Pollination by wild bees, present and future values

Ciaran Ellis – Environment Camp 2012

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Pollination for Soft Fruits

- 35% of food crops rely on insect-mediated pollination
- Essential to the production of marketable soft fruit

Ensuring sufficient pollination

- **Improve natural habitat**

- **Boxes of commercial bumblebees**
- **Honeybee hire/lend**

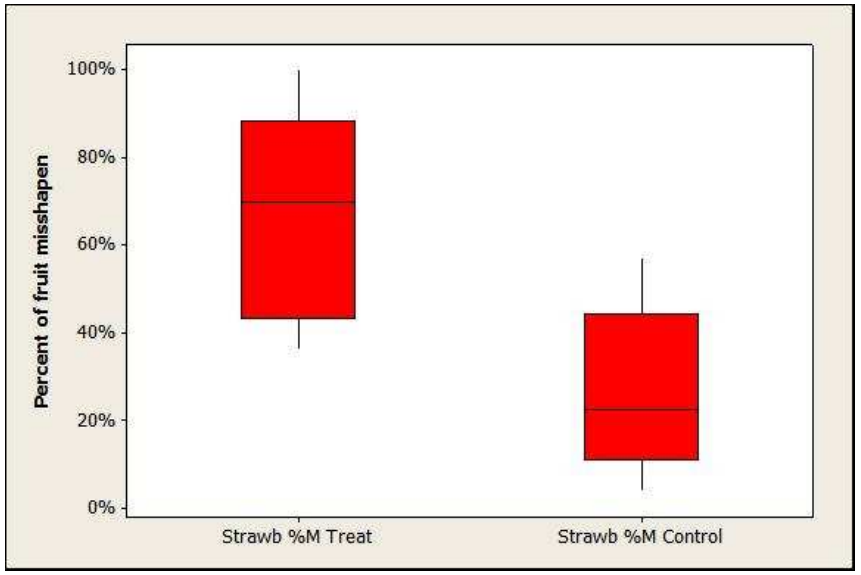
Field Work

- Bee activity monitored on strawberries, raspberries on 25 farms.

Exclusion experiment

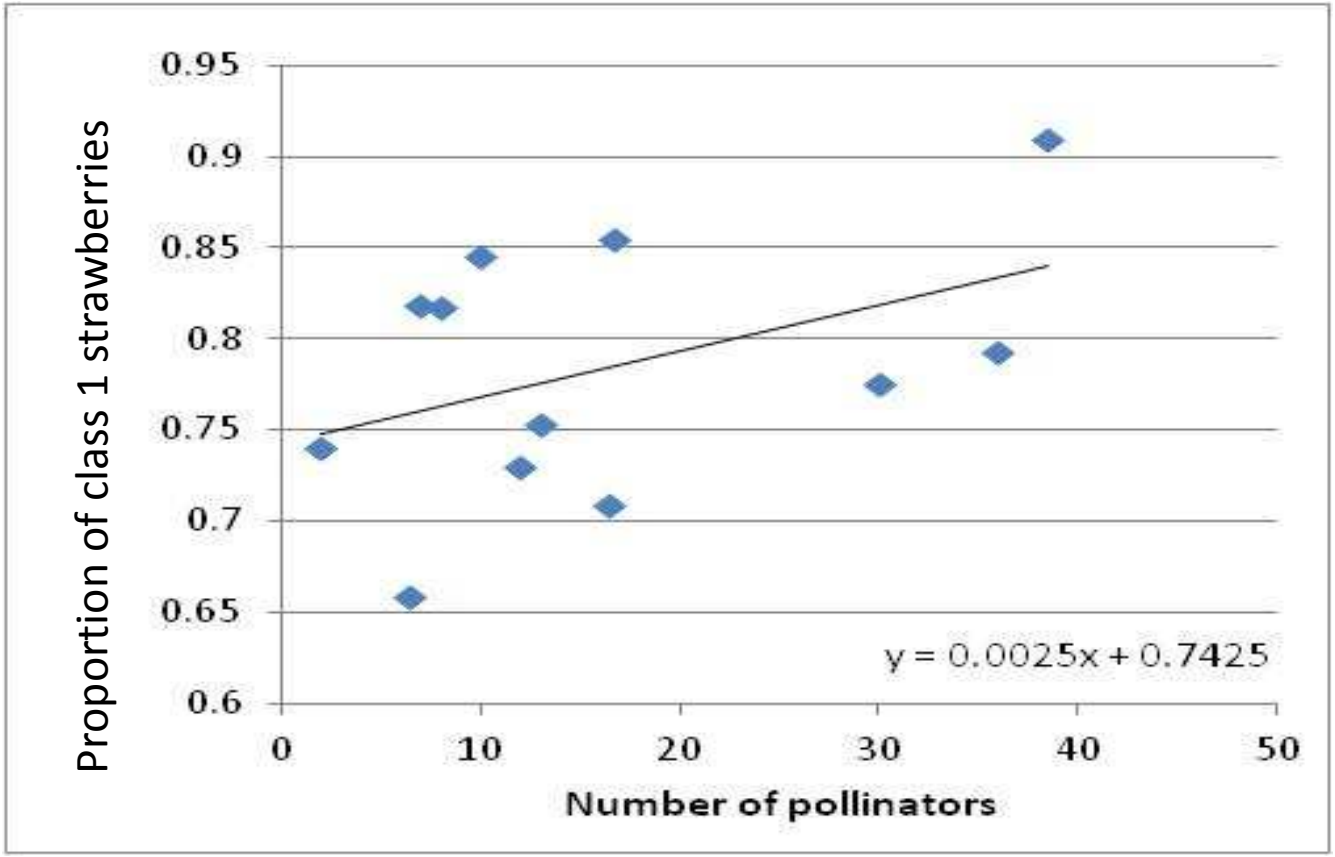
- 10 raspberry farms and 10 strawberry farms insects excluded from areas of crop.
- ~1mm holes.

