benefits of coupling belowground carbon dynamics to eddy-covariance measurements of ecosystem CO_2 exchange with the atmosphere

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White Paper: Recommendations for Belowground Carbon Data and Measurements for the AmeriFlux Network

McFarlane et al. (2014)

"Integrating measurements of eddy covariance fluxes with belowground C will yield substantial improvements to process-level representations of the C cycle in ecosystem and Earth system models."

2 Examples:

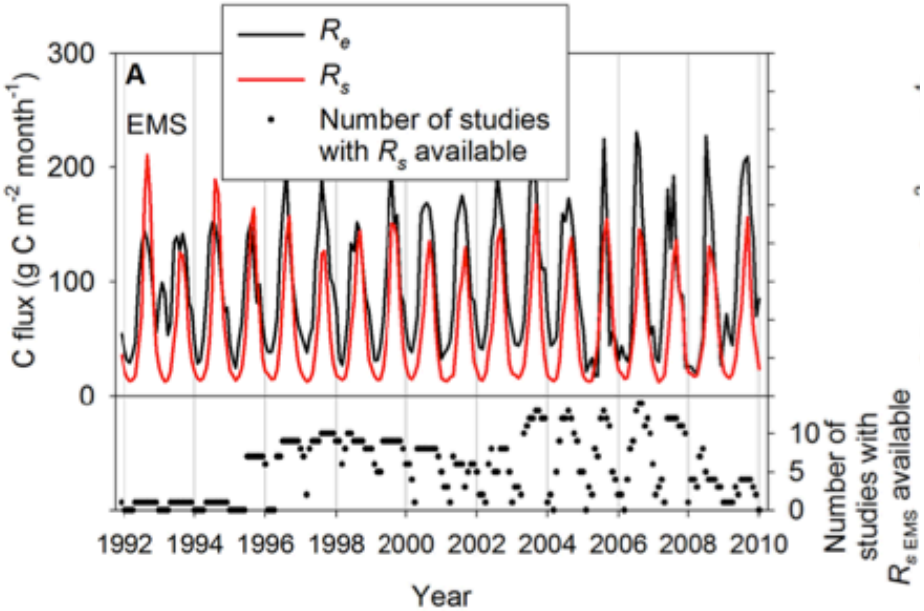
I. Site-scale analysis of phenology: above vs. belowground ecosystem respiration

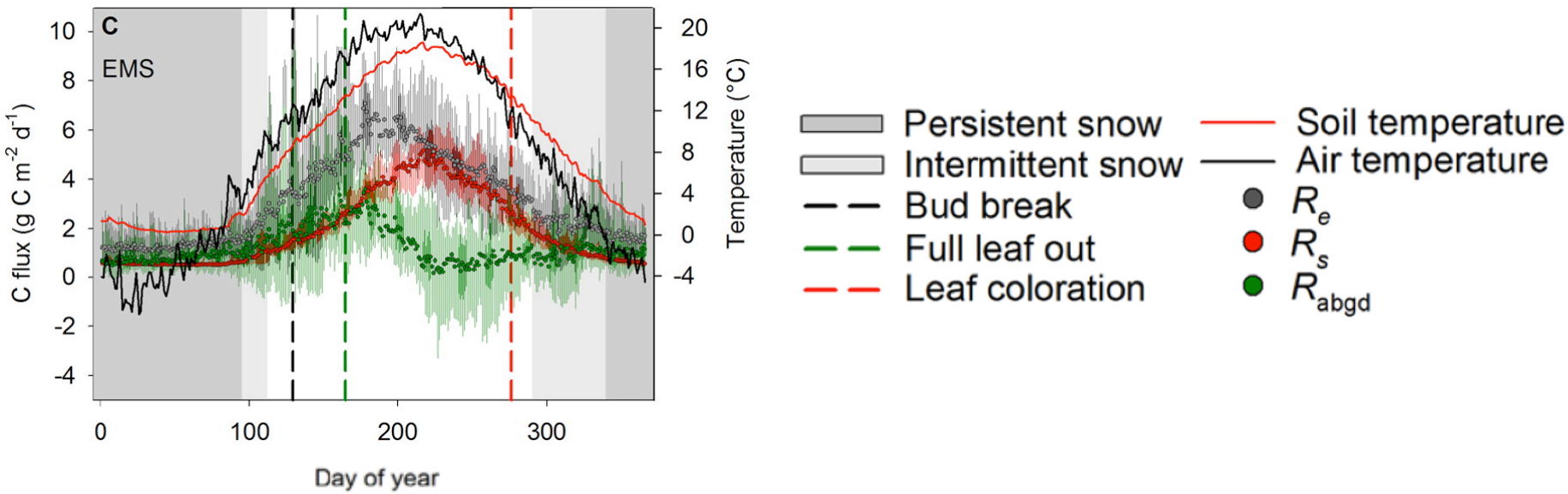
II. Global-scale analysis of C partitioning coefficients and "costs" of N and P uptake

