

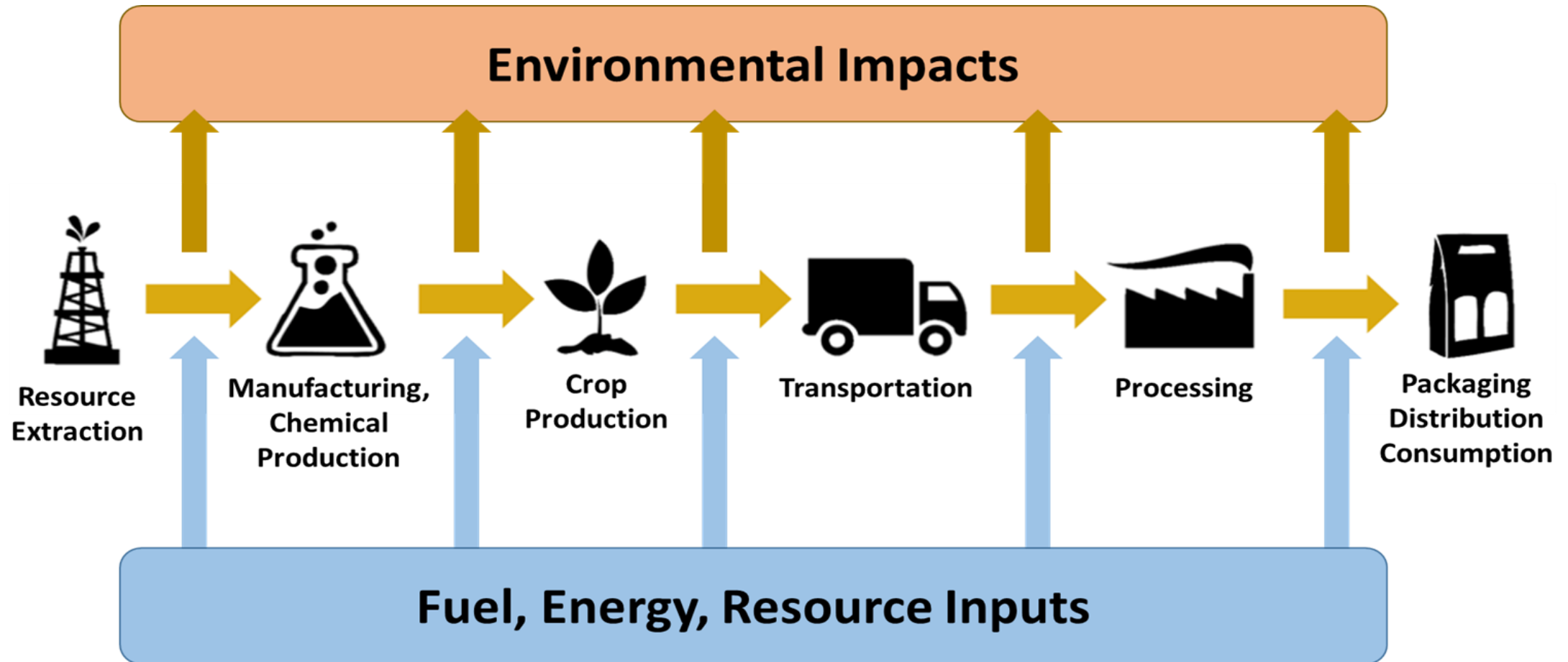


***Understanding Environmental  
Performance in California Prune  
through Life Cycle Assessment***

**Elias Marvinney, UC Davis Dept. of Civil and Environmental Engineering**

# LCA: input/ output analysis for industrial (agro-eco)systems

Methodological toolset for calculation of environmental impacts and benefits



*Impacts are inevitable and ubiquitous – the right question is, what does society receive in exchange?*

# What can LCA do for you?

## Industry

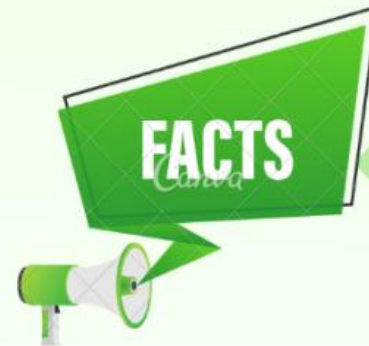
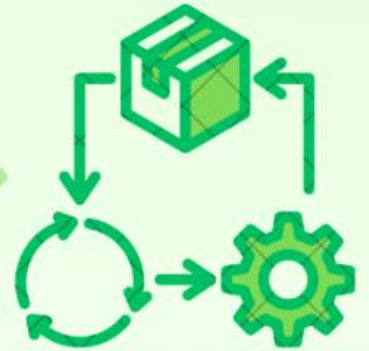
- Sustainability marketing
  - Consumer demand
    - Product labels
    - Demonstration of commitment
- Regulatory compliance
  - Environmental Product Declaration (EPD)
    - International markets
- Relevant and current datasets
  - Policy-makers
  - Regulators



# What are EPDs and why do they matter?

EPDs are declarations of the life-cycle environmental impacts of a product!

It also takes into account the environmental impacts after transportation, installation, and recyclability.



## EPDs are transparently honest!

Most Green certificates only tell you what is green about the product. EPDs tell you what's good, what's bad, and what's ugly about the product.

When you choose to use a product with an EPD, you're making an informed choice.

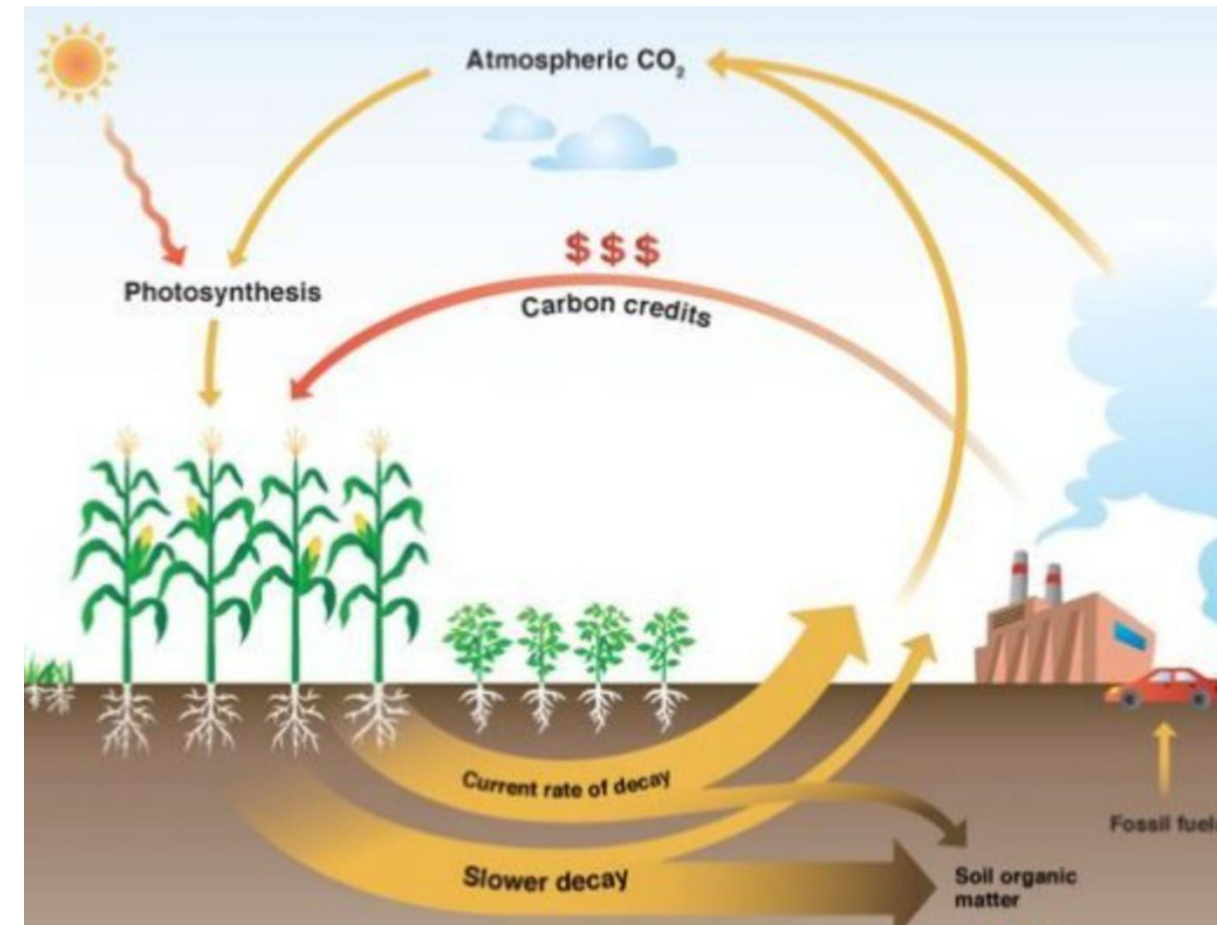
**Choose a product that is genuinely green throughout its entire life cycle!**

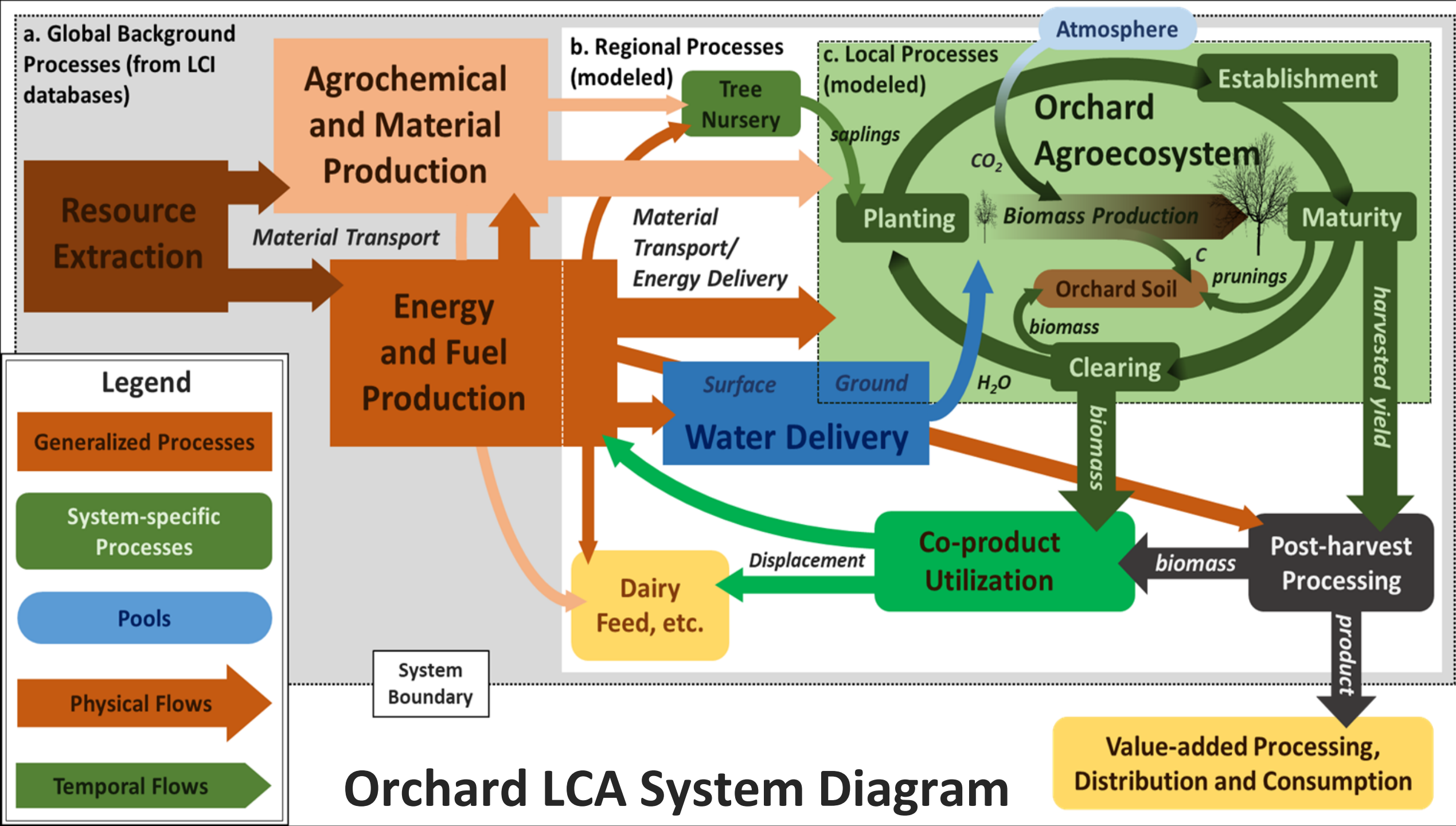
# What can LCA do for you?

## Growers

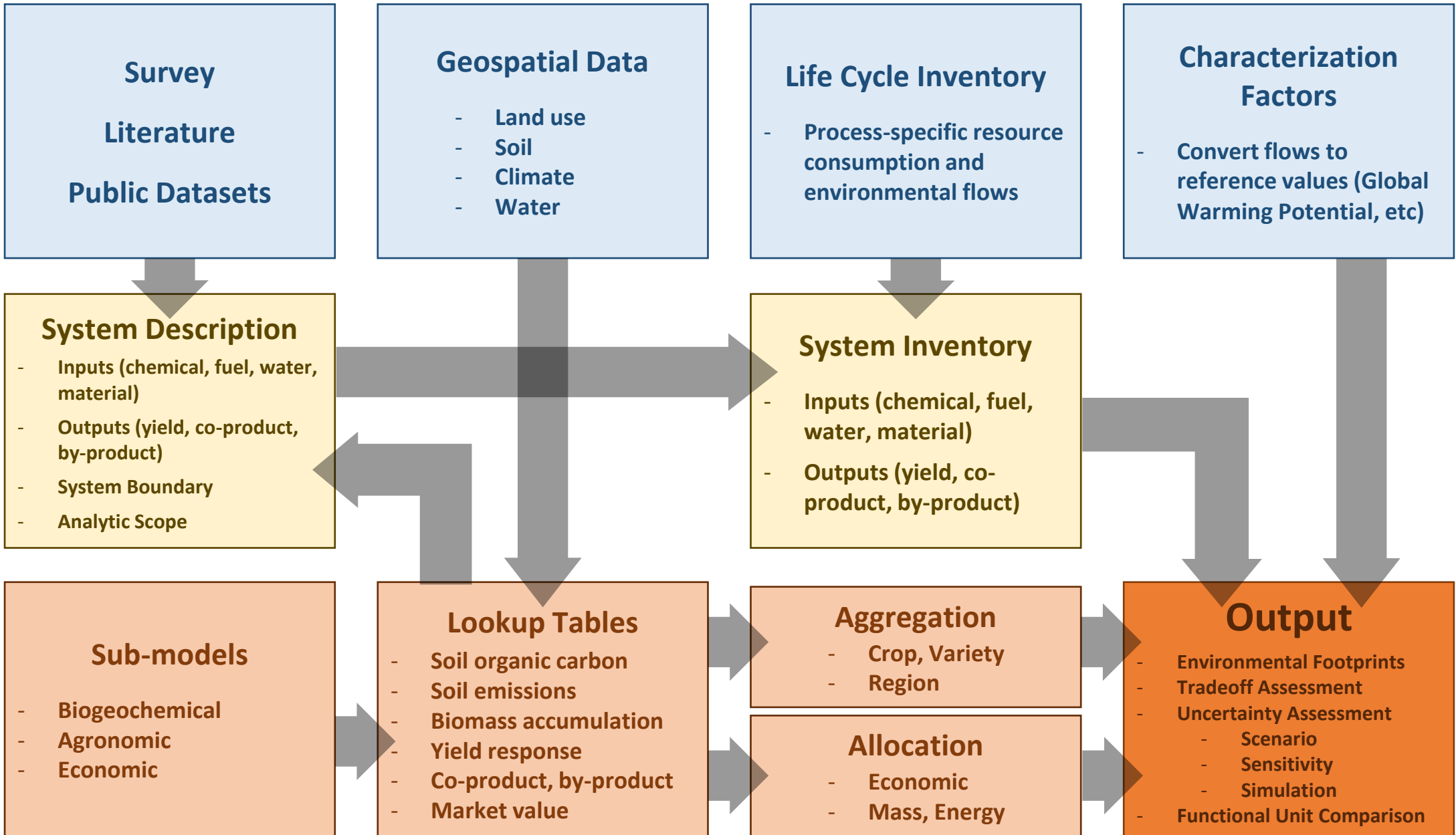
- Hotspot analysis
  - Impacts assessed for generalized category and specific inputs/operations
- Tradeoff assessment
  - Assessment of practices/ systems in multiple impact categories
- Industry benchmarking
  - Current versus historical: efficiency gains and improvements
  - Case-study comparison with regional average

- Carbon credit potential
  - SOC and avoided emissions
  - Quantification and verification
  - Additionality and “leakage”





