Recovery of carbon stocks after wildfires in boreal forests: a synthesis

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Background

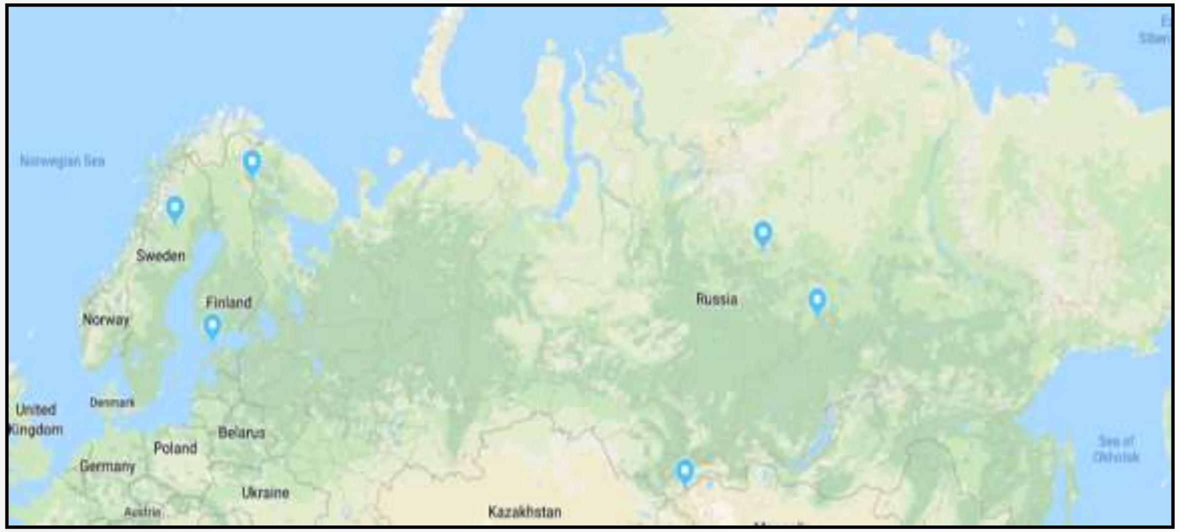
- 10-15 million ha of boreal forests burn annually
- Climate warming has already increased and will increase the extent, intensity and frequency of forest fires in high-latitude boreal forests
- Fires decrease forest carbon (C) stocks and may cause long-term changes in C dynamics by altering forest regrowth, successional trajectories, litter production, organic matter decomposition and the fluxes of energy, water and nutrients

