

The application of population modeling techniques to the development of Non-Detriment Findings for *Galanthus*

Matthew Smith,
Microsoft Research,
Cambridge, UK

Modelling is a typical part of ecological investigations and PVAs

- One issue with some current NDFs is that the assumptions made in their formulation are not transparent – especially levels of uncertainty
- Models allow us to objectively summarise what we think are the important processes determining the dynamics of the system we are interested in
- They can potentially lead to useful quantitative predictions – conservative quotas

The Turkish *Galanthus* system works – but we're not precisely sure why

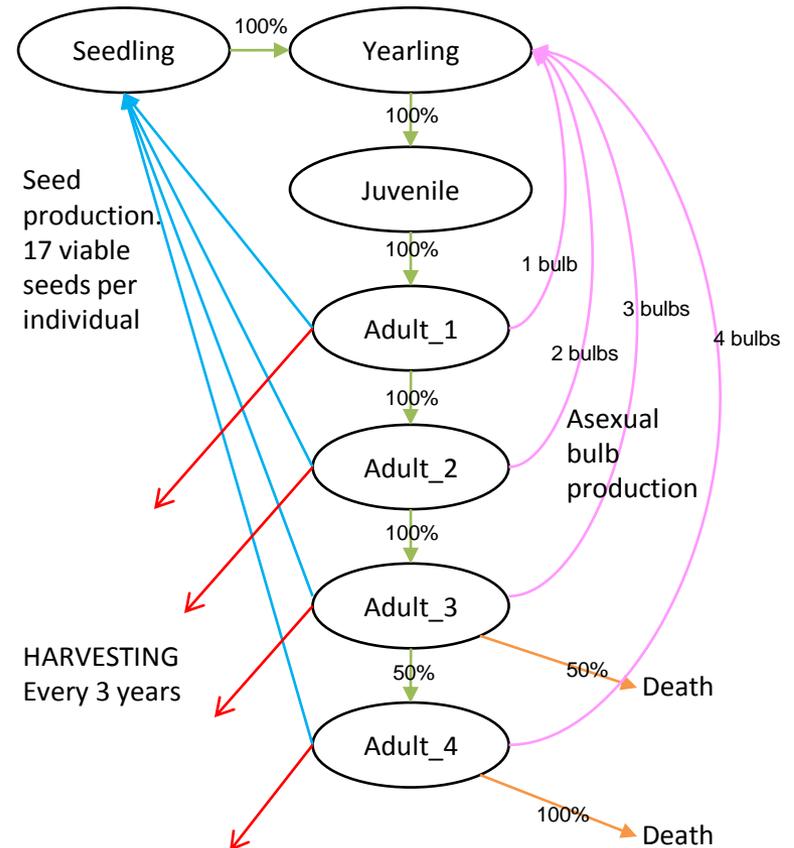
- The Turkish NDF system is based on experience of what are and are not sustainable harvest levels and methods.
- For outsiders it is difficult to learn from the example – what is generally relevant?
- What is it about *Galanthus elwesii* that allows these NDFs to be made in this way?
- If we understood the underlying processes more we could apply this knowledge to other systems.

We investigated the *Galanthus* dynamics using a population model

- In a perfect environment, what would be sustainable harvesting methods?
 - Extraction quantities?
 - Rotation periods?
- Does the model support the observation that current methods are sustainable?
- How hard could the system be pushed before harvesting is detrimental?
- What do we expect to differ between habitats or for different taxa?