# Modeling approach and general structure

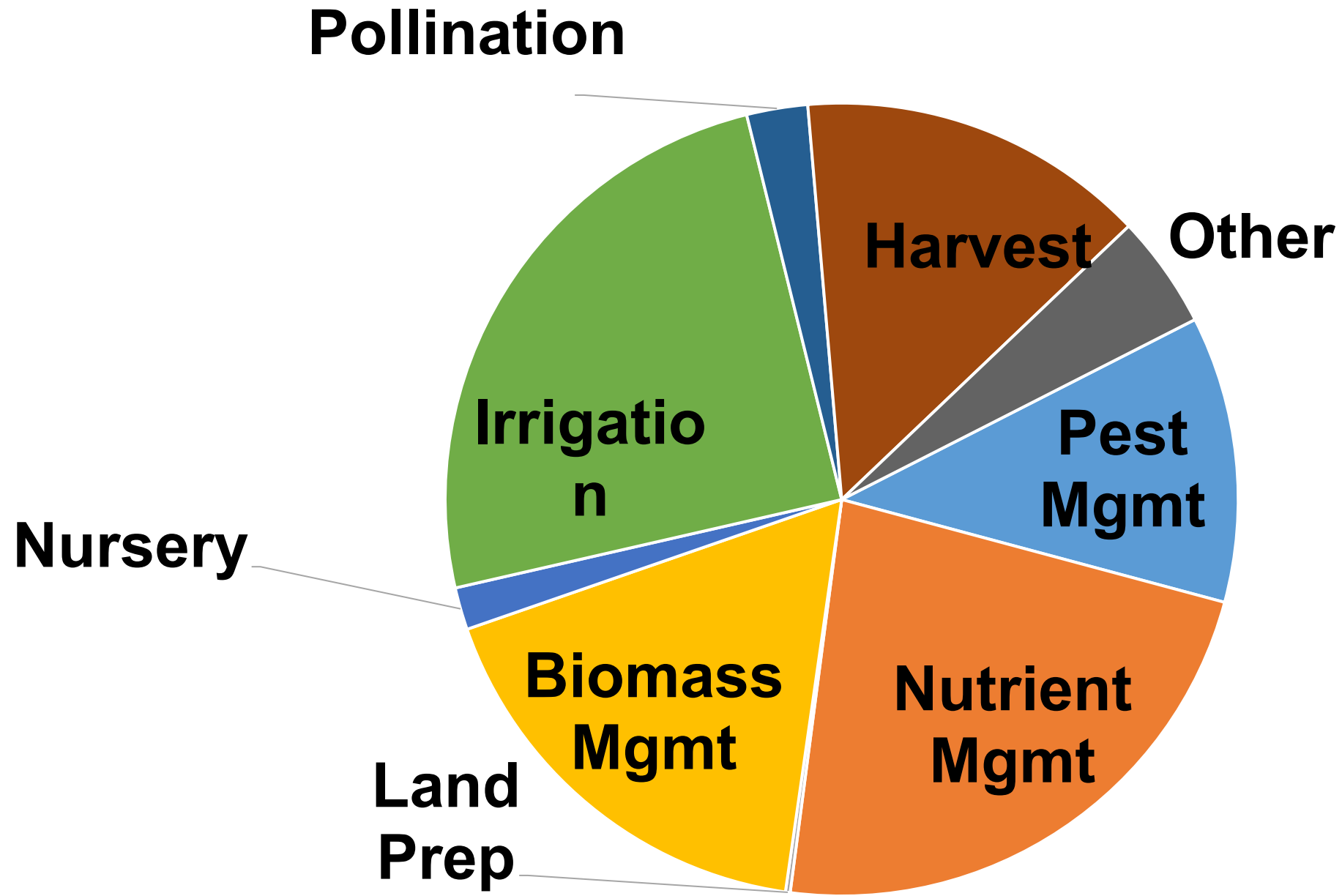


# CA Prune LCA

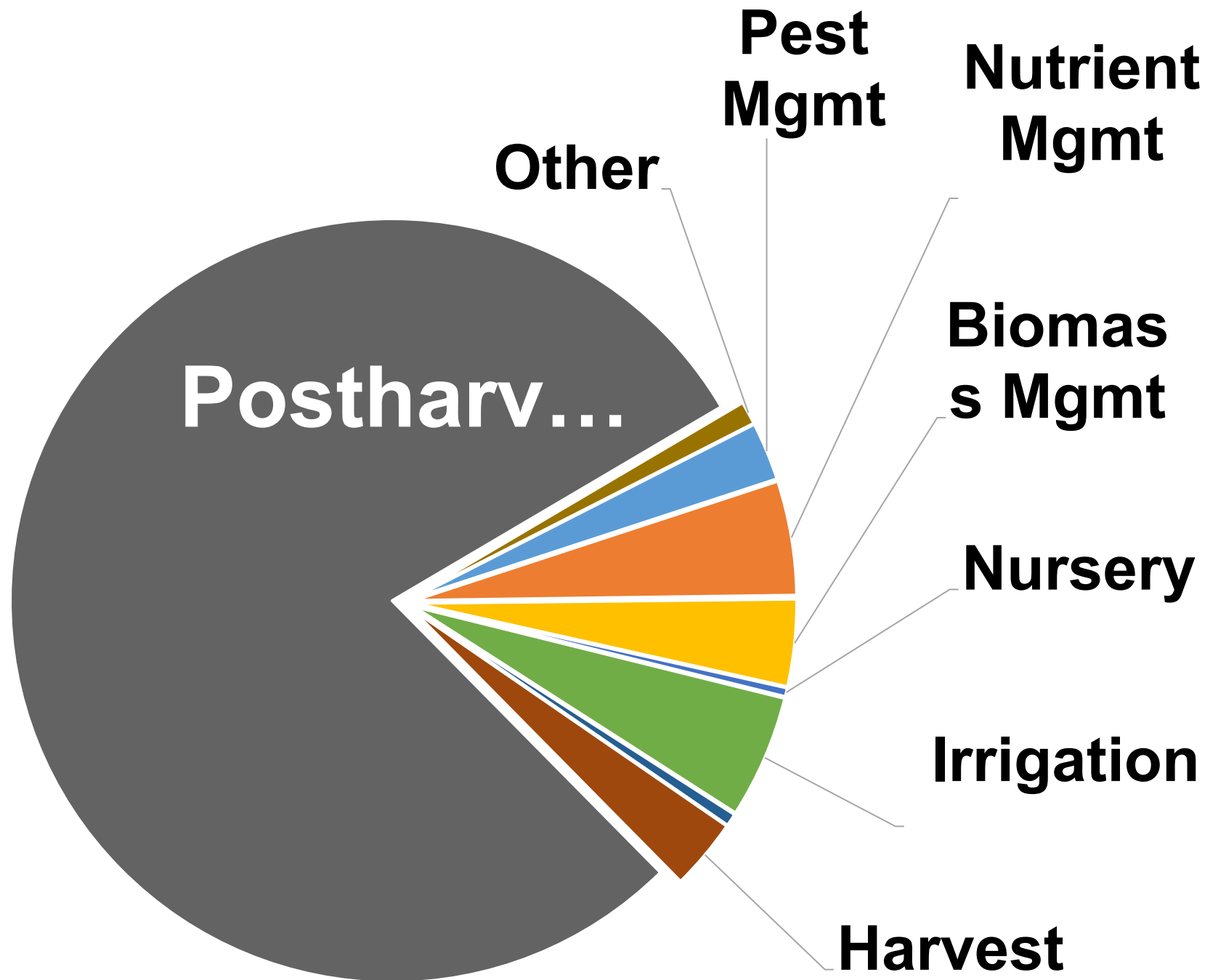
Results:

Categorical  
at Farm Gate

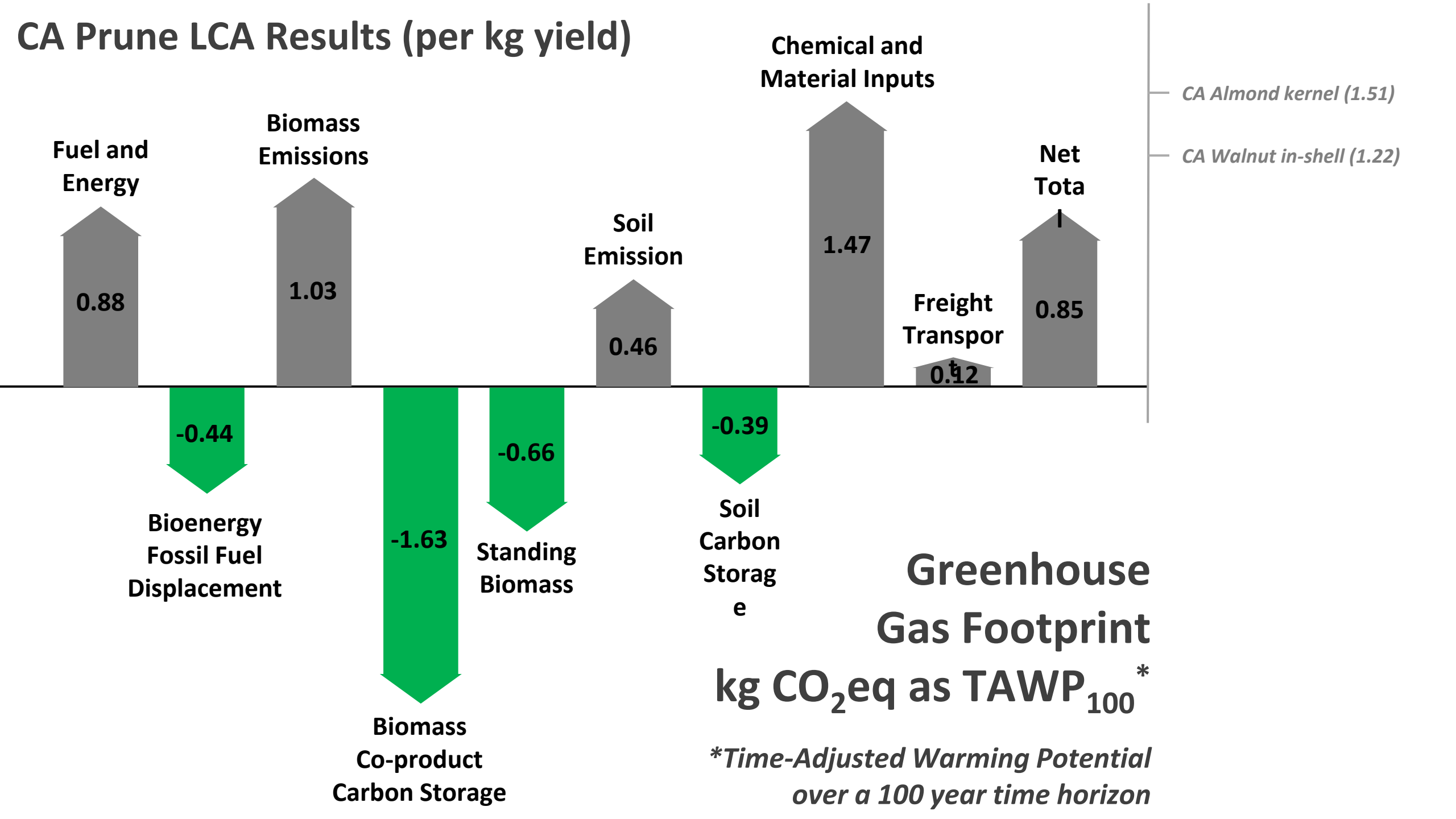
GWP100 (kg CO<sub>2</sub>eq)



**CA Prune  
LCA  
Results:  
Categorical  
at Dryer  
Gate**

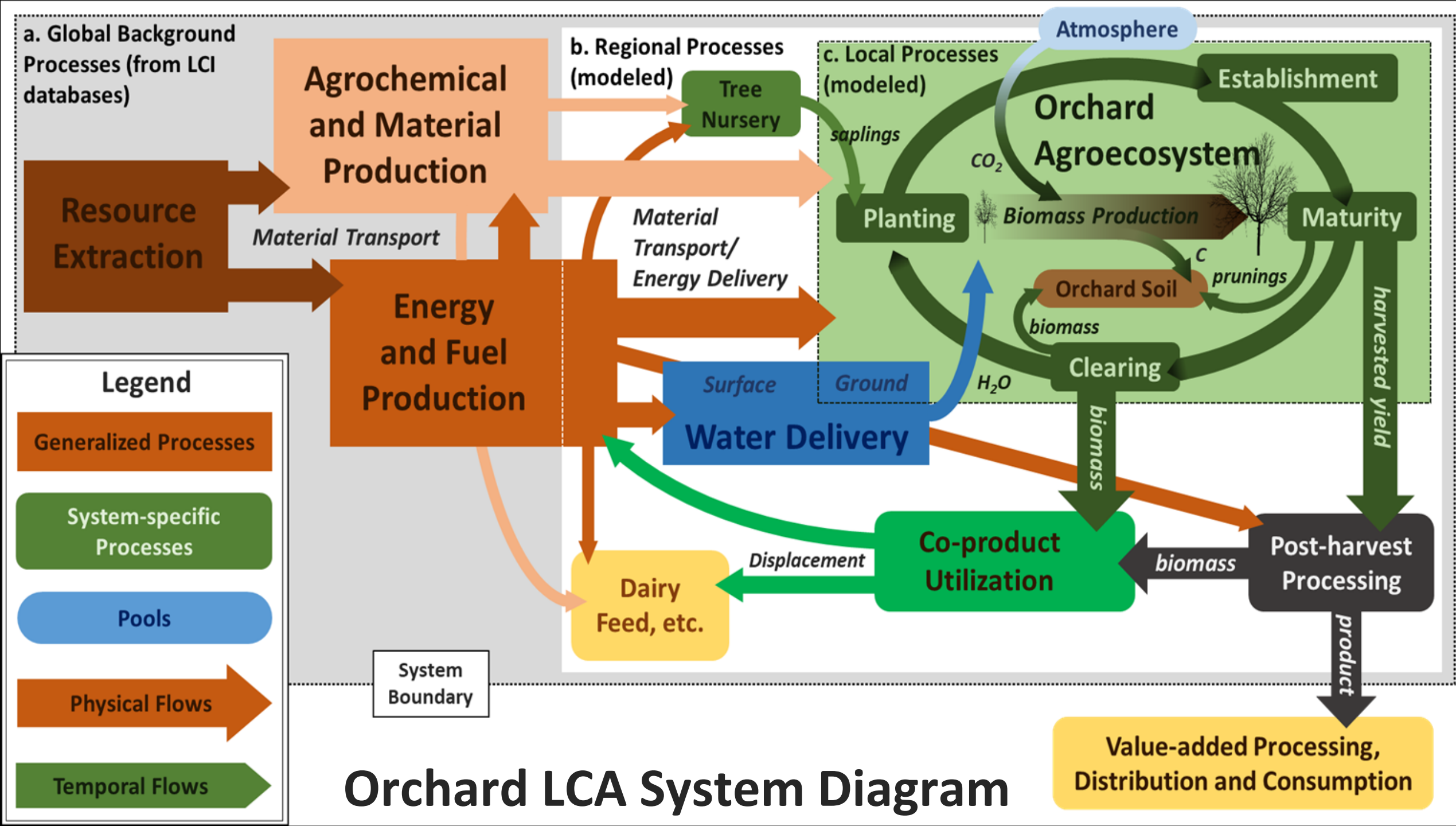


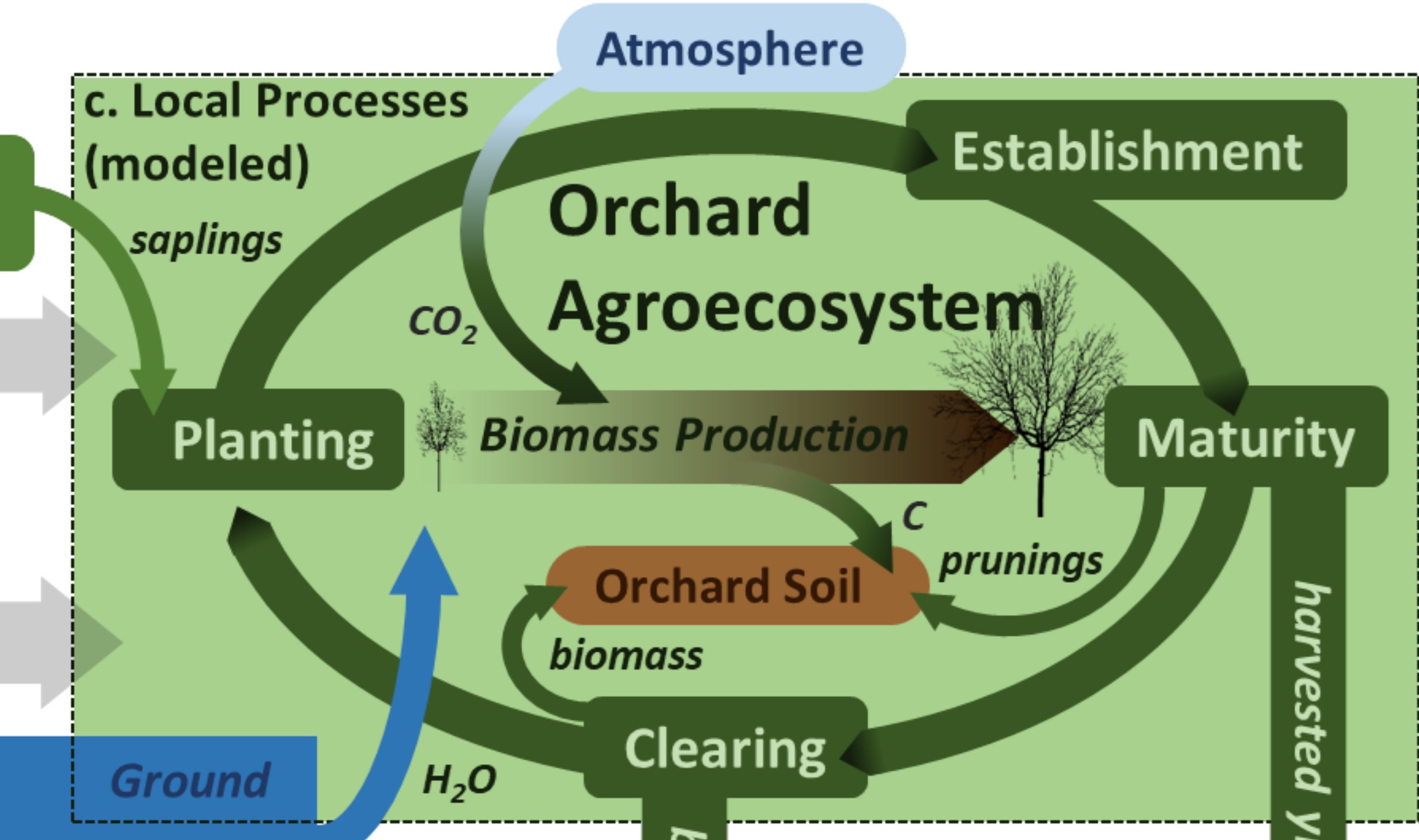
# CA Prune LCA Results (per kg yield)

