25 years of collaboration HH – KK on phenology modelling

What did we learn?

29 June 2016, Joensuu, Koen Kramer

WAGENINGEN UR
For quality of life

Boreal and Temperate Trees in a Changing Environment – Modelling the ecophysiology of seasonality.
28-29 June 2016, Joensuu, Finland.

Hänninen, 1990

Observations on dormancy

Table 1. Terminology of bud dormancy in trees used in the study.

State of bud, name of period	Definition	Process	End of period
Dormancy, bud dormancy	No visible growth	Dormancy release	Bud burst
Rest	No visible growth, and 1) no or reduced growth competence, or 2) no growth competence at low forcing temperatures and full growth competence at high forcing temperatures	Rest break (Ontogenetic development)	Rest completion (Bud burst)
Quiescence	No visible growth, and full growth competence at all forcing temperatures	Ontogenetic development	Bud burst

Hänninen, 1990

Progress in science – Hänninen, 1990

$$M_{chl}(t) = \begin{cases} 0 \text{ CU day}^{-1}, & T(t) \leq -3.4\,°C \\ 0.159 \text{ CU day}^{-1}\,°C^{-1} \cdot T(t) + 0.506 \text{ CU day}^{-1}, & -3.4\,°C < T(t) \leq 3.5\,°C \\ -0.159 \text{ CU day}^{-1}\,°C^{-1} \cdot T(t) + 1.621 \text{ CU day}^{-1}, & 3.5\,°C < T(t) \leq 10.4\,°C \\ 0 \text{ CU day}^{-1}, & T(t) > 10.4\,°C \end{cases}$$

$$m_{frc}(t) = \begin{cases} 0 \text{ FU day}^{-1}, & T(t) \leq 0\,°C \\ \dfrac{28.361 \text{ FU day}^{-1}}{1 + e^{-0.185\,°C^{-1} \cdot (T(t) - 18.431\,°C)}}, & T(t) > 0\,°C \end{cases}$$

