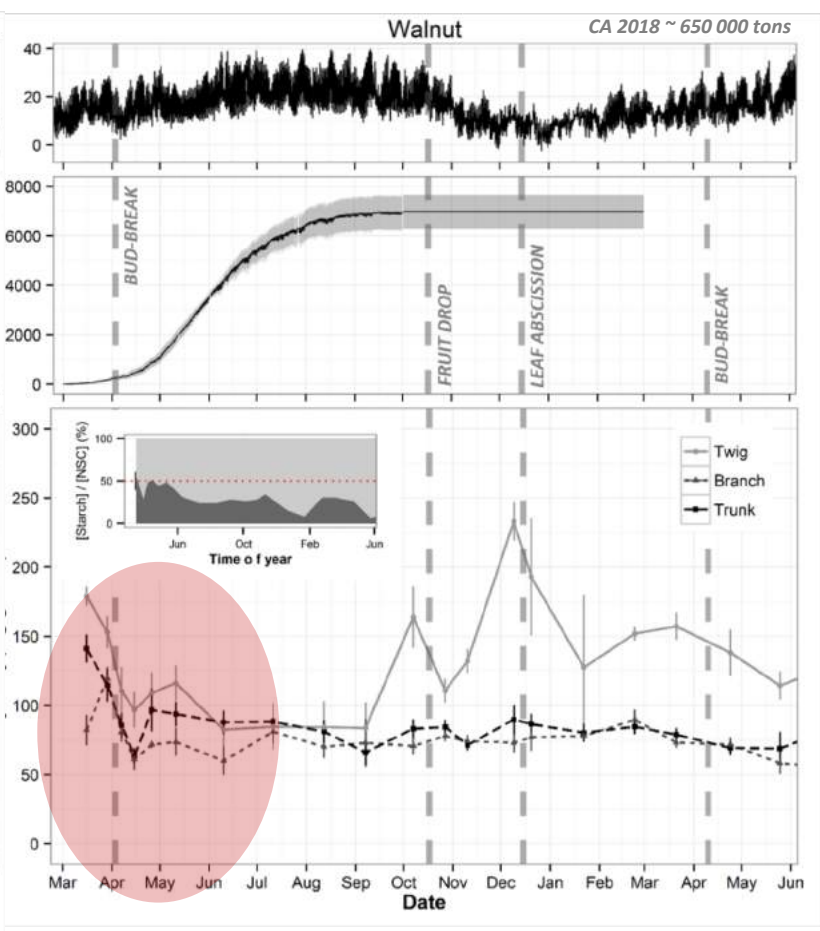
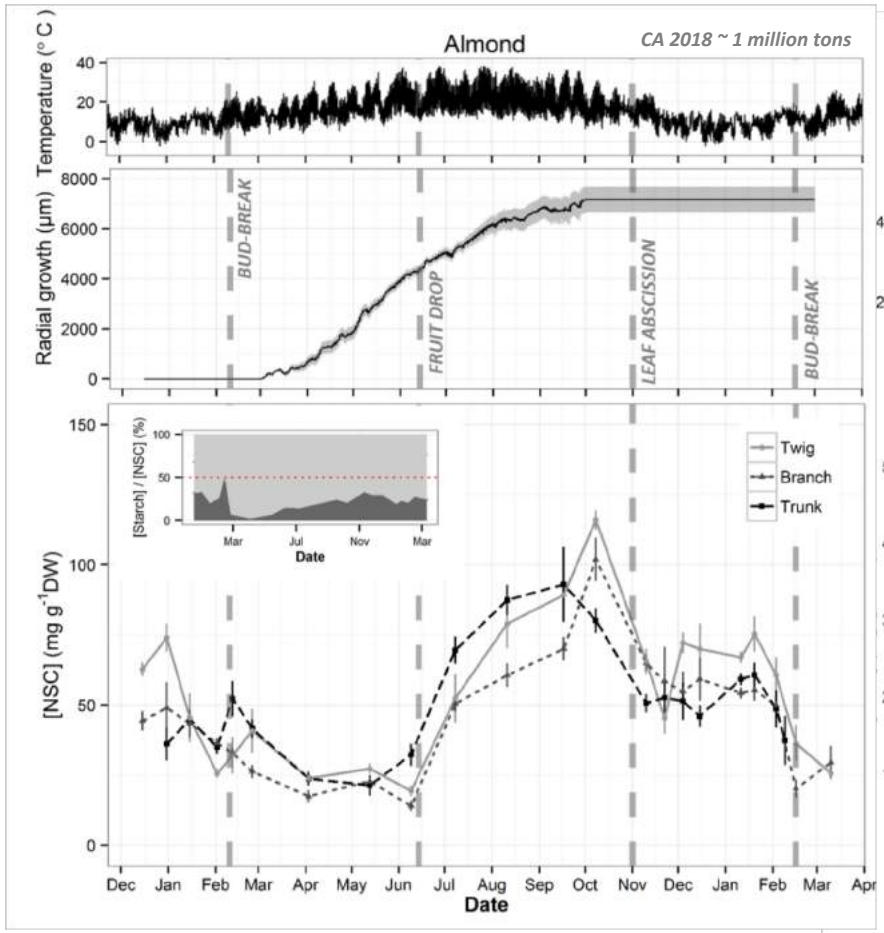


