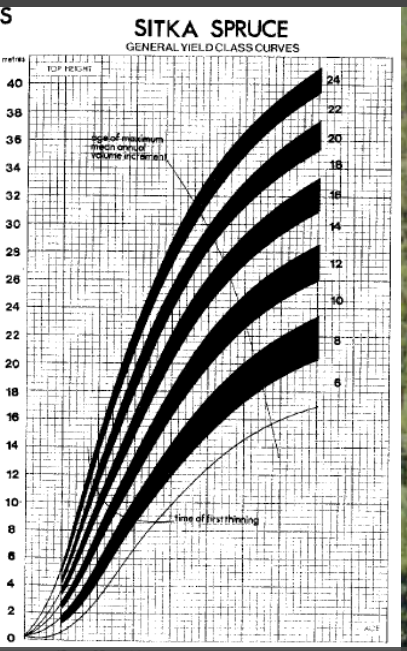
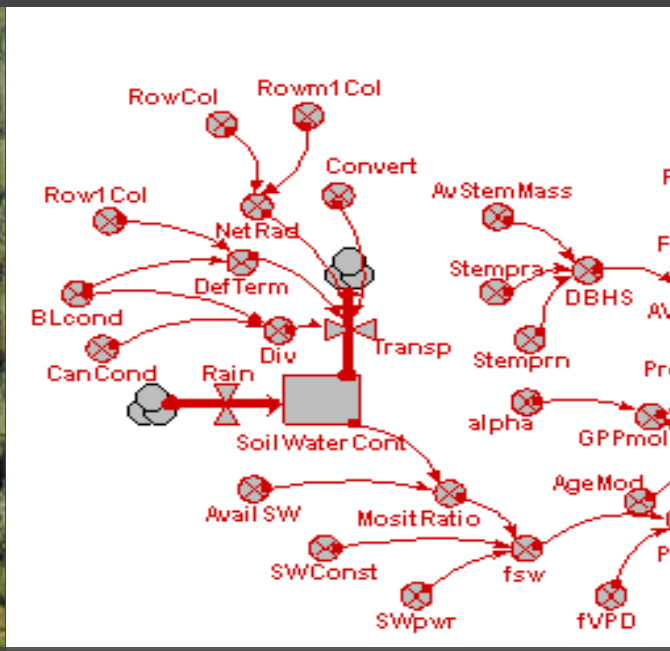
Creating a hybrid process-empirical model for growth prediction of Sitka spruce in the UK