$$M_{frc}(t) = C(t) \cdot m_{frc}(t)$$

$$S_{chl}(t) = \int_0^t M_{chl}(\tau)\, d\tau \qquad S_{chl}(t) \geq CU_{crit}$$

$$S_{frc}(t) = \int_0^t M_{frc}(\tau)\, d\tau \qquad S_{frc}(t) \geq FU_{crit}$$

INVESTIGATIONS ON THE ANNUAL CYCLE OF DEVELOPMENT OF FOREST TREES

II

Autumn dormancy and winter dormancy

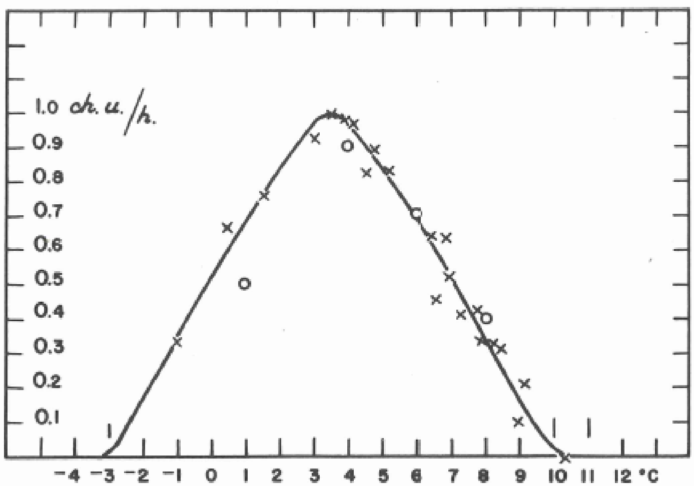
RISTO SARVAS

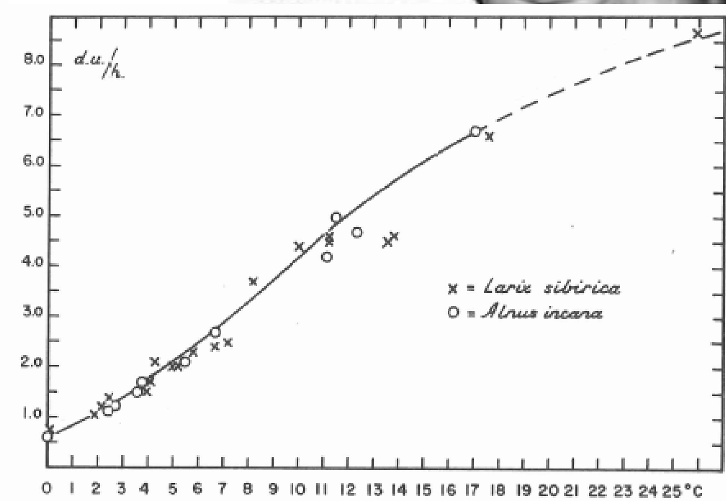
† 8. IV. 1974

TUTKIMUKSIA METSÄPUIDEN KEHITYKSEN VUOTUISESTA SYKLISTÄ

Syys- ja talvihorros

TIIVISTELMÄ





- State – rate approach: Sarvas (1972)
- Competence function: Pelkonen, Hari (1972, 1980, ...)

WAGENINGEN UR
For quality of life

Progress in science - Hänninen & Kramer, 2007

$$S(t) = \int_{t_0}^{t} R(t)\,dt$$

$$R(t) = f(E(t))$$

$$S(t) = S_i(t), i = 1,2,3\ldots$$

$$R_i(t) = f_i(E(t), S_i(t))$$

$$R_i(t) = f_i(E(t), S_j(t))$$

$$R_o(t) = C_o(t) \cdot R_{o,\mathrm{pot}}(t)$$

$$R_o(t) = C_o(S_r(t)) \cdot R_{o,\mathrm{pot}}(T(t))$$

SILVA FENNICA
Silva Fennica 41(1) review articles
www.metla.fi/silvafennica · ISSN 0037-5330
The Finnish Society of Forest Science · The Finnish Forest Research Institute

A Framework for Modelling the Annual Cycle of Trees in Boreal and Temperate Regions

