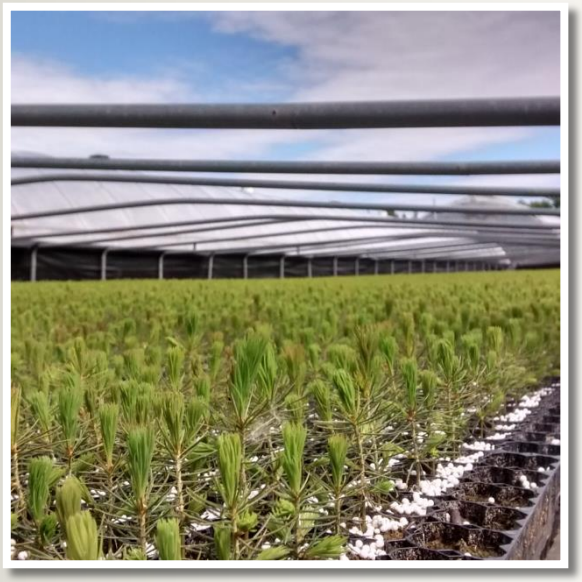
Rothamsted Research

where knowledge grows

Joint EFSA-EPPO Workshop: Modelling in Plant Health: How can models support risk assessment of plant pests and decision making?



Parma, Italy
December 13, 2016

ECONOMICS IN TREE NURSERIES

Vasthi Alonso Chávez

Frank van den Bosch

Christopher A. Gilligan

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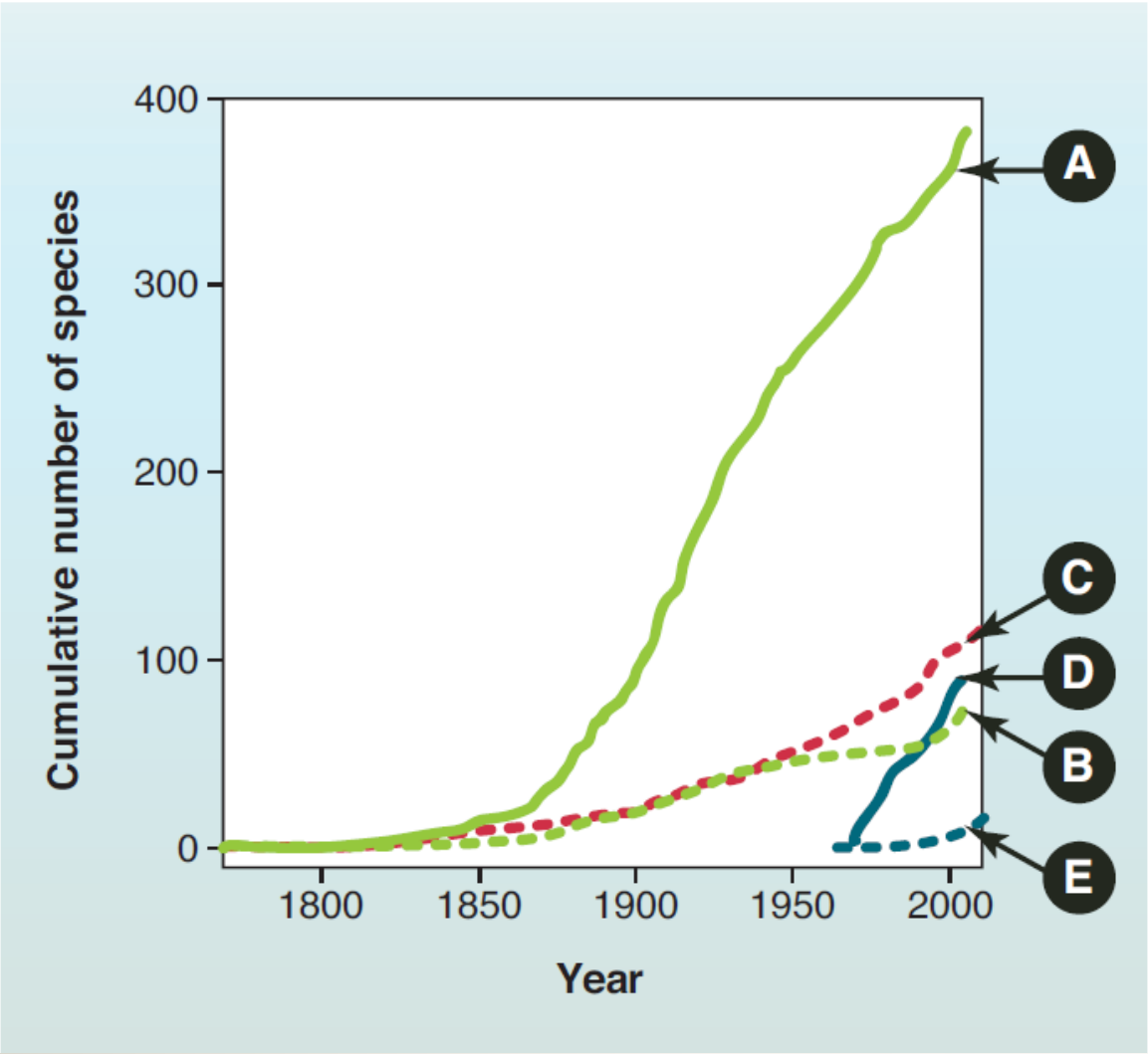
ROTHAMSTED RESEARCH