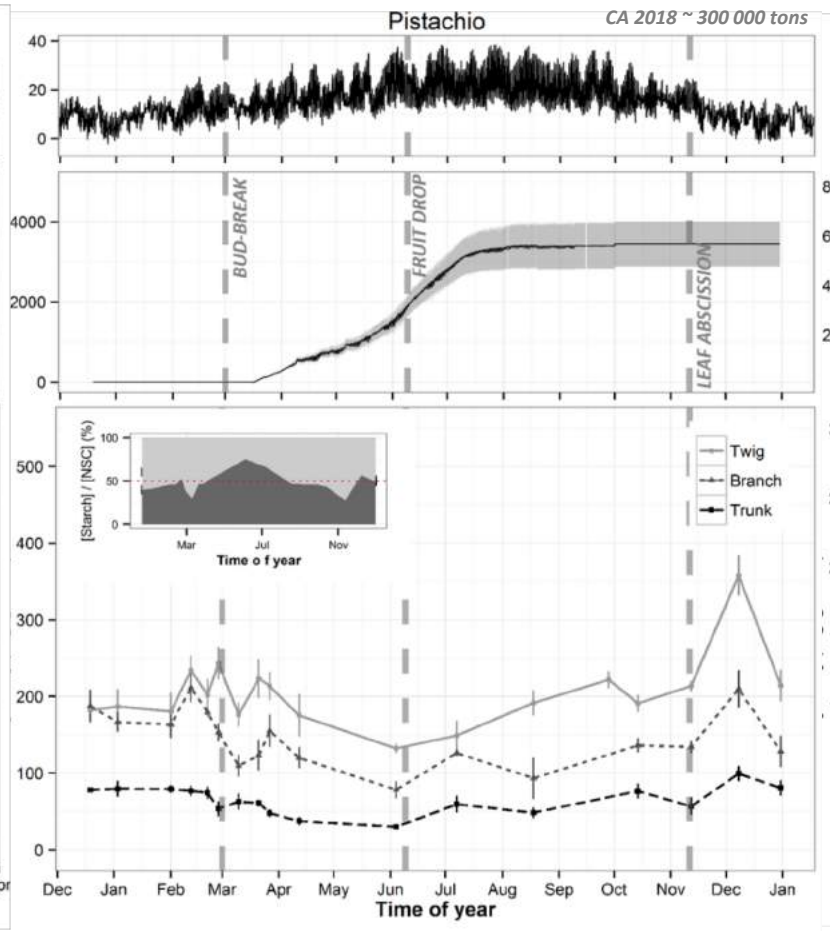


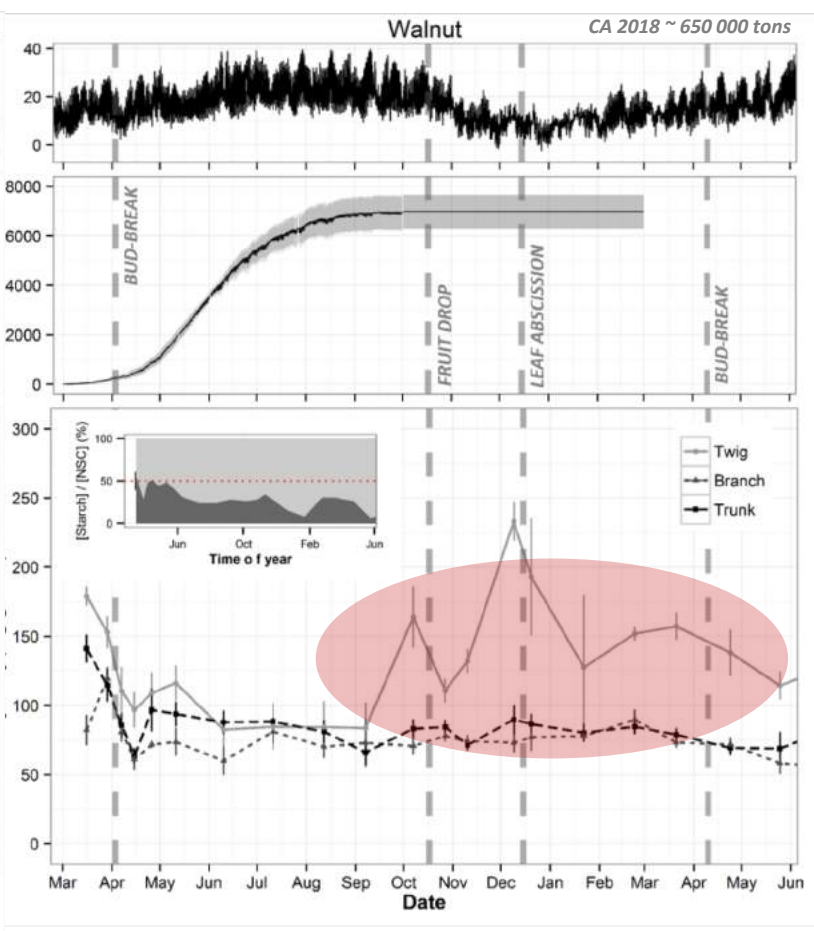


Different phenology leads to different patterns of NSC mobilization, accumulation