Soil respiration in a northeastern US temperate forest: a 22-year synthesis

Giasson et al (2013) Ecosphere

Harvard Forest EMS [shown] & HEM towers
>100,000 obs. of soil respiration [Rs]
18-site years of eddy covariance data

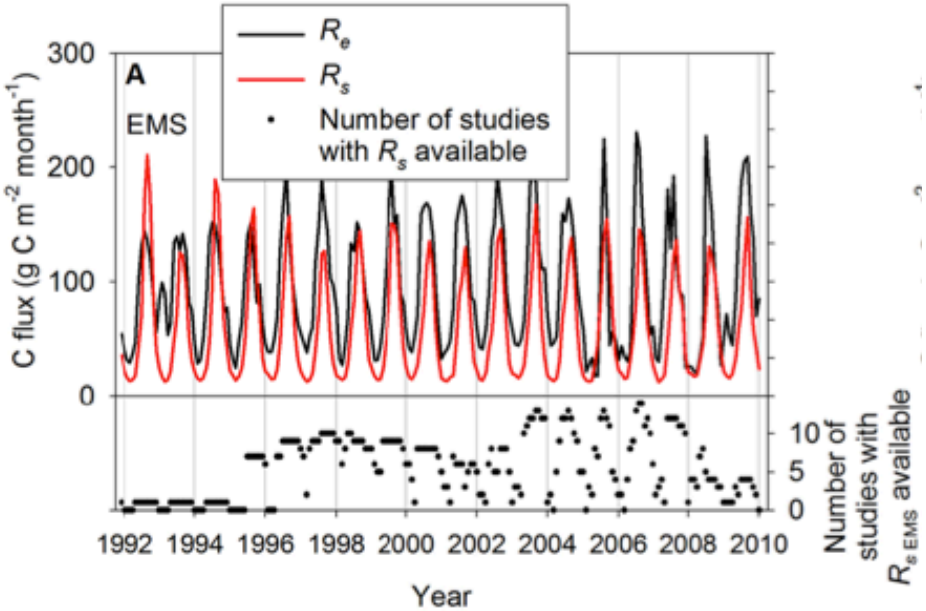