IMPORTS AND INTRODUCTIONS OF PLANT PESTS AND PATHOGENS



Cumulative number of non-native introductions

A. Insects in association with trees to the USA
B. Insect pests and pathogens to the USA
C. Tree pathogens to Europe
D. Non-native invertebrates to Great Britain
E. Tree pests and pathogens to the UK

Boyd *et. al.* (2013) *Science.*

SO WHY IMPORT?

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ROTHAMSTED RESEARCH

DEMAND VARIABILITY

2007

2009

J&A Growers (2015).

OBJECTIVES

To understand how the economic flows in a tree nursery increase/decrease the probability of introducing an invasive pathogen

METHODS

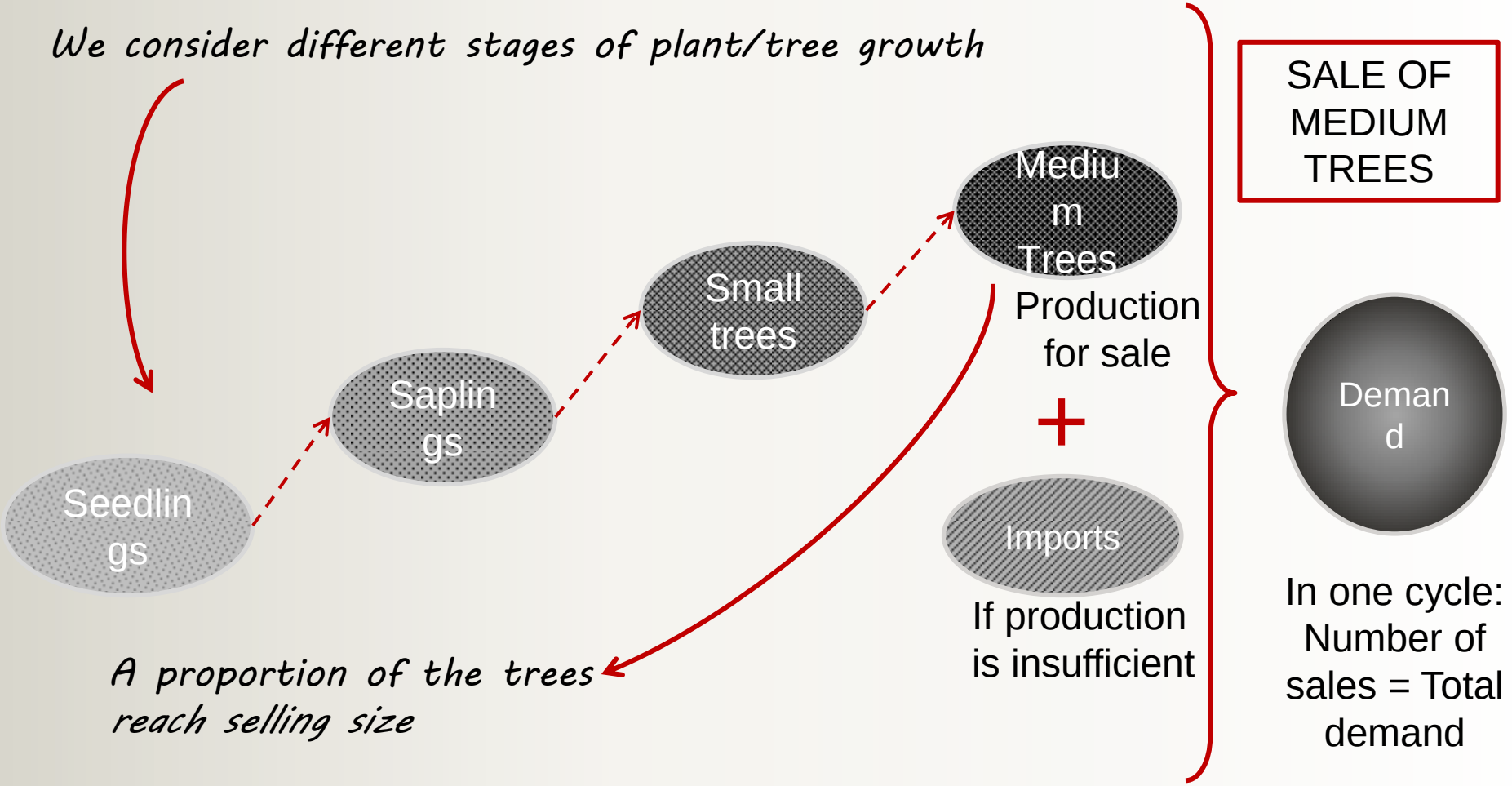
Dynamics of tree growth

- Planting rates
