Modelling economic impact and strategies to increase resilience against tree disease outbreaks

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1. Project Objectives

A. How can we model the trade-offs between economic returns, ecosystem service provision and resistance against disease within a forest?

B. How can we model the impact of various management options in the context of resilience and resistance of forest ecosystems to pathogen invasion?

Question: how does disease, which acts to reduce the value of timber once infected, impact the optimal rotation length of a single-aged forest over one rotation?

FIGURE 1: *Phytophthora ramorum on larch (Scottish Borders) by permission of Steve Hendry (FR)*

2. The model without disease

The optimal rotation length is the time which maximises net present value (NPV). The NPV includes the costs and benefits of establishing and harvesting a forest over one rotation:

NPV = [Cost of planting] + [Net benefit of timber]

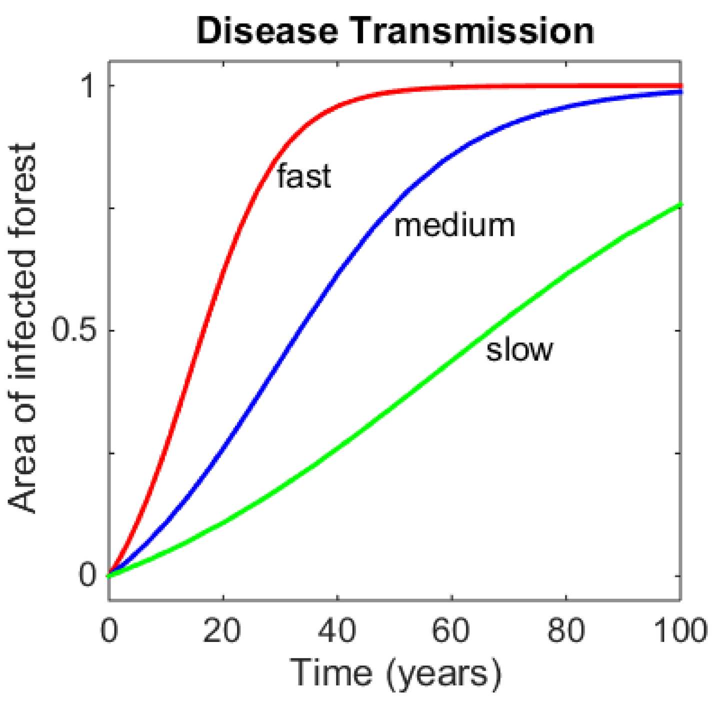
The optimal rotation length is given by

[Relative cost of waiting for timber to grow] − [Discount rate] = 0

3. The model with disease

Disease acts to reduce the net benefit of the timber from infected trees at the end of the rotation. We include this and a term representing non-timber subsidies and the NPV becomes

NPV = [Cost of planting] + [Net benefit of timber (with disease)] + [Non-timber subsidies]



Disease system (Figure 2)

We use a susceptible-infected system where the area of forest changes from susceptible (S) to infected (I) through disease transmission and external pressure