BALANCING SUPPLY AND DEMAND ON SEASONAL TIME SCALE

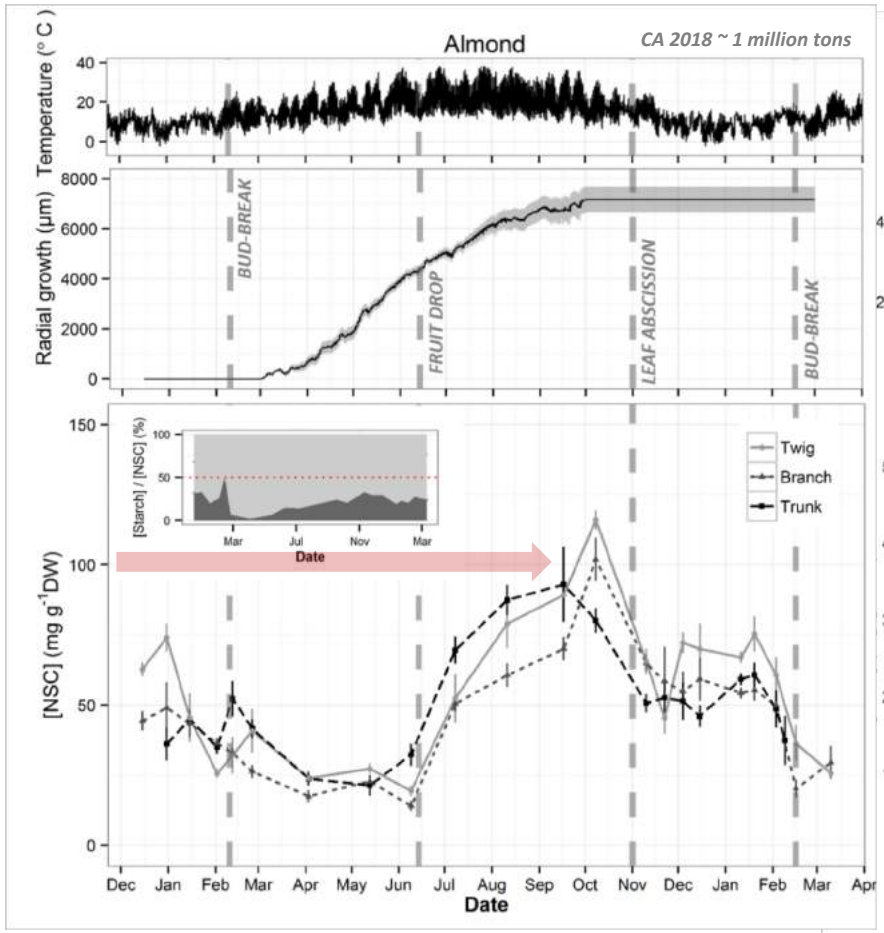


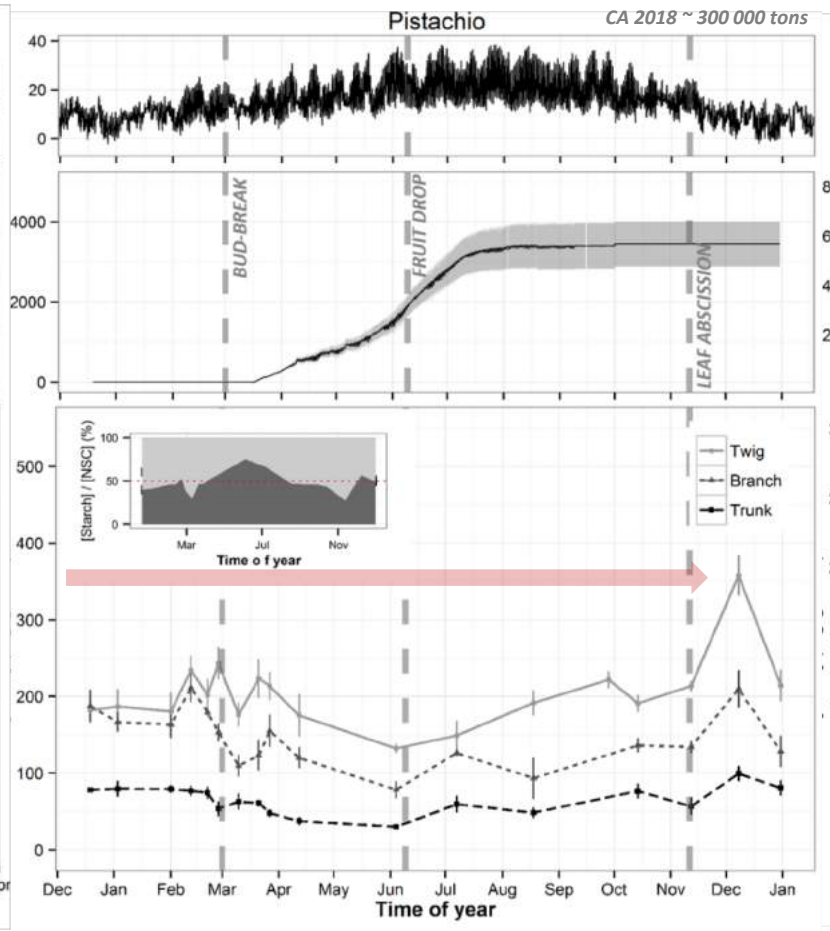