- Transition rates
- Survival rates

Economic nursery dynamics

- Costs (production, imports)
- Prices
- Demand
- Profit

ECONOMIC NURSERY DYNAMICS



MODEL – POPULATION DYNAMICS

In one production cycle grower:

Starts off with a certain population of trees in all the different growth stages at a given selling cycle then: P_{t+1}

1. Assess current number of plants and plant more

2. Sells according to demand

3. Numbers of trees are managed (if too large, grower discards some or all unsold ones)

After this set of actions we obtain the grower obtains the new population of trees for next selling cycle.

MODEL – ECONOMIC DYNAMICS

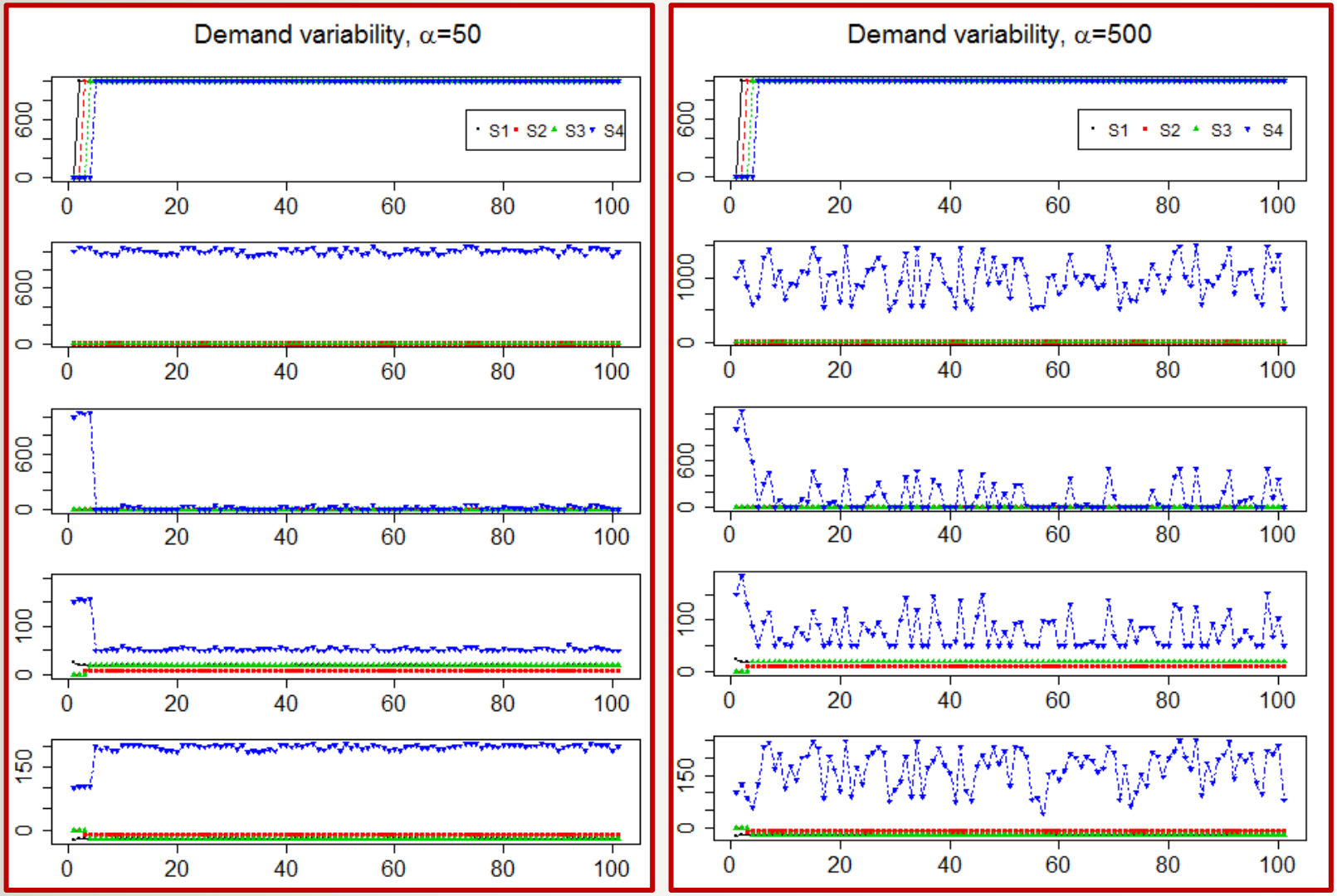
In one production cycle t grower incurs:

1. Production costs κ_{Pt}
2. Importing costs κ_{It}
3. Total sales G_t
4. Profit $G_t - (\kappa_{Pt} + \kappa_{It})$

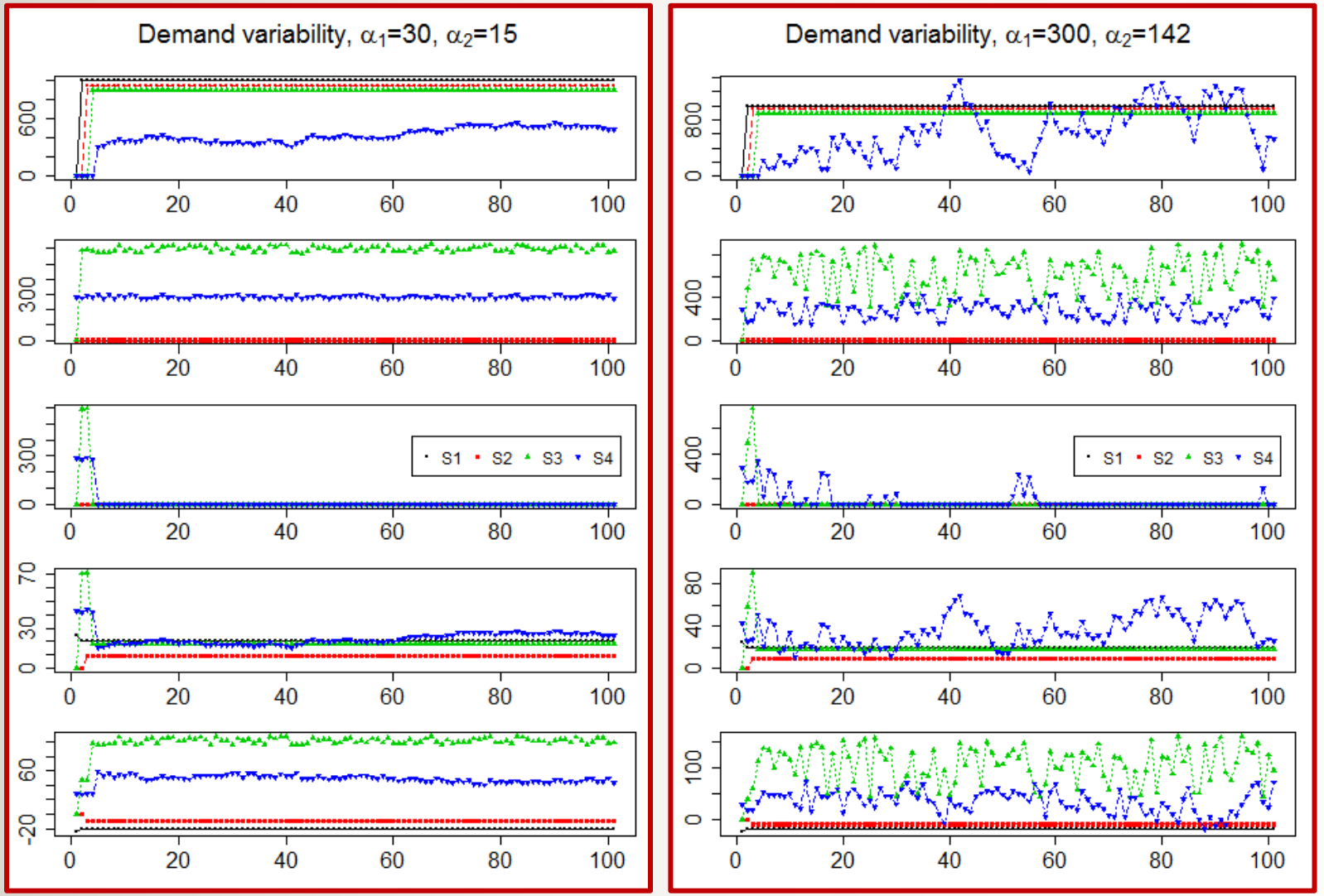
These depend upon the variable demand in each cycle