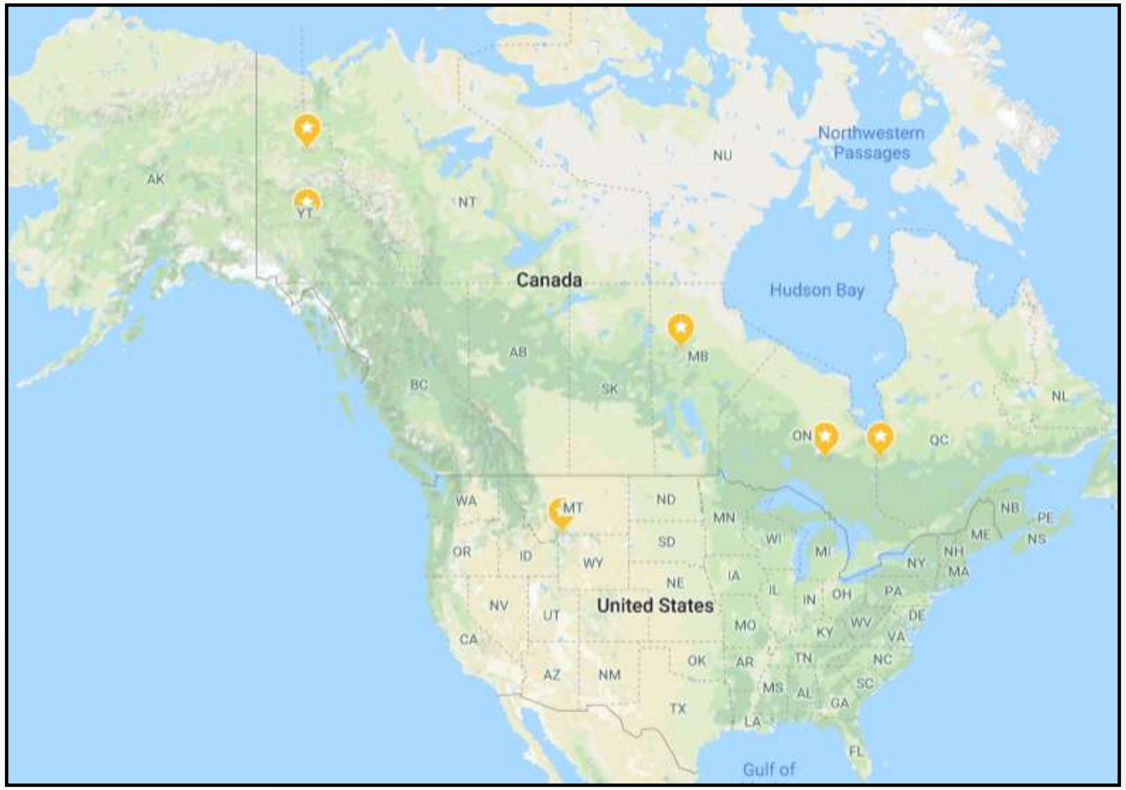
➢ Quantifying the magnitude of post-fire C changes and the rate of recovery of C stocks is necessary for understanding how changing fire frequency and intensity influence regional and global C budgets and for predicting future changes in C budgets.

Research questions