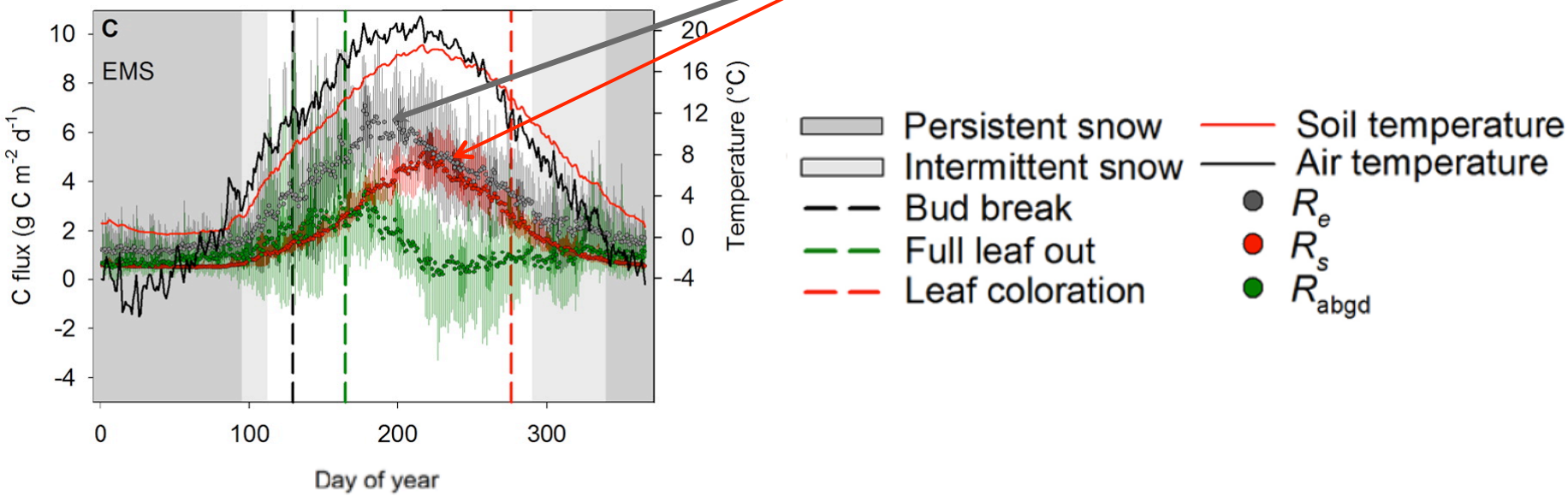
Soil respiration in a northeastern US temperate forest: a 22-year synthesis

Giasson et al (2013) Ecosphere

Peak in Reco 20-40 days **prior** to peak in soil respiration



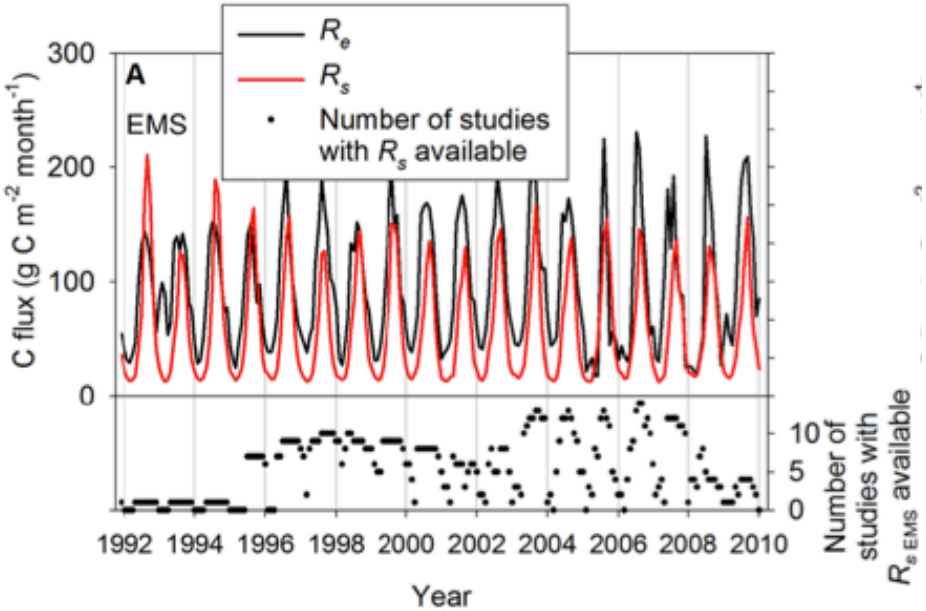
Reco [gray] peaks before Rsoil [red]