$$\xi_t = \mu_t + \alpha_t$$

DYNAMICS OVER TIME – NO HOLDING



DYNAMICS OVER TIME – HOLDING



ROTHAMSTED RESEARCH

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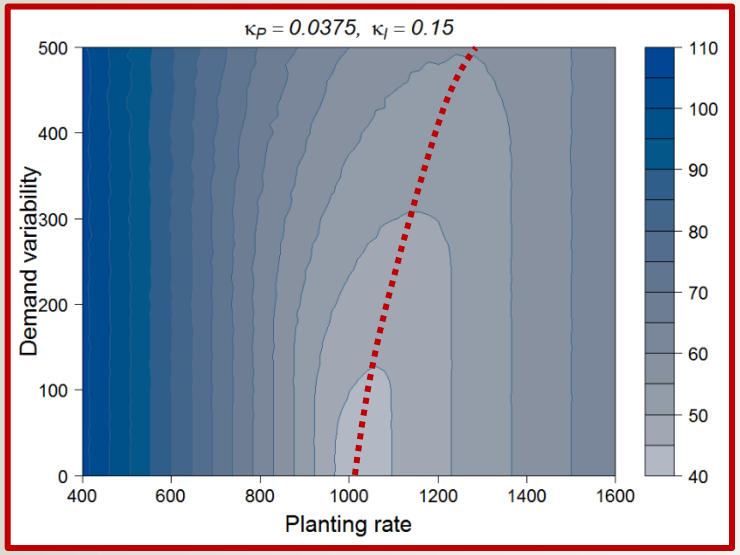
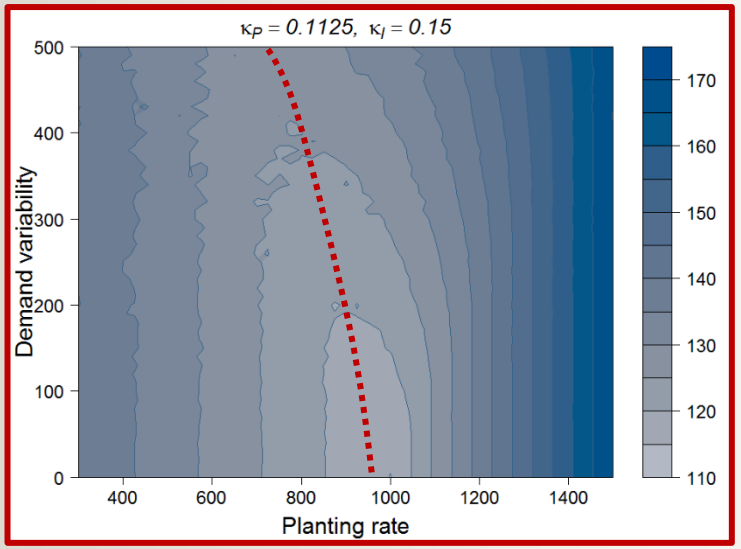
RESULTS – PRODUCTION & IMPORTING COSTS