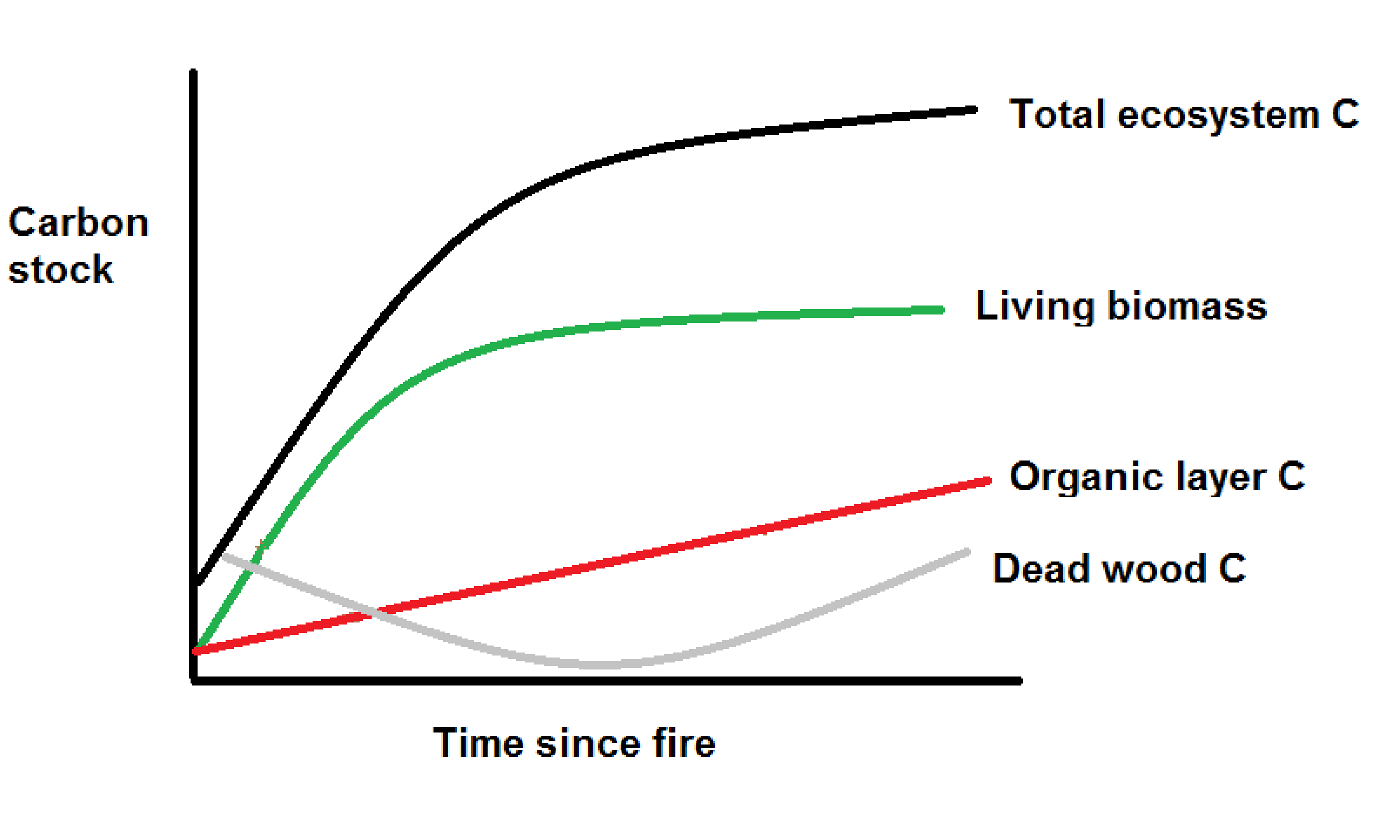
- How quickly forest C pools recover after fire and how the recovery of C stocks vary across boreal zone?
- How fires change the distribution of C among different ecosystem components?
- To what extent time since fire and climatic conditions explain the variation in C accumulation rate?

