# Economics of invasive pests and diseases: implications for management and policy.

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



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The Scottish Government Riaghaltas na h-Alba

- Invasive pests and diseases are a growing threat to agricultural crops, livestock and forests worldwide.
- This is an interesting biodiversity problem for economists and ecologists to think about.
- A fast-growing literature in economics (see forthcoming special issue of ERE)

# Forest pests and diseases

- since 1860, 62 insect species and 16 pathogens introduced into the USA are considered as having a *"high negative impact"* on forest ecosystems (Aukema et al., 2010).
- Dutch elm disease has killed millions of elms across Europe, causing large losses to the environment, biodiversity and landscape.
- The introduction of Ash Dieback to UK in 2010 brought a renewed focus from government on the problem of managing such invasions.

- Other diseases moving into the UK with serious ecological effects include *dothistroma* red needle blight and *Phytophthera ramorum*


Figure 2: Phytophthora ramorum on larch in the South of Scotland.

Economic analysis of policy and management responses to pests and diseases needs to take a number of important factors into account, including:

1. That the optimal response to a new disease is likely determined by a mix of economic, ecological and epidemiological factors;

2. That impacts occur to both commercial crops and non-market forest benefits such as recreation, landscape quality and forest biodiversity.

3. Because pests and diseases create “shiftable externalities”, the actions of private forest owners, acting in their own best interests, may not be sufficient from a economic optimality point of view – so the state might need to offer landowners incentives to “do more”.

# Issue 1. The arrival of a new pest or disease will likely change the optimal management of a forest

We look (very briefly) here at 2 situations:

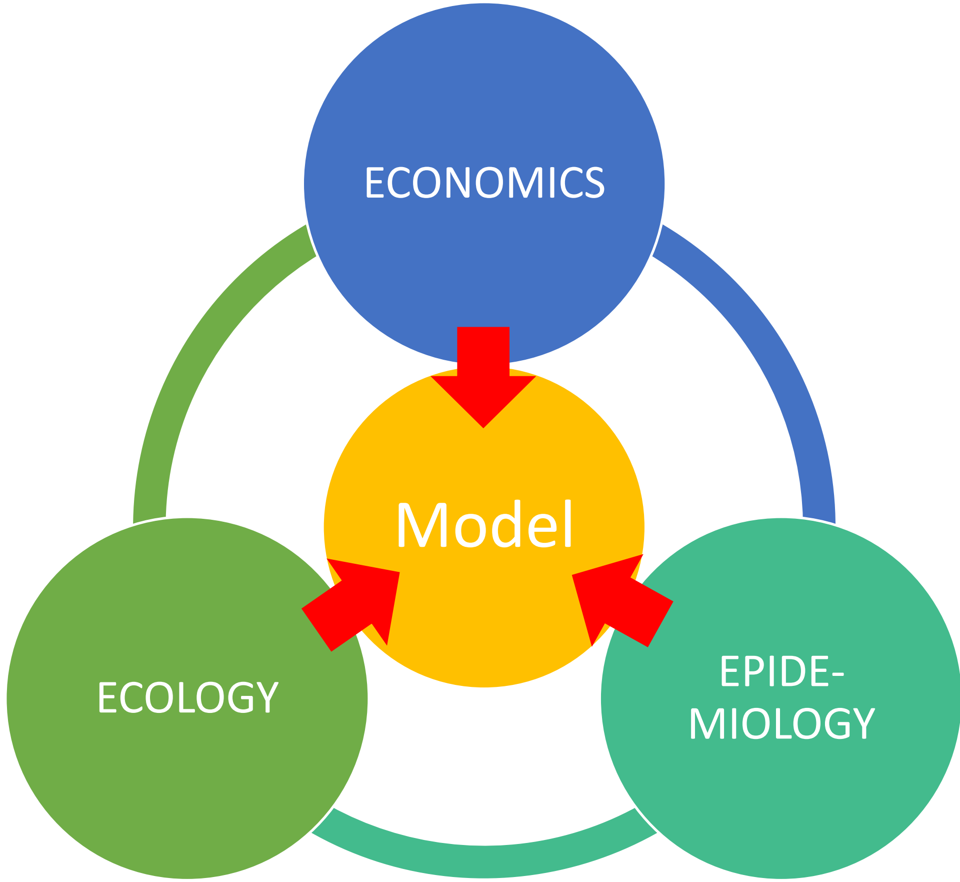
- Single species, only care about timber values (MacPherson et al, *ERE*, 2017)
- Single species, care about timber and non-timber values (MacPherson et al, *Ecol. Econ.* 2017)