Bees improve strawberry yield



- Difference between ~70% misshapen and ~20% misshapen
- £ = p(ms)*£class2 + (1-p(ms))*£class1
- Given perfect fruit sells for double imperfect...
- £2,650 per tonne with bees
- £2,020 per tonne without bees
- Farms produce ~100t
- £**63,000 per year**

Bees improve strawberry yield



Increase £3.75/t/bee.

- Lowest (bees = 2): P(Class 1)*3000 + (1-P(Class 1)*1500 = £2,260
- Highest (bees = 40): = £2,760
- (2,760-2,260)/38 = £3.75

What we know…

- Economic value of pollinators – increase per tonne by £630 (strawberries) and £4,420 (raspberries).
- Across a farm this is an increase of £62,000 (strawbs), £131,000 (raspbs).
- For every additional bee on strawberries makes an extra £3.75 per tonne.

Do the farmers value wild bees?

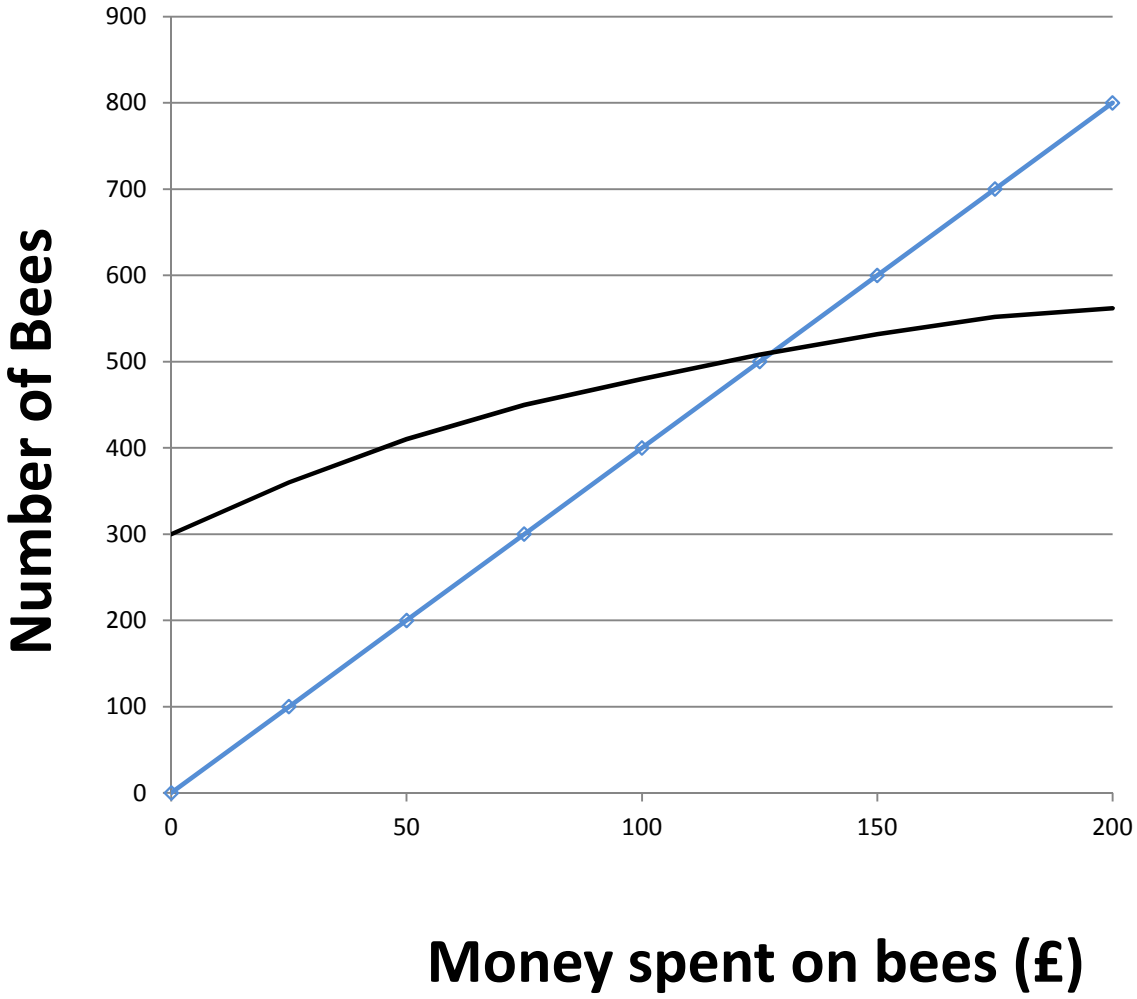
YES!

- Particularly in summer months

BUT…

- Few actively manage for pollination and some farms have very few wild bees.