- Data in total of **368 plots** from **15 fire chronosequence studies** from different parts of boreal zone (latitudes 44–67°N)
- Chronosequences covered at minimum the first 100 years after fire
- MAT varied from -9.5°C to +5.2°C and MAP from 295 mm to 824 mm.
- The mean annual GPP 0.31-0.94 kg m^2





Schematic C dynamics after fire

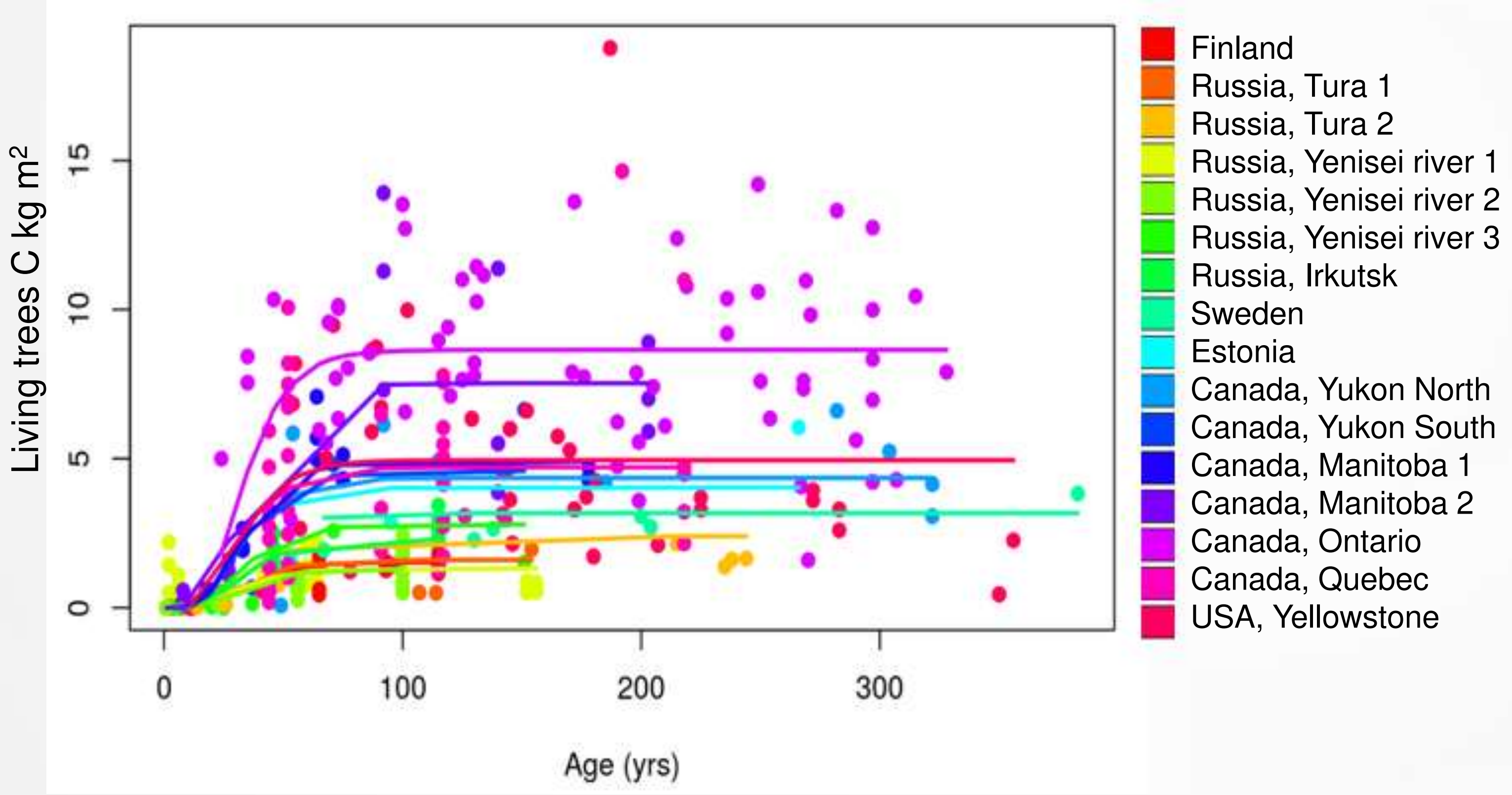