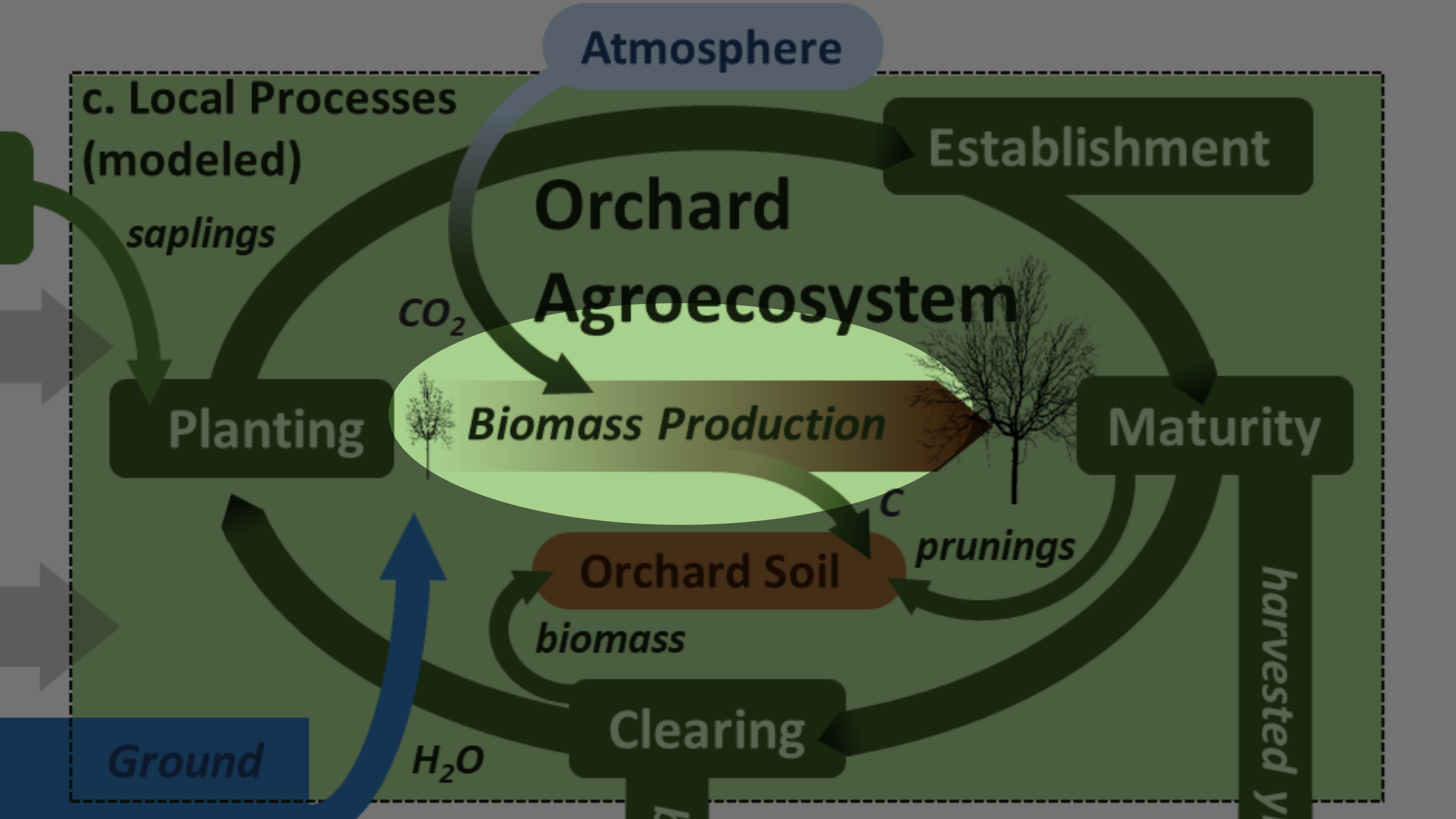


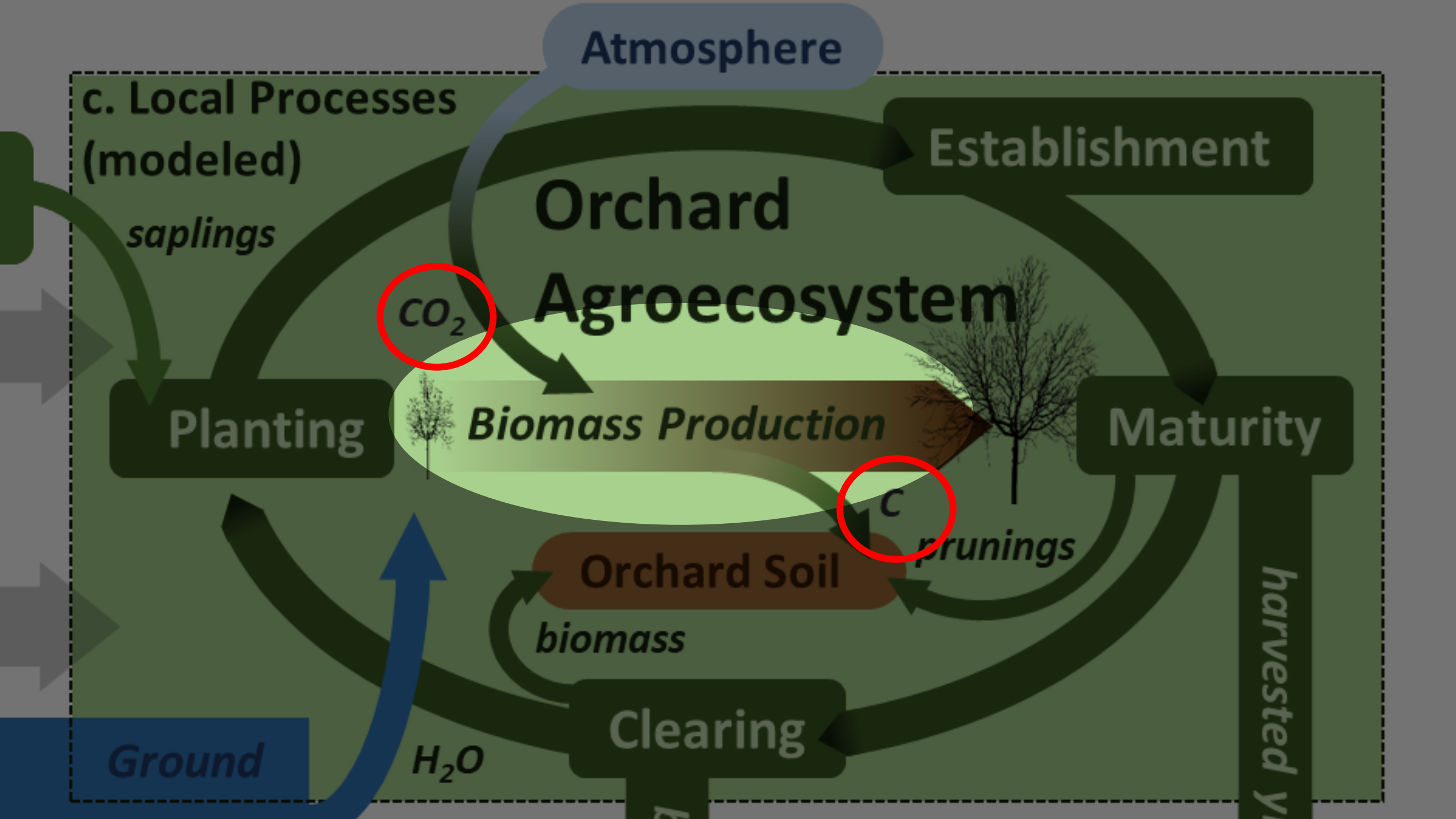
**Greenhouse Gas Footprint**  
**kg CO<sub>2</sub>eq as TAWP<sub>100</sub>\***

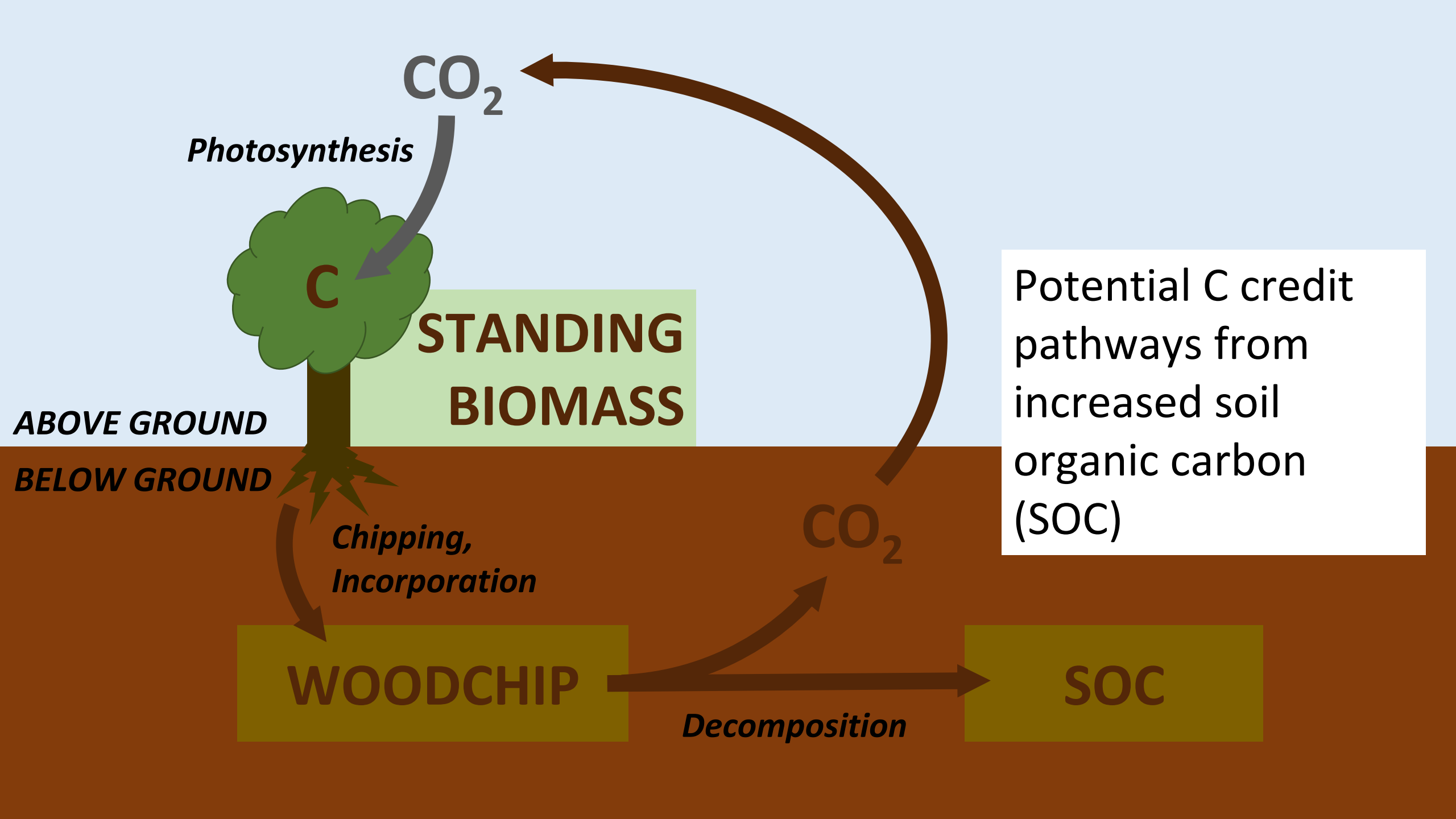
*\*Time-Adjusted Warming Potential over a 100 year time horizon*

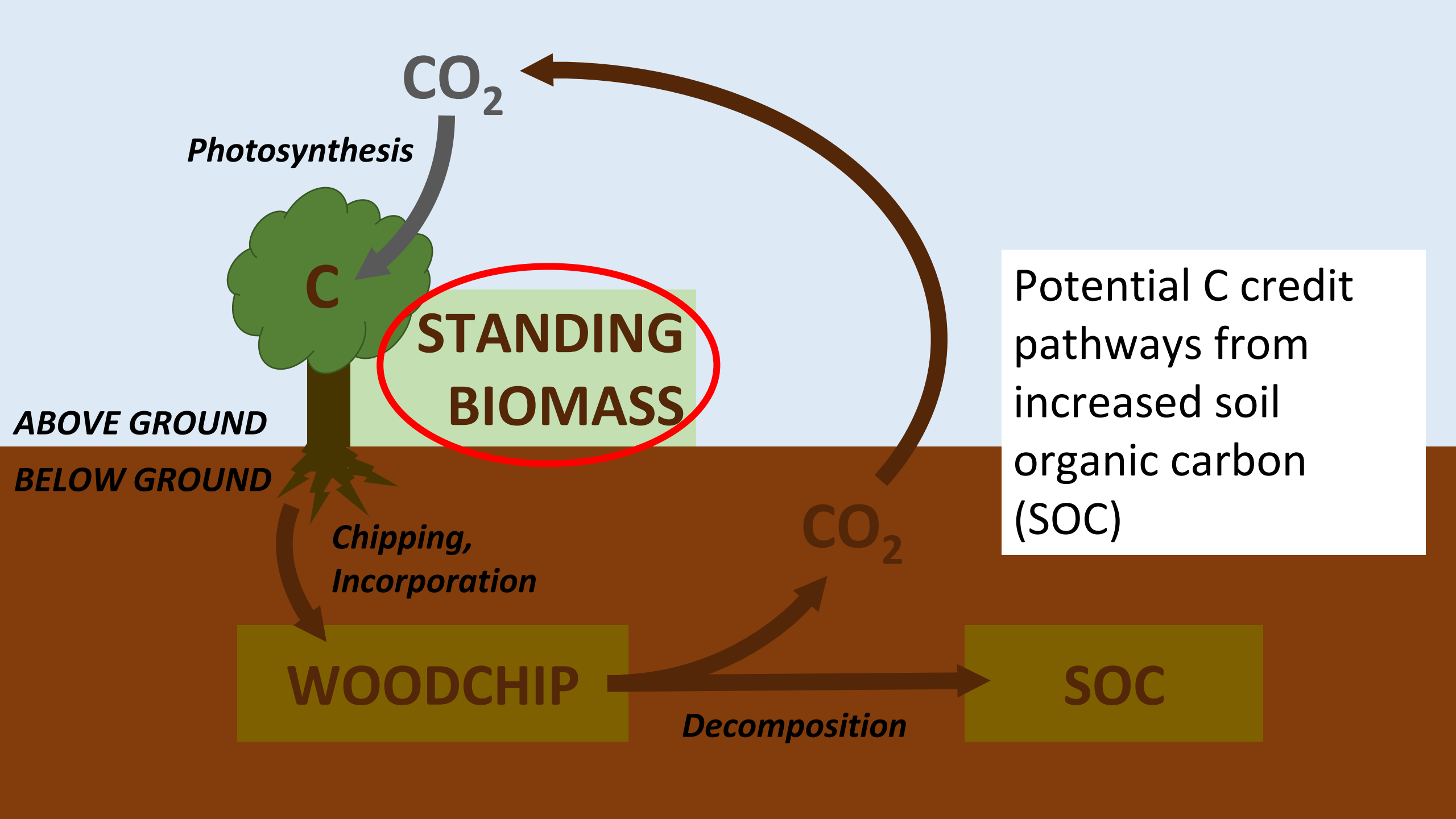












$CO_2$

*Photosynthesis*

C

**STANDING BIOMASS**

**ABOVE GROUND**

**BELOW GROUND**

*Chipping, Incorporation*

**WOODCHIP**

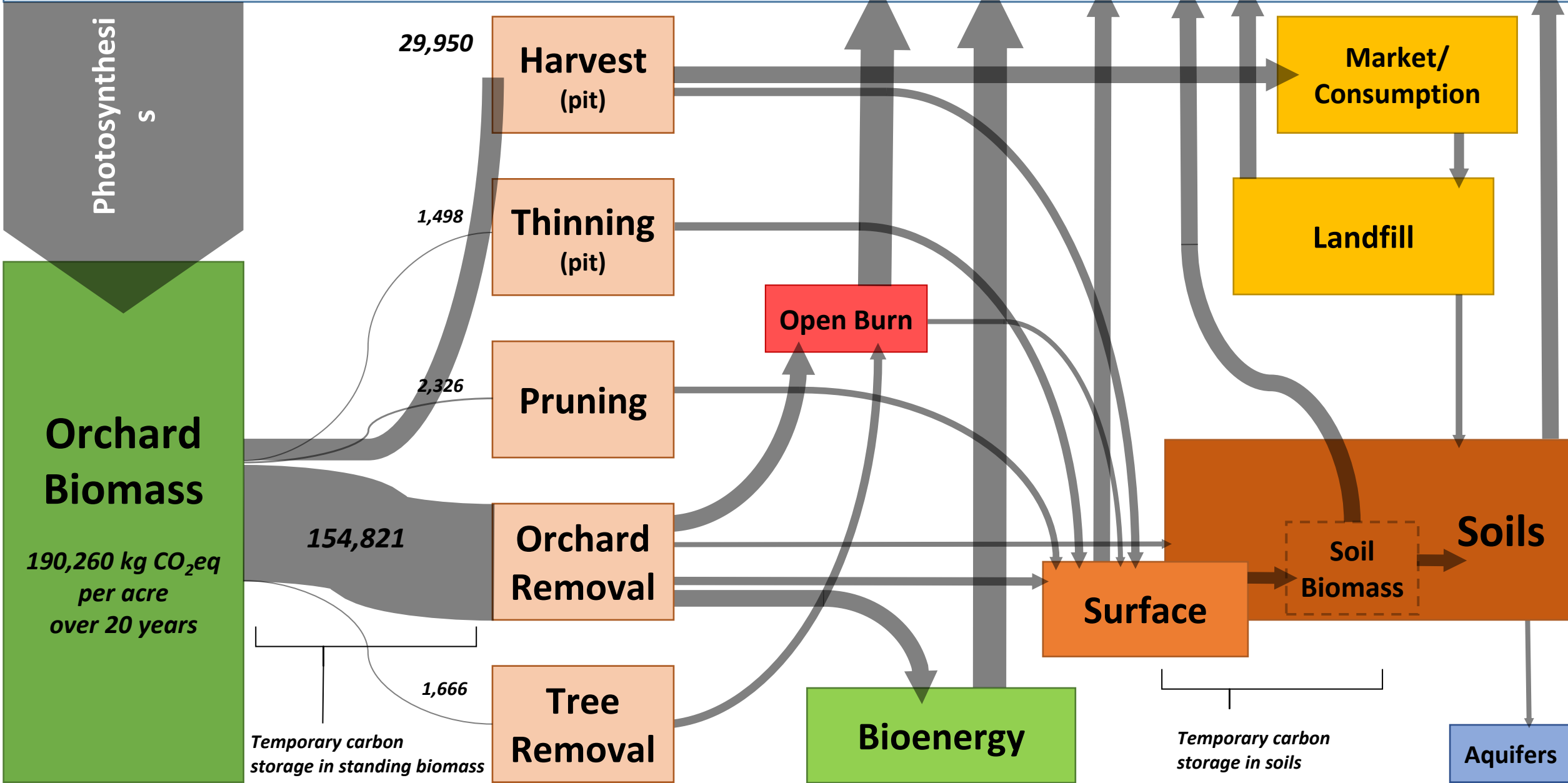
*Decomposition*

**SOC**

$CO_2$

Potential C credit pathways from increased soil organic carbon (SOC)

# Atmosphere



Photosynthesis

**Orchard Biomass**

190,260 kg CO<sub>2</sub>eq per acre over 20 years

Temporary carbon storage in standing biomass

Temporary carbon storage in soils

**Harvest (pit)**

**Thinning (pit)**

**Pruning**

**Orchard Removal**

**Tree Removal**

**Open Burn**

**Bioenergy**

**Surface**

**Soils**

**Market/Consumption**

**Landfill**

**Aquifers**

29,950

1,498

2,326

154,821

1,666

Market/Consumption

Landfill

Soils

Soil Biomass

Aquifers

# *Phellinus pomaceus*: “Heart Rot”

ROI = 5-7 yrs after planting

Average productive lifespan

- 1998: 30 years
- 2018: 25 years
- 2022: 20 years

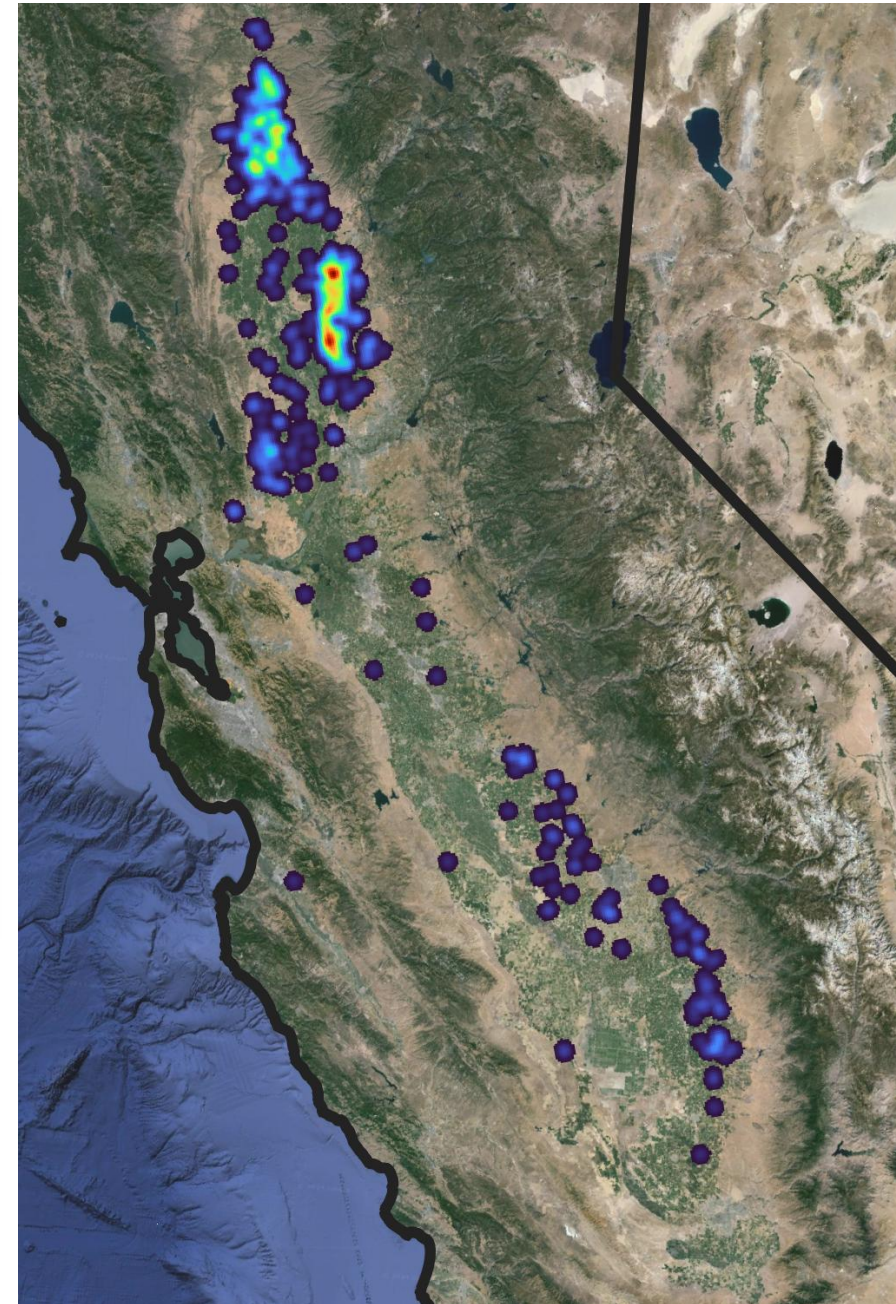
23 years down to 13 = **43%  
yield reduction**