How to meet pollination requirements

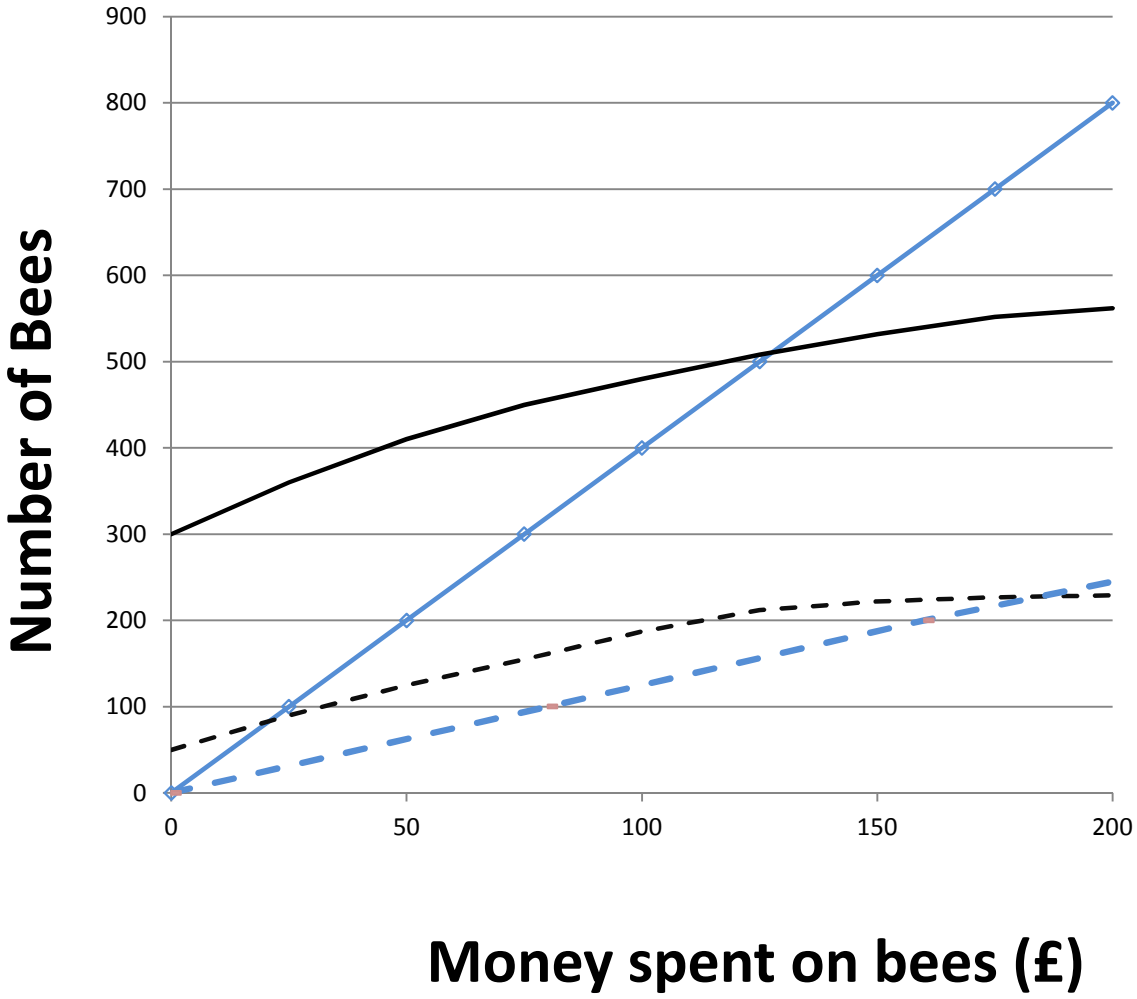


- Blue line – commercial bees
  Number of bees depend on £
- Black lines – Wild bees
- Number of bees depend on area

Value of wild bees to future production

- Why might wild bees be important?
  - **Insurance value**
  - "Biodiversity provides insurance against uncertain provision of ecosystem services"
  - Diverse bees, less fluctuations (Baumgartner "The insurance value of biodiversity", Winfree 2007 "Native bees as Insurance for Honeybee Declines")
  - BUT good substitutes make for poor insurance!
  - **Option value – Kassar & Lasserre 2002**
  - Value from "keeping options open"
  - Important if loss is irreversible

Should farmer's value wild bees?



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Evidence of Price Shocks?

Value of keeping the option of using wild bees around.

Threats to wild bee may be slow acting, need to invest now to manage risks for the future.