Soil respiration in a northeastern US temperate forest: a 22-year synthesis

Giasson et al (2013) Ecosphere

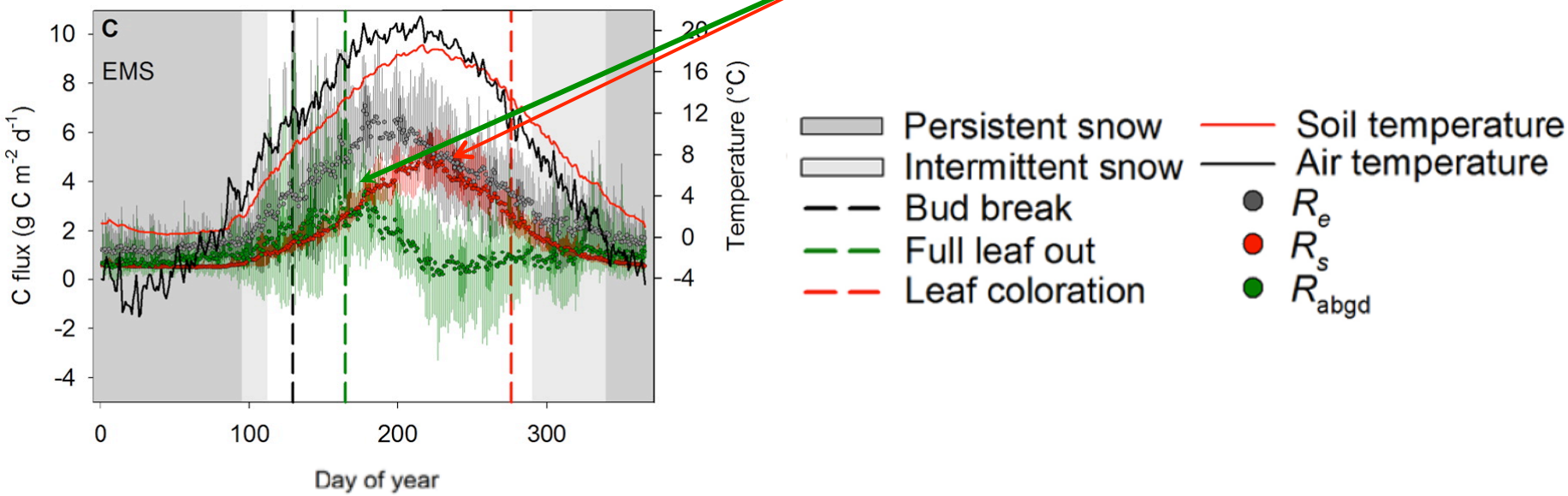
Aboveground respiration small fraction of and early contributor to total Reco



$R_{aboveground}$ = Reco – Rsoil

$R_{aboveground}$ peaks before Rsoil [red]