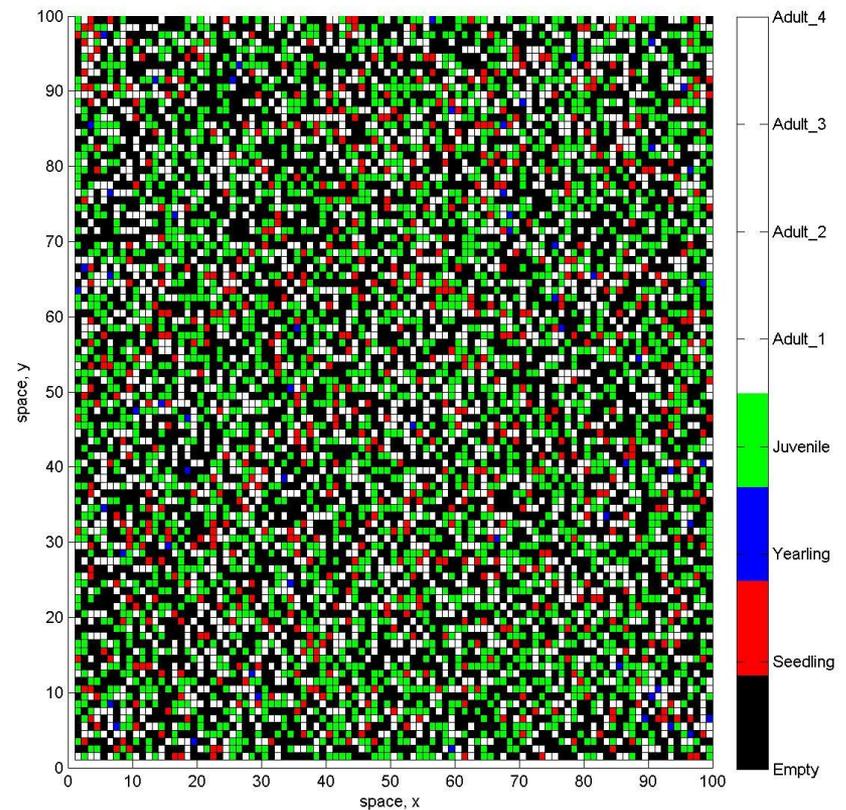
An initial modelling investigation based on no data but expert knowledge

- This life history diagram summarises our knowledge of the *G. elwesii* life cycle in optimum habitats in Turkey