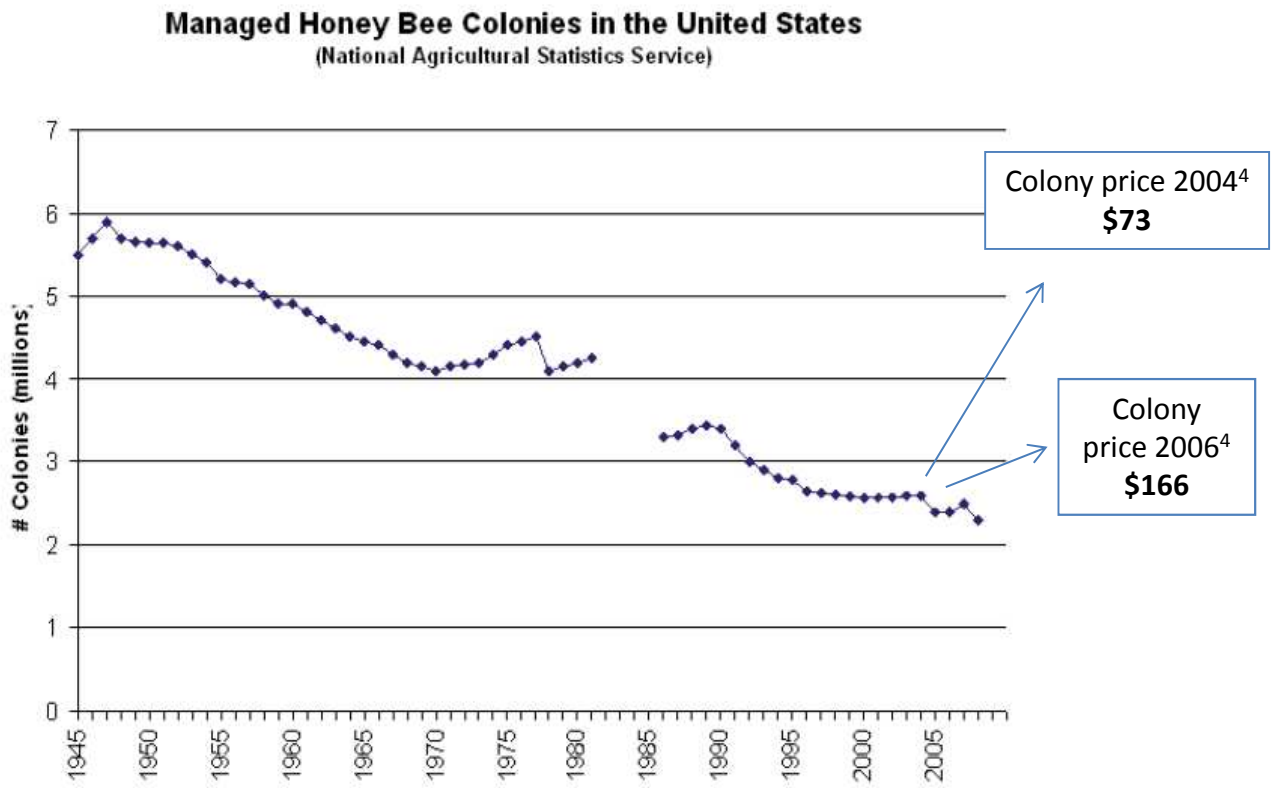


Figure 1. The number of managed honey bee colonies (in millions) in the United States from 1945 to 2008 as reported by the USDA National Agricultural Statistics Service. The current level of approximately 2.5 million colonies is very low given that the US needs 1.5 million colonies in California each year to pollinate almonds. Three years of on average 30% colony losses in the US (2006–2008) threaten our ability to provide such pollination services to agriculture. No data on colony numbers were recorded for 1982–1985.

3 (Chart). Pettis & Delaphane (2010) Apiologie 41, 256–263
4. Burgett et al (2010) American Bee Journal 150, 35-41

Option value

- “Wild bees are unpredictable”
- “Just keep buying the boxes year after year”

(Though regulation risk was a bit of a concern)

- Time-frame issue?
- Under what assumptions would their be a private option value?
- Would society make different decisions?

Modelling wild bee numbers over time

1) $\frac{dN_t}{dt} = N_t r(N_t - \alpha)\left(1 - \frac{N_t}{K}\right) - \gamma N_t P_t - \beta N_t C_t$