S → (Disease transmission) → I

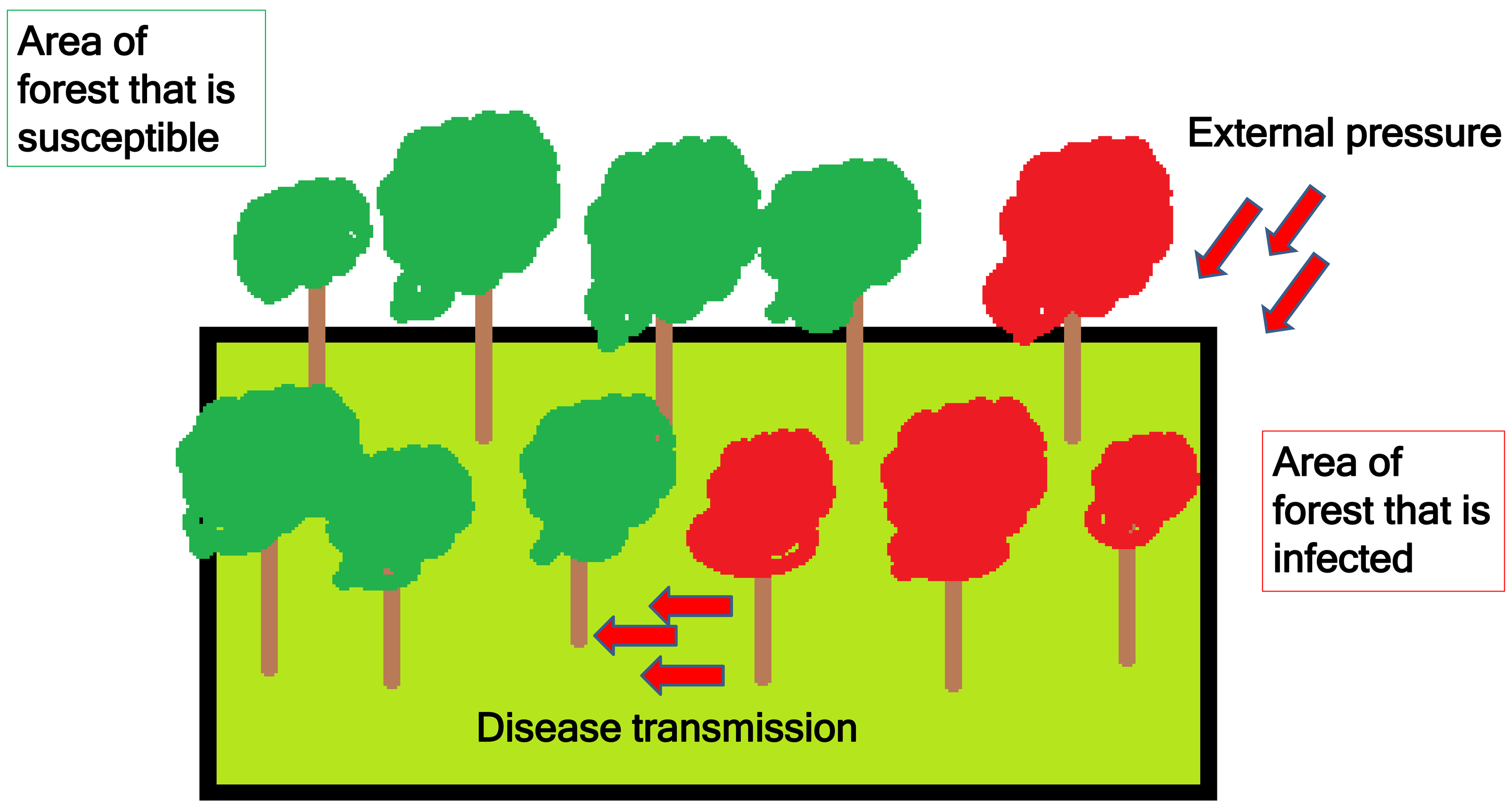


FIGURE 2: *A susceptible-infected (SI) disease system in a forest of fixed area.*

4. General Result The optimal time to harvest is when

[Relative benefit of waiting for timber to grow] − [Discount rate] = [Relative cost of waiting for disease to spread] − [Gain from accruing subsidies for one more instant]

5. Results

No non-timber subsidies, Figure 3(a)

- **Disease shortens the rotation length: it is a balance of letting timber grow for one more instant but letting the disease spread further**

Including non-timber subsidies, Figure 3(b)

- **Disease shortens the rotation length but subsidies increase it: it is a balance of letting timber grow and accruing subsidies for one more instant but letting the disease spread further**