*34% of trees surveyed  
showed visible infection*

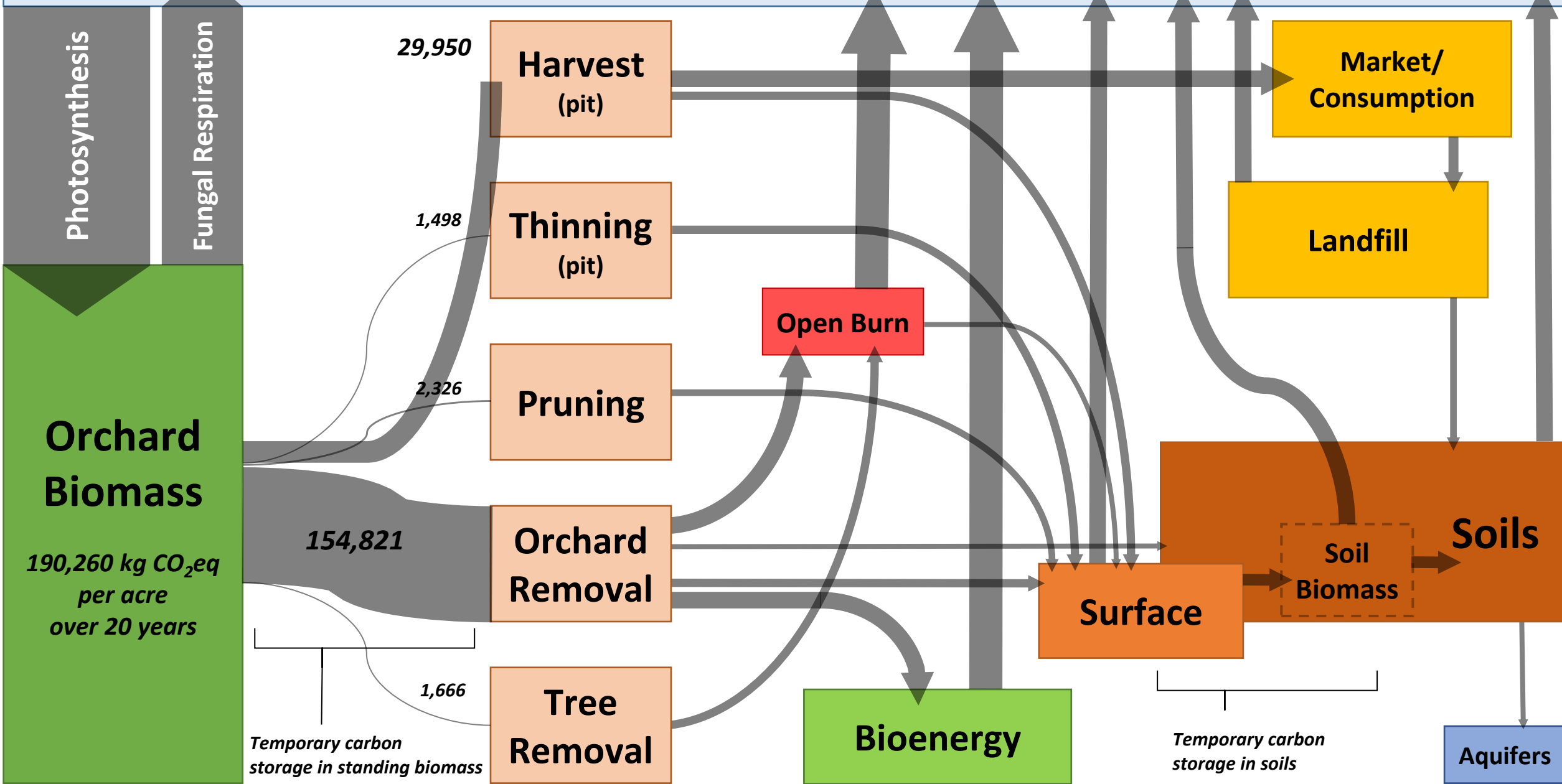
## Symptoms:

- Decayed heartwood
- Broken limbs
- Loss of major scaffolds
- Shortened productive lifespan

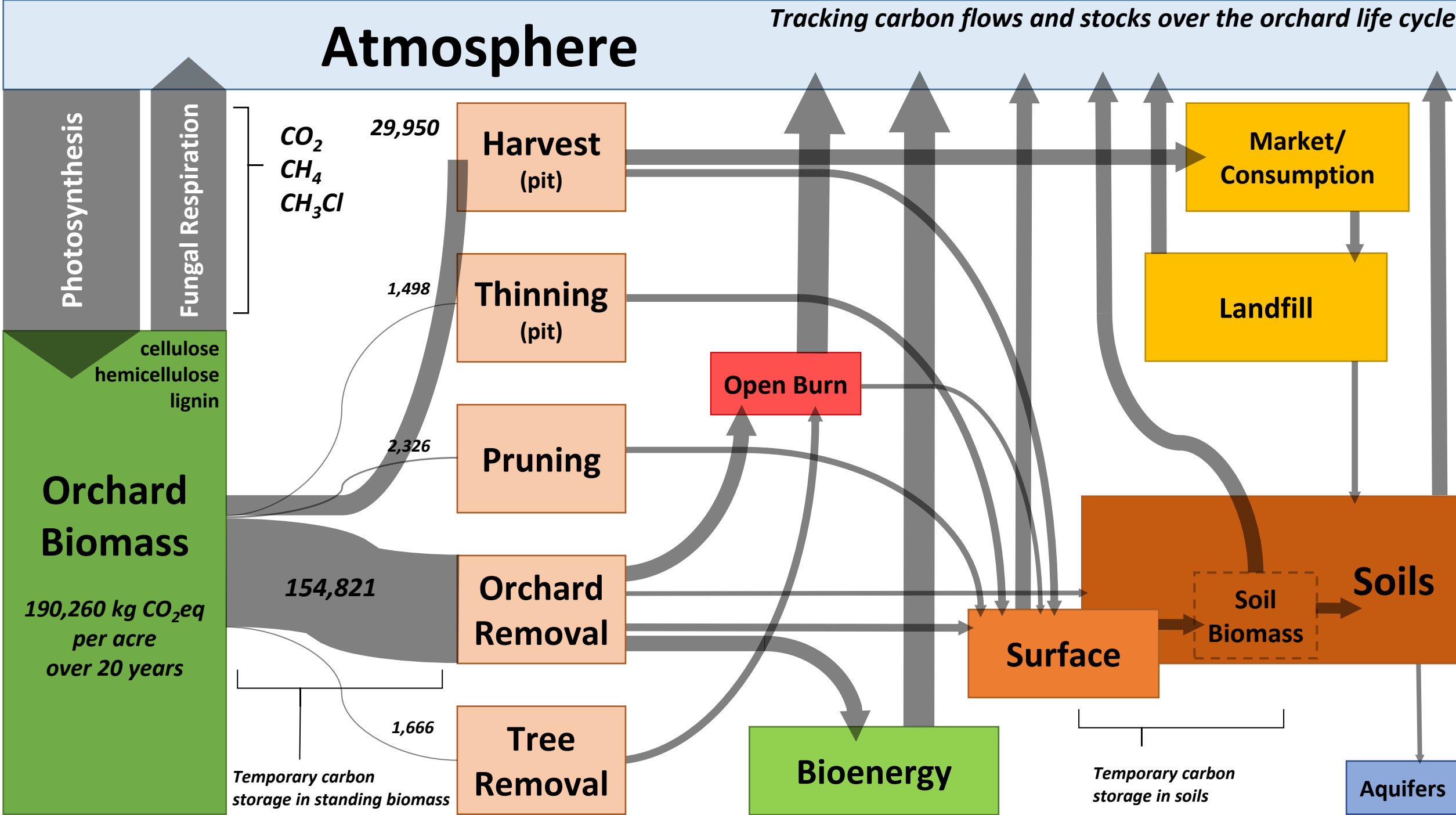


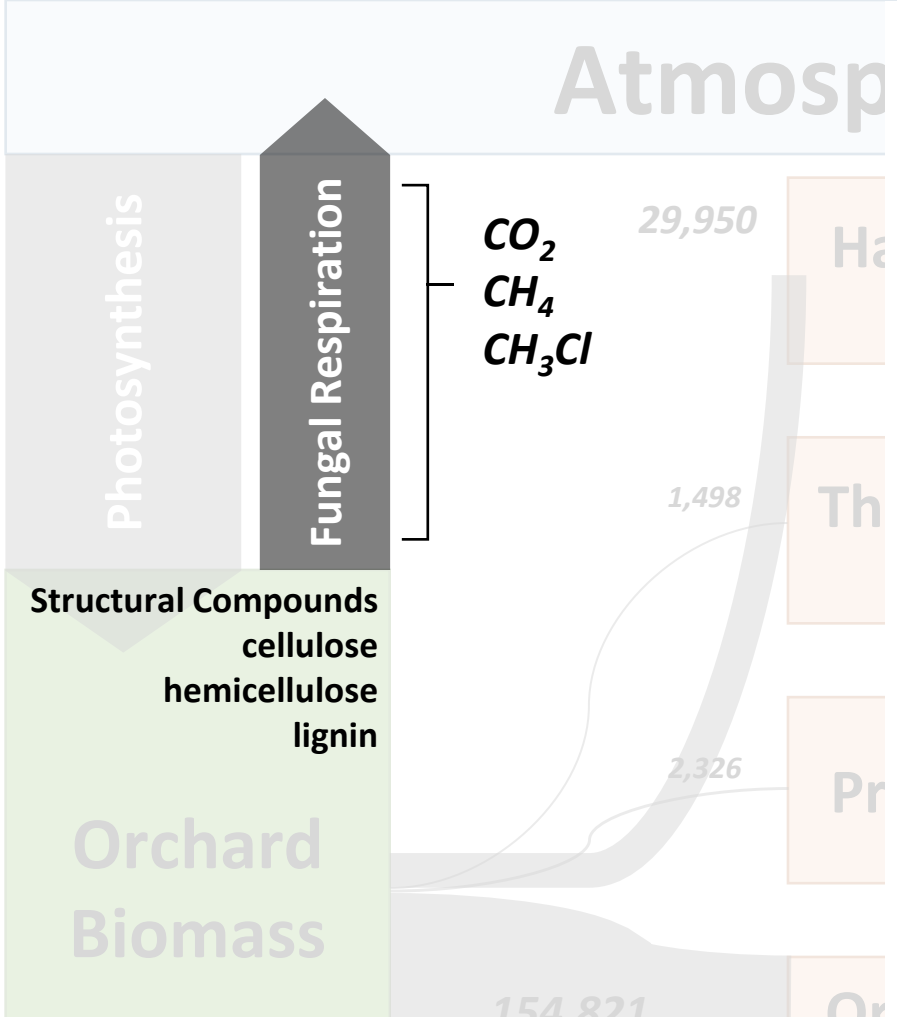
Laurel Hoffman, Dept of Plant Pathology  
University of Davis, CA, Hoffman@ucdavis.edu

# Atmosphere

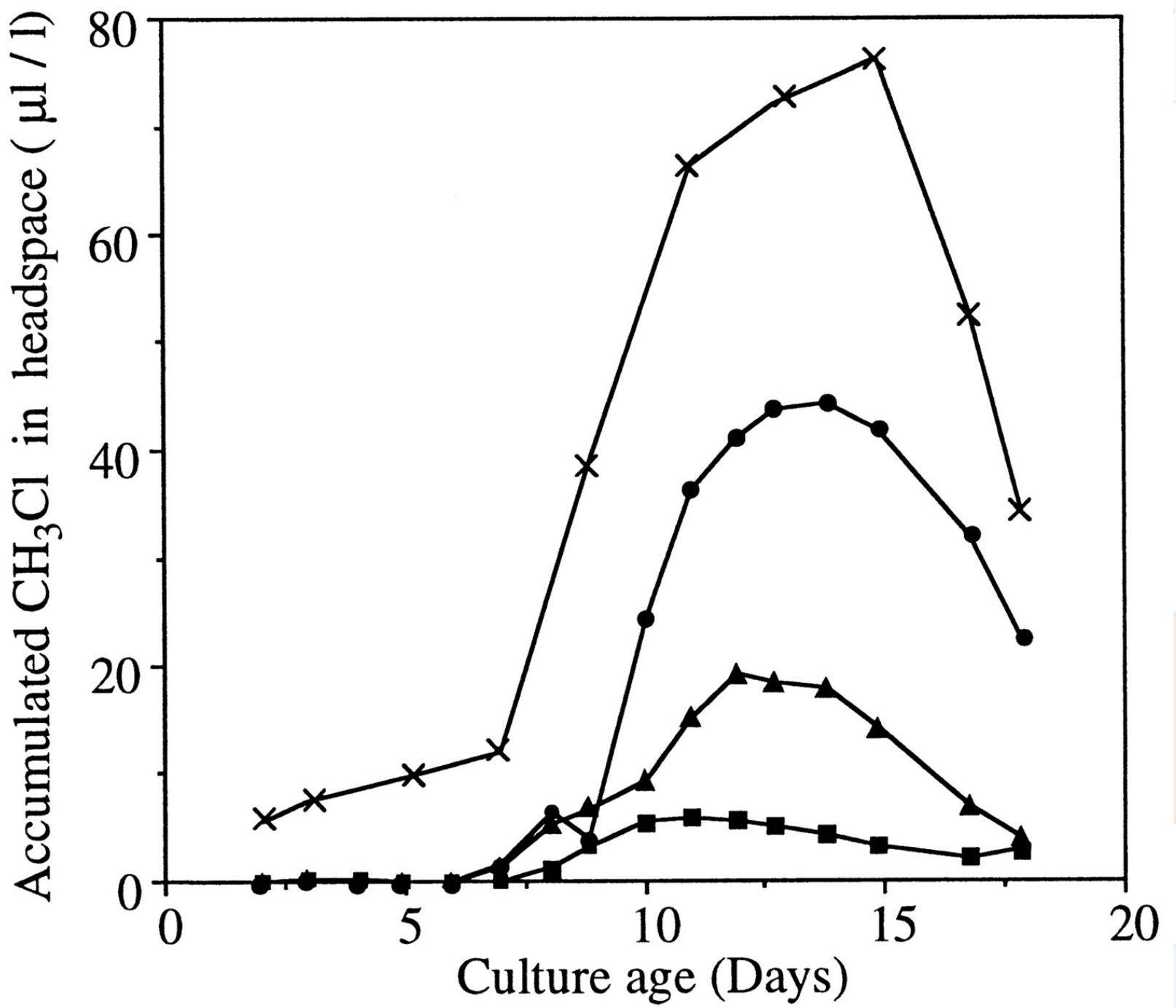


# Atmosphere





from Saxena *et al* 1998:  
 “Biochemical Characterization of Chloromethane Emission from the Wood-Rotting Fungus *Phellinus pomaceus*”



# Atmosphere

Photosynthesis

Fungal Respiration

### Assumptions:

- *Phellinus* decay in scaffolds is widespread if not ubiquitous
- Therefore, carbon storage reduction is has been 'baked into' prior estimates of prune orchard biomass accumulation
- Quantification of this pre-existing C loss allows quantification of the climate benefit of addressing *Phellinus* in the orchard

## Orchard Biomass

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154,821

1,666

Orchard Removal

Tree Removal

Bioenergy

Surface

Soil Biomass

Soils

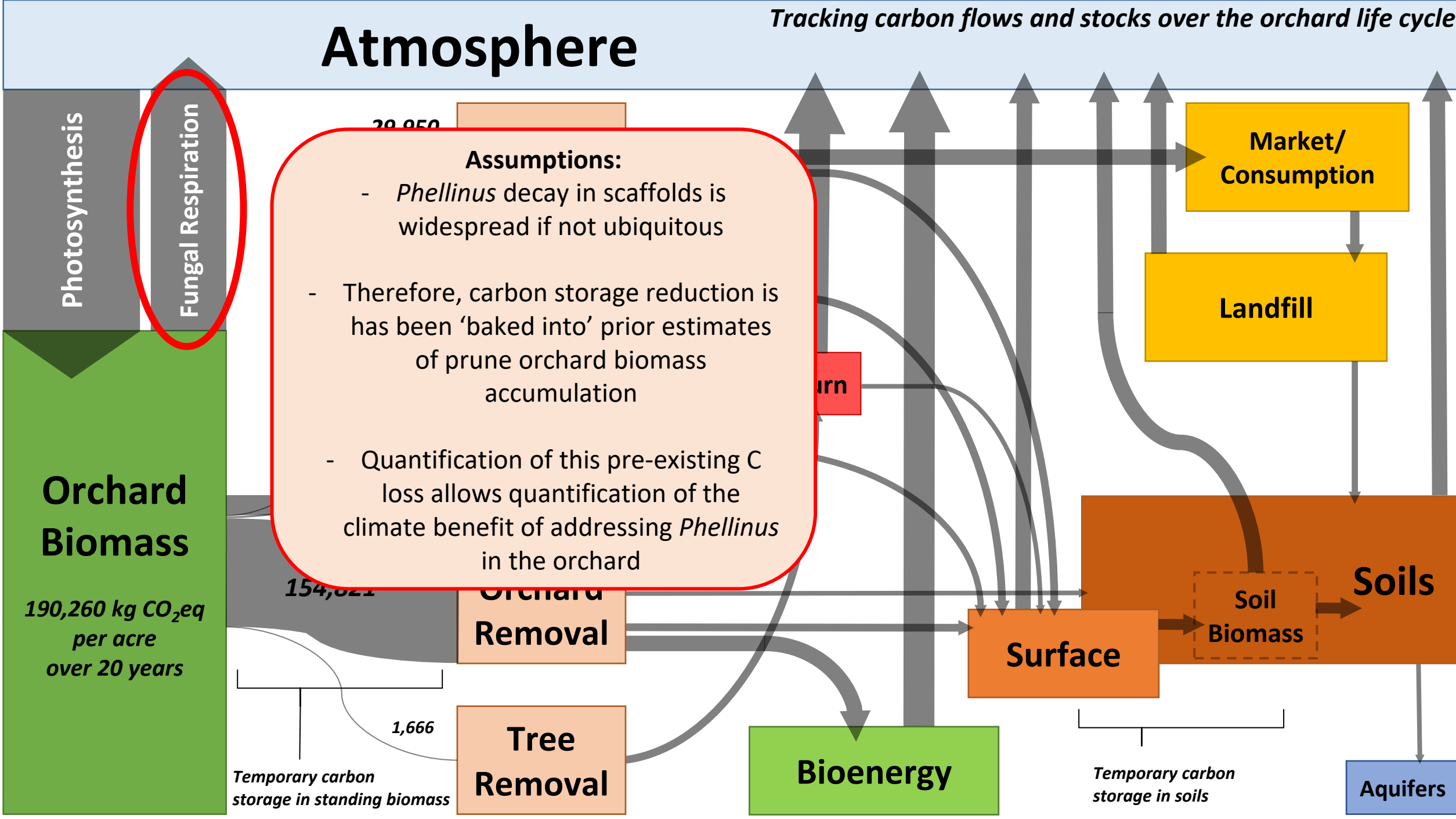
Market/Consumption

Landfill

Aquifers

Temporary carbon storage in standing biomass

Temporary carbon storage in soils



# Atmosphere

Photosynthesis

Fungal Respiration

## Orchard Biomass

190,260 kg CO<sub>2</sub>eq  
per acre  
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Open Burn