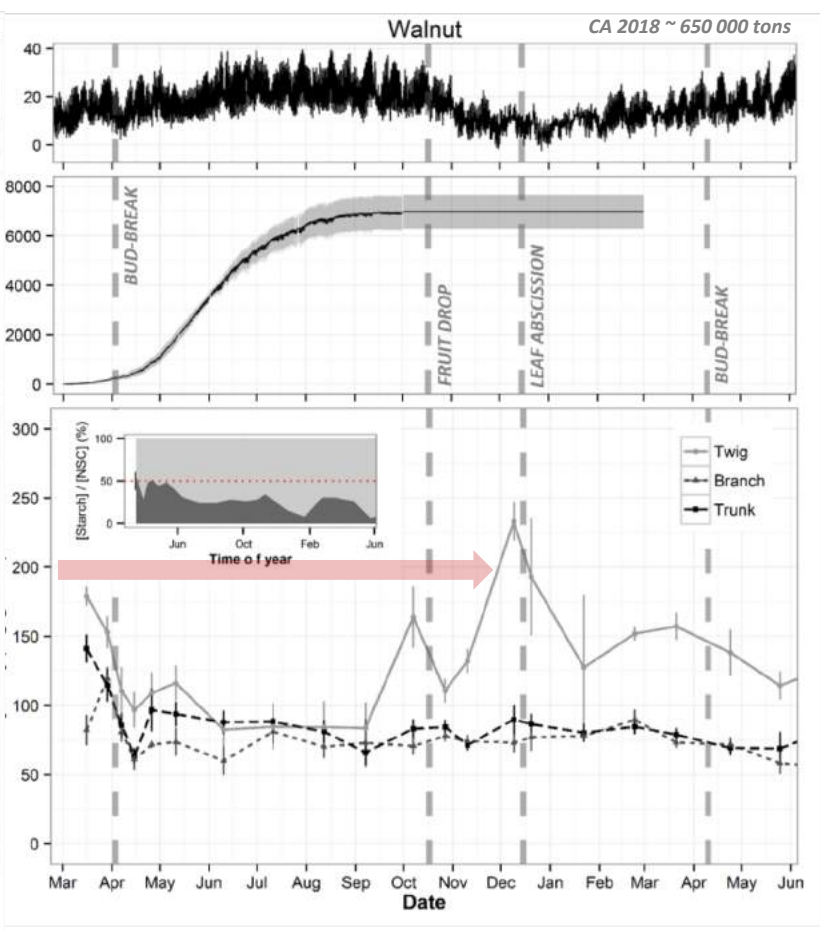


Different phenology leads to different patterns of NSC mobilization, accumulation
Organs don't necessarily have same patterns