# 1a. The effect of disease on the optimal rotation length of an even-aged, plantation forest (MacPherson et al, ERE, 2016)

We develop a generalizable, bioeconomic model framework which combines an epidemiological compartmental model with a Faustmann optimal rotation length model, to explore the management decision
of when to harvest.

Assumptions

- Forest owner is risk neutral.
- Maximise NPV(not minimise the disease spread).
- Underlying parameters such as the price of timber and the interest rate are constant and known.
- One rotation in which disease arrives.
- We ignore non-timber benefits (but relax this later)

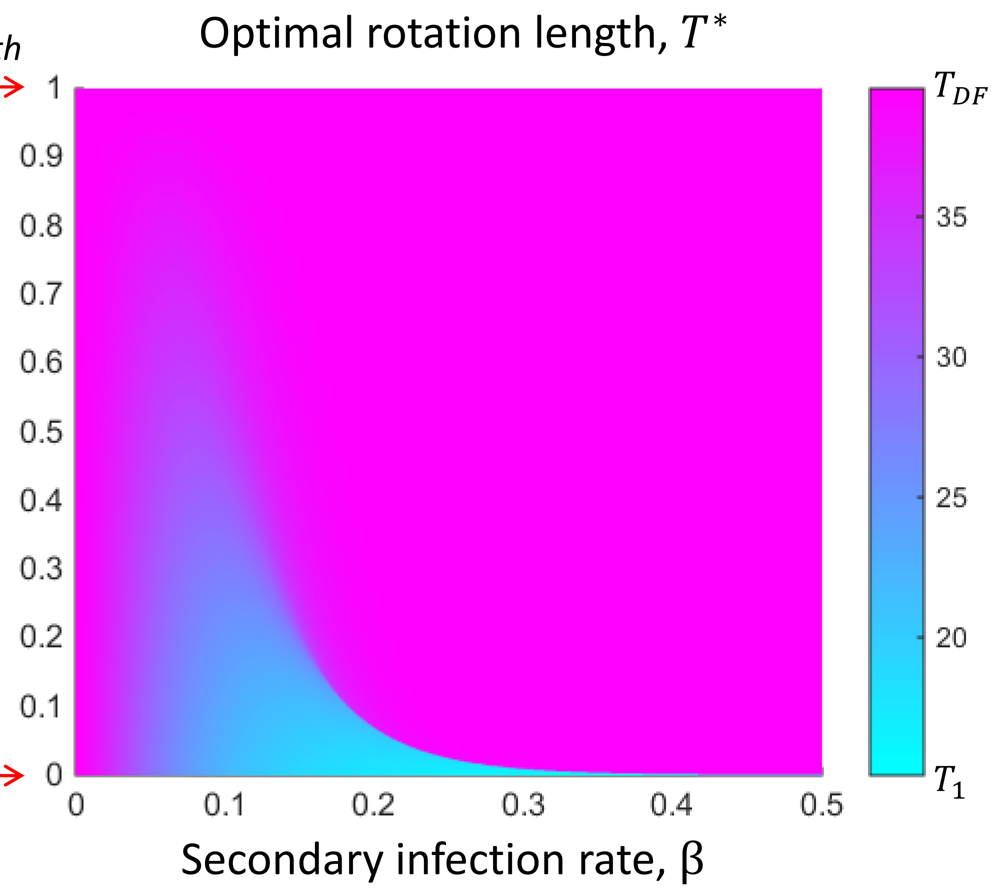


# Results:

*Timber that is infected is worth the same as healthy.*

Relative revenue from timber that is infected, $\rho$

*Timber that is infected is worth nothing.*




*Disease-free optimal rotation length*

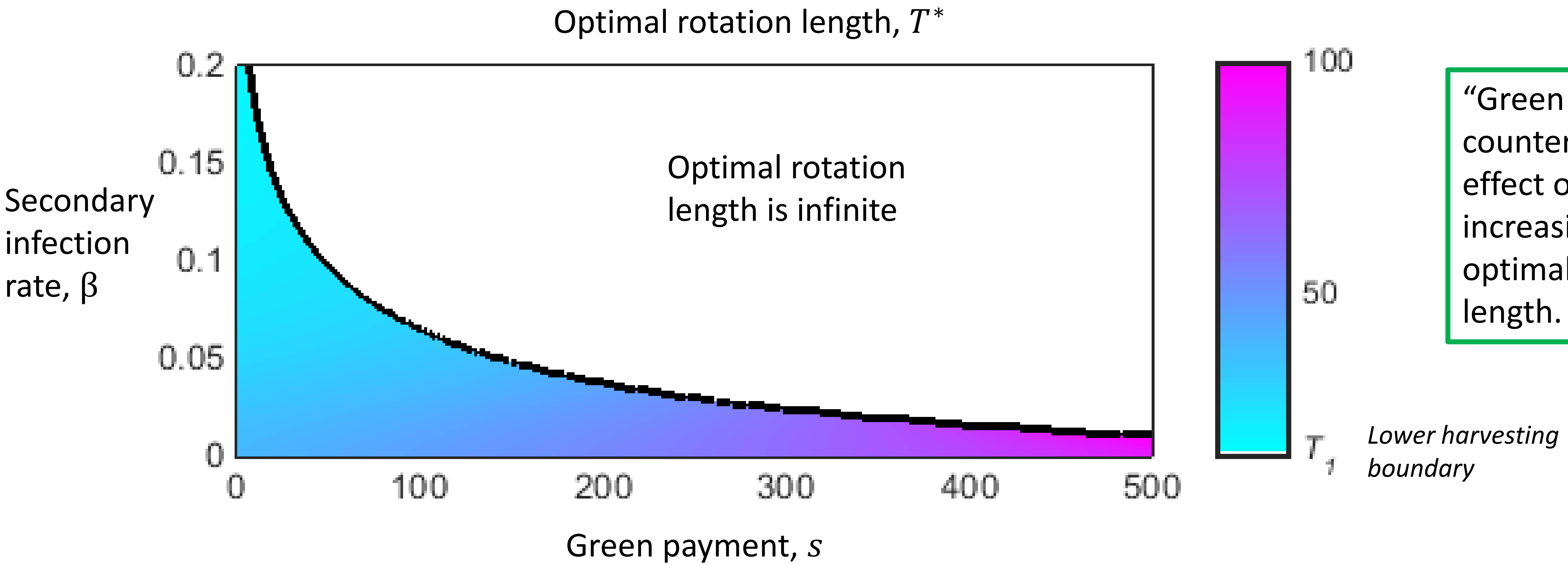
*Lower harvesting boundary*

Trade-off between the forest growing for longer and the disease spreading further.

Macpherson et al. *Environ Resource Econ* (2016)

- So the optimal management response depends on an interaction of economic, epidemiological and ecological parameters

# 1b. The effect of disease on the optimal forest rotation: timber and non-timber values




"Green payment" counters the negative effect of disease by increasing the optimal rotation length.

Macpherson et al. *Ecological Economics* 134(2017):82-94

KEY RESULTS

- A complex trade-off in waiting for the trees to grow larger, and thus obtaining higher non-market benefits; compared with the penalty of the infection spreading further over time.

- At some critical level of non-timber benefit, the optimal rotation length becomes infinite ( so it is optimal to never harvest the trees)

# Issue 2. The effects of invasive pests and pathogens on strategies for forest diversification

Diversification of the tree species composition of production forests is a frequently-advocated strategy to increase resilience to pests and diseases,