Jack Lonsdale

UNBC UNIVERSITY OF NORTHERN BRITISH COLUMBIA

Aims

Improve growth predictions of Sitka spruce in the UK

Especially young stands

Easy initial parameterisation

Create a basis for more complex forest systems

Sitka in the UK: A short history

'Strategic supply' following War

Planted with even aged, monoculture stands

Sitka spruce 80% commercial timber in UK

Seeds of Pacific NW provenance

Currently shifting from this management

Current yield tables

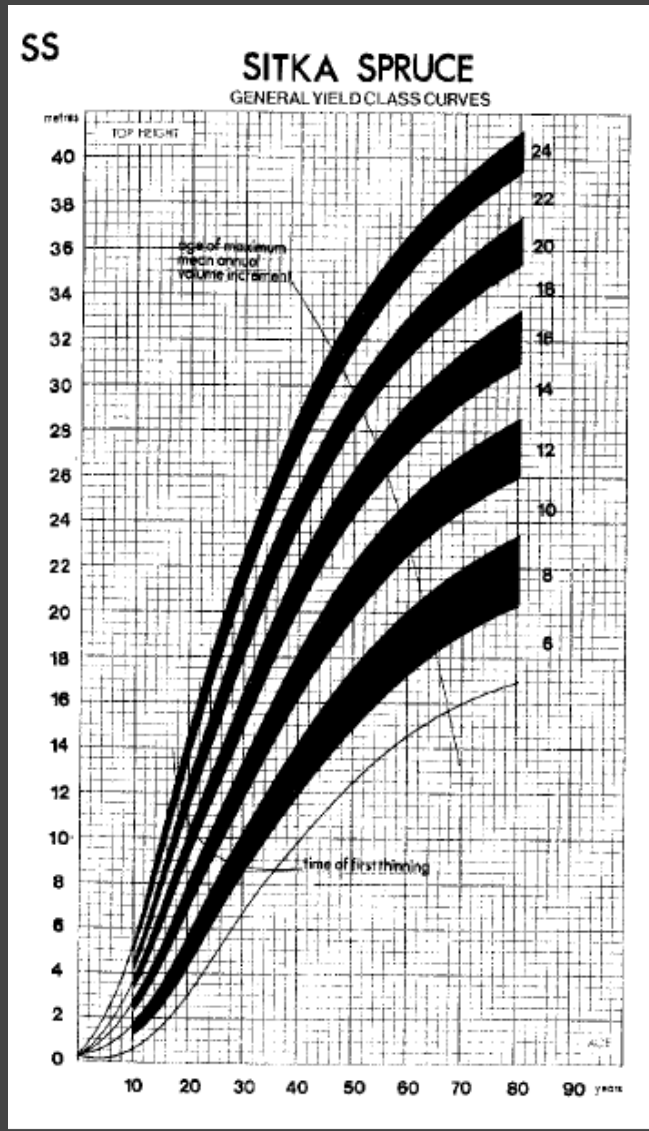
Edwards & Christie 1981

Most commonly used

Assess site quality by max MAI: Yield Class

No predictions for stands less than ~20 years

Only predicts for given stands



Improving this model

Data - Difficult to get hold of

Next best thing - model the model

Can be re-done when/if data appears!

Dynamic system model

Stand represented by few state variables:

H, V, N, Ω

Transition functions

Methodology used based on SCUBE

Height-age model

Edwards & Christie spacing effect on *H*

Linearised Chapman-Richards equation:

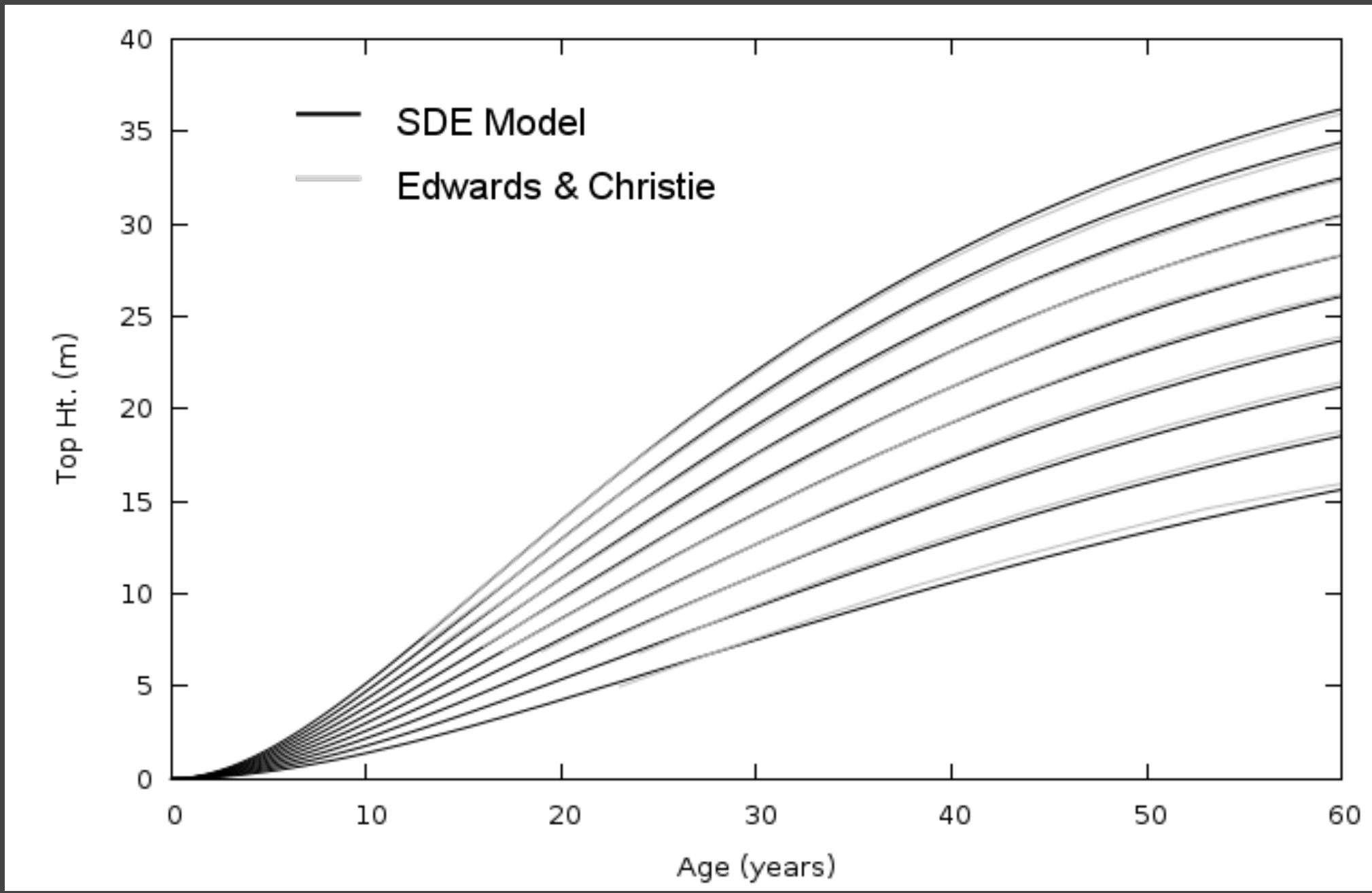
$$\frac{dH^c}{dt} = b(a^c - H^c)$$

Used EasySDE with Yield table data

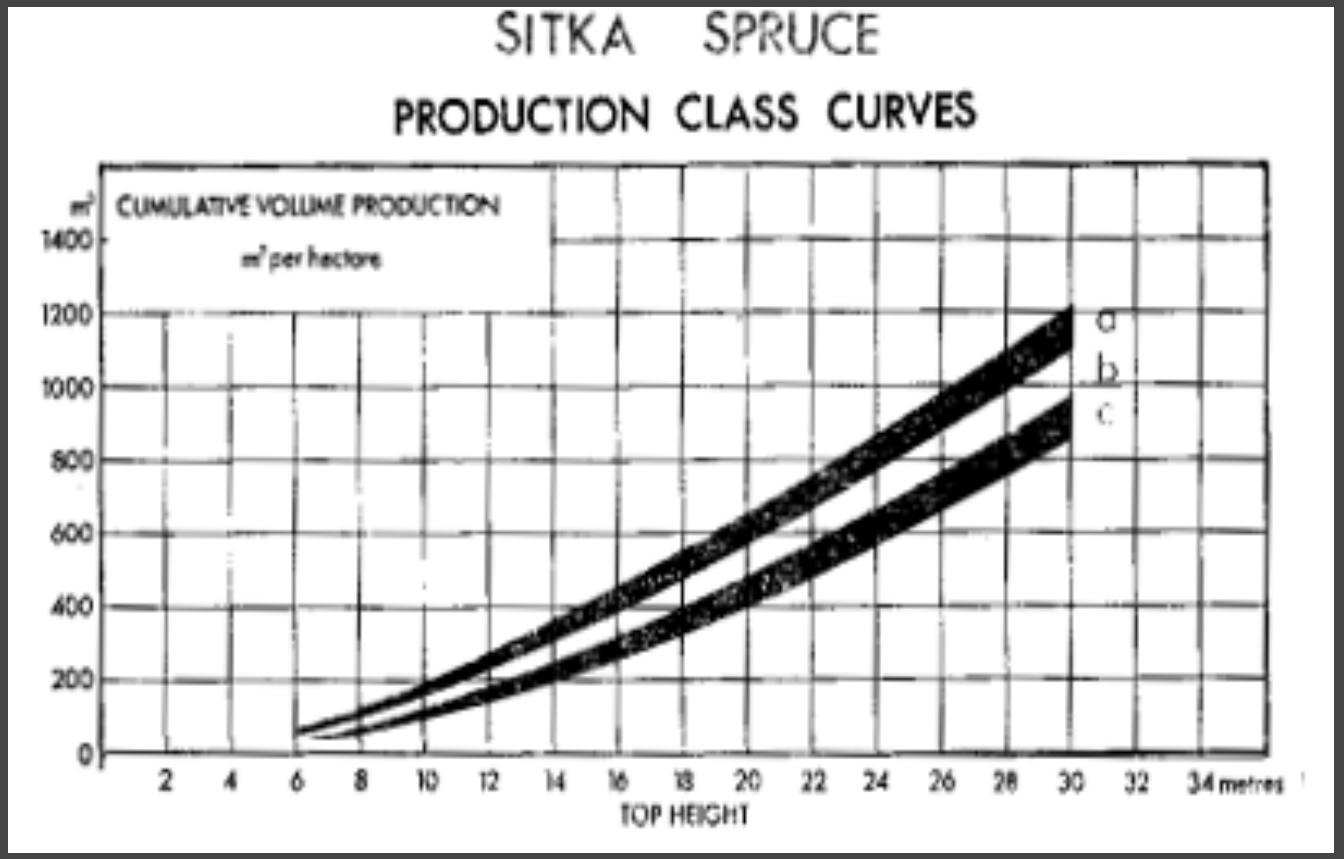
3 ways of including site quality:

$$a = q$$
$$b = q$$
$$b = q, a = \alpha b^{\beta}$$ ← Best fit

Height-age model



Cumulative volume



Cumulative volume production:

$$V_c = aH^b - c$$

Differentiates to:

$$\frac{dV_c}{dH} = \alpha H^{\beta}$$

Volume

Change in stand volume dependent on loss through mortality

$$\frac{dV}{dH} = \alpha H^{\beta} + k\frac{V}{N}\frac{dN}{dH}$$

or

$$\frac{dV}{dH} = \alpha H^{\beta} + kV\frac{d\,lnN}{dH}$$

Mortality

Rearrange previous equation to:

$$\frac{dVN^{-k}}{dH} = \alpha H^{\beta} N^{-k}$$

with $x = H^{\beta+1}/(\beta+1)$

$$\frac{dVN^{-k}}{dx} = \alpha N^{-k}$$

Requires a second ODE...

Mortality

Let $VN^{-k} = y$

$N^{-k} = z$

1. $\frac{dy}{dx} = \alpha z$

2. $\frac{dz}{dx} = ay + bz + c$

Linear equation which can be solved analytically

Occupancy

Young/Thinned stands

Less than optimal growth

Model from open to closed stands

Applied to previous rate equations

Occupancy

Occupancy (Ω): 0 Unoccupied - 1 Occupied

Actually easier to look at 'unoccupancy' (U):

$$1 - \Omega = U$$

Simply:

$$\frac{dU}{dx} = -\gamma U$$

Reorganise & integrate:

$$U e^{\gamma x} = \text{Constant}$$

What about the hybrid model?

Why complicate things?

Remote sensing parameterisation

Measure q and Ω

Improve the process model...