BALANCING SUPPLY AND DEMAND ON SEASONAL TIME SCALE

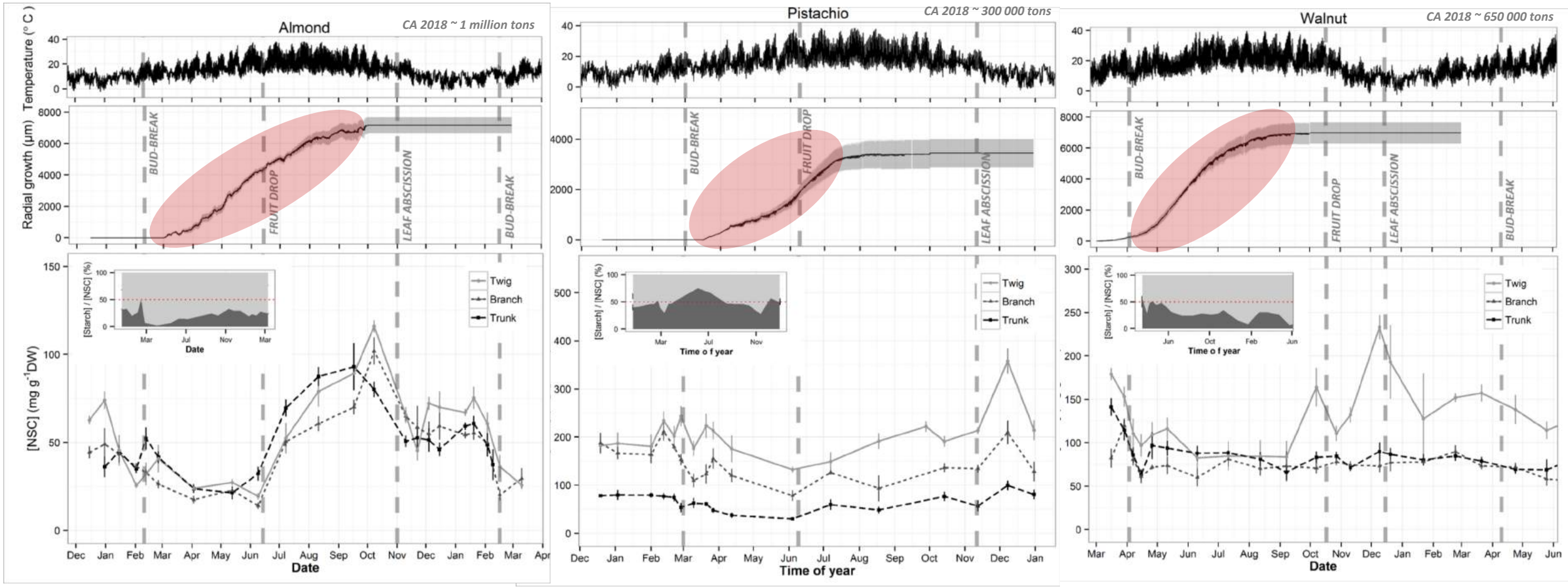






Different phenology leads to different patterns of NSC mobilization, accumulation
Organs don't necessarily have same patterns
[NSC] and [Starch]/[NSC] are variable among species