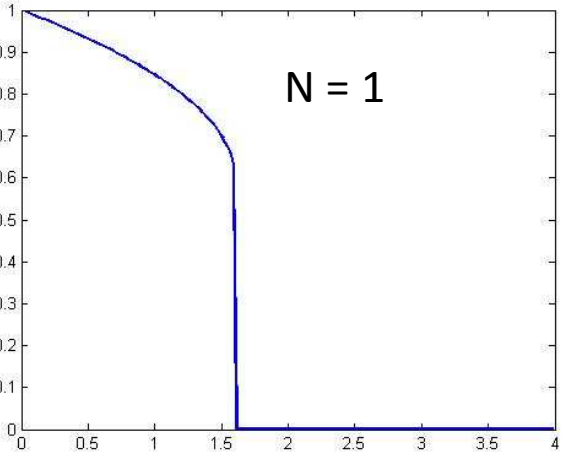
2) $S_t = aN_t + bC_t$

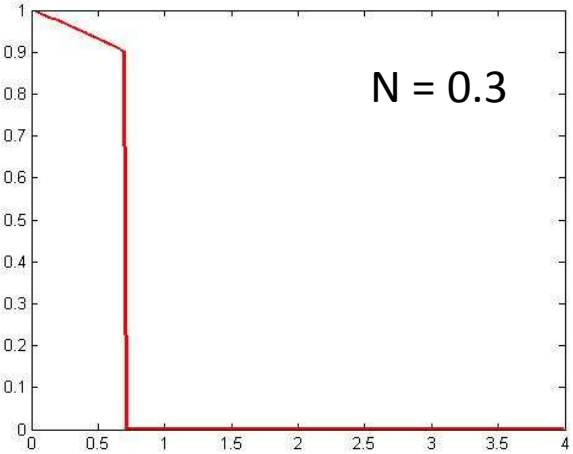
$$\frac{dN_t}{dt} = N_t r(N_t - \alpha)\left(1 - \frac{N_t}{K}\right) - \gamma N_t P_t - \beta N_t \left(\frac{S_t}{b} - \frac{a}{b} N_t\right)$$

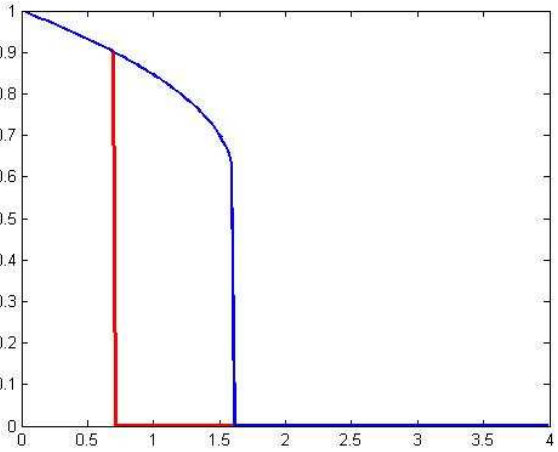
Nt = wild bee population at time t
R = reproductive rate (b – d)
Alpha = minimum population size
K = carrying capacity
P = pesticide level
Gamma = Pesticide potency
St = pollinator requirements

Model results

$$\frac{dN_t}{dt} = N_t r(N_t - \alpha)\left(1 - \frac{N_t}{K}\right) - \gamma N_t P_t - \beta N_t\left(\frac{S_t}{b} - \frac{a}{b} N_t\right)$$



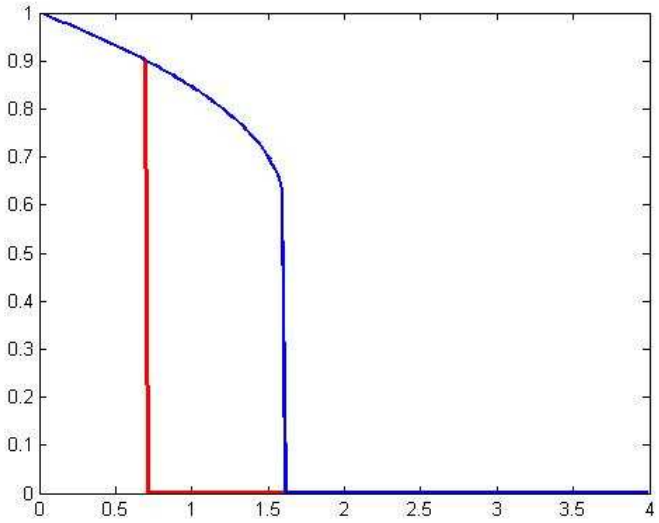




Hysteresis

R =1; alpha = 0.2; k = 1; gamma = 0.1; beta = 0.01; b = 1; a = 0.5; s = 10

Model results



$$\frac{dN_t}{dt} = N_t r(N_t - \alpha)\left(1 - \frac{N_t}{K}\right) - \gamma N_t P_t - \beta N_t\left(\frac{S_t}{b} - \frac{a}{b}N_t\right)$$

$$\pi_t = (aN_t + bC_t)\sigma - \rho C_t$$

Addition of a market where commercial prices increase . Choice is constrained by profit. Vulnerable if supply shocks occur (as in honeybees).

R =1; alpha = 0.2; k = 1; gamma = 0.1; beta = 0.01; b = 1; a = 0.5; s = 10

Summary

- There is a use value to wild bees and commercial bees but investment in wild bees is minimal.
- When such close substitutes, value of keeping diversity is decreased (as limited insurance value), BUT we should be thinking about option values.
- Use modelling to find optimal investment paths for wild bee and commercial bees under different scenarios.
- Time perspective will be important! Social and private outcomes might be different.

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Any questions?