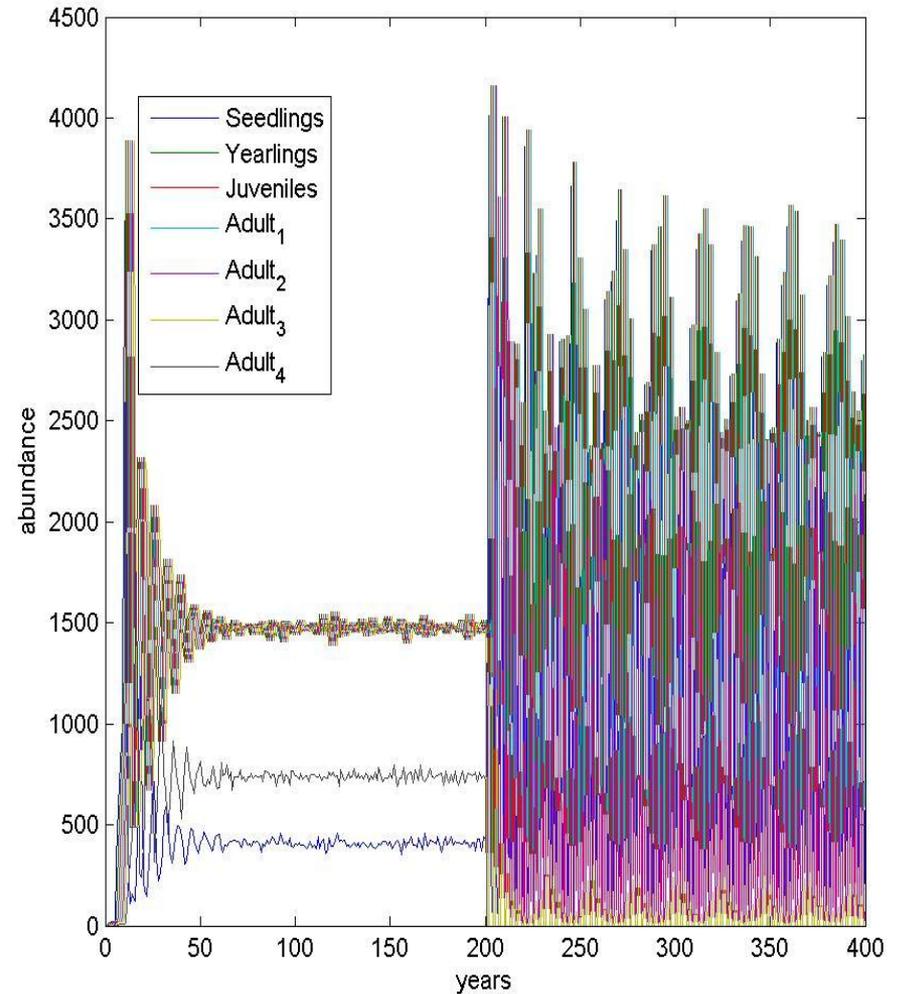
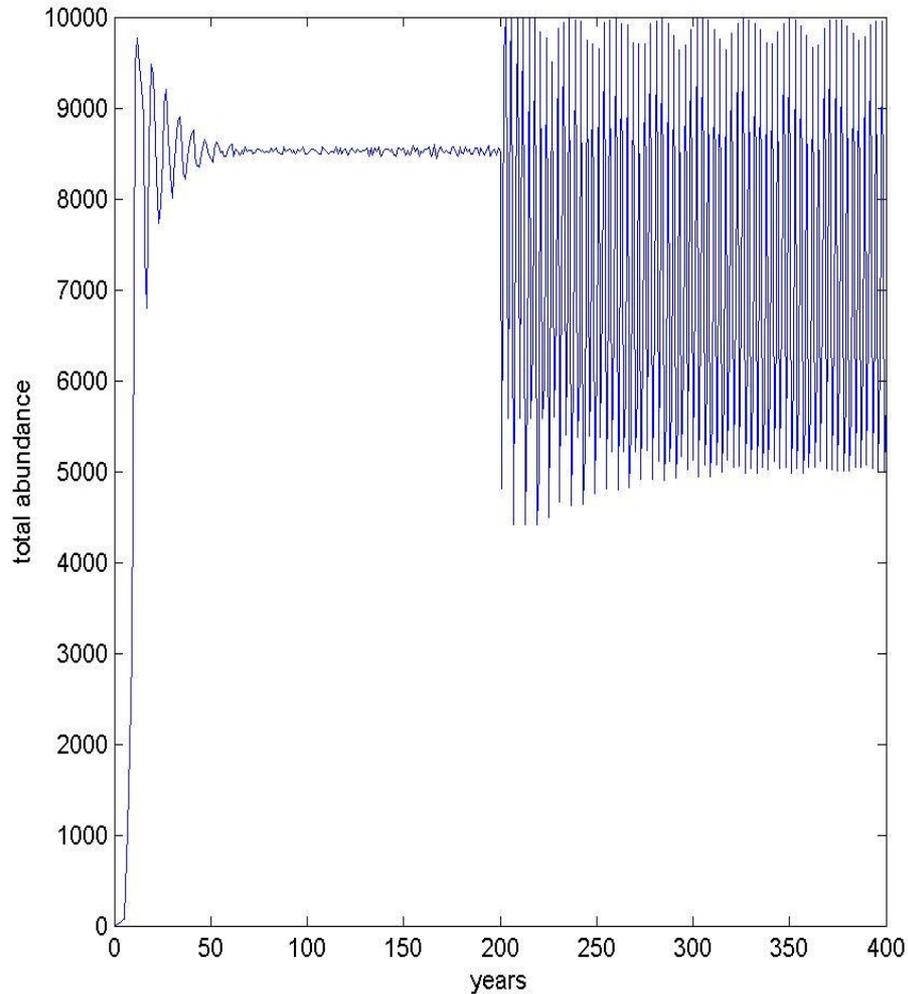


The model suggests practical ways to develop future predictive models

- An individual based model is usually a big computer program that has rules of interaction for each individual – they are often quite difficult to assess as an “outsider”