BALANCING SUPPLY AND DEMAND ON SEASONAL TIME SCALE

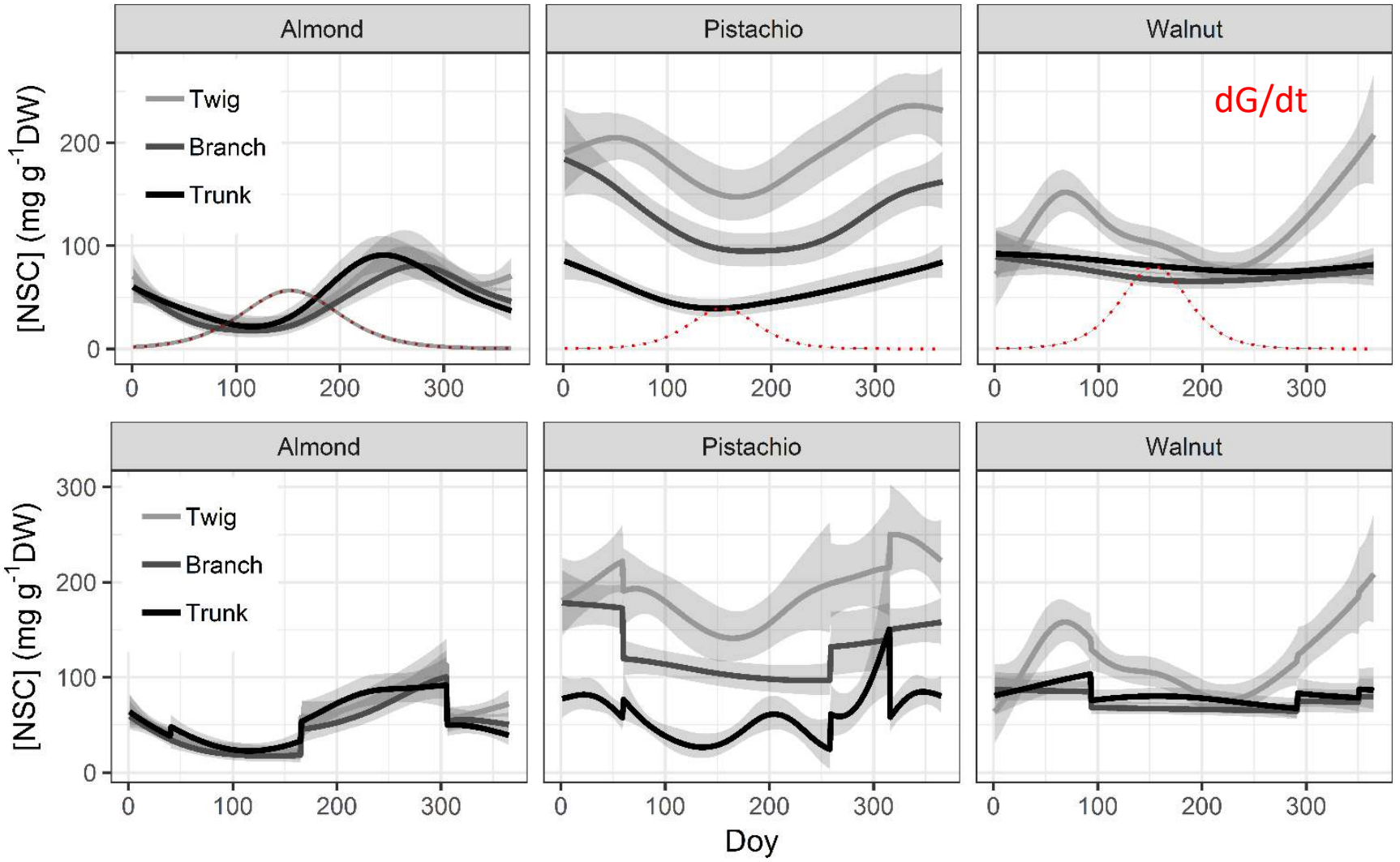


Different phenology leads to different patterns of NSC mobilization, accumulation AND utilization for growth

Organs don't necessarily have same patterns

[NSC] and [Starch]/[NSC] are variable among species

Caracterizing NSC seasonal using Generalized additive models

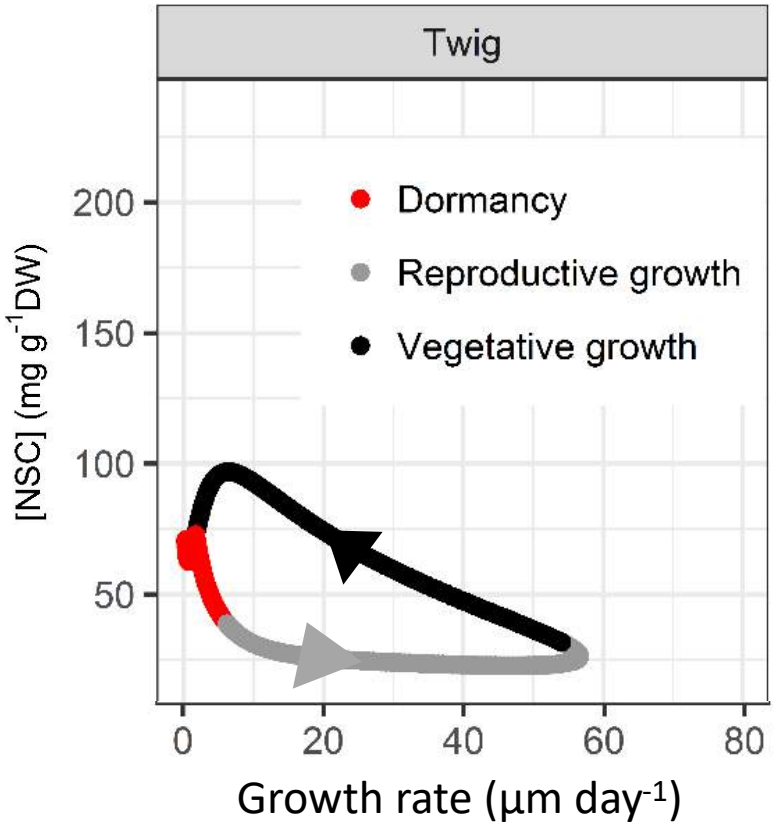


Max growth rate occurs when [NSC] is low, but no clear trade- off

Phenology explains a part of the variability

Temporal trade – off between growth / fruit production / storage ?