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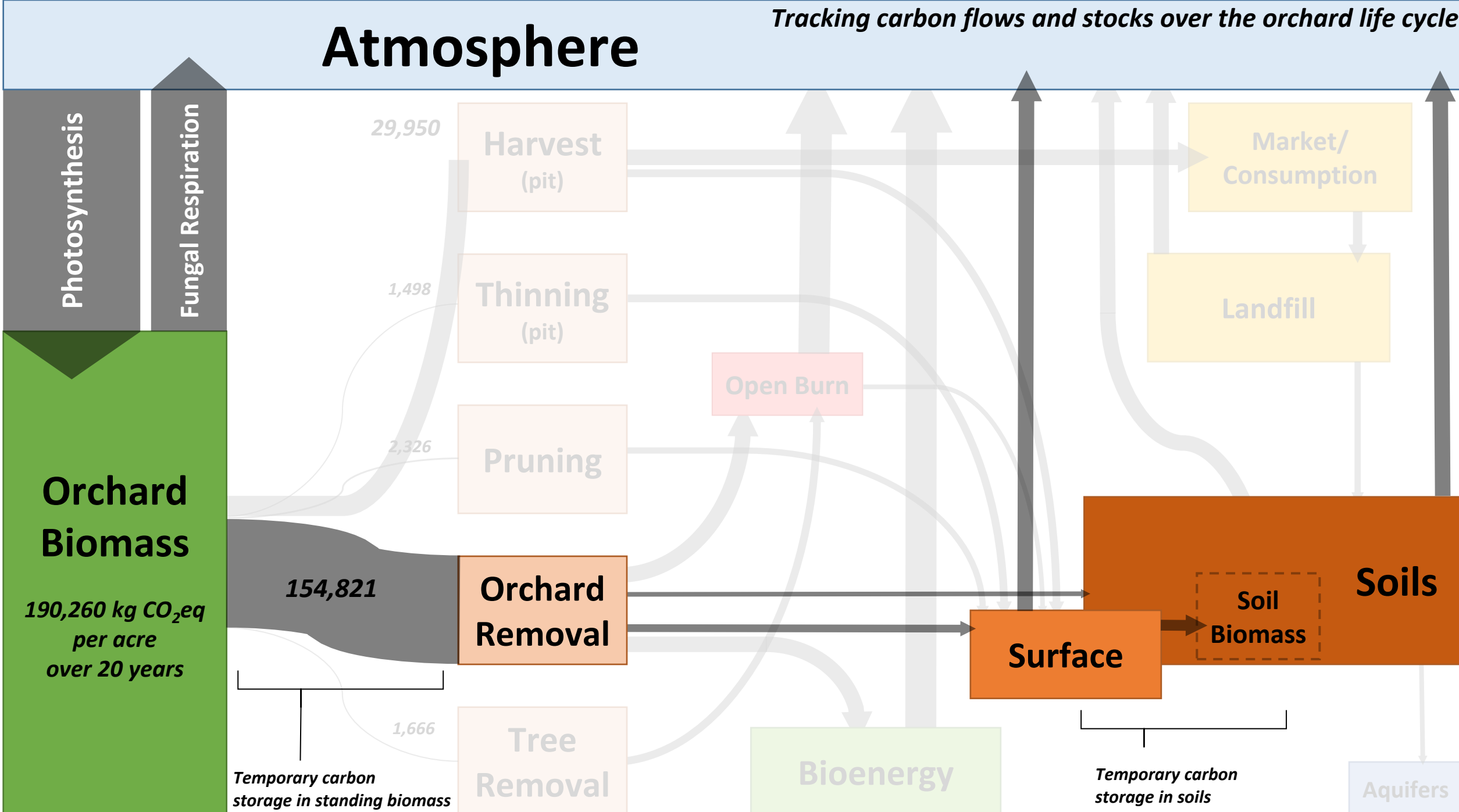
Market/Consumption

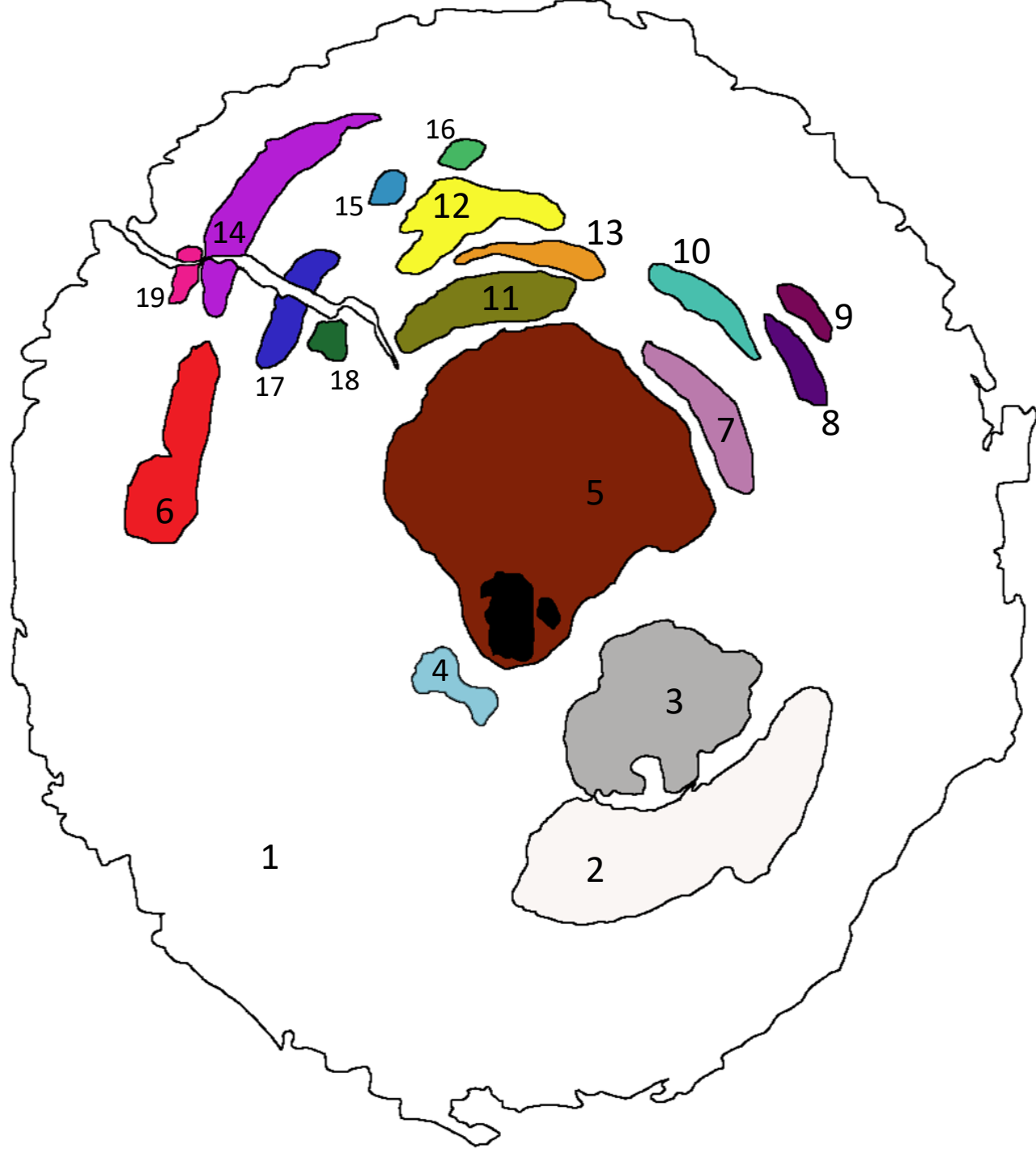
Landfill

Soil Biomass

## Soils

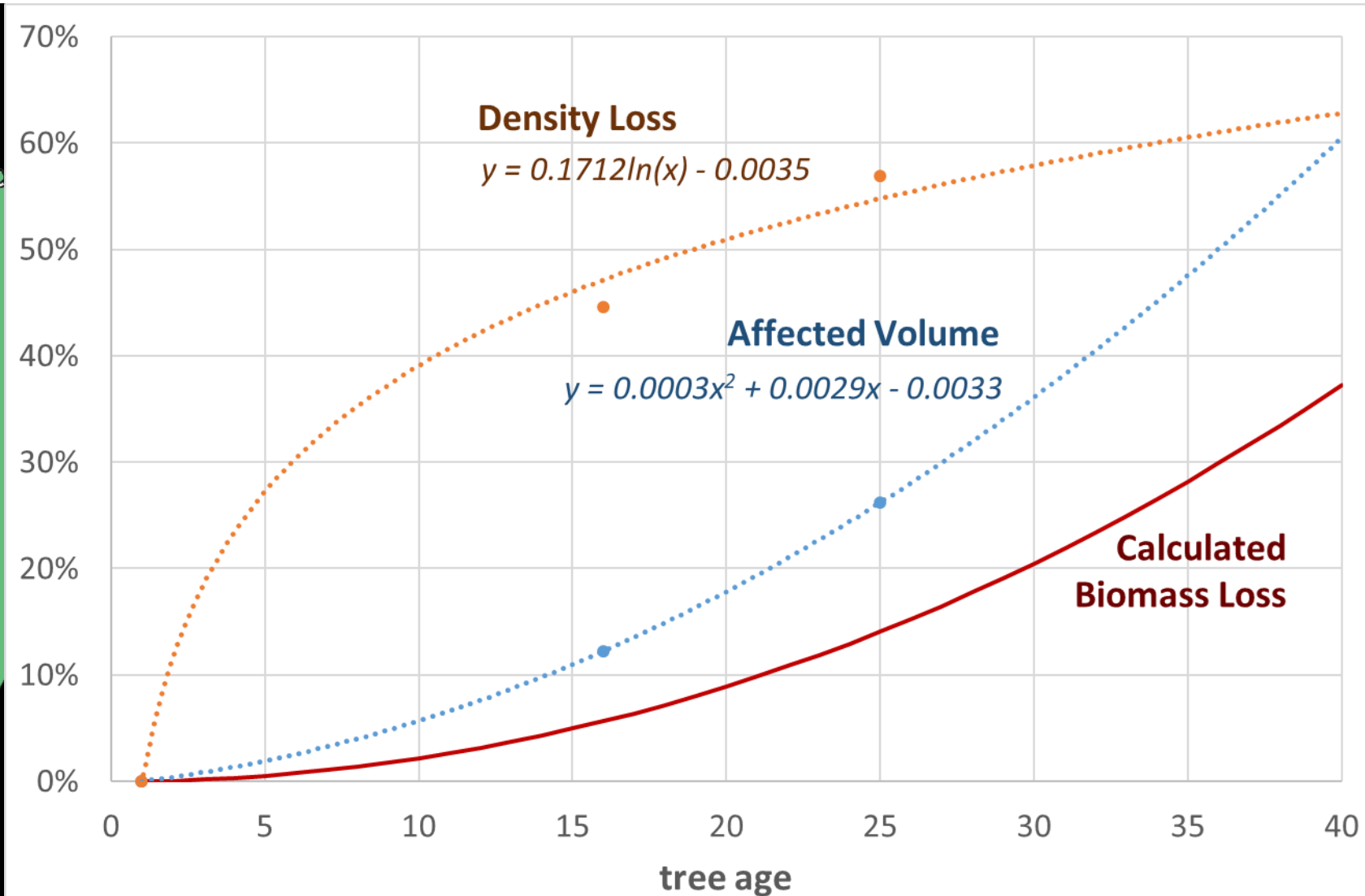
Aquifers



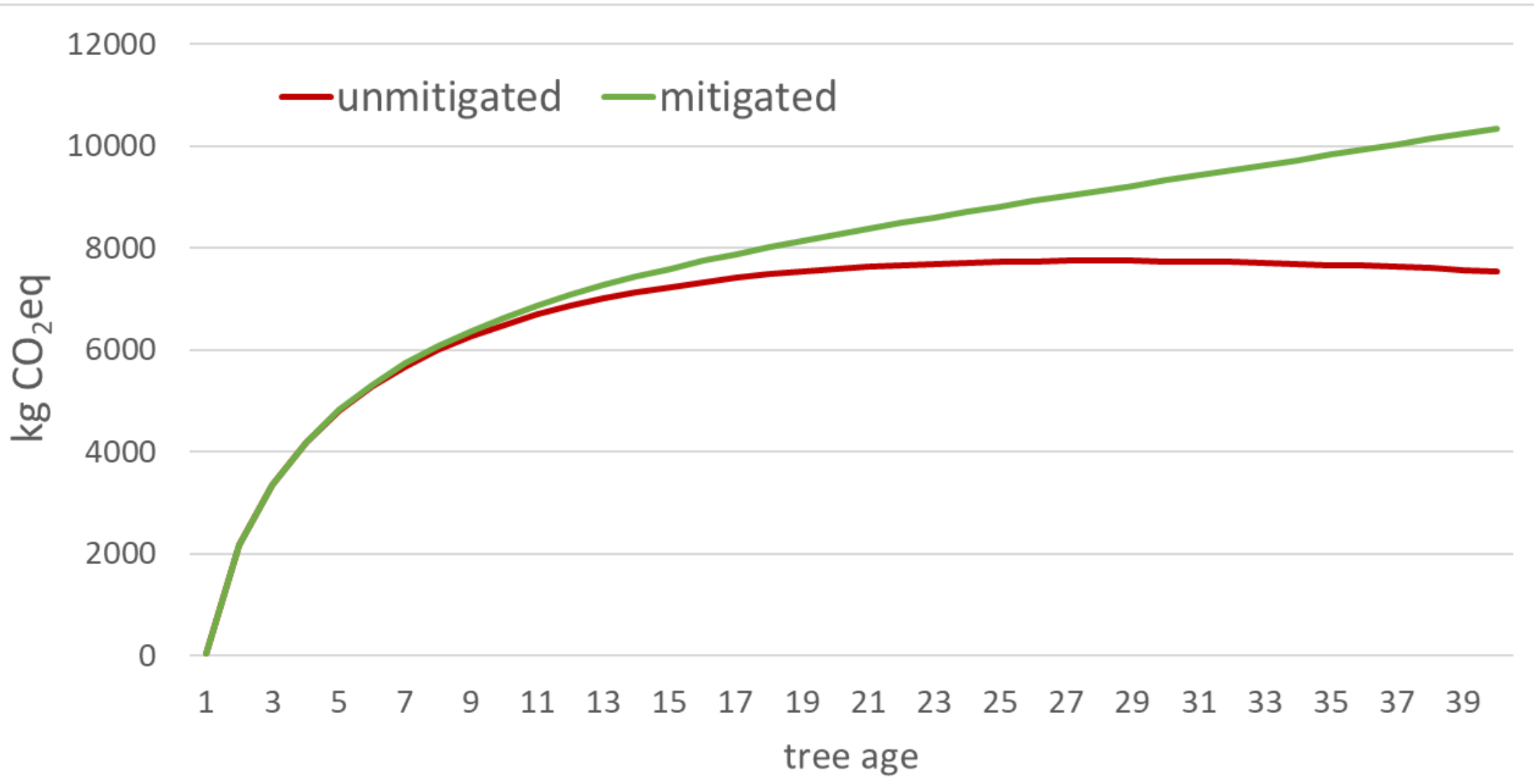


# Ongoing work:

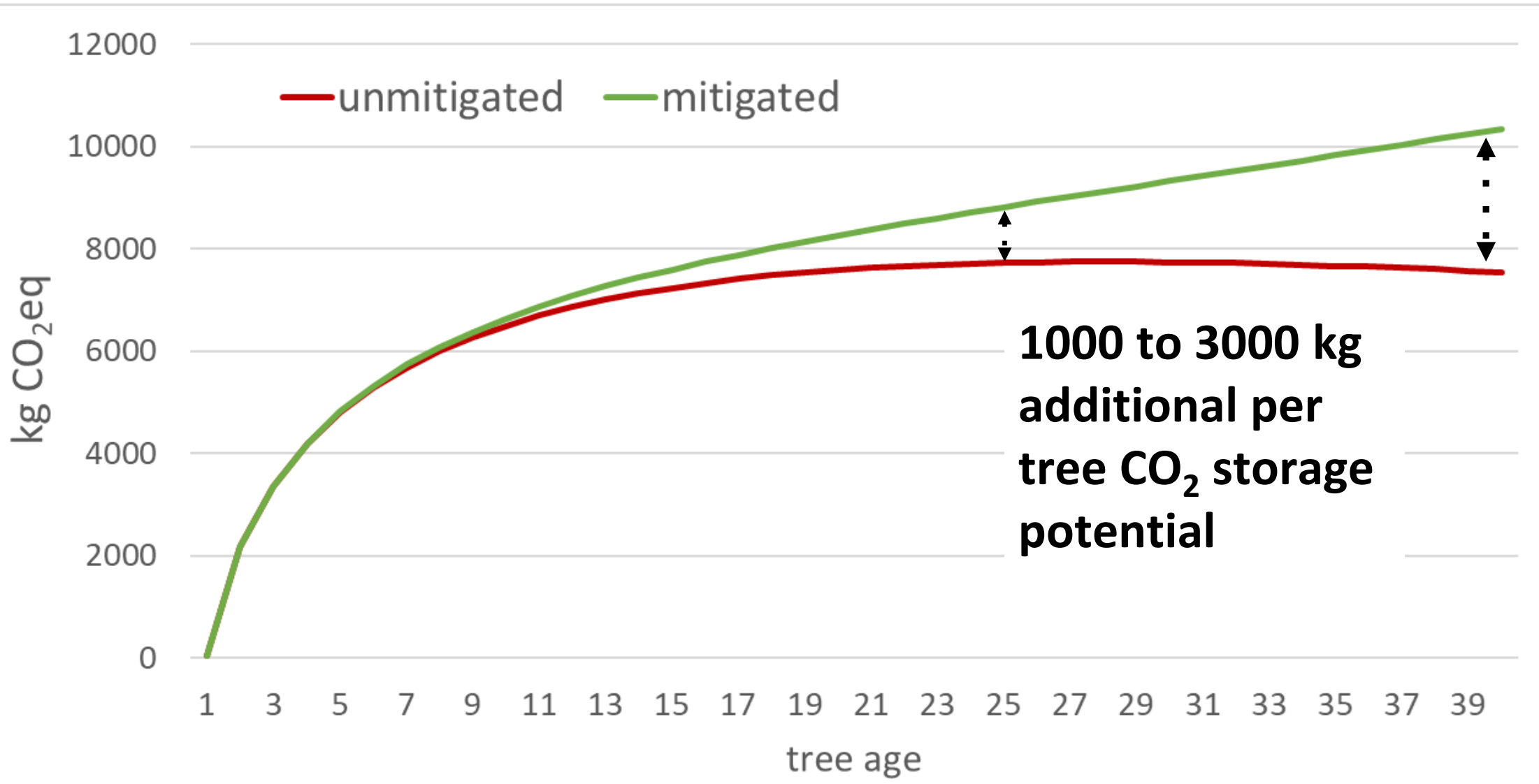
## Density loss and affected volume over time