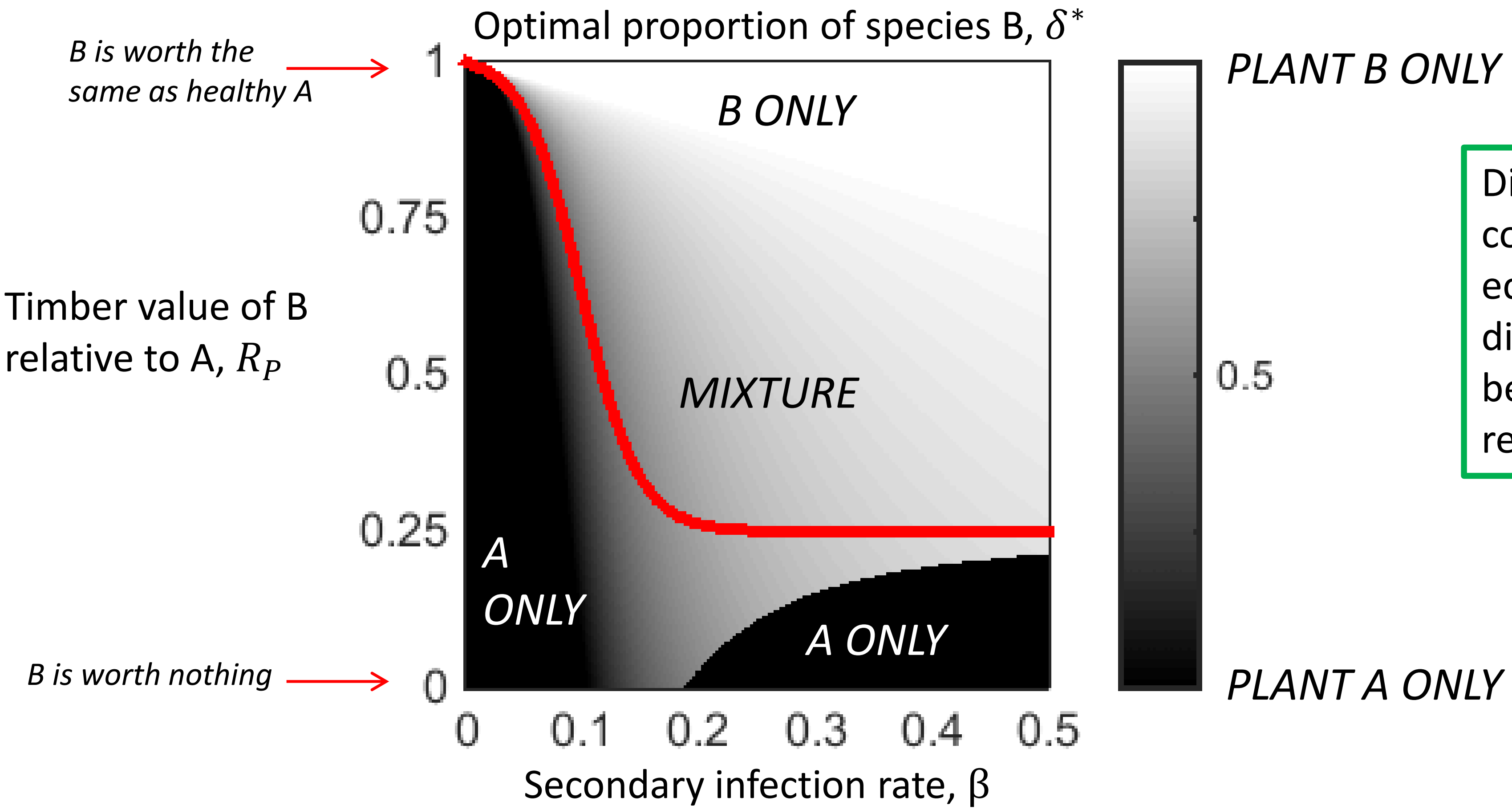
KEY AIM: We develop a novel bioeconomic model to quantitatively assess the effect of tree disease on the optimal planting proportion of two tree species.

*We model two separate decisions.*

(i) one of two species (monoculture): which do they plant?

(ii) mixture of two species: how much of each which do they plant?

# Results:




Diversifying the species composition reduces the economic loss from disease even when the benefit from the resistant species is small.

Macpherson et al. *Ecological Modelling* 350(2017):87-99

# KEY RESULTS

- We find that **diversifying the species composition can reduce the expected loss from disease, even when the direct economic benefit from the resistant species (B) is small**.
- This happens because planting the resistant species reduces the speed of spread.
- This key result is sensitive to a pathogen's characteristics (probability of arrival, time of arrival, rate of spread of infection) and its costs (damage of the disease to the susceptible species A and reduced benefit of planting the resistant species B)
- Also depends on the risk attitudes of the land manager.