ALMOND

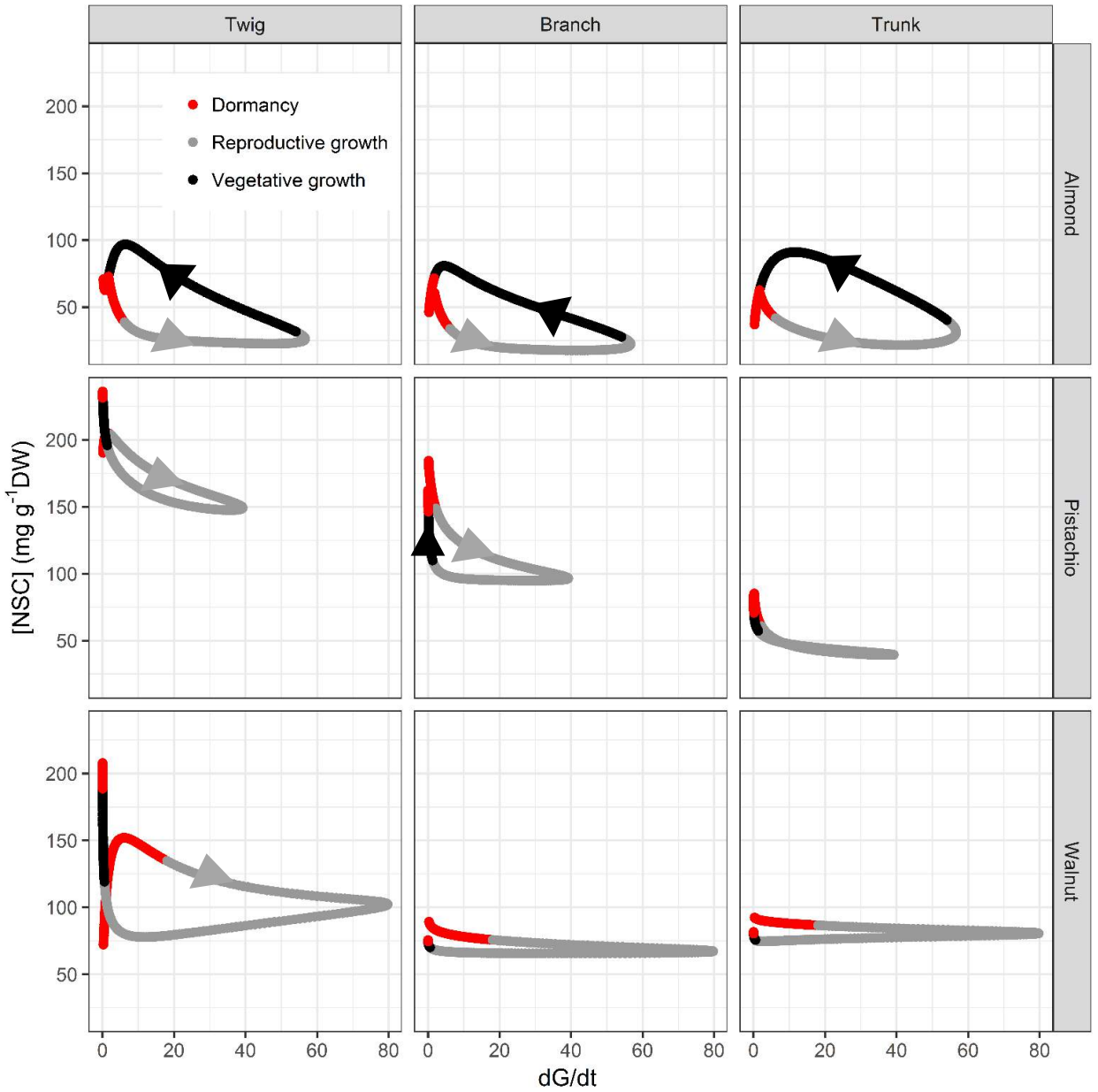


Maximum growth rate coincide with min [NSC]

Highest [NSC] and Δ[NSC] coincide with min growth rate

No accumulation during fruit production

BALANCING SUPPLY AND DEMAND ON SEASONAL TIME SCALE



2 behaviors :

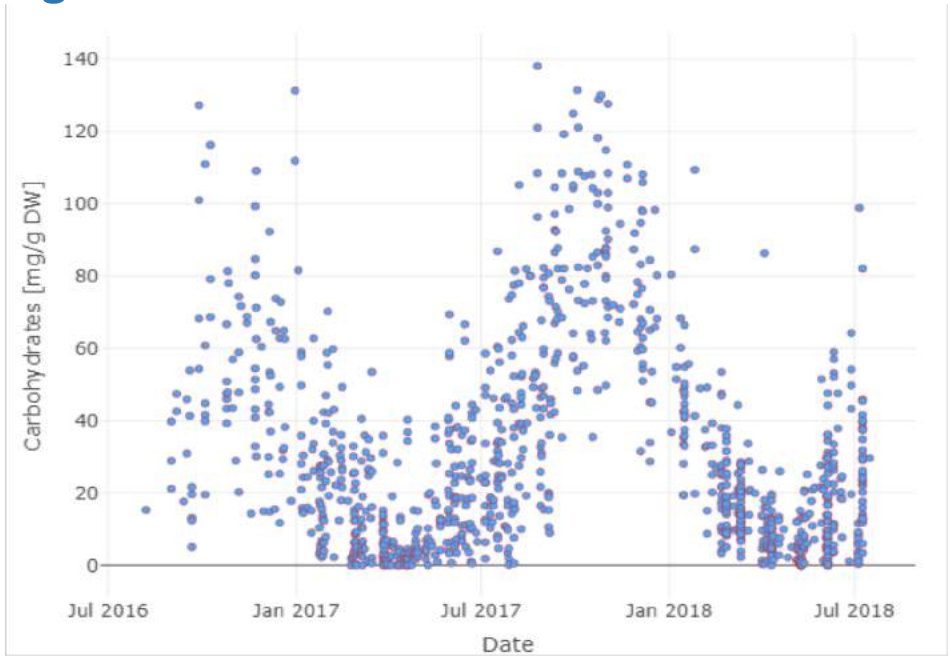
⇒ *Almond accumulates NSC when growth slows*