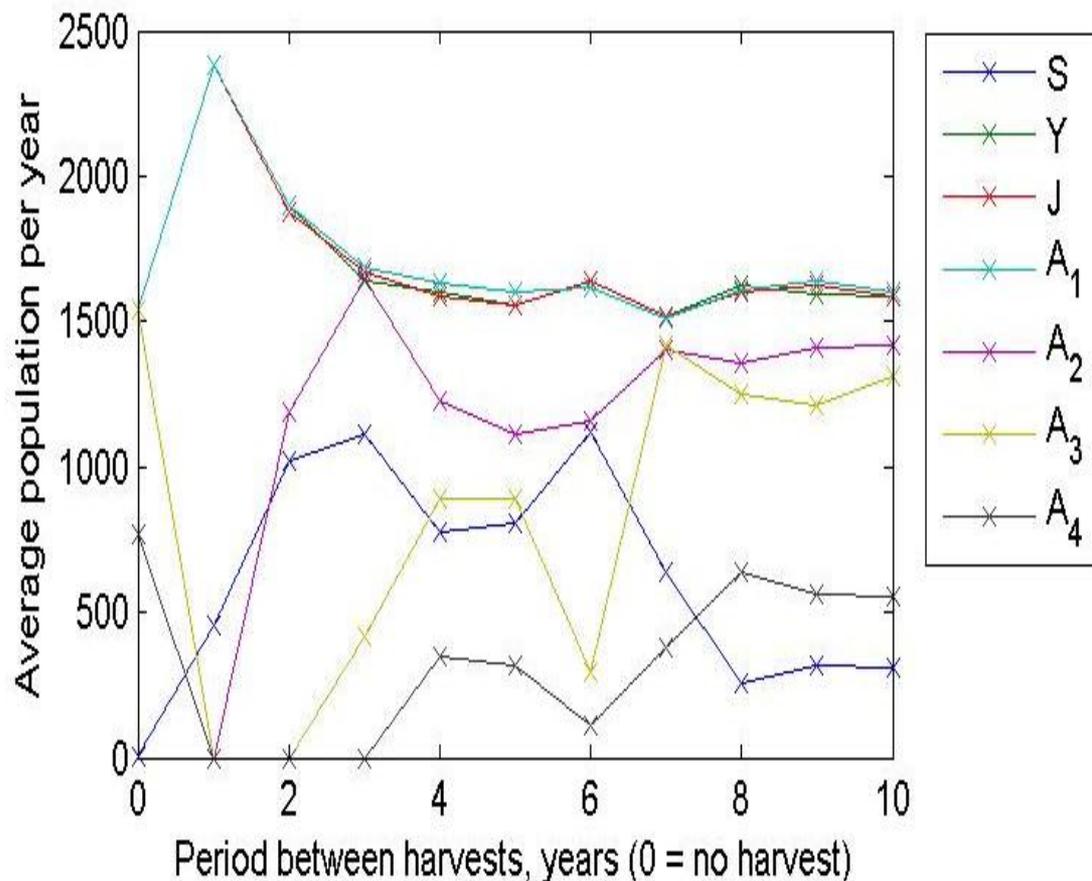
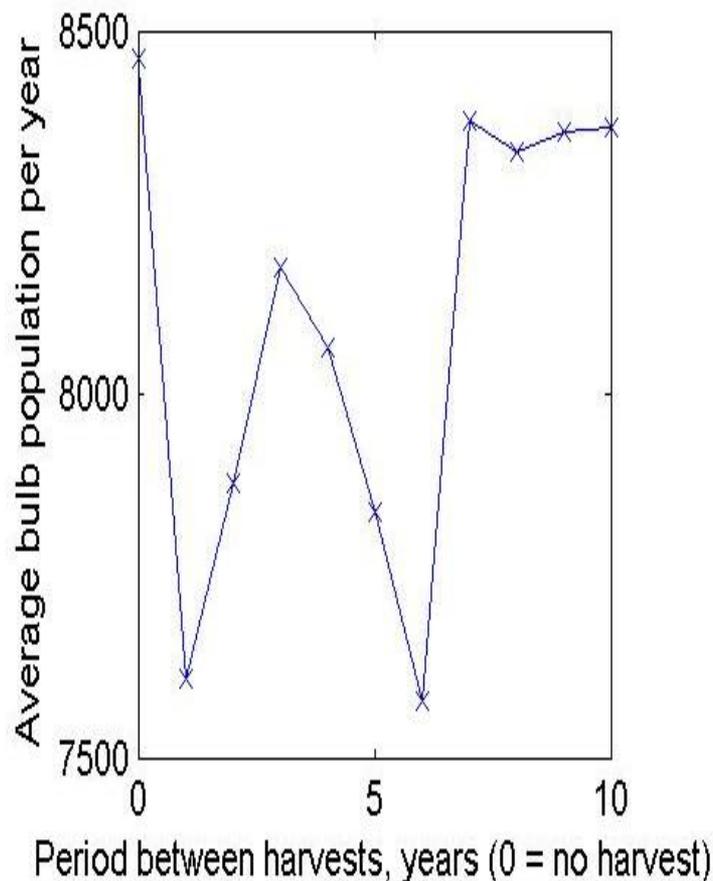
The model predicts that the current harvest methods are sustainable