# Hypothetical wood decay mitigation effect on biomass

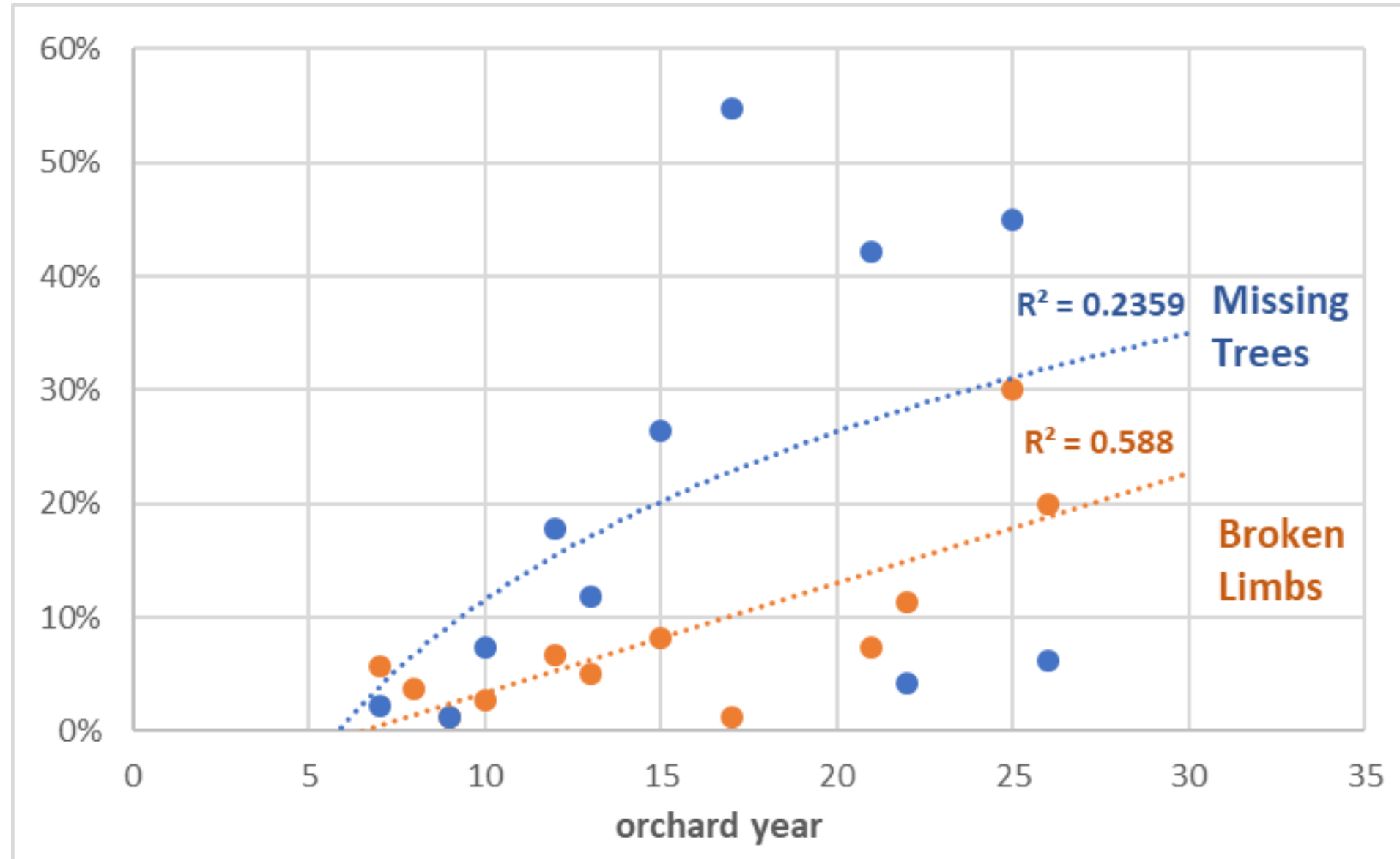


# Hypothetical wood decay mitigation effect on biomass



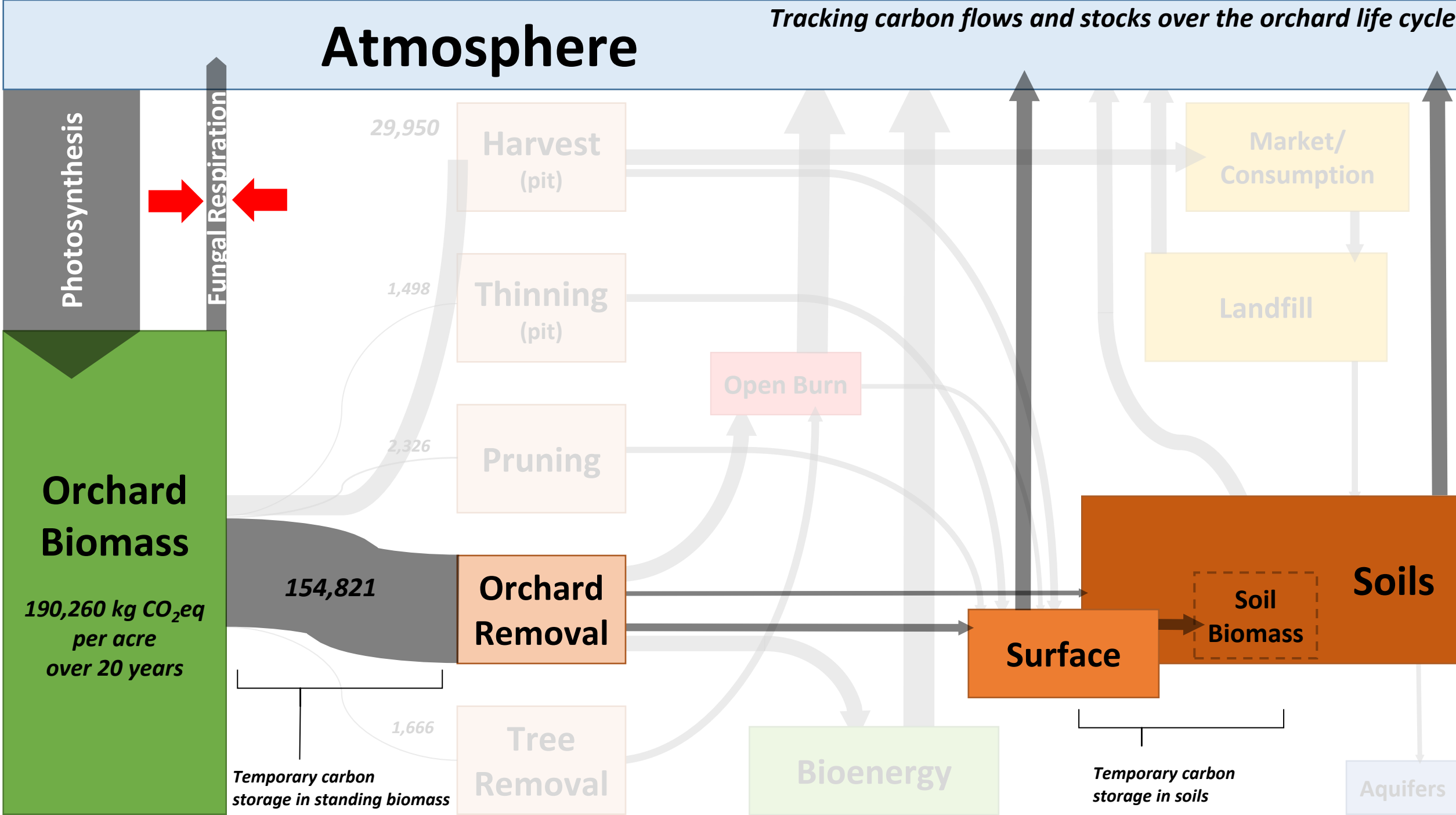
# Missing tree and broken limb biomass loss

*Variation in infection patterns and severity from orchard to orchard determine sample size needed for biomass and wood decay modeling*



*Data courtesy of Dave Rizzo lab collaborators (2021)*

# Atmosphere



Photosynthesis

Fungal Respiration

**Orchard Biomass**

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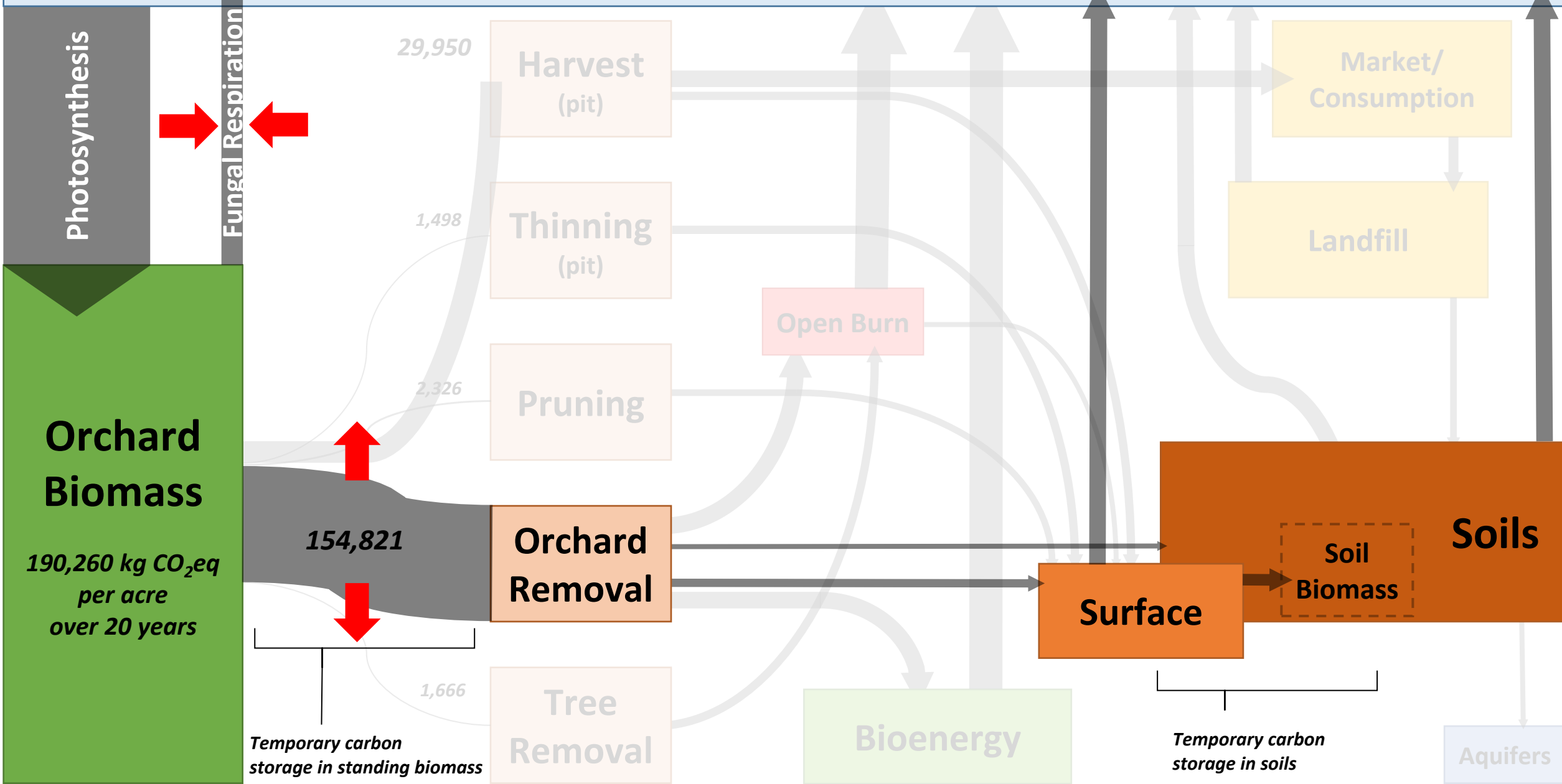
Soil Biomass