⇒ *Pistachio and Walnut accumulate NSC when growth stops*

Are these behaviors linked to phenology ?

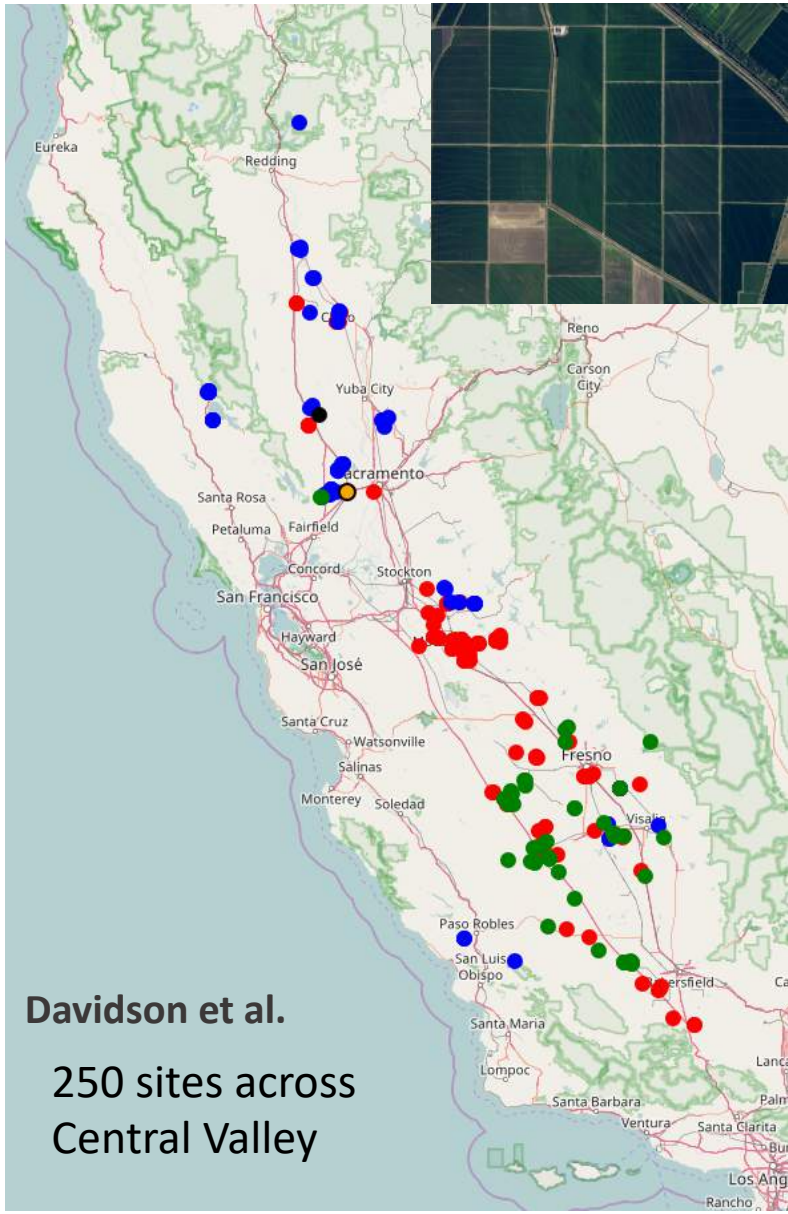
- *Late phenology has less favorable (T°) for photosynthesis and growth*
- *Priority to storage*

Collecting several seasonal trends to characterize climate effect



DESCRIPTIVE APPROACH

Space for time



MECHANISTIC APPROACH to understand effects and regulations

- *EFFECT OF CLIMATE ? CLIMATE CHANGE ?*
- *RESILIENCE TO ABIOTIC AND BIOTIC STRESSES ?*
- *TRADE-OFF WITH OTHER FUNCTIONS*

THANK YOU

Team work :

Aude Tixier
Jessica Orozco
Adele Amico Roxas
Paula Guzman
Mason Earles
Or Sperling
Maciej Zwieniecki