Quantifying the Importance of Belowground Plant Allocation for Sequestration of Carbon in Soil

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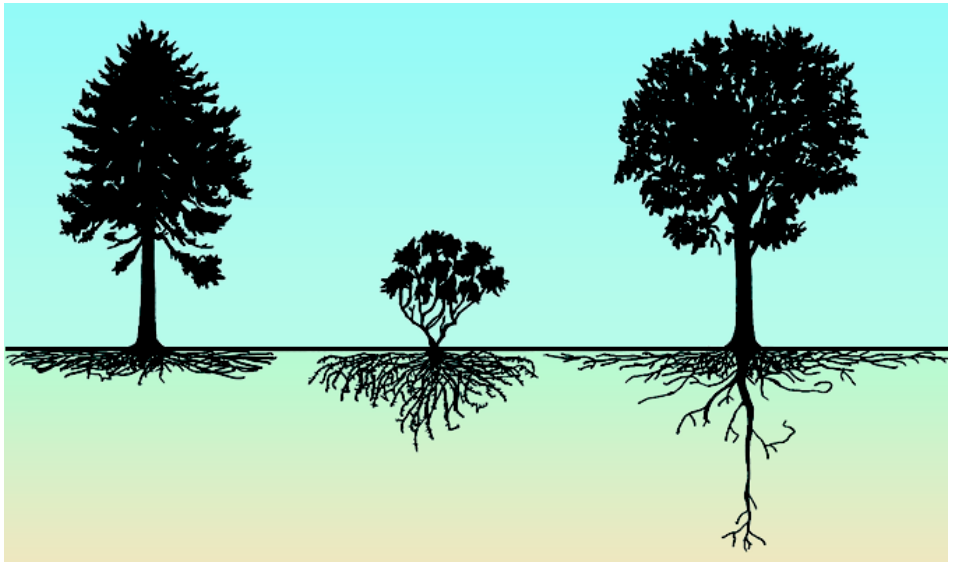

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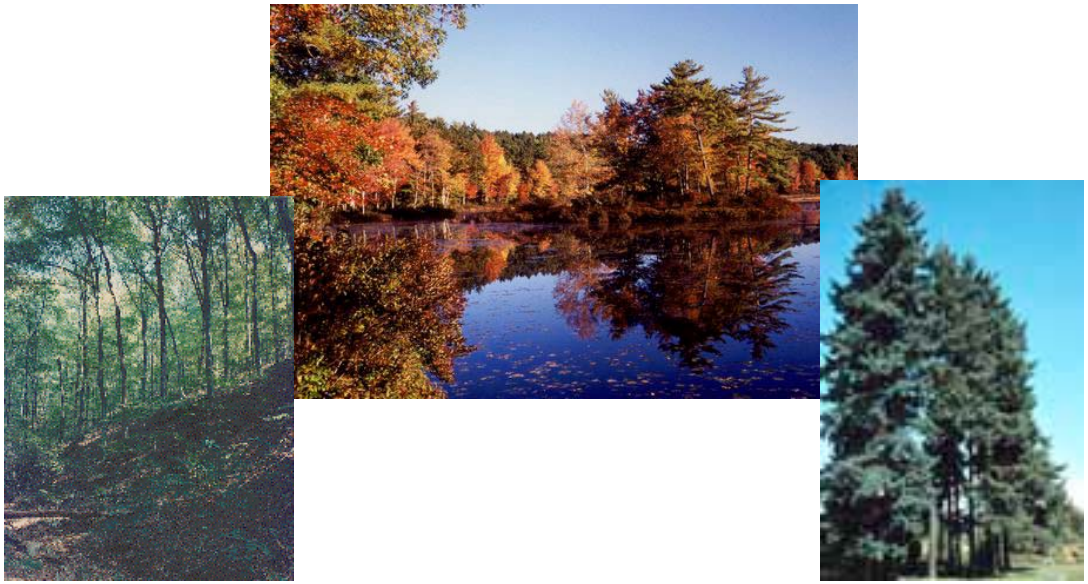
Temperate Forests



To sequester more C in temperate forests, is there an advantage to increasing plant allocation belowground vs. aboveground?

