Impact of drought on C cycle of temperate deciduous forest: a modeling analyses of C allocation

Matteo Campioli\textsuperscript{1} & Hans Verbeeck\textsuperscript{2}

\textsuperscript{1} Research Group of Plant and Vegetation Ecology, University of Antwerp, Belgium
\textsuperscript{2} Laboratory of Plant Ecology, Ghent University, Belgium
INTRODUCTION – C cycle

INTRODUCTION - drought

- **projections**
  - precipitation response
    summer 1980/90 - 2080/90

- **observations**
  - e.g. reduction in biomass production in summer 2003

IPCC - Christensen et al. 2007

Nature - Ciais et al. 2005
INTRODUCTION – C cycle & drought

C flux land-atmosphere
- C uptake photosynthesis
- C release respiration

C allocation ecosystem
- C distribution organs (roots, stem, leaves)
- e.g. leaves → fast C return atmosphere
- e.g. wood → slow C return atmosphere

- integrated datasets
  - Eddy covariance networks
- many observations
- advanced modeling

- no integrated datasets
- many observations
  - single measurements
    - e.g. ↓ wood production
- limited modeling
OBJECTIVE

• model C allocation temperate forest
  – nonfoliar vegetation (branches, wood, roots)
• model effect drought on C cycle
• study C allocation (temporal, drought)
METHODOLOGY – study site

beech forest NE France
- altitude 300 m
- temperature 9.2°C
- precipitation 820 mm
- 30 years old
- large datasets
METHODOLOGY - model

1. Canopy module (LEAVES: photosynthesis, evapotranspiration)

2. Allocation module (NON-LEAVES: respiration, growth, C storage, mortality)

3. Changes drought
   (i) ↓ photosynthesis  (ii) ↑ fine roots mortality  (iii) ↑↓ fine roots growth
   (iv) ↓ wood growth    (v) ↑ reserve
RESULTS – model testing

GPP (Mg C ha\(^{-1}\) d\(^{-1}\))

<table>
<thead>
<tr>
<th>Year</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
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<tbody>
<tr>
<td>Modelled stem biomass (Mg C ha(^{-1}))</td>
<td>23</td>
<td>25</td>
<td>27</td>
<td>29</td>
<td>31</td>
<td>33</td>
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<tr>
<td>Measured stem biomass (Mg C ha(^{-1}))</td>
<td>24</td>
<td>26</td>
<td>28</td>
<td>30</td>
<td>32</td>
<td>34</td>
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measured stem circumference (cm)

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<td>Meas.</td>
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photosynthesis

stem phenology

reserve

wood growth

discrepancy seasonality – good annual scale

wood respiration (error 1%)
root respiration (error 6%)
fine root turnover (error 1%)
RESULTS – temporal variability

The diagram illustrates the temporal variability of carbon reserves in different compartments of a forest ecosystem. The x-axis represents the day of the year in 1999, while the y-axis shows the Mg C reserve ha\(^{-1}\) for each compartment.

- **Structural Wood**: The graph shows a gradual increase in carbon reserves from early to late in the year, with a peak around the middle of the season.
- **Non-Structural Wood**: This compartment experiences a seasonal variation, with a peak in the winter months.
- **Leaves**: Carbon reserves in leaves fluctuate significantly, with a peak in the late summer and early autumn.
- **Fine Roots**: The carbon reserves in fine roots are relatively stable throughout the year, with slight variations.

The top right corner of the diagram shows the same data for the years 2000 to 2004, indicating a possible long-term trend in carbon reserves across different seasons and years.

The term **REW** (Reindeer Equivalent Value) is also mentioned, which could be a measure of the productivity or carbon sequestration capacity of the ecosystem.
RESULTS – C cycle & drought

Drought effect

1. ↓ biomass production (severe drought)
2. ~ respiration
3. ↑ post-drought fine root production
4. changes allocation
   - ↑ fine roots growth
   - ↑ C reserve
   - ↓ wood production

INCREASE ALLOCATION
SHORT-TERM C POOLS (+16%)
CONCLUSION

• drought decreases C storage forest:
  – reduced assimilation
  – reduced accumulation long-term C pools

• future needs:
  – EXP: integrated datasets
  – MOD: drought-effect leaves
  – MOD: interannual growth dynamics