Heikki Hänninen and Koen Kramer

- E-models
- ES-models

S – state

R – rate

C – competence

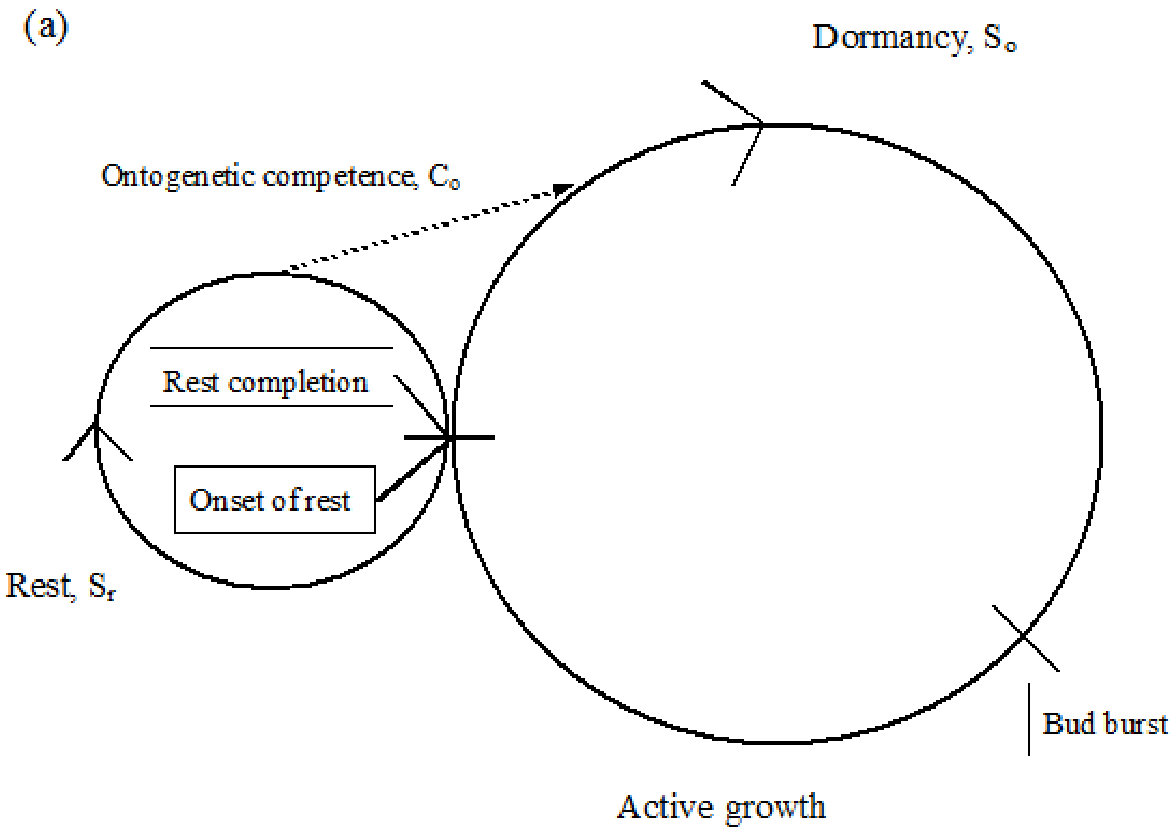
E – environment

pot = potential

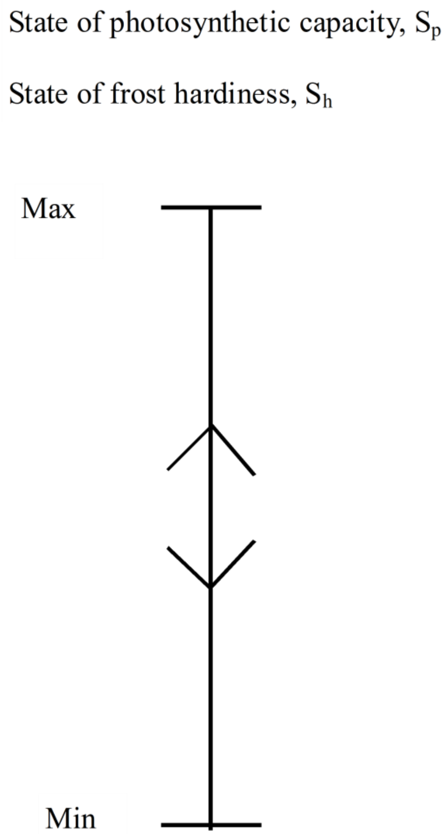
WAGENINGEN UR
For quality of life

Models of ontogenetic development

fixed sequence

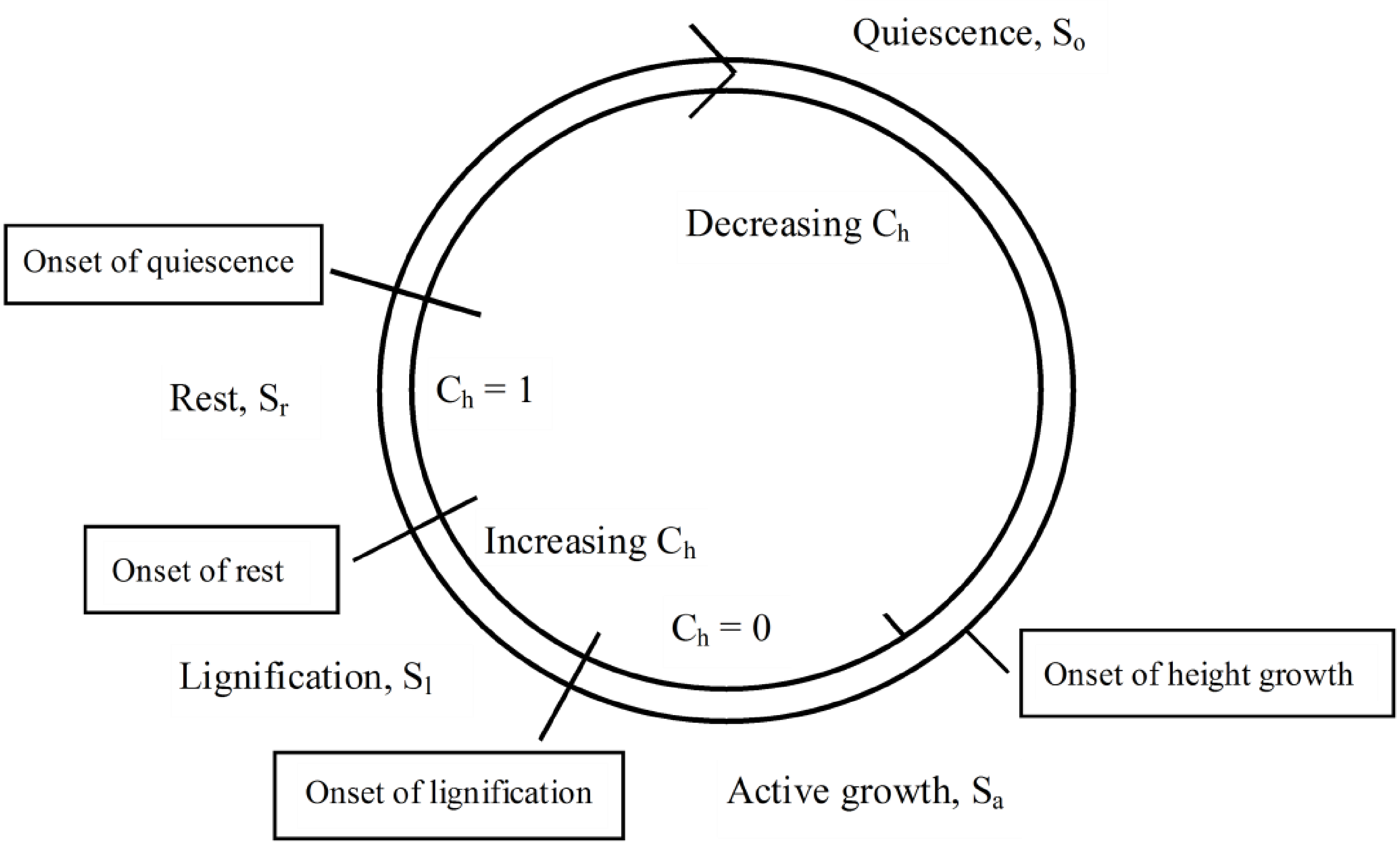


fluctuating



Pelkonen
Hari
Leinonen
Kellomaki

coupled fixed-sequence – fluctuating development model



WAGENINGEN UR
For quality of life

Leinonen
Kellomaki

Characteristics fixed sequence- vs fluctuating development

	Fixed-Sequence	Fluctuating
Driving force	environment	fluctuations in environment
Genetics	rate of ontogenetic development, thresholds	stationary states, time constants
Development	irreversible	Reversible

WAGENINGEN UR
For quality of life

The Annual Cycle of Development of Trees and Process-Based Modelling of Growth to Scale Up From the Tree To the Stand

Koen Kramer[1] and Heikki Hänninen[2]

