Retrospective analysis of sapling growth vs. light interception

O. Taugourdeau, J. Dauzat, S. Griffon, F. de Coligny, S. Sabatier, Y. Caraglio and D. Barthélémy
Background

Methodology to **Quantify plants responses to their environment**

Characterization of light environment
→ whole plant
→ intra-plant

Long-term responses to local light env.

Stoll & Schmid, 1998
Retrospective analysis of sapling growth vs. light interception

**Background**

Methodology to **Quantify plants responses to their environment**

Characterization of light environment
→ whole plant
→ intra-plant

Link with FSPM:

Parametrization of plant growth simulators

**FSPM September 2010 (Davis)**
Background

Methodology to **Quantify plant response to their environment**

Frameworks for test hypothesis

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**A modular concept of plant foraging behaviour: the interplay between local responses and systemic control**

HANS DE KROONI, ERIC J. W. VISSERI, HEIDRUN HUBERI, LIESJE MOMMER1,2 & MICHAEL J. HUTCHINGS1


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**A conceptual framework for the study of modular responses to local environmental heterogeneity within the plant crown and a review of related concepts**

Koji Kawamura

Retrospective analysis of sapling growth vs. light interception

**Background**

Methodology to **Quantify plant response to their environment**

Frameworks for test hypothesis

*A modular concept of plant foraging behaviour: the interplay between local responses and systemic control*

HANS DE KROON¹, ERIC J.W. VISSER¹, HEIDRUN HUBER¹, LIESJE MOMMER¹² & MICHAEL J. HUTCHINGS¹


*A conceptual framework for the study of modular responses to local environmental heterogeneity within the plant crown and a review of related concepts*

→ Need of simulation
Retrospective analysis of sapling growth vs. light interception

Sinoquet et al., 2007

Delagrange et al., 2006

Pearcy et al., 2004

Stephan et al., 2007

Light interception simulation = 3D virtual plant

Light interception simulation

3D virtual plant
Retrospective analysis of sapling growth vs. light interception

- Retrospective analysis of growth
- Reconstruction of a dynamic virtual plant
- Field reconstruction and light interception simulation
- Link between light interception and following growth
Retrospective analysis of sapling growth vs. light interception

Using markers of growth to make growth unit delimitation

Protea cynaroides

G.U.

G.U.

G.U.

G.U.


INVITED REVIEW

Plant Architecture: A Dynamic, Multilevel and Comprehensive Approach to Plant Form, Structure and Ontogeny

DANIEL BARTHÉLÉMY¹,* and YVES CARAGLIO²
Using markers of growth to make *(a posteriori)* growth unit delimitation


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*Protea cynaroides*  
*G.U.*  
1  
*ca*  
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*Carya laciniosa*  
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INVITED REVIEW

Plant Architecture: A Dynamic, Multilevel and Comprehensive Approach to Plant Form, Structure and Ontogeny

DANIEL BARTHÉLÉMY\(^1\,*\) and YVES CARAGLIO\(^2\)
Retrospective analysis of sapling growth vs. light interception

Annual shoot identification

Hivernal bud

During budbreak
Annual shoot identification

*Abies alba*

*Hivernal bud*

During budbreak
Retrospective analysis of sapling growth vs. light interception

Annual shoot identification and datation

Abies alba

During budbreak
Retrospective analysis of sapling growth vs. light interception

Annual shoot identification and datation

*Abies alba*

**Outside**: 2010

**Trunk**: 2010

**Branche**: 2005

**Inside**: 1989

**During budbreak**
Markers removing

Populus nigra

Godin & Caraglio, 1998
Retrospective analysis of sapling growth vs. light interception

Markers removing

More than visible → Allometry

Fagus sylvatica

Unpublished data

Godin & Caraglio, 1998
Markers removing

Godin & Caraglio, 1998

More than visible
→ Allometry

Fagus sylvatica

Unpublished data

Measure simplification

Abies alba
Retrospective analysis of sapling growth vs. light interception

- Retrospective analysis of growth
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Hypothesis: Past light availability drives present firs saplings growth
Retrospective analysis of sapling growth vs. light interception

Experimental context

Aix-en-Provence (South France)
Retrospective analysis of sapling growth vs. light interception

Experimental context

- 35 saplings per box
- 290 plants/ m²
- 80% neutral shading
- 2 water treatments (wet, dry)
- 4 years of growth
- 1 box measured per treatment

