

A scenic landscape photograph of a coastal area. In the foreground, there are various green plants and trees, including a large, dark tree on the right. The middle ground shows a dense forest of trees. In the background, a body of water (the sea) is visible under a cloudy sky. The overall scene is a natural, outdoor setting.

Adapting the model

Predicting the effects of
environmental change for
conservation

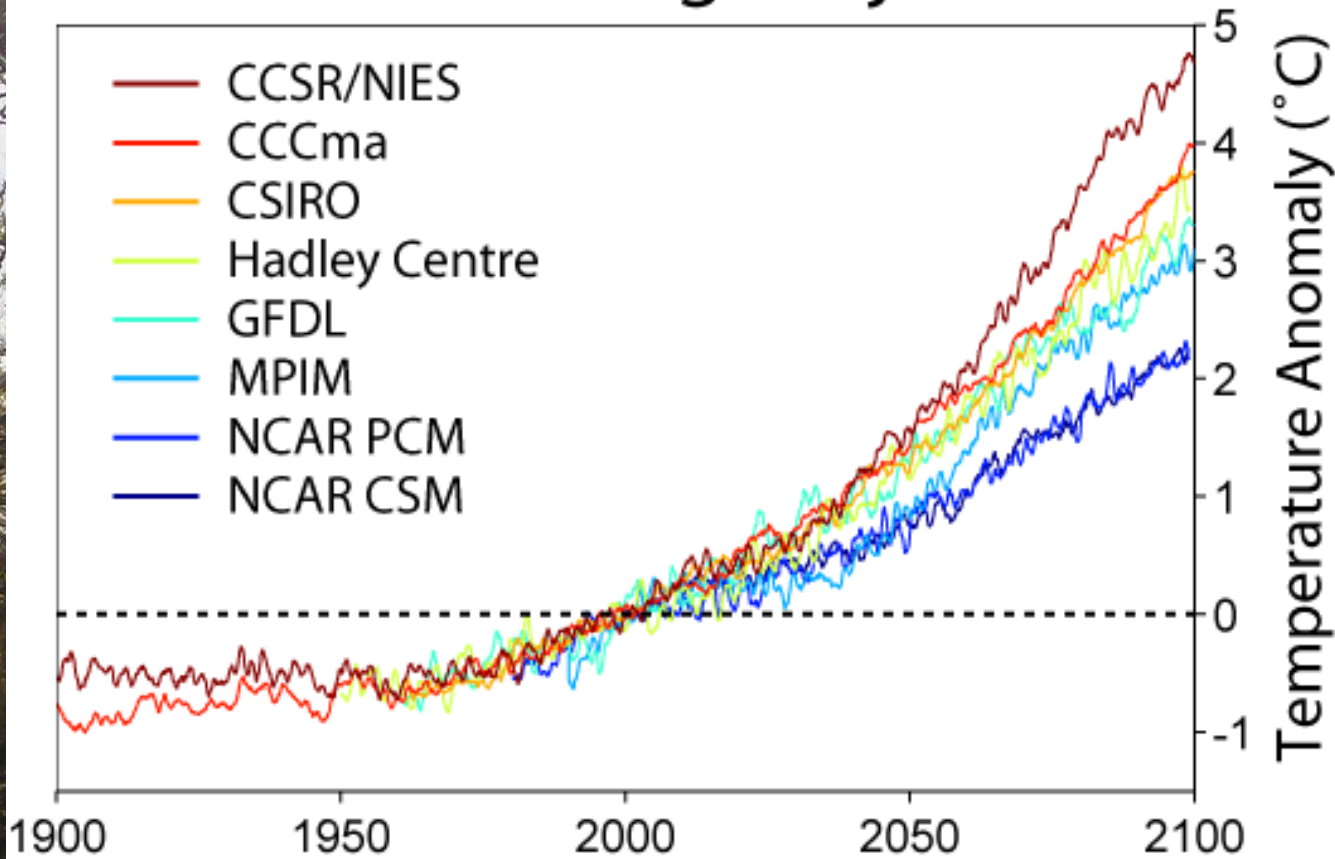
Matthew R. Evans, Centre for Ecology and Conservation, University of Exeter