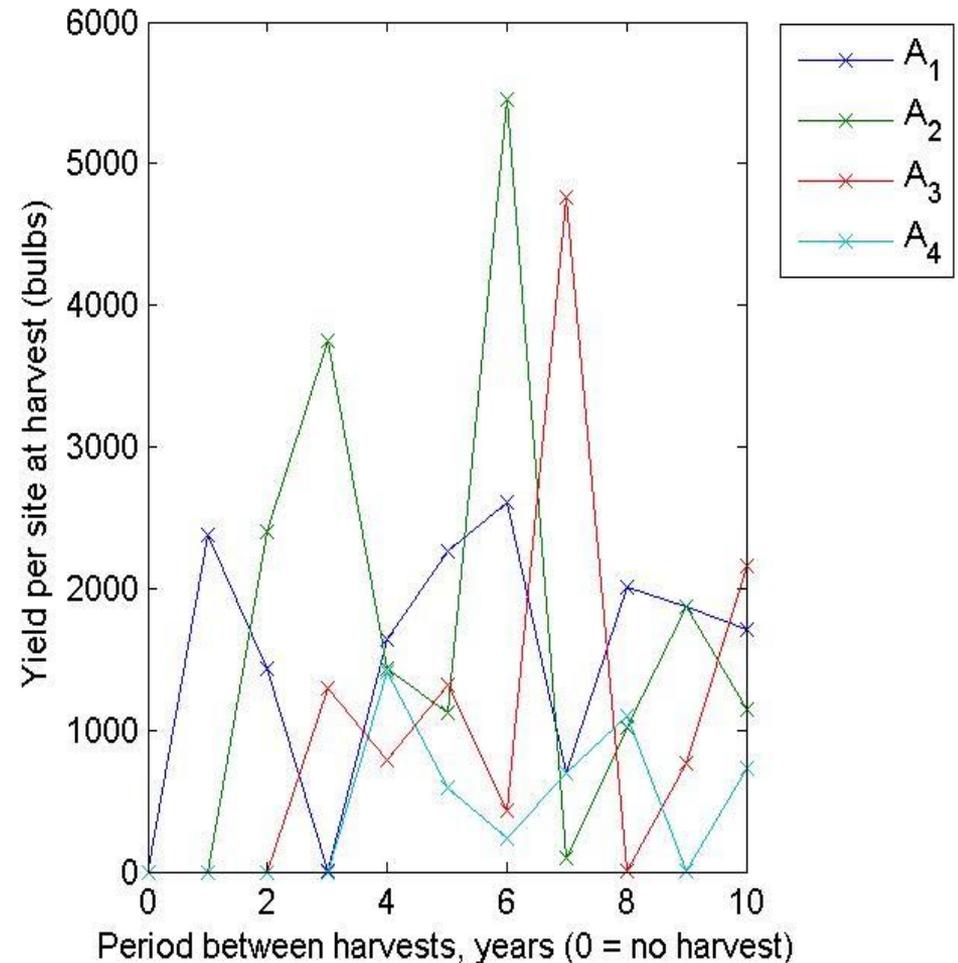
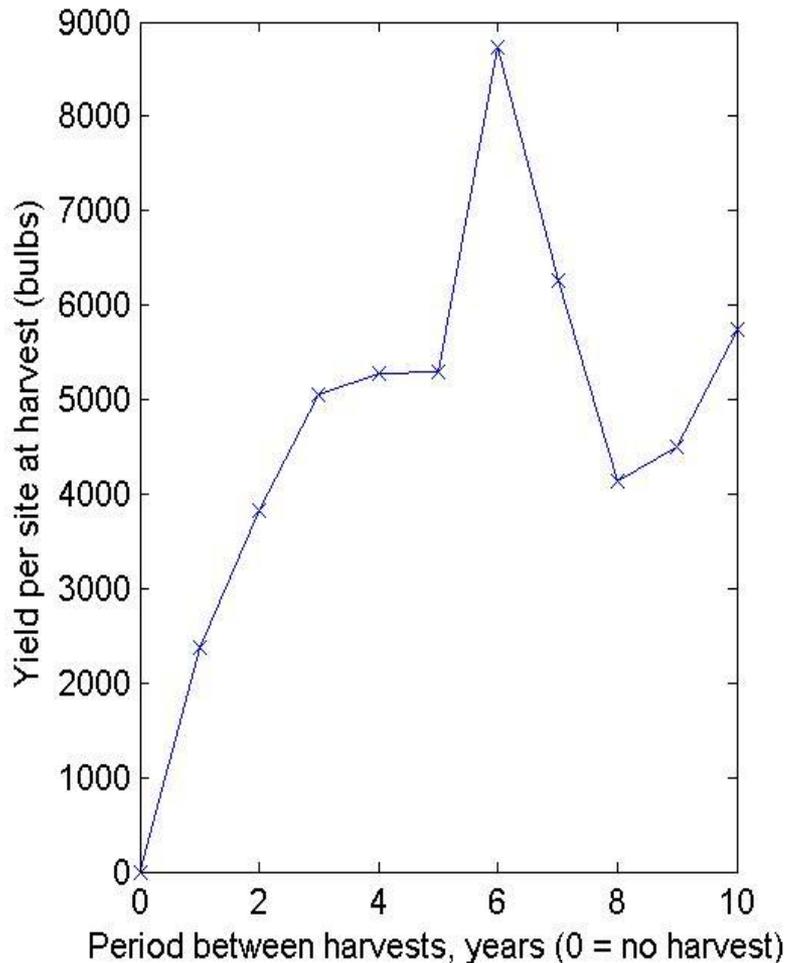
We can identify several reasons why harvesting is non-detrimental