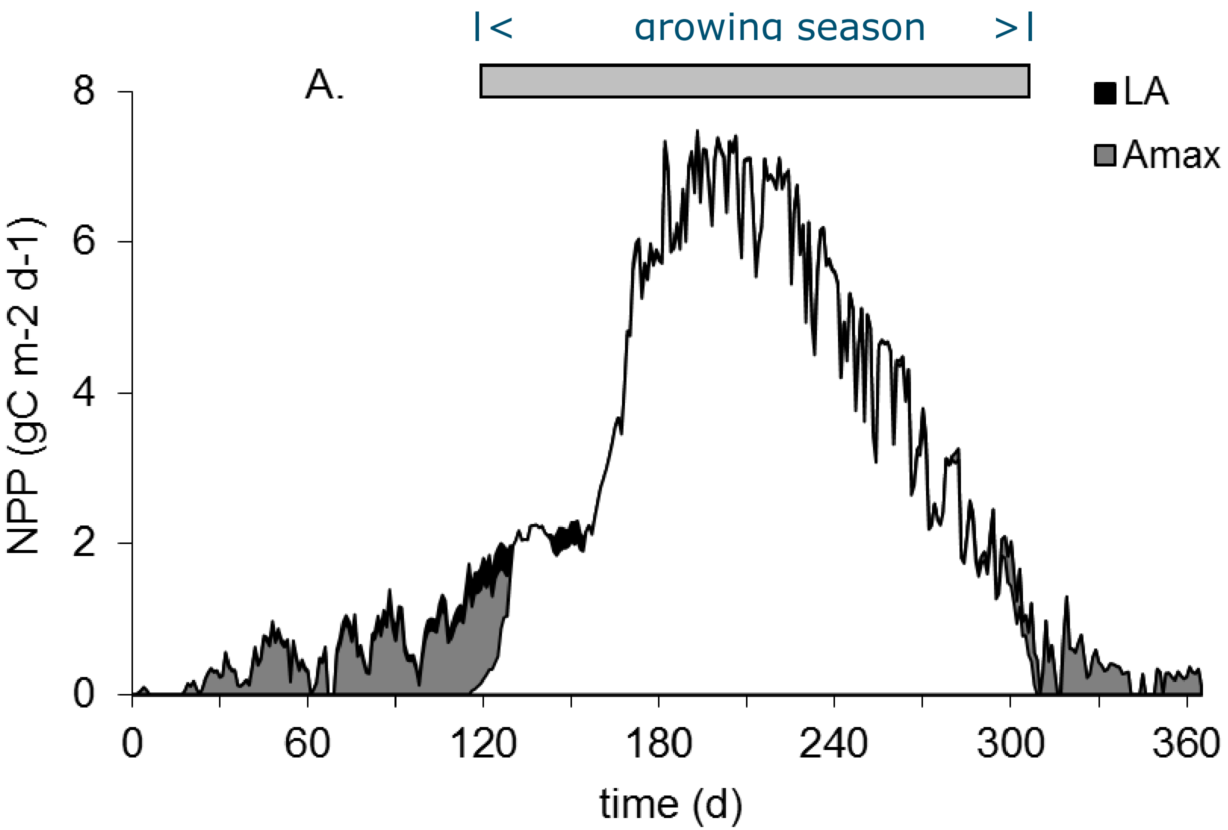
A. Noormets, *Phenology of Ecosystem Processes*,
DOI 10.1007/ 978-1-4419-0026-5_9, © Springer Science+Business Media, LLC 2009

Modelling annual cycle of development to assess:

- timing of bud burst (fixed-sequence)
- timing growth cessation (fixed-sequence)
- seasonality frost hardiness (fluctuating)
- seasonality of photosynthetic capacity (fluctuating)