Aix-en-Provence (South France)
Retrospective analysis of sapling growth vs. light interception

Reconstruction of a dynamic virtual plant

Measurements:
- Topology
- By GU:
  - Length
  - Base diameter
  - Year

MTG (Godin & Caraglio, 1998)
Reconstruction of a dynamic virtual plant

Measurements:
- Topology
- By GU:
  - Length
  - Base diameter
  - Year

MTG (Godin & Caraglio, 1998)

Angles not exhaustively measured

Model based on observation and measurement
Retrospective analysis of sapling growth vs. light interception

Needles not measured

Size allometry

Three needles layers

Model partially based on observation and measurement
Retrospective analysis of sapling growth vs. light interception

Annual shoot datation
Retrospective analysis of sapling growth vs. light interception

A posteriori development reconstruction!
Retrospective analysis of sapling growth vs. light interception

A posteriori development reconstruction!

Linking light interception and growth
Retrospective analysis of sapling growth vs. light interception

- Retrospective analysis of growth
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Retrospective analysis of sapling growth vs. light interception

Field reconstruction
Light interception simulation

Sky vault division into 46 sky sectors

Dauzat et al. 2007
Retrospective analysis of sapling growth vs. light interception

Light interception simulation

Weights depend on sun path during the integration period

Sky vault division into 46 sky sectors

Dauzat et al. 2007
Retrospective analysis of sapling growth vs. light interception

Light interception simulation

Visible pixels receive lights

Dauzat et al. 2007
Retrospective analysis of sapling growth vs. light interception

Light interception simulation

Toricity for neighbour boxes

Dauzat et al. 2007
Retrospective analysis of sapling growth vs. light interception

Light interception simulation

Assign intercepted light for each plant part

Dauzat et al. 2007
Retrospective analysis of sapling growth vs. light interception

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\[ \text{N. Area Increment } y_3 \text{ to } y_4 = f(\text{NA } y_3) \]

<table>
<thead>
<tr>
<th>Condition</th>
<th>( R^2 )</th>
<th>AIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet</td>
<td>0.69</td>
<td>280</td>
</tr>
<tr>
<td>Dry</td>
<td>0.70</td>
<td>295</td>
</tr>
</tbody>
</table>

ANOVA (model 1, model 2):
- \( F \)-value: 3.39 (*
- \( F \)-value: 0.71 (ns)
Retrospective analysis of sapling growth vs. light interception

N. Area Increment y3 to y4 = f(NA y3)

N. Area Increment y3 to y4 = f(NA y3, LI y3)

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<tr>
<td>Wet</td>
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Retrospective analysis of sapling growth vs. light interception

\[ N. \text{ Area Increment } y_3 \text{ to } y_4 = f(NA \ y_3) \]
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</table>

\[
\text{Total Needles Area } y_3
\]

\[
\text{Needles Area Increment } y_3 \text{ to } y_4
\]

\[
\text{Light Interception } y_3
\]
Retrospective analysis of sapling growth vs. light interception

**1st hypothesis:** Preferential carbon allocation

Navas & Garnier, 2002

Response to shade

Response to drought

Aboveground allocation

Underground allocation

Destructive measurement planned for next winter
Retrospective analysis of sapling growth vs. light interception

1st hypothesis: Preferential carbon allocation

Navas & Garnier, 2002

1st hypothesis:

Response to shade

Response to drought

Aboveground allocation

Underground allocation

2nd hypothesis: Carbon assimilation limitation due to hydraulic stress

Destructive measurement planned for next winter
Conclusions & Perspectives

Use of **botanical expertise and dedicated softwares** to make **past light interception** simulations which allows to assess feedback **between light and growth**
Conclusions & Perspectives

Use of *botanical expertise and dedicated softwares* to make *past light interception* simulations which allows to assess feedback *between light and growth*

• **Lags in plant responses:** growth reconstruction on several years
• **Asymmetric branches development:** more complex plants

→ Model parametrization
Conclusions & Perspectives

Use of **botanical expertise and dedicated softwares** to make **past light interception** simulations which allows to assess feedback **between light and growth**

- **Lags in plant responses**: growth reconstruction on several years
- **Asymmetric branches development**: more complex plants

→ Model parametrization

→ Demo session of the software used: Xplo