3PGS

Simple as process models go

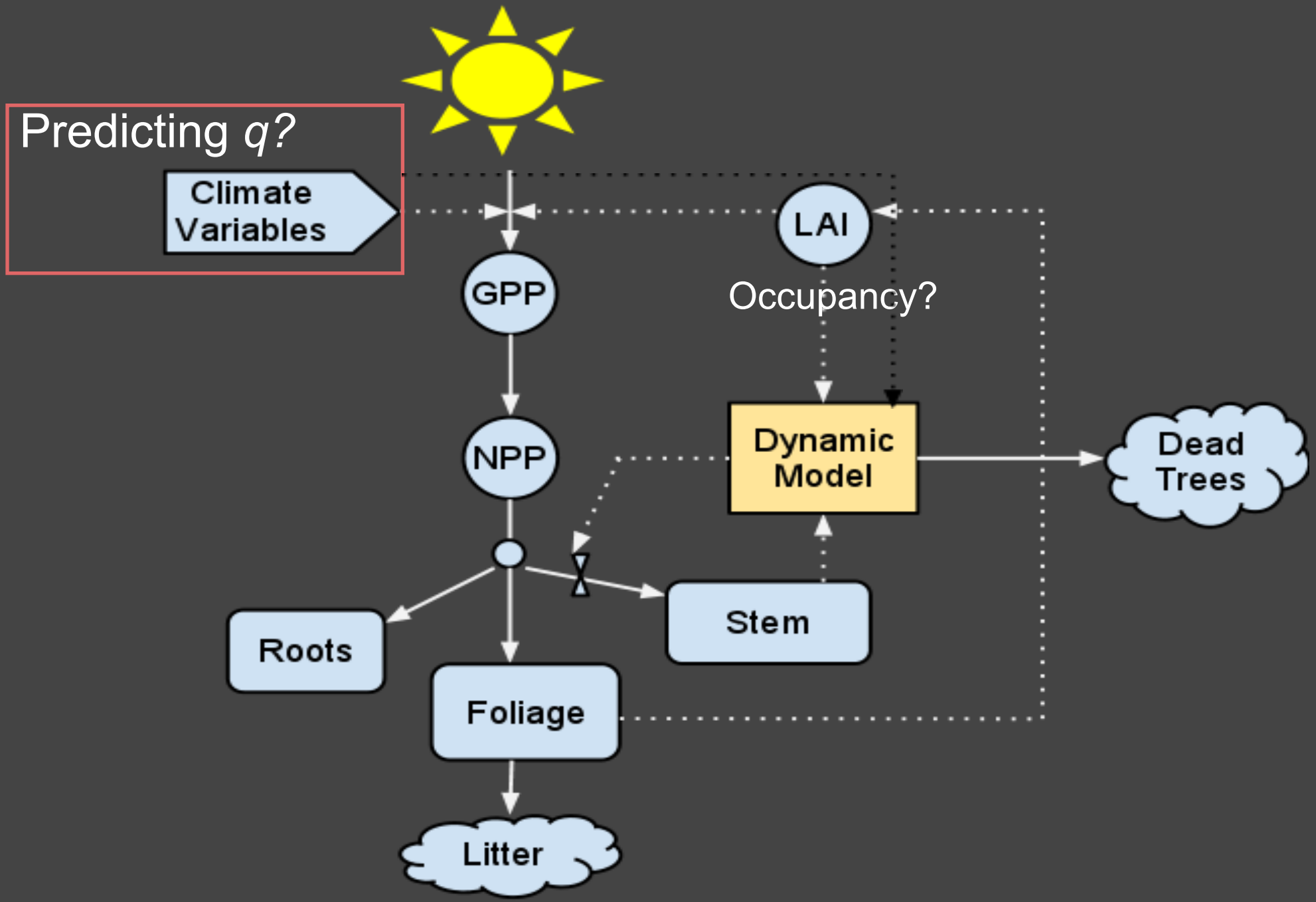
Driven by APAR

Allows satellite derived parameterisation

But, stem growth driven by basal area

Generic mortality (3/2 thinning rule)

3PGS - Simplified



3PGS Integration

A work in progress...

The future

Finish fiddling and test models

Use real data

Then, try with more complicated stands, using different dynamic models...

To sum up

Dynamic systems model under development

Will include predictions for young stands

This will be integrated with 3PGS

Future possibilities for use in other stands

Acknowledgements

Oscar Garcia, UNBC

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