- Living biomass accumulates over time until it stabilizes or even decline
- C increases linearly in O-horizon, mineral soil C remains quite unchanged
- Dead wood shows an U-shaped pattern

Carbon accumulation in living trees

Gompertz function

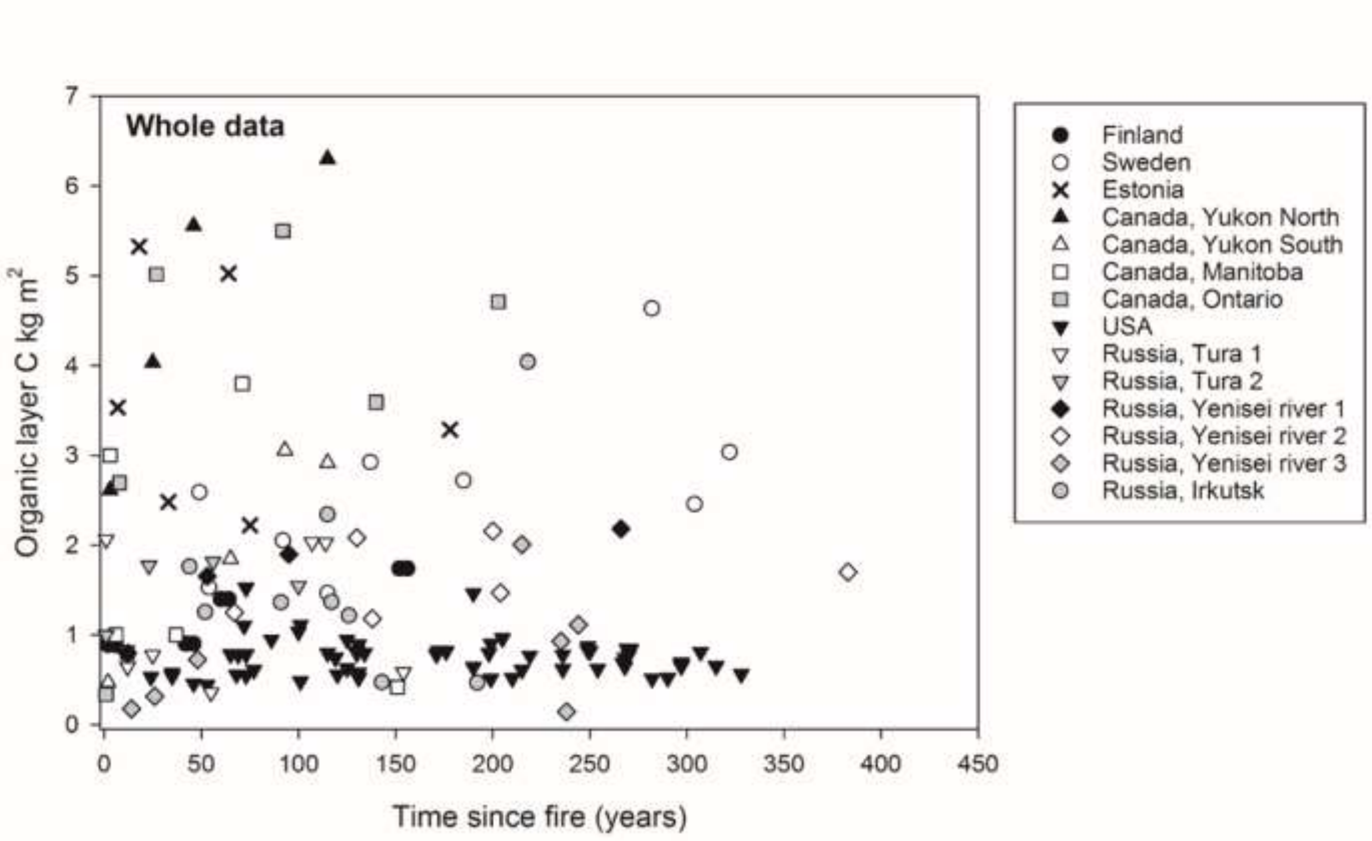
$y = (a_0 * Climate\ variable + a_1)e^{b - c*Time}$