Kramer & Hänninen, 2009

assess importance of frost hardiness



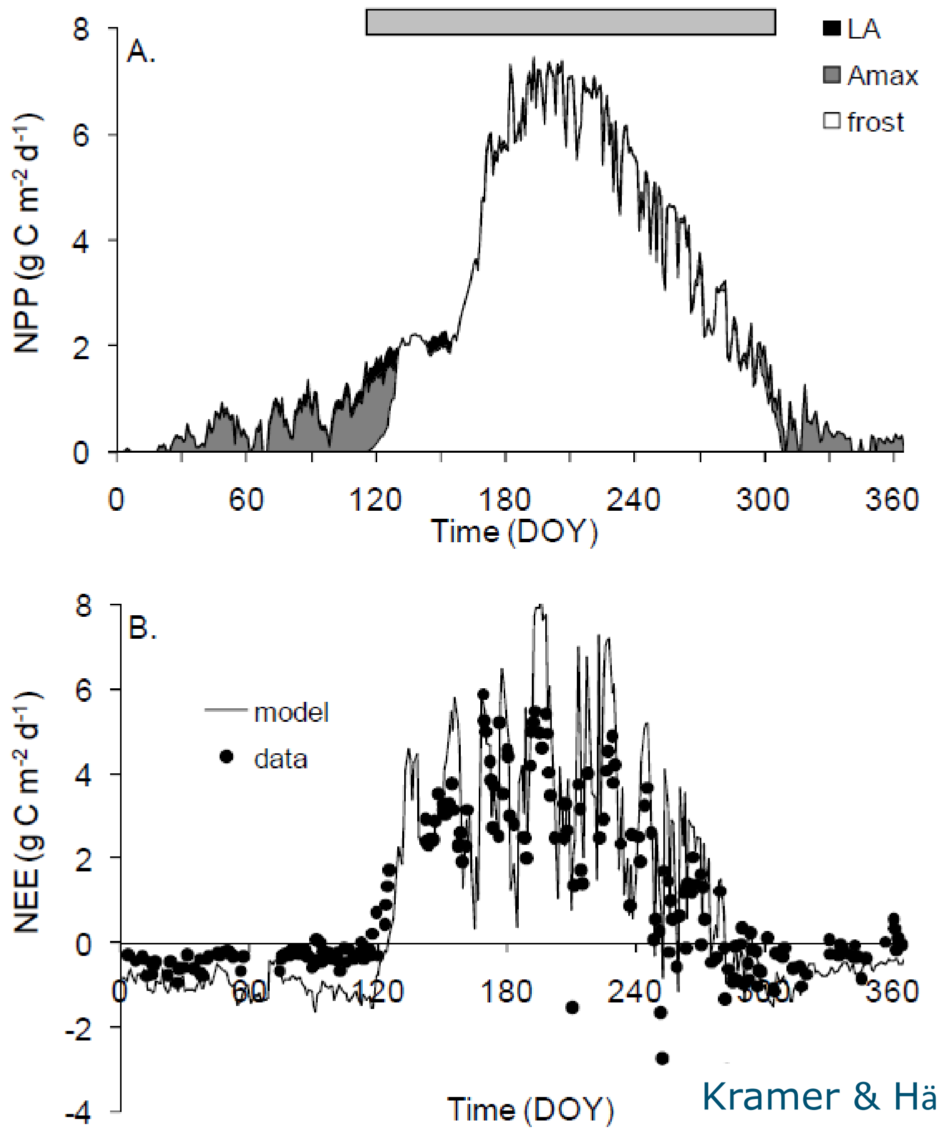
LA – effect of frost damage on leaf area