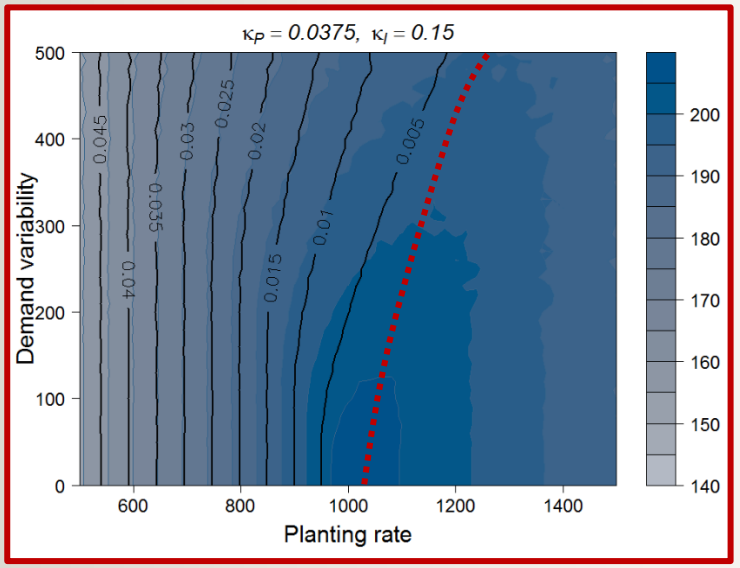
Mean demand =1000 trees
Import cost / tree =0.15 units
Sale price / tree = 0.45 units

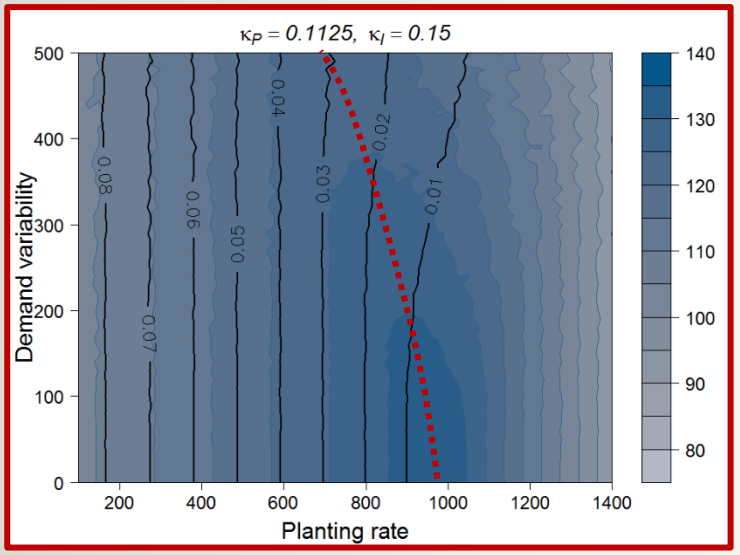
Total costs increase as demand variability increases for any fixed planting rate.

For $\kappa_P \ll \kappa_I$ $\min(\kappa_T)$ is reached when tree production larger than the mean demand μ as demand variability increases.

For $\kappa_P \lesssim \kappa_I$ $\min(\kappa_T)$ is reached when the tree production smaller than the mean demand μ as demand variability increases.

RESULTS – PROFIT CONTOURS





Mean demand =1000 trees
Import cost / tree =0.15 units
Sale price / tree = 0.45 units

As producer looks for optimum profit:

If demand variability increases probability of introducing a pathogen increase for fixed planting rates.

For $\kappa_P \ll \kappa_I$ optimum profit requires a tree production larger than the mean demand μ. No crossover with probability.
Probability of introduction reduced.

For $\kappa_P \lesssim \kappa_I$ optimum profit requires a tree production smaller than the mean
demand μ. Large crossover.

RESULTS – OVERVIEW

ROTHAMSTED RESEARCH

- As demand variability increases, the number of imports increase if the planting rate remains the same.

- Ratio between production costs and import costs determines the optimum profit contours. Assuming that producers aim for maximum profit, this ratio is linked to the probability of introducing invasive pathogens.

  - If $\kappa_P \ll \kappa_I$ probability of introduction largely reduced.
  - If $\kappa_P \lesssim \kappa_I$ probability of introduction largely increased.

- Holding unsold trees can mitigate the number of imports needed in any given cycle.

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