Temporary carbon storage in soils

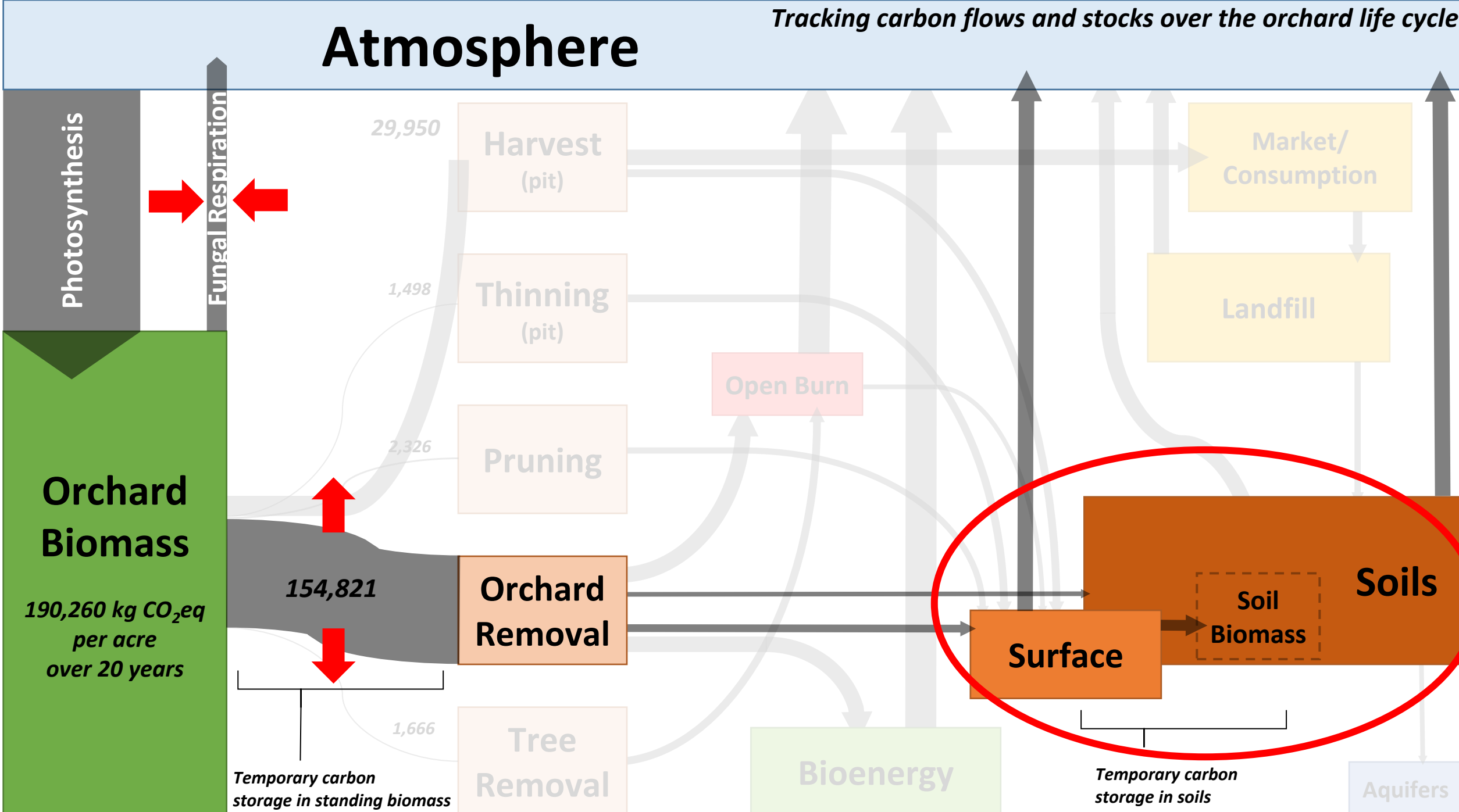
Bioenergy

Aquifers

# Atmosphere



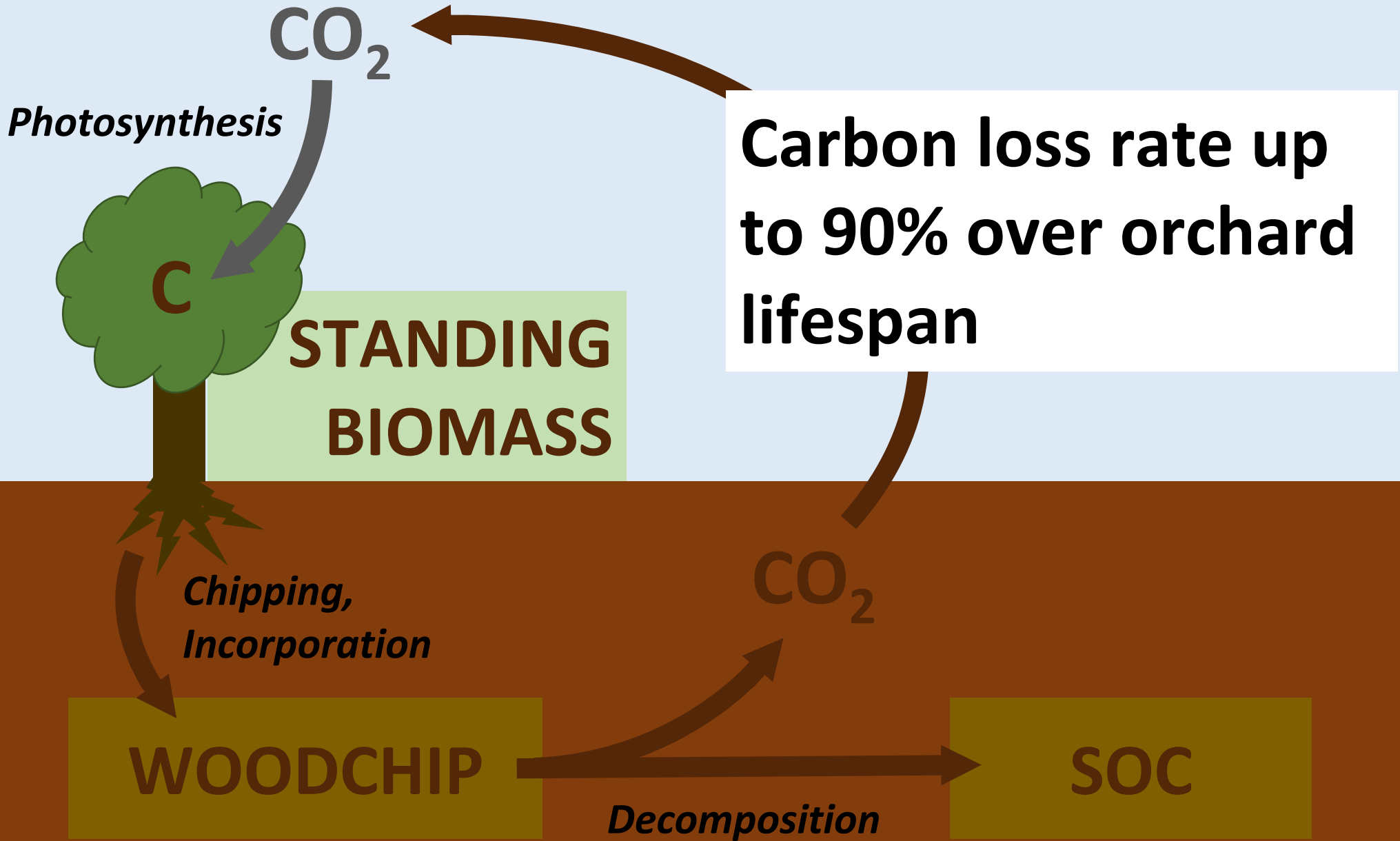
# Atmosphere



# Standing biomass at orchard end-of-life: “Orchard Recycling”



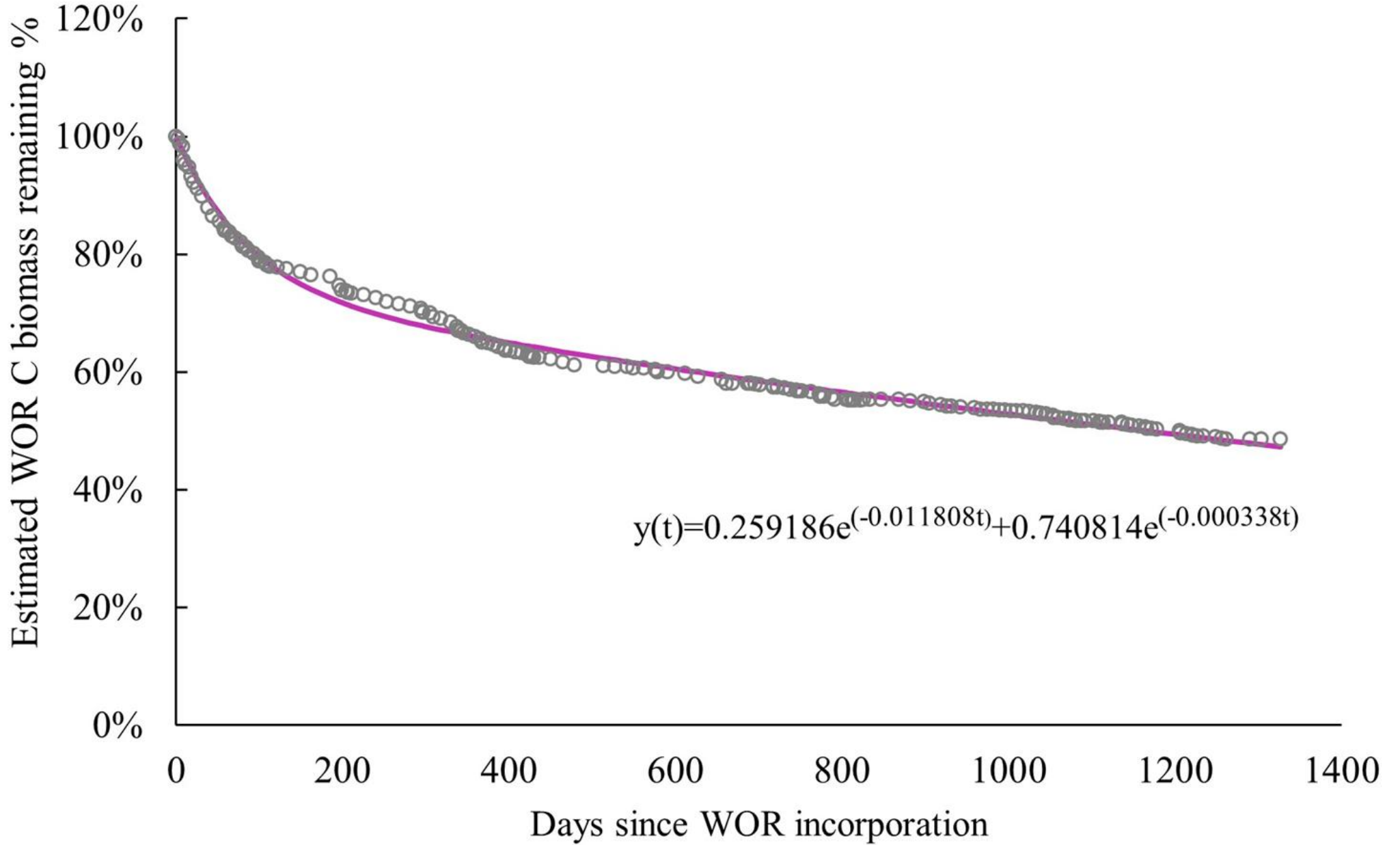
***Returning biomass  
directly to orchard soil***



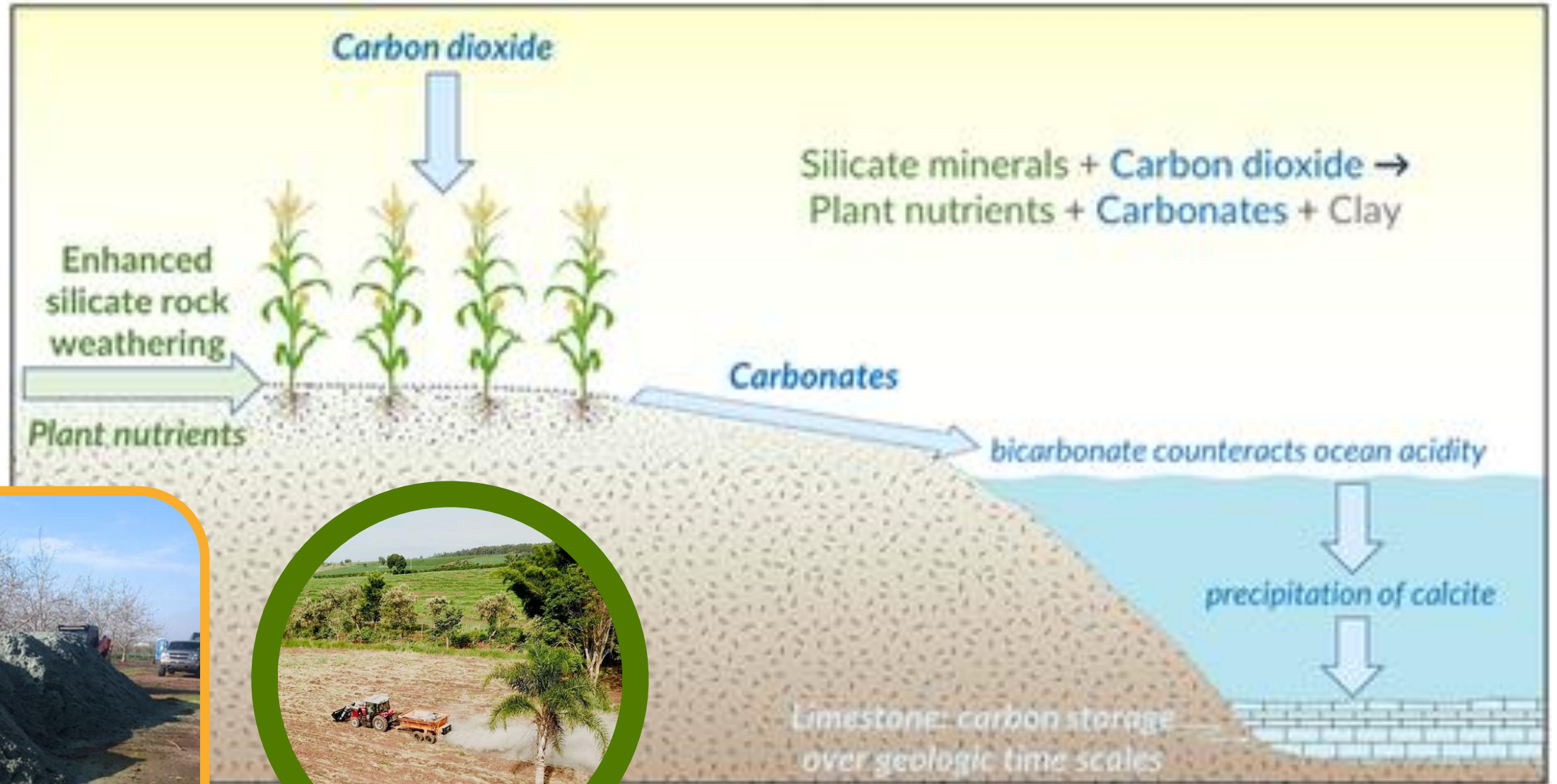
**Photosy**



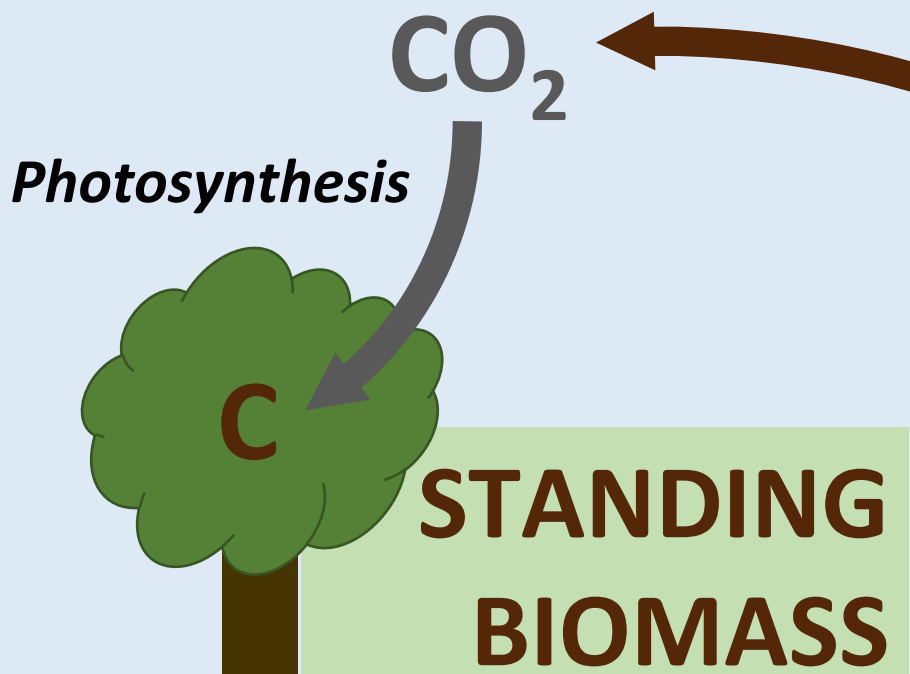
○ wood biomass C      — fitted curve



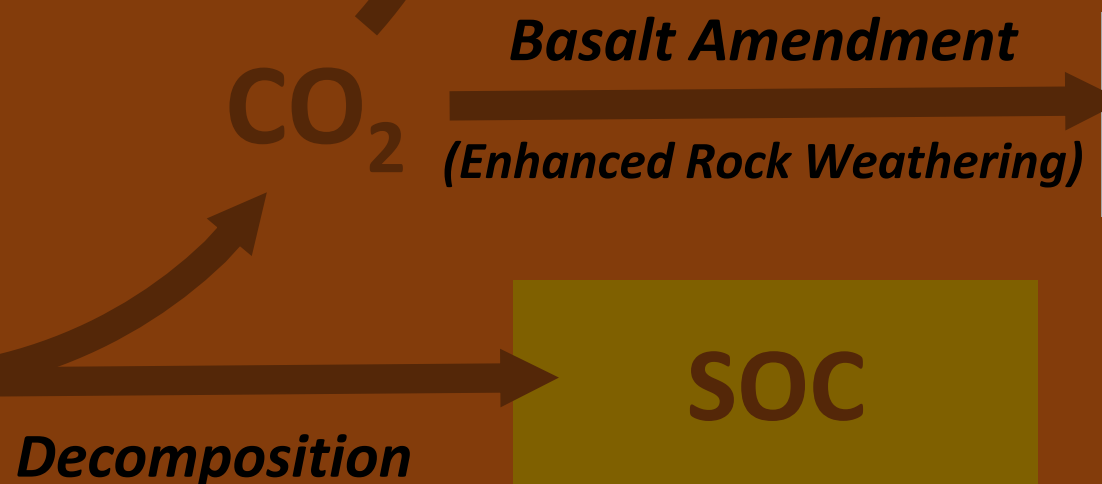
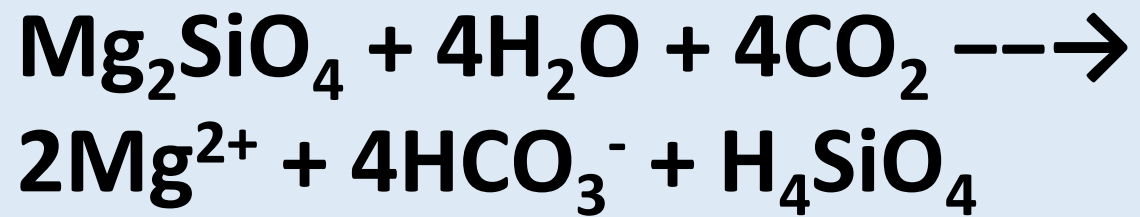
# Enhanced Rock Weathering