- High potential birth rates
- Harvest after reproduction has occurred
- High survival throughout life
- What if these are not true? – e.g. collection of some juveniles, higher mortality, habitat heterogeneity?
- Stochasticity is a key unknown
 - how variable are environmental conditions and demographic parameters?

The model allows us to compare harvest methods – wild population

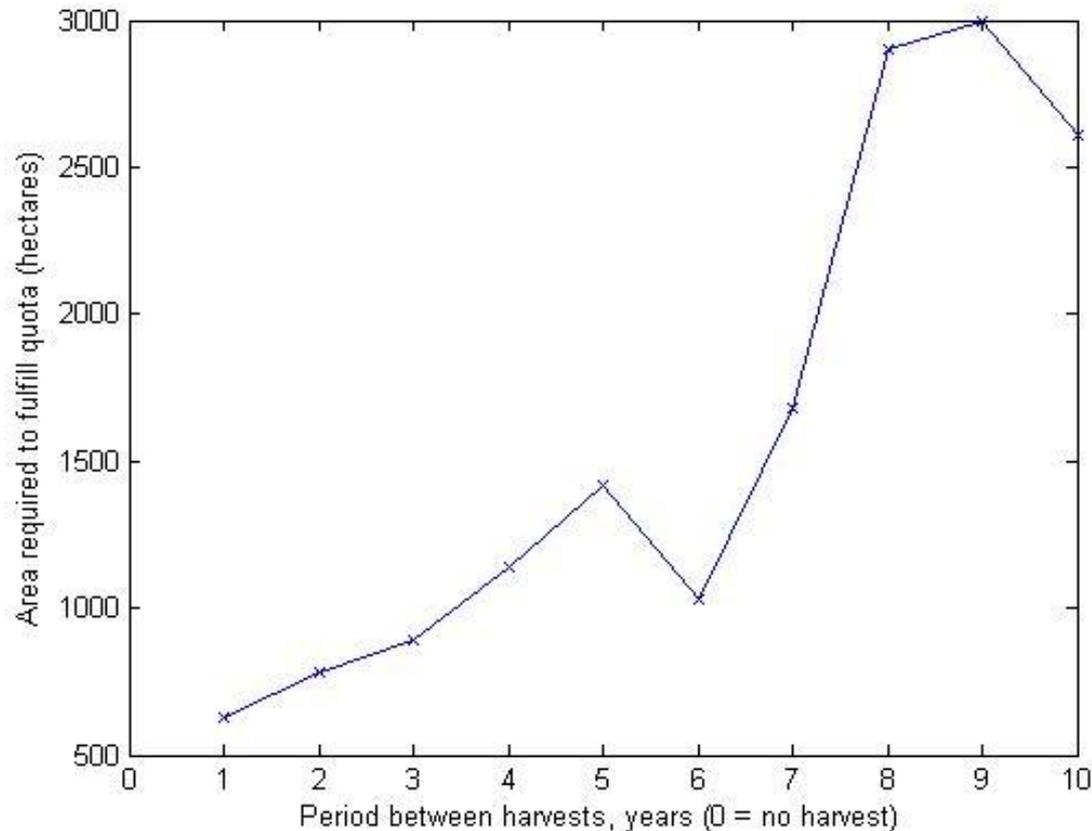


The model allows us to compare harvest methods – e.g. yield



The model suggests other metrics to monitor to ensure sustainable harvests

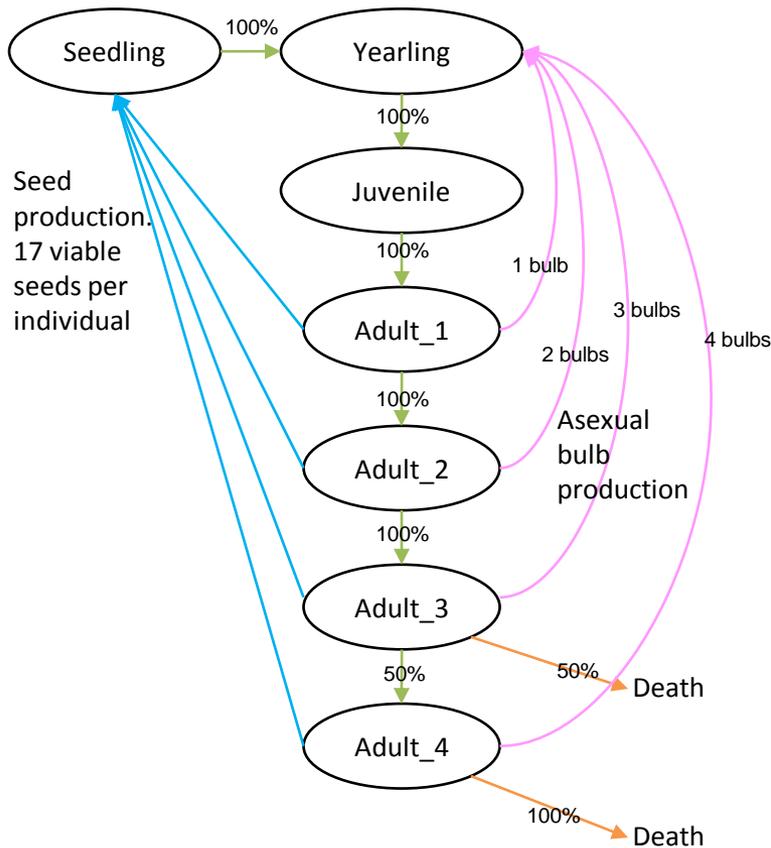
- Land area required to achieve quota



The model indicates the parameters that might be most important to obtain

- Viable seed production
 - Asexual bulb production
 - Density dependent mechanisms
 - Mortality rates
 - Age specificity
 - Stochasticity
-
- We can also perform data gathering experiments