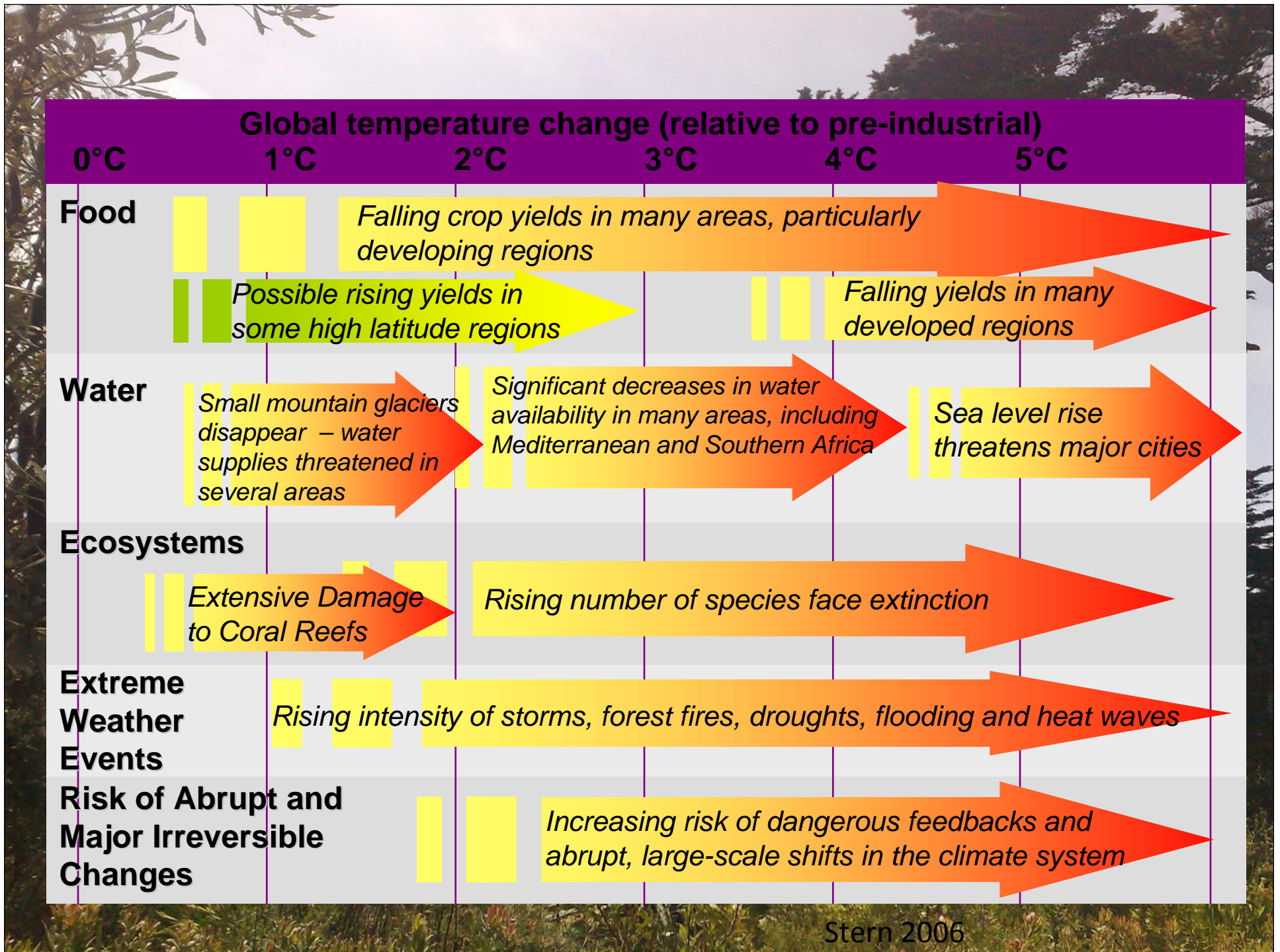
A changing world

- The world is changing at an unprecedented rate
- A triumvirate of threat (Travis 2003)
 - Climate change
 - Habitat loss
 - Habitat fragmentation
- Unprecedented pressures on the biological world

Climate change