Potential evapotranspiration (PET) best explained the variation in C accumulation rate

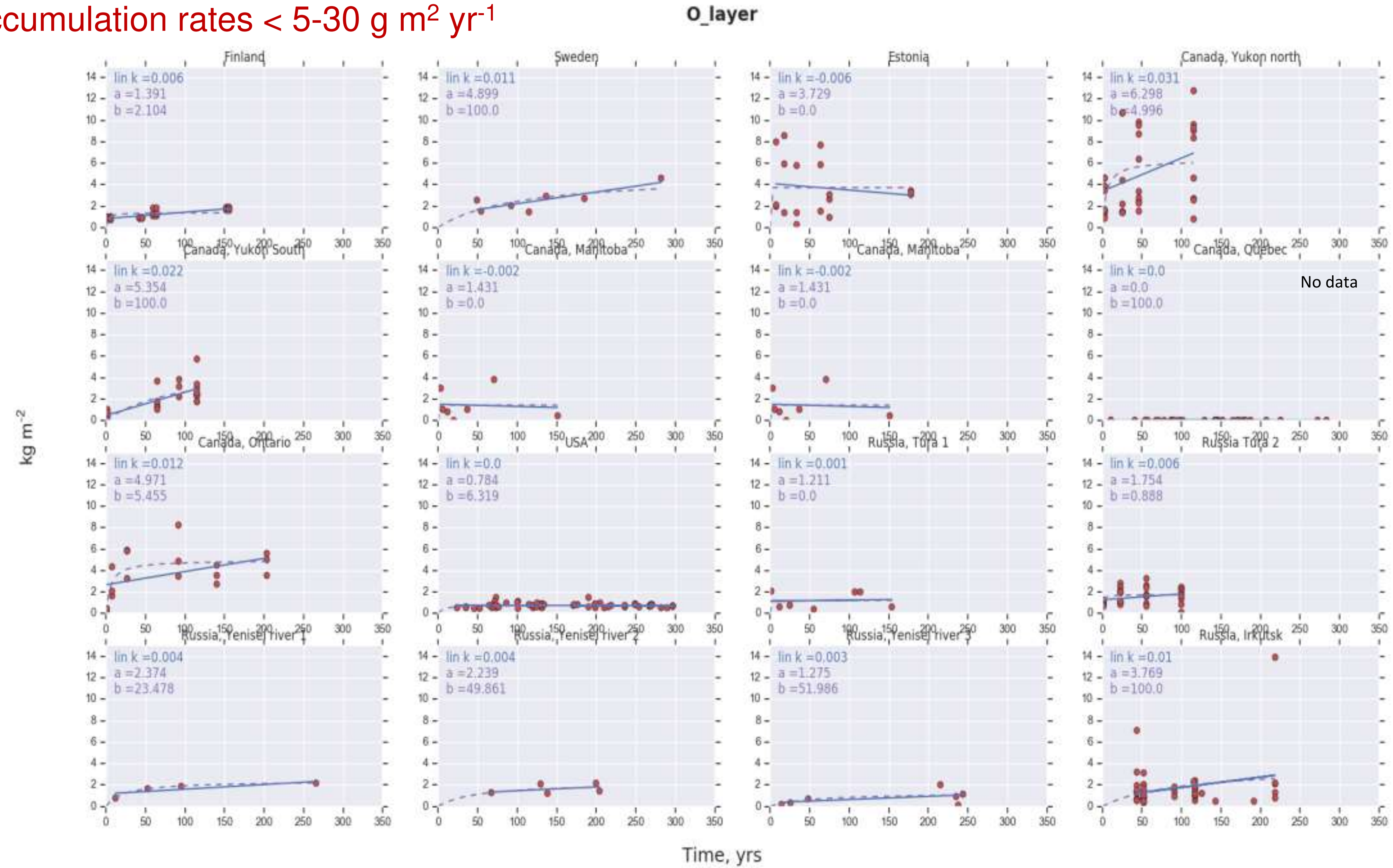
Model	AIC
Precipitation	1674.542
Summer precipitation	1679.842
GPP	1679.583
Precipitation/PET ratio	1680.593
Drought index (pdsi)	1681.594
Temperature	1675.959
PET	**1672.256**
Summer temperature	1675.075
Summer precipitation	1681.479