> max between bud break & full leaf out



Soil respiration in a northeastern US temperate forest: a 22-year synthesis

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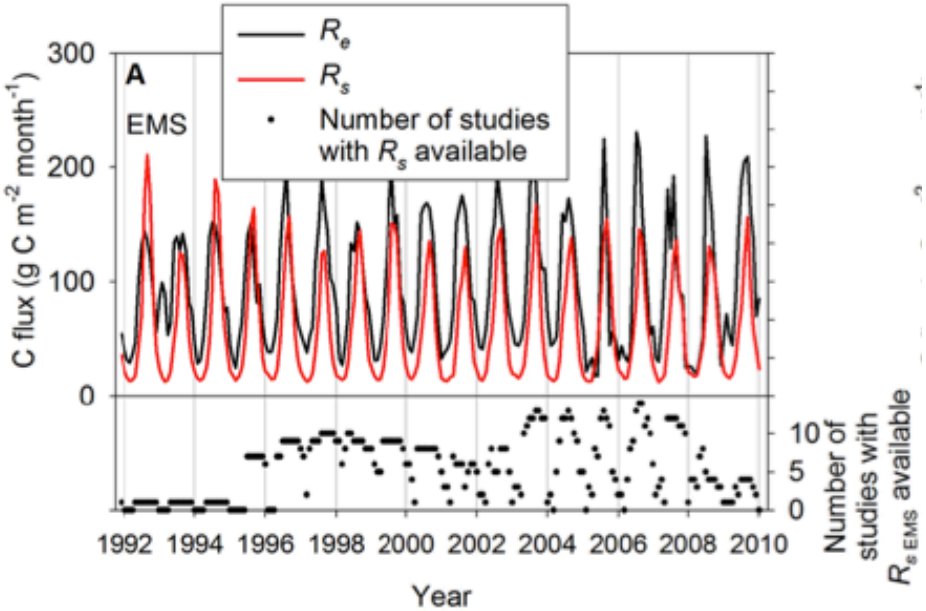
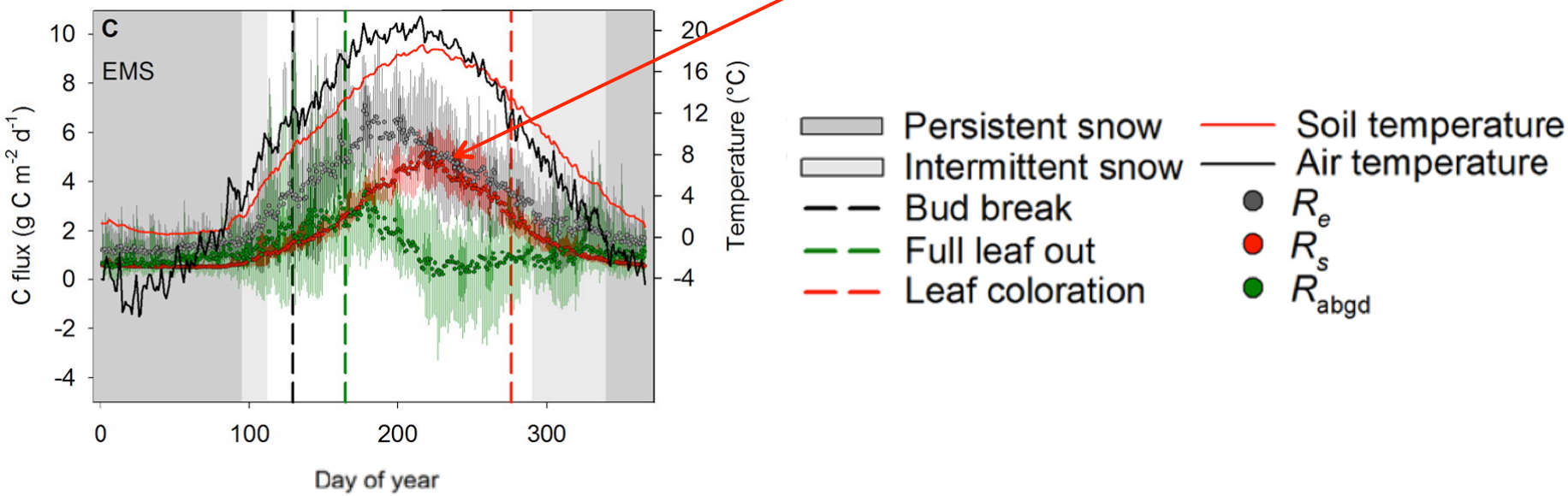
Belowground processes critical to understanding Reco / NEP



Rsoil is majority of Reco flux
64 ± 12% [range 50-90%]



Global-Scale Analysis of Belowground C Fluxes & Coupled Biogeochemical Cycles

Gill & Finzi (*in prep.*)

What fraction of GPP is allocated belowground?
How does this flux relate to soil resource acquisition?

Number of independent observations; different studies measured different things

Biome	La Thuile GPP	Total Belowground Carbon Flux	Annual Net Nitrogen Mineralization	Hedley Fractionation Phosphorus Pools	Annual Precipitation
Tropical	8	20	15	45	9
Subtropical	8	2	23	9	9
Mediterranean	25	11	11	8	26
Temperate Grassland	21	7	30	40	25
Temperate Deciduous	23	24	59	17	30
Temperate Coniferous	9	33	49	8	9
Boreal	9	24	47	6	15
Total Studies	**103**	**121**	**234**	**133**	**123**

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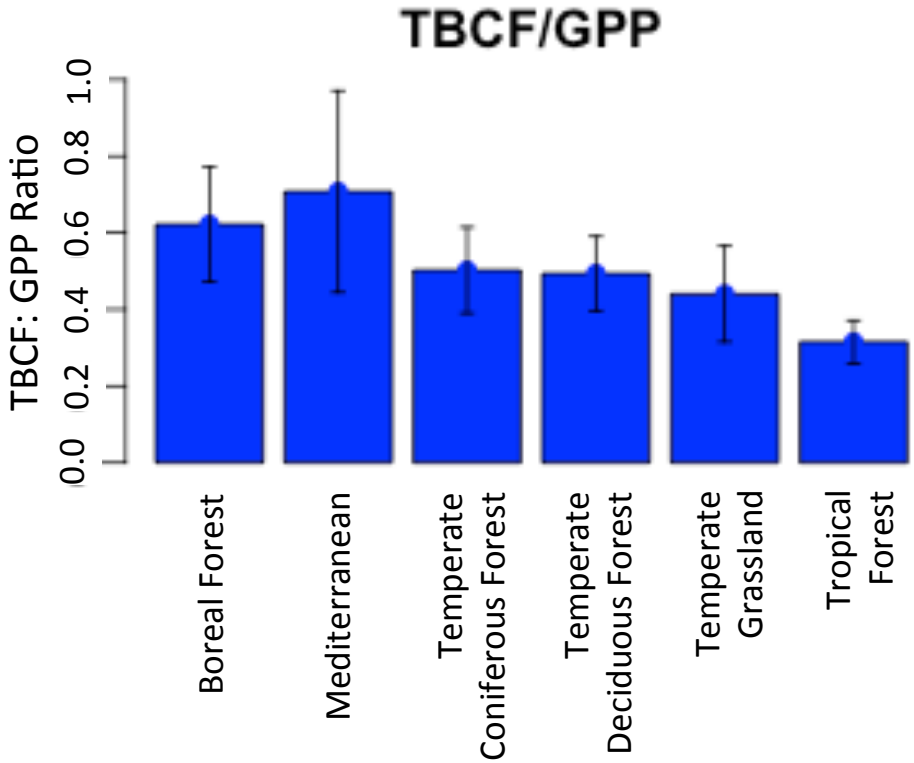

What fraction of GPP is allocated belowground?

Lowest in Tropics, 30%

Boreal and Mediterranean Biomes, 60-70%

Partitioning coefficients for MODELS!

Global-Scale Analysis of Belowground C Fluxes & Coupled Biogeochemical Cycles

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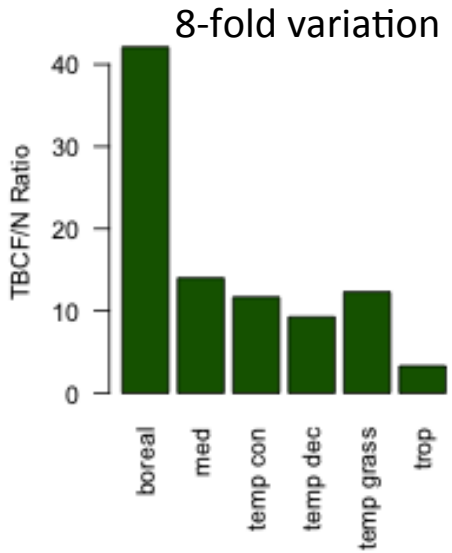
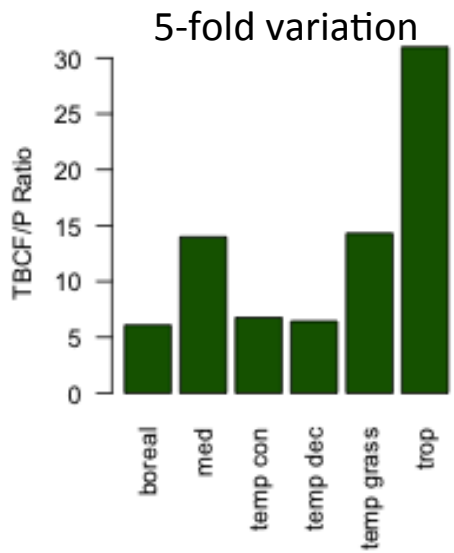




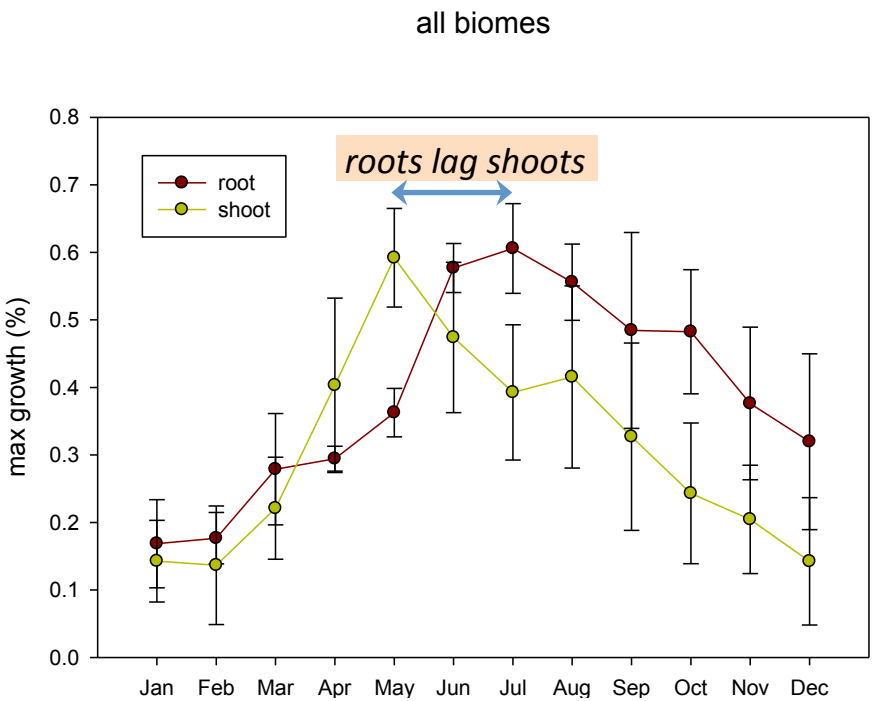
How does this flux relate to soil resource acquisition?

C investment belowground proportional to known biome-scale variations in N vs P limitation

High C partitioning coefficient and N "cost" in boreal biome suggests N limitation more significant constraint on GPP than P limitation in the tropics.

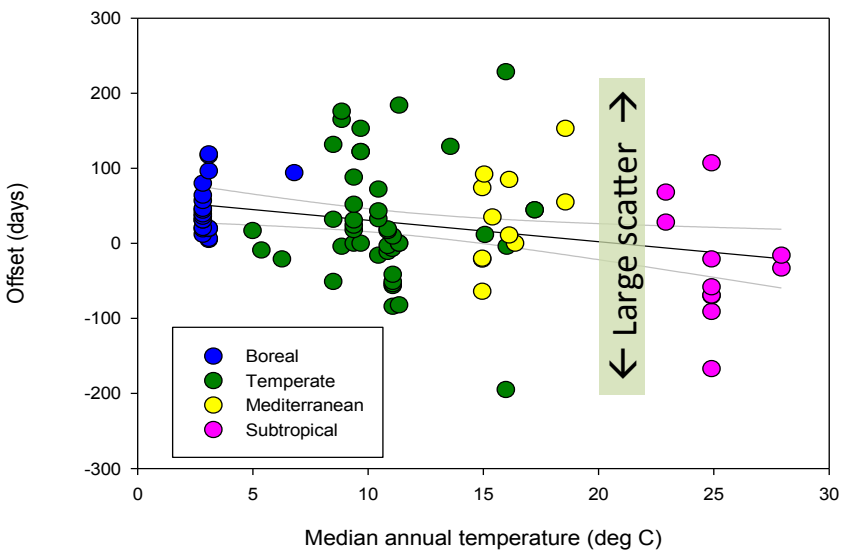
Are above and belowground phenology in sync? A meta-analysis & hypothesis

Abramoff & Finzi (New Phytologist)



Take Away: root and shoot growth is asynchronus unlike what most models assume

* reasonably widespread phenomenon
* root and shoot phenology are NOT in sync
  [boreal & temperate forest, Mediterranean and subtropical studies]



* Increasing offset due to climatic control over offset between peak
* Boreal lab >> subtropical
* Variability suggests endogenous controls more important