Amax – effect of frost hardiness on photosynthetic capacity

WAGENINGEN UR
For quality of life

Kramer & Hänninen, 2009

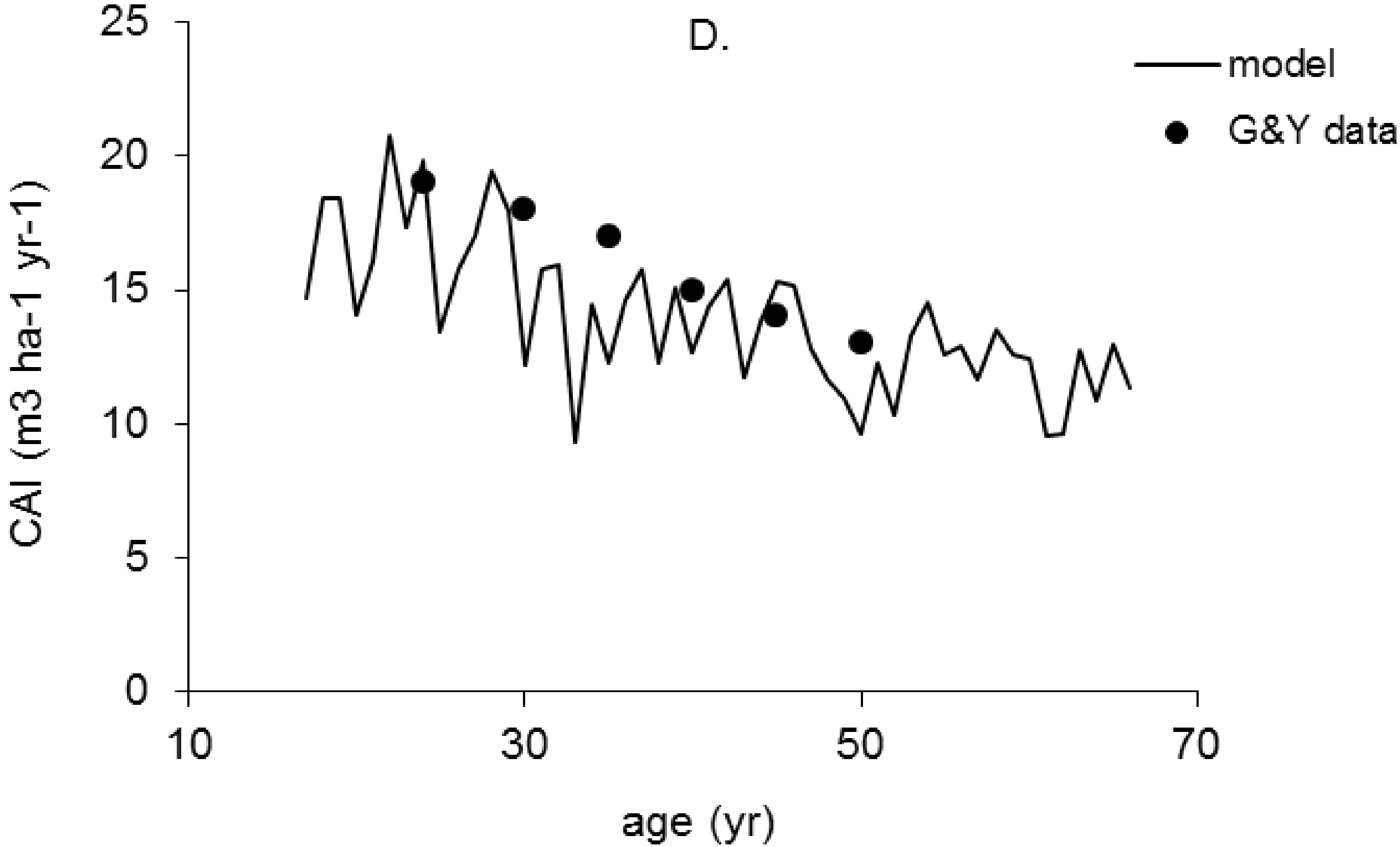
Implications for gas exchange



Kramer & Hänninen, 2009

WAGENINGEN UR
For quality of life

Long-term implications on growth & yield



Kramer & Hänninen, 2009

Chapter 15
Plant Development Models

Isabelle Chuine, Iñaki Garcia de Cortazar-Atauri, Koen Kramer, and Heikki Hänninen

M.D. Schwartz (ed.), *Phenology: An Integrative Environmental Science*,
DOI 10.1007/978-94-007-6925-0_15,

WAGENINGEN UR
For quality of life

25 years of collaboration HH – KK on phenology modelling – what did we learn?

- there is still a lot to be learned considering the ontogenetic development of plants, and trees in particular
- we have developed a nice conceptual framework, yet our models are still a strong simplification of reality