Age/stage structured population models are the standard method



$$S_{T+1} = \sum_{j=1,2,3,4} A_{j,T} r_1 (1 - N/K)$$

$$Y_{T+1} = S_T + \sum_{j=1,2,3,4} A_{j,T} b_j (1 - N/K)$$

$$J_{T+1} = Y_T$$

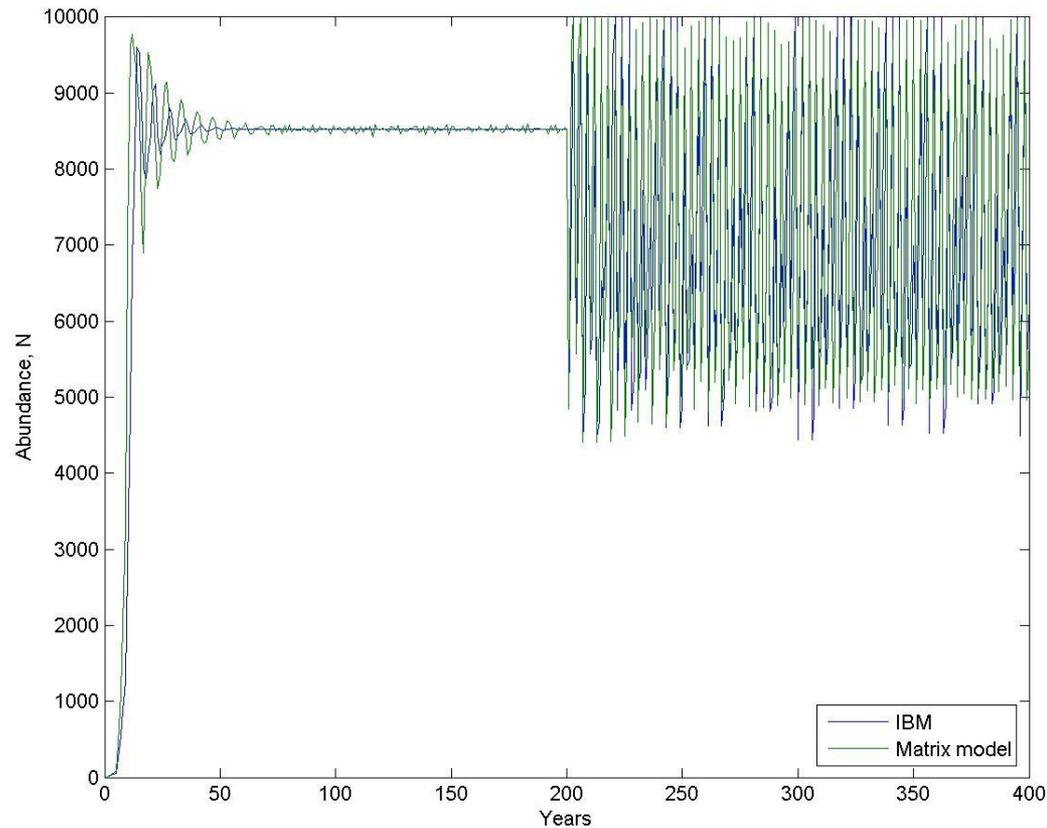
$$A_{1,T+1} = J_T$$

$$A_{2,T+1} = A_{1,T}$$

$$A_{3,T+1} = A_{2,T}$$

$$A_{4,T+1} = 0.5 A_{3,T}$$

The matrix model can be fit to the dynamics and does a good job



Summary and recommendations

- Population modelling provides a formal information processing framework to aid in making NDFs
- A sufficiently accurate population model for making NDFs will require adequate data collection
- Modelling without data still helps us identify plausible key components in the system that determine sustainable harvest levels
- Data quantity and quality could be assessed by incorporating uncertainty into the model – what can we effectively predict?

Summary and recommendations

- Is modelling a realistic goal for NDFs?
- I recommend that Scientific Authorities produce a preliminary model even in the absence of data
- Having a parameterised and tested model to accompany the NDF would increase its transparency and transferability
- Problem – how generally relevant is any given NDF model?

A vision of the future

- “Our field and harvest inspections and validated population models make us confident that this level of harvesting will not be detrimental to the survival of the taxon (<0.1% chance of reducing the population by >5% over 10 years).”
- Our population model, and field experiments, indicate that twice as many plants could be removed on a 3-year rotation and still be non-detrimental, provided all other conditions remain unchanged (<5% chance of reducing the population by >5% over 10 years).”