# Issue 3. What does it take to get forest owners to enrol in PES-type programmes for disease and pest control?

- A contract design problem

- We ran a choice experiment with a sample of private forest owners in Finland (where about 70% of woodland is privately owned)

- Sample of 243 woodland owners collected by mail

# Choice experiment design

- 6 cards for each person
- two alternatives and opt-out in each card

| ATTRIBUTES | LEVELS |
|---|---|
| **Disease management options** | -Avoiding timber harvesting during summer<br>-Stump treatment with chemicals<br>-Avoiding thinning<br>-Removing damaged/dead trees |
| **Contract length (years)** | 5, 10, 20, 30 years |
| **Inspection and reporting frequency** | -Once every year<br>-Once every second year |
| **Annual grant payment rate (€/ha/year)** | 10€, 30€, 70€, 120€, 180€, 250€ |
| **Bonus payment to you for bringing in neighboring forest owner (€/ha/year)** | 0€, 10€, 20€, 40€, 60€, 80€ |

**Please consider a situation in which some new pest or disease would likely cause damages in your forests during next five years.**

| **1. VALINTATILANNE** | **Sopimus A** | **Sopimus B** | En halua solmia kumpaakaan näistä kahdesta sopimuksesta |
|---|---|---|---|
| **Torjuntakeino** | harvennuksista luopuminen | kesähakkuista luopuminen | |
| **Sopimuksen pituus** | 5 vuotta | 30 vuotta | |
| **Tarkastus- ja raportointitiheys** | joka toinen vuosi | kerran vuodessa | |
| **Korvaus** (€/hehtaari/vuosi) | 30€ | 70€ | |
| **Naapuribonus** (€/hehtaari/vuosi) | 60€ | 10€ | |
| **Laita rasti valintaasi:** | ◯ | ◯ | ◯ |

**Table 8A. Various models interactions (std.err in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)**

| | MNL | MIXL |
|---|---|---|
| *Mean* | | |
| ASC = U(SQ) + no thinning | -1.263*** (0.070) | 0.743* (0.435) |
| Remove dead trees | 1.862*** (0.141) | 3.035*** (0.346) |
| No summer logging | 1.552*** (0.139) | 2.154*** (0.288) |
| Chemical treatment | 1.806*** (0.140) | 2.771*** (0.373) |
| Length of contract | -0.047*** (0.005) | -0.104*** (0.015) |
| Inspection frequency | 0.014 (0.075) | 0.016 (0.150) |
| Grant payment | 0.002*** (0.001) | 0.014*** (0.003) |
| Neighbour bonus | -0.004** (0.002) | 0.014*** (0.004) |
| *Interactions* | | |
| Bonus* (affected by a disease now) | | -0.010** (0.005) |
| Bonus* (high expectations of worse diseases) | | -0.014*** (0.005) |
| Grant* (prefer local cooperat.) | | 0.011*** (0.004) |

Can see (!) that:

- Higher price makes forest owners more likely to enrol
- Don’t like longer contacts
- Inspection frequency not significant
- Neighbour bonus increases sign-ups
- Management options: relative to abandoning thinning, each one increases likelihood of participation

Not shown:

- Significant variation in preferences for almost all attributes

# Results on the "Neighbour bonus"

- Designed to encourage spatial coordination (literature on the agglomeration bonus: Banerjee et al, JEEM, 2017)
- Had speculated that past experience with cooperation with neighbours would affect strength of this attribute on participation, but this did not happen.
- Being affected by a current disease problem, or worrying more about future disease, decreases the positive effect of the neighbour bonus on stated participation.

# Conclusions from this work so far….

- Increasing arrivals of new forest pests and diseases in many countries
- Government spend money responding to this and determines the regulatory environment
- Many of the impacts reach far beyond commercial value of timber
- We can show in a classic Faustmann model how optimal management responds to a new pest or disease: shows us the importance of interactions between economic, ecological and epidemiological parameters.
- We can also use stated preferences to investigate the factors determining the likely uptake of PES-type schemes which are designed to incentivise private landowners to take more action
- See also Sheremet et al, Jnl Ag Econ, 2017 – what are UK public willing to pay to take actions to “do something” about invasive pests and diseases?