Carbon in the organic layer

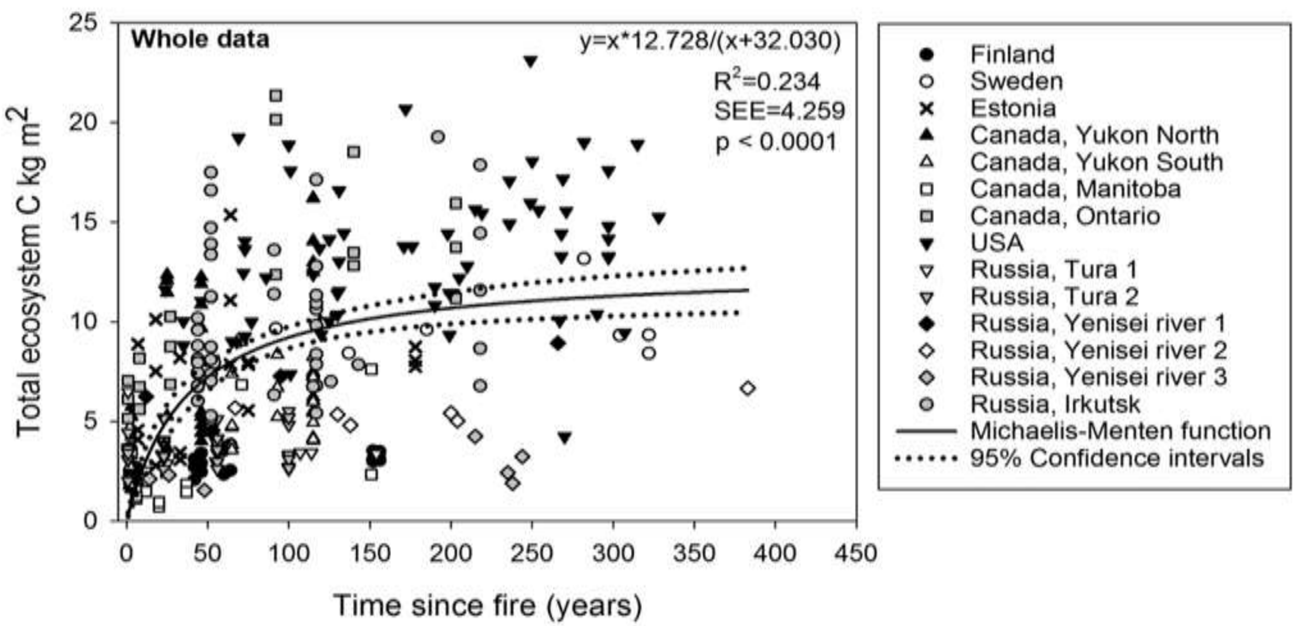


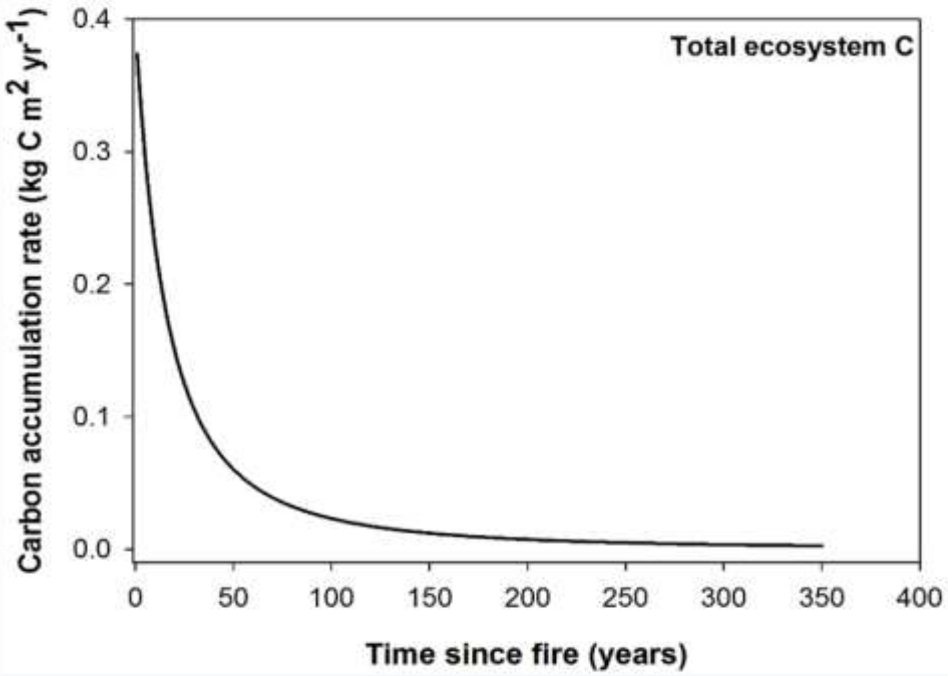
- No clear trend, large variation
- Average C accumulation rate 6 g C m^2 yr^{-1}