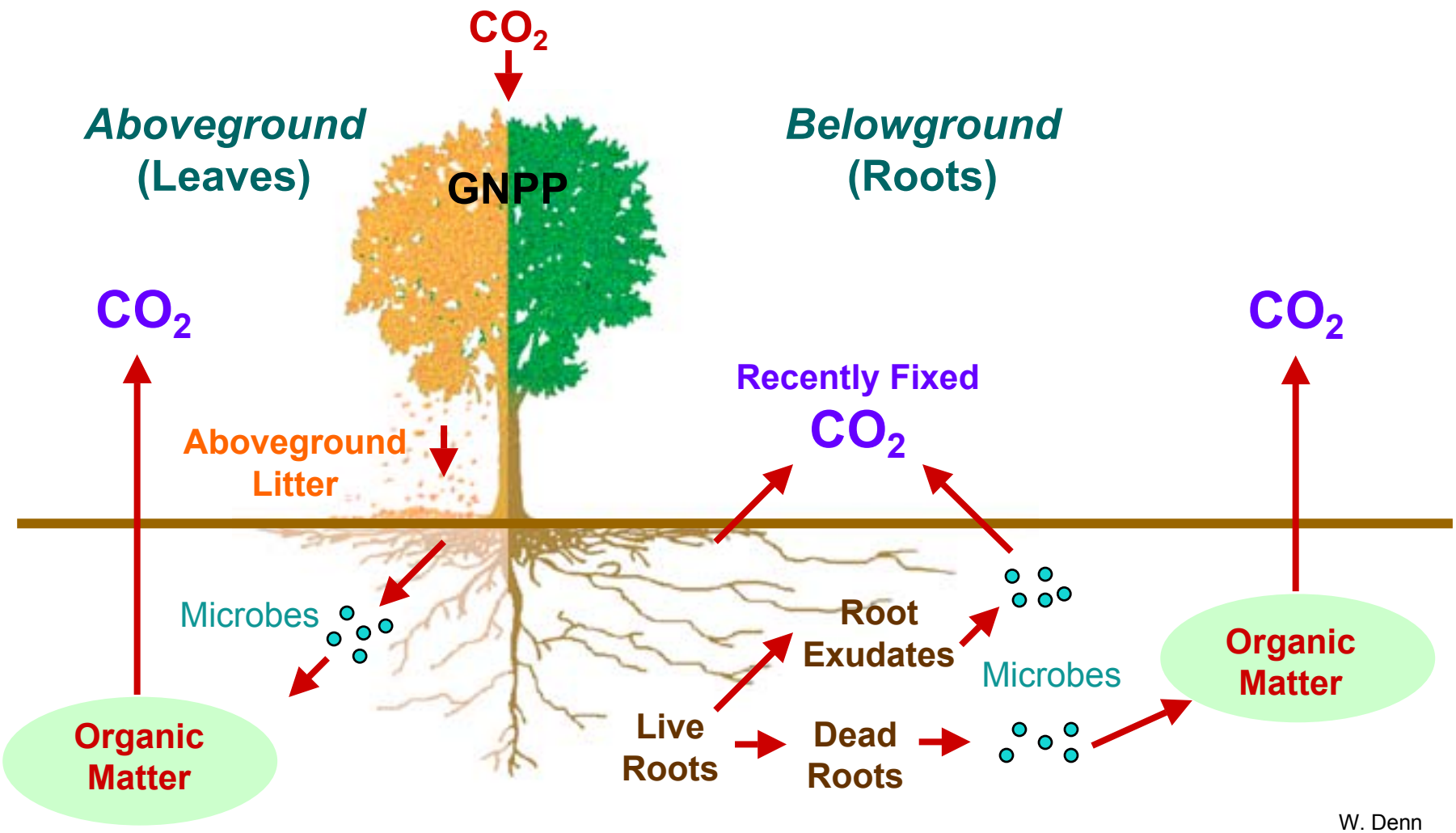
- Residence time of root vs. litter inputs
- Decomposition dynamics of roots vs. litter
- Total residence time of belowground C, including SOM

For same NPP

Slower Turnover = More Storage

PLANT ALLOCATION

ROOTS VS. LEAVES



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Component	Approach
Root Lifetimes	^{14}C, screen, methods comparison
Decay rate of roots vs. leaves	Litter bags with Roots or Leaves Soil depth vs Litter quality
Decomposition pathways & products, roots vs. needles	^{13}C labeled litter, ^{13}C-PLFA
SOM turnover times	^{14}C, respiration, NPP
Fate of recent photosynthate	^{13}C pulse label. Track roots, respiration, microbes
Total residence time	Ecosystem model