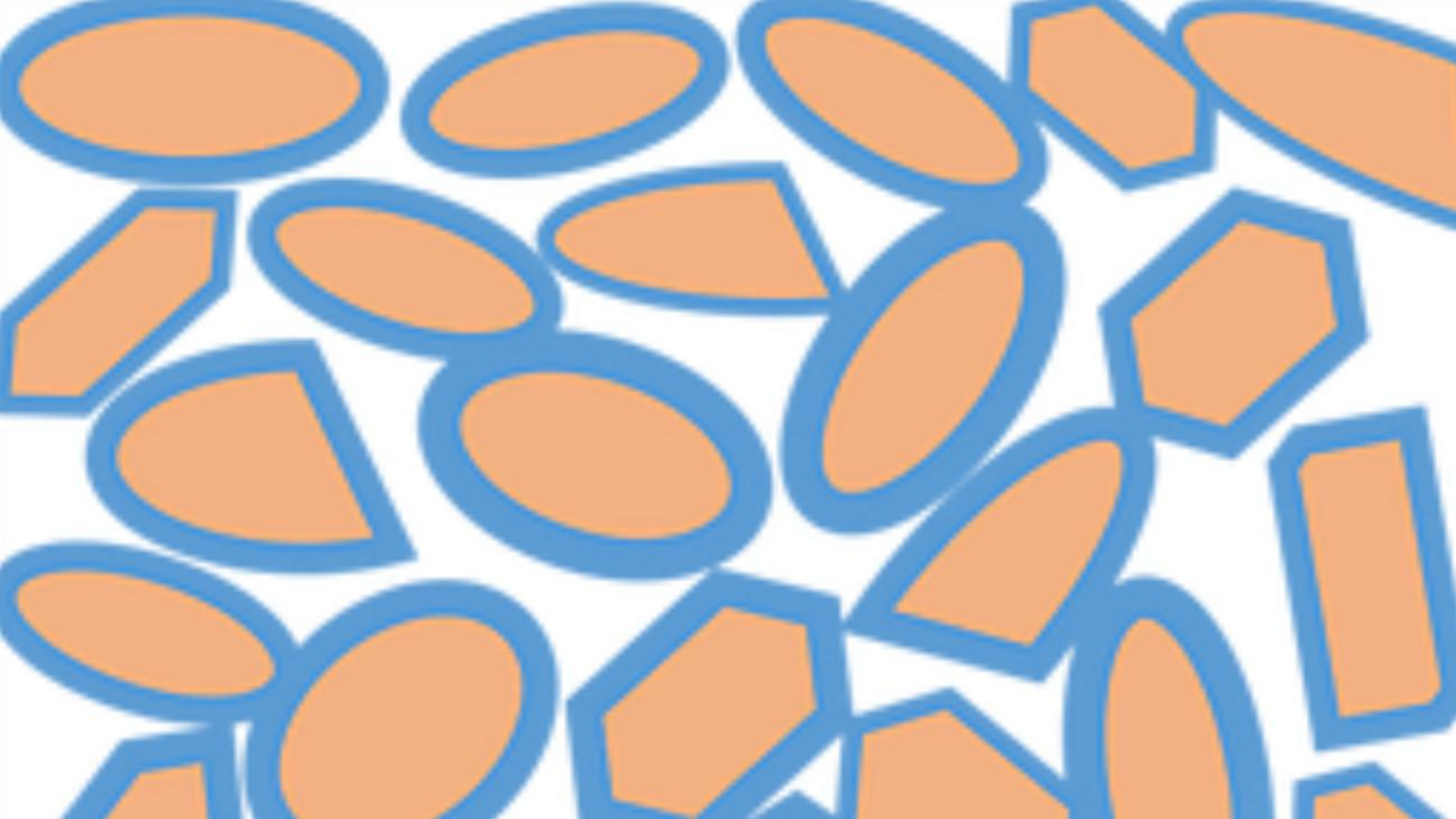


***Quarry byproducts for agricultural amendment and potential carbon credit***

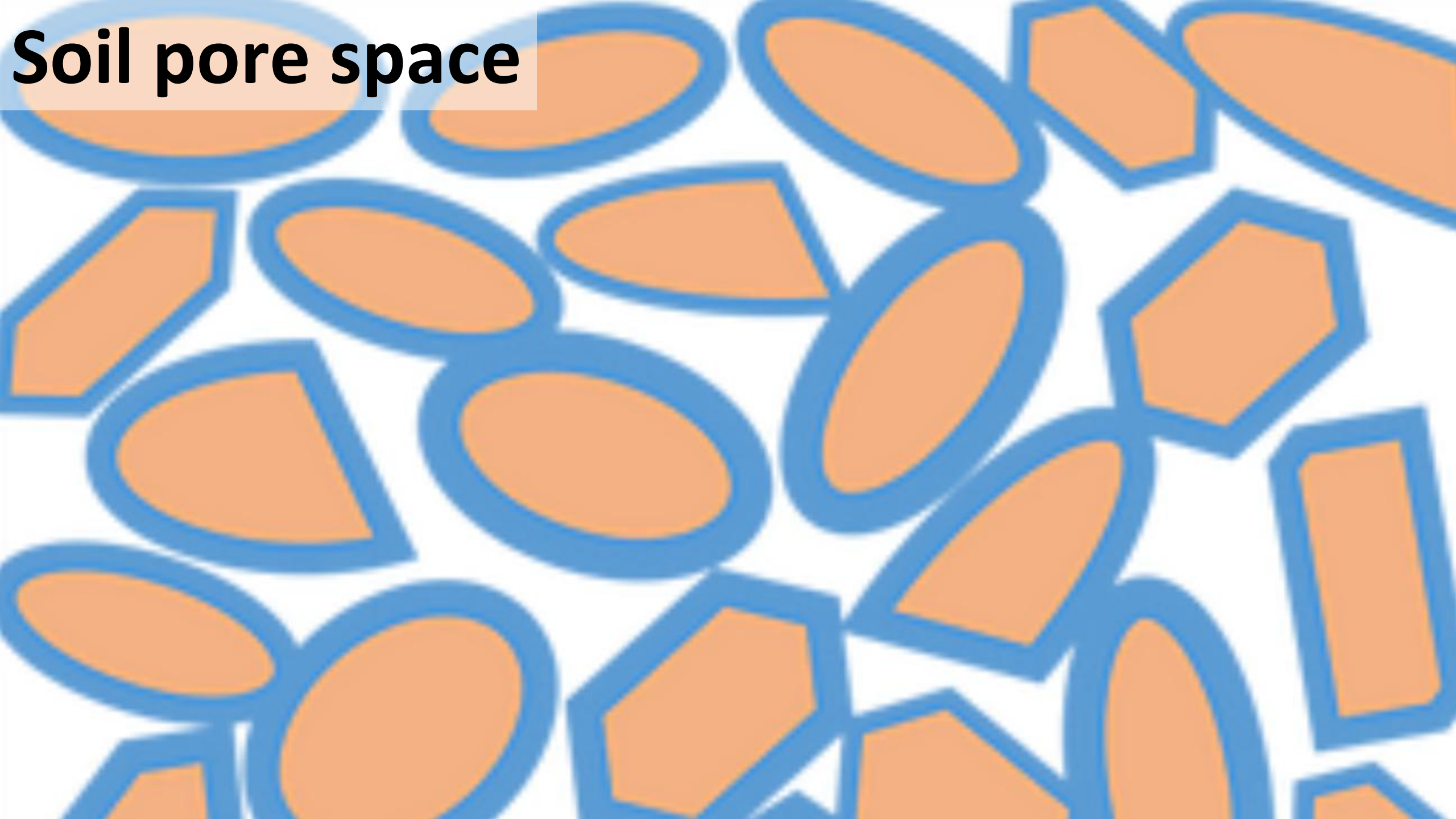


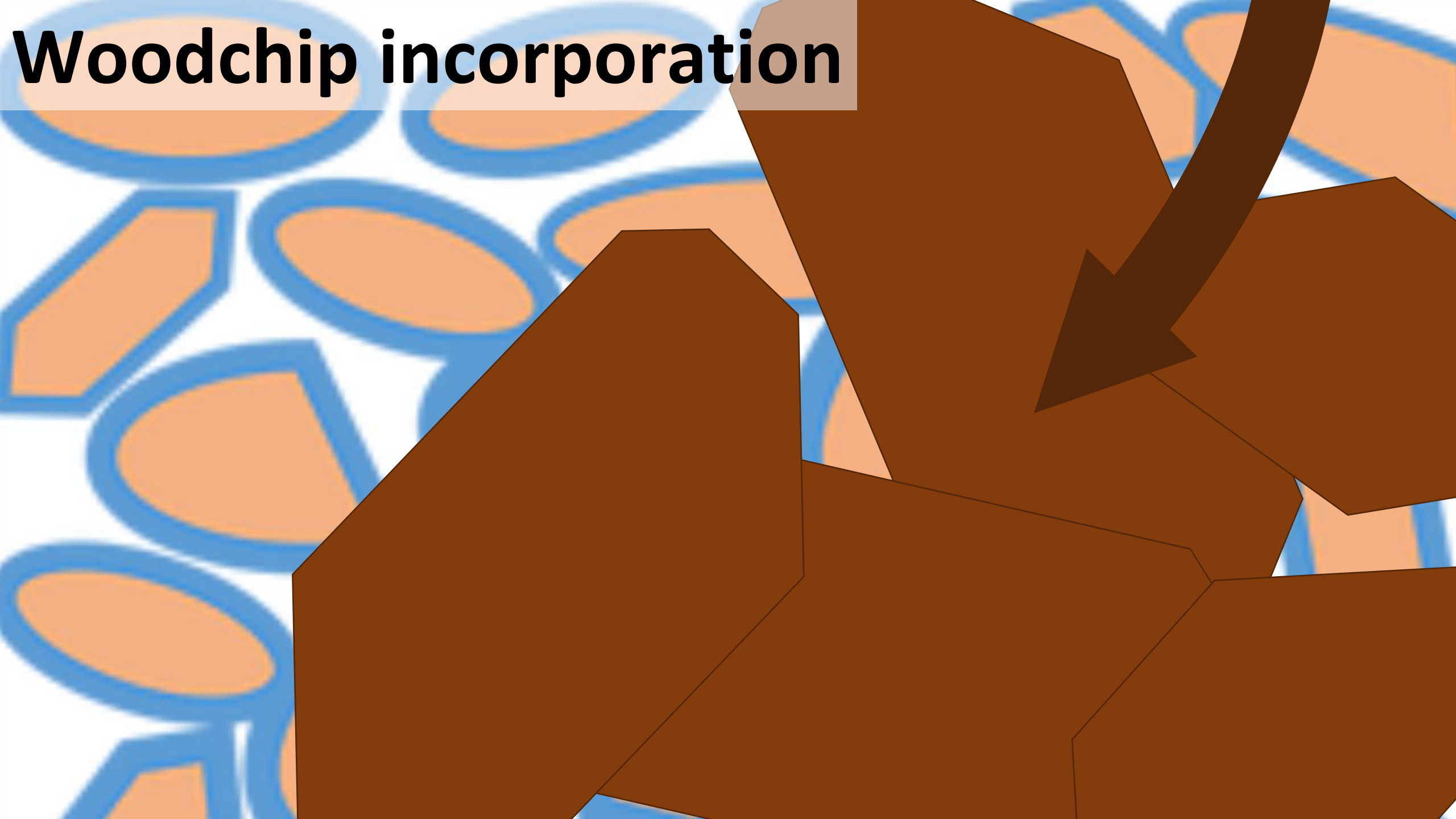
Rock flour as a “failsafe”:  
chemical barrier to prevent C  
loss to atmosphere, instead  
sequestering as inorganic C



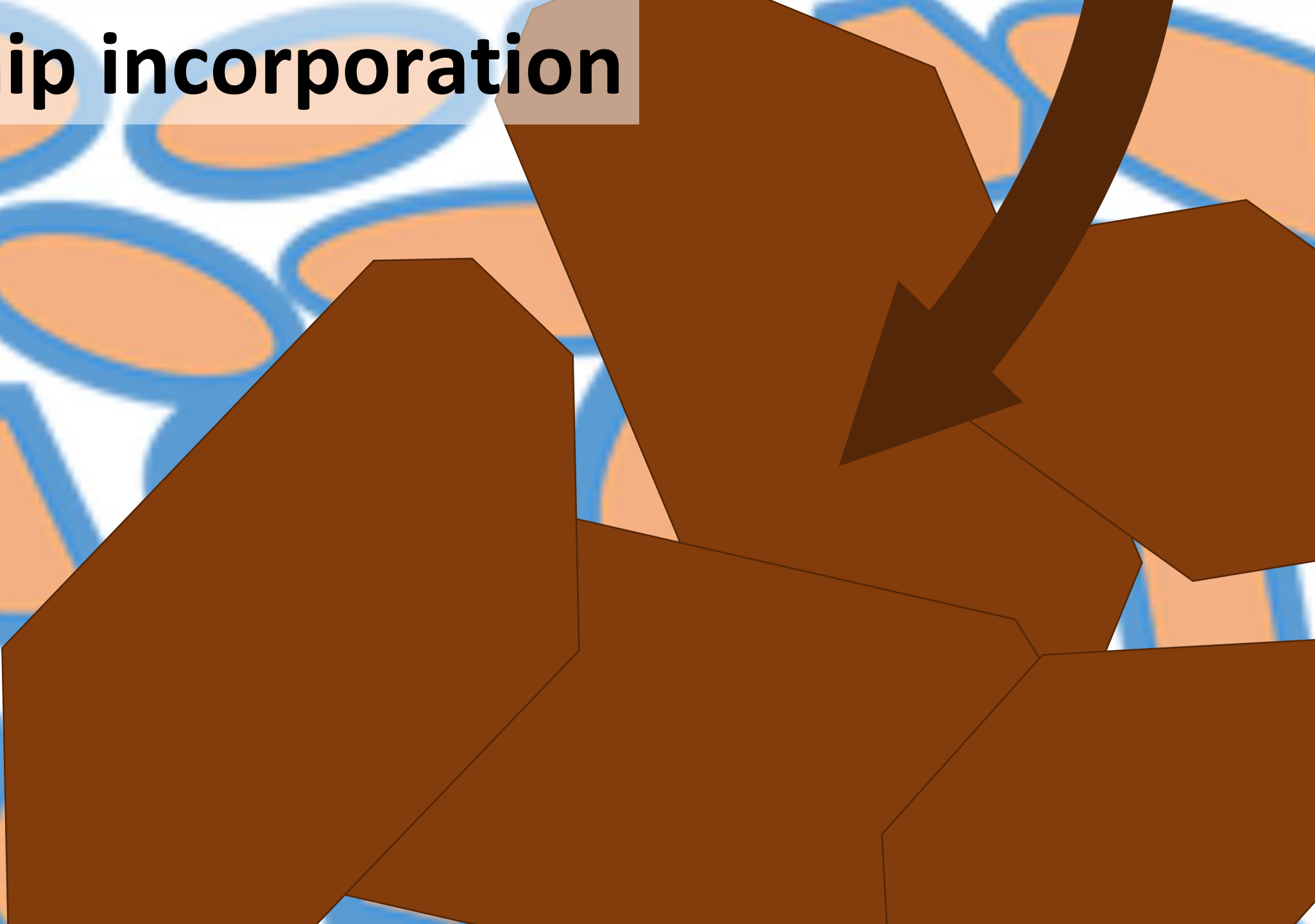


# Soil pore space





# Woodchip incorporation



# Decomposition

$\text{CO}_2$

C



**Emission**

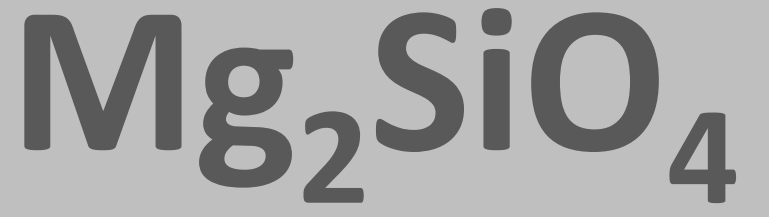


**CO<sub>2</sub>**

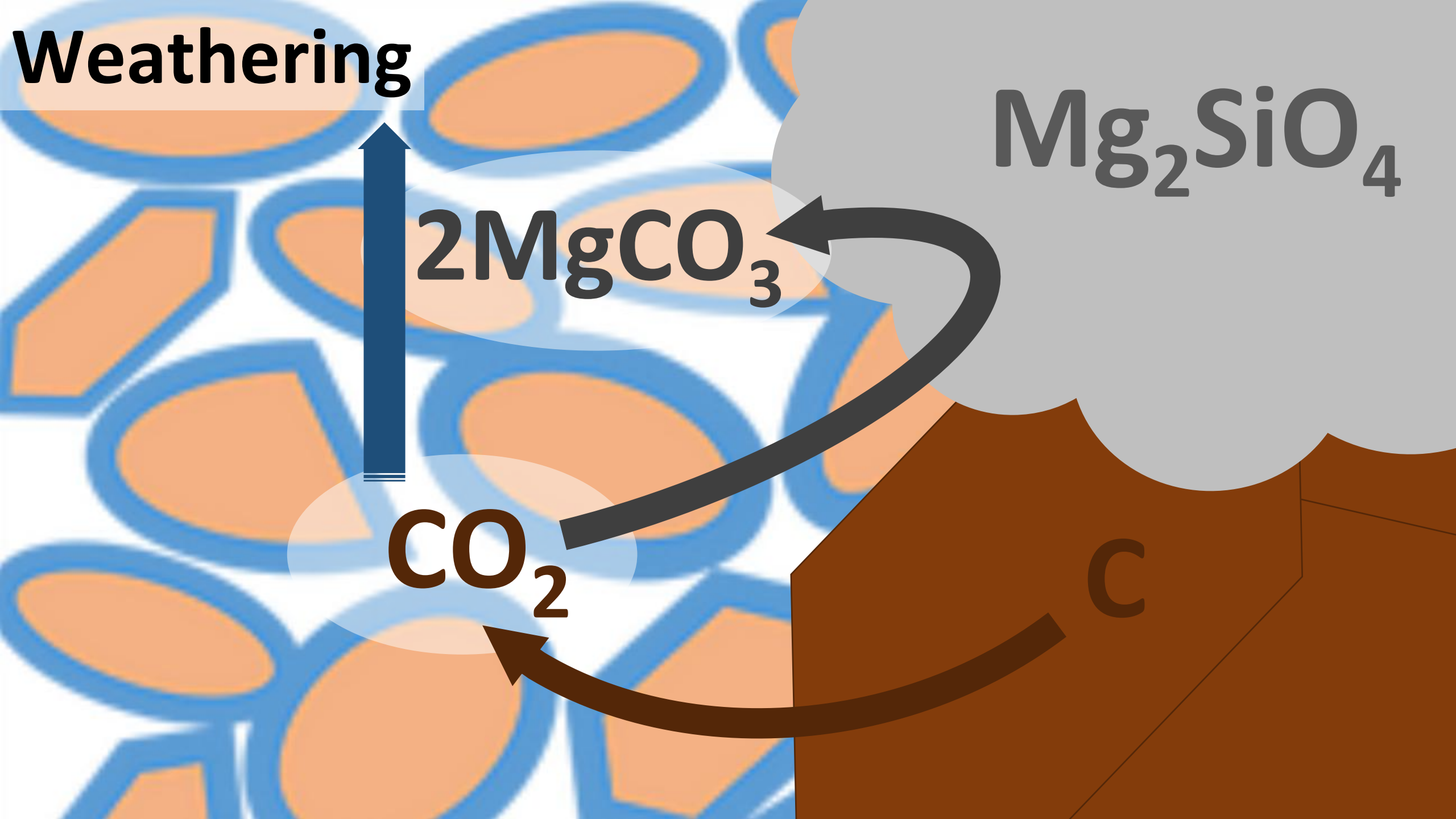
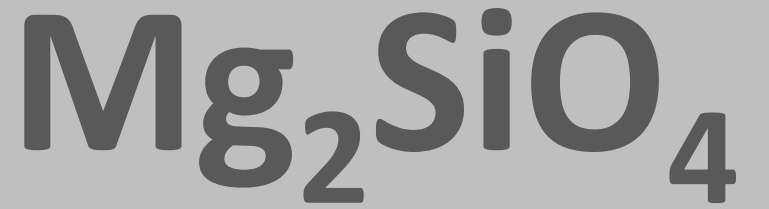
**C**



# Rock Flour Amendment



**Weathering**



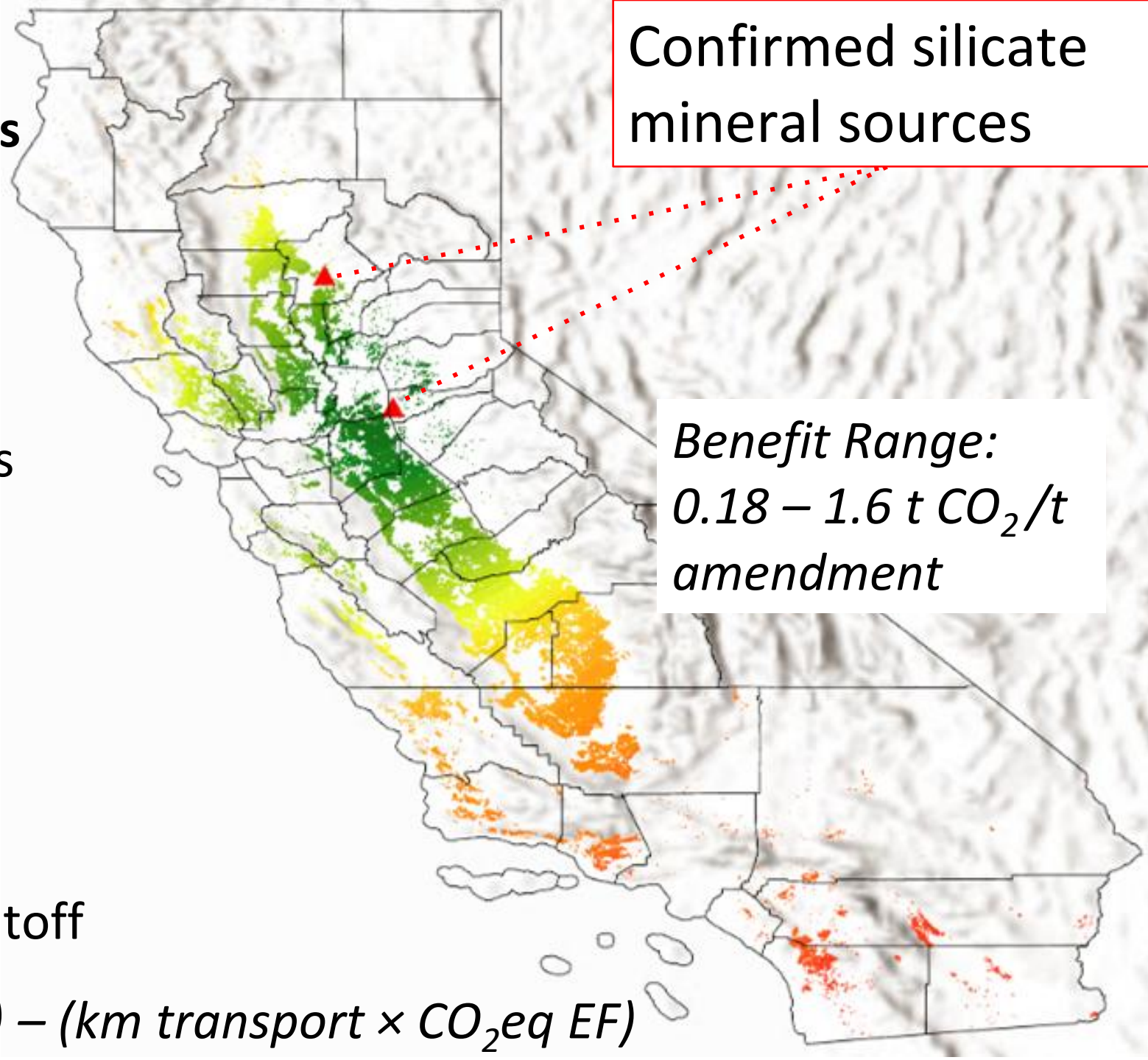
# Suitability Mapping

**C benefit potential calculated as**  
weatherable mineral content  
of amendment material  
× mass ratio mineralized CO<sub>2</sub>  
to weatherable mineral  
- freight transport CO<sub>2</sub> emissions

## Ongoing work:

- Pedoclimatic conditions
- Applied water
- Crop specific mineralization benefits from biomass CO<sub>2</sub>
- Cost vs credit value-based cutoff

$$(\%SiO_2 \times (4 \times MWCO_2) / MWSiO_2) - (km \text{ transport} \times CO_2eq \text{ EF})$$





**Thank  
you!**

*Contact: [emarvinney@ucdavis.edu](mailto:emarvinney@ucdavis.edu)*