C accumulation rates < 5-30 g m^2 yr^{-1}



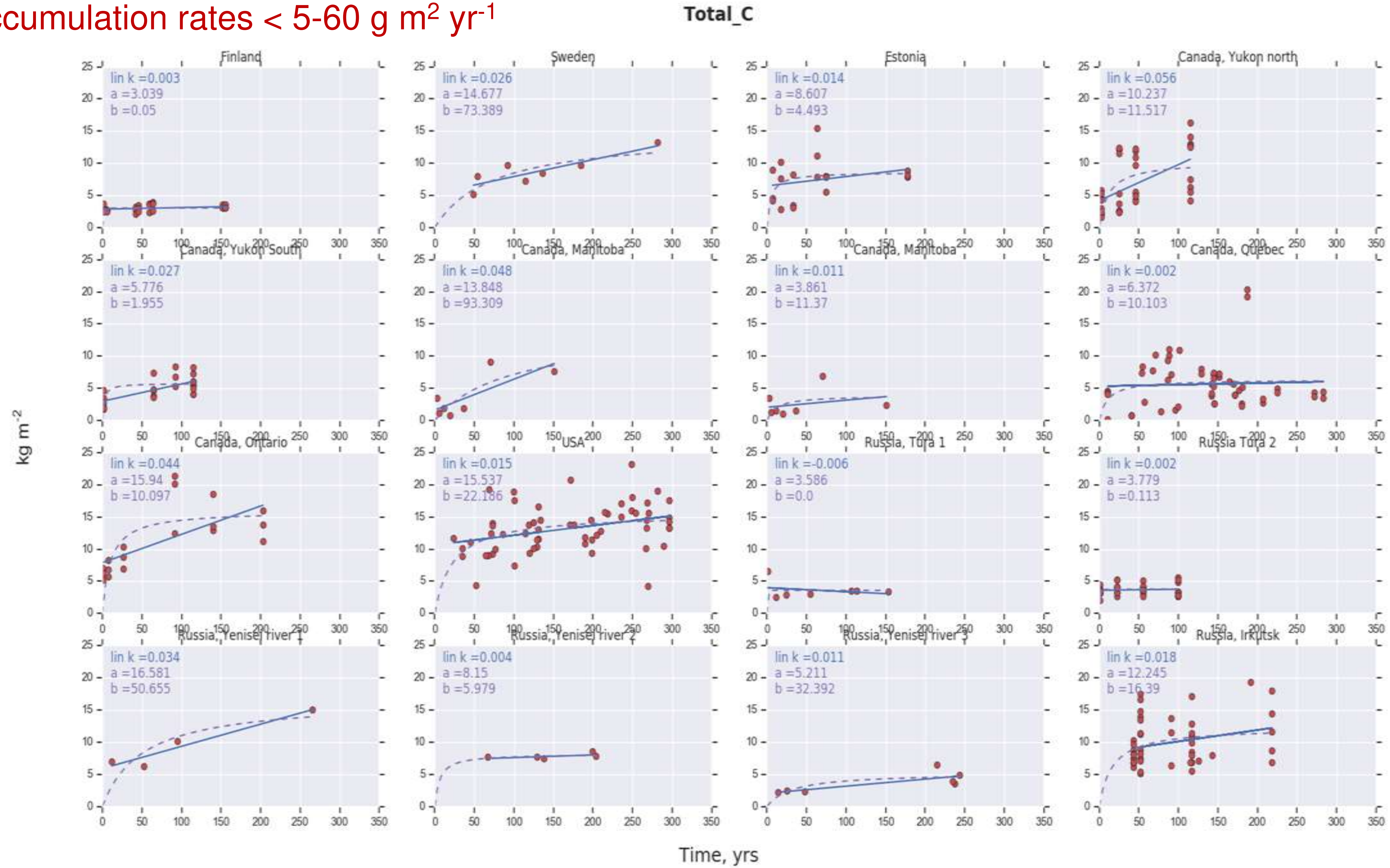
Total ecosystem carbon (living trees + ground vegetation + dead trees + organic layer)





Time since fire and PET together explained 57% of the variation in total ecosystem C stocks

C accumulation rates < 5-60 $g\ m^2\ yr^{-1}$



Conclusions

- Annual C accumulation rates varied from < 5 to 60 g m^2
- PET is the most important factor explaining the C accumulation in trees and total ecosystem
- Accumulation pattern is not clear: linear vs. curved?
- O-horizon: several factors affect (climate→ biomass production and decomposition), changes in vegetation, successional trajectories, microbial communities, organic matter quality, the amount of dead trees and rhizosphere priming effect, the formation of pyrogenic compounds etc.
- Soil is naturally heterogenic, and during the fire, the severity of combustion is variable ranging from a light burning to an extensive combustion of surface soils layers which may further increase the spatial variation → adequate number of samples?

Methodological remarks

- Weaknesses of the chronosequence method:
- Assumption that only time since disturbance causes the differences
- Pre-fire structure and fire severity are very difficult to identify and may vary within the chronosequence (also the severity of previous fires may have varied between the sites)
    - Difficult to ascertain the similarity of plots within the chronosequence
        - Fertility, paludification, soil texture
        - Stochastic phenomena, history in pest and diseases

Thank you!

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