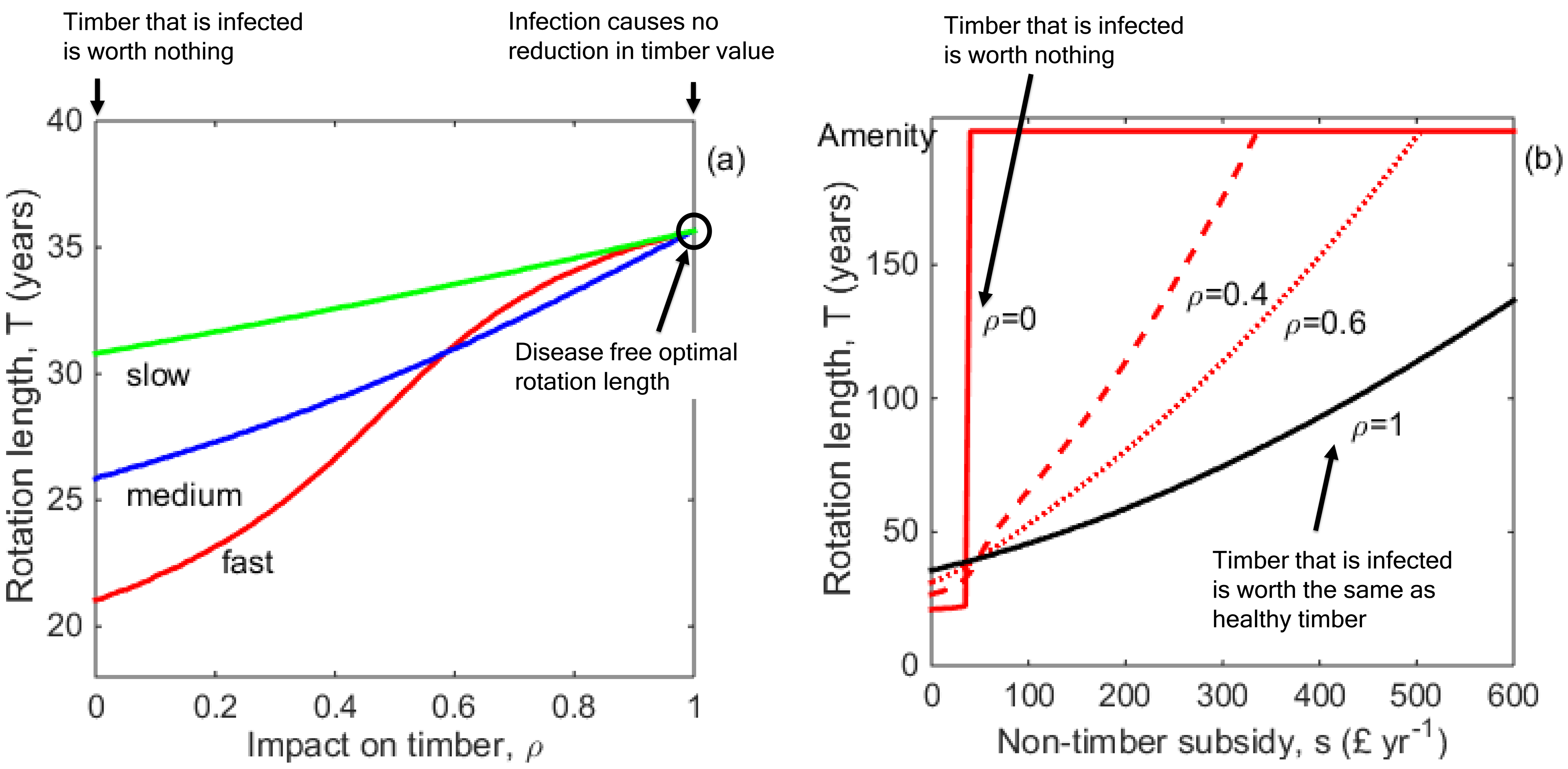


FIGURE 3: *The optimal rotation length against (a) the effect of disease on timber, ρ and (b) subsidies, s. In (a) subsidies are set to zero, and the disease transmission is fast (red), medium (blue) and slow (green). In (b) the disease transmission is fast, and the price of timber that is infected is varied on the figure with $\rho = 0$ infected timber is worth nothing and $\rho = 1$ infected timber is worth the same as healthy timber.*

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