Root Lifetimes: Dominant Paradigm in Forest Ecology

Fine roots live 1-2 years

Fine roots are made from recently fixed photosynthate

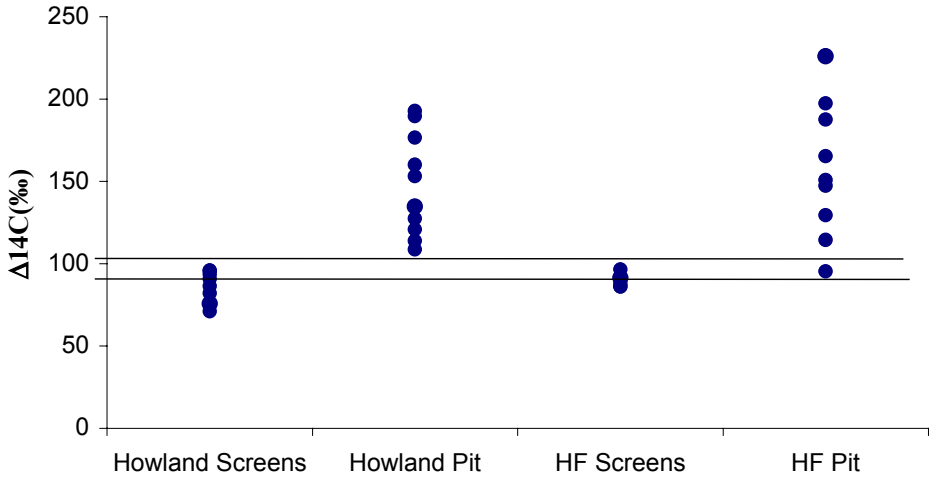
Technique	Turnover time
Sequential Coring*	1-2 years
In-growth cores*	1-2 years
Mini-rhizotrons	months
Screen counting	months
Litter bag*	2-5 years

*assumes all roots turnover at same rate

BUT!

Bomb-^{14}C technique in temperate and tropical forests shows that fine roots may be living many years.

Average age 3-18 y !



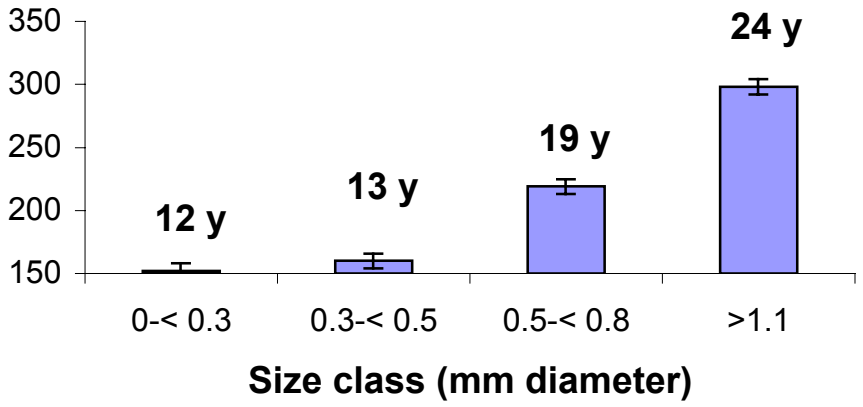
Gaudinski et al., Oecologia, 2001

DETERMINING THE LIFESPAN OF FINE ROOTS

- *Hypothesis:*
- **Fine roots have a continuum of lifetimes, from months to many years**
- *Methods:*

Apply ^{14}C technique in four forests, with fine size class resolution and by branching order. Compare bomb-^{14}C approach with traditional techniques at same sites

Preliminary Results from Harvard Forest:
Root ages 12–24 years. Ages differ with root size.



Error bars are analytical error

DECOMPOSITION

PATHWAYS, RATE, AND STORAGE

- **Do roots decompose more slowly than AG litter?**
- **Are roots and litter associated with different decomposer communities and decay products?**

- Do roots produce more stable SOM than litter?
- Are differences due to Chemistry or Soil Location?
- How does soil depth influence decomposition rate, SOM products, and long-term stabilization?

DECOMPOSITION

Experimental Approach

Compare decomposition and humification:

- **Fine root vs. needles**
- **O vs. A horizon**

Methods

- **Dual-labeled ^{13}C and ^{15}N pine roots and needles**
- **PVC microcosm with screen for roots & hyphae**
- **Follow fate of $^{13}C/^{15}N$-labelled substrates in:**
  - **Microbial biomass and community (PLFA)**
  - **Labile and resistant SOM fractions**
  - **(POM, fulvics, humics, humin)**
  - **Mineralized CO_2 and inorganic N**

SIGNIFICANCE AND BENEFITS TO SEQUESTRATION

Early Results

- **Roots live longer than needles or leaves.**

  3-24 years vs 1-3 years

Implications for Sequestration

- ***Roots have advantage for sequestration.***
- Reduces estimates of belowground NPP (~50%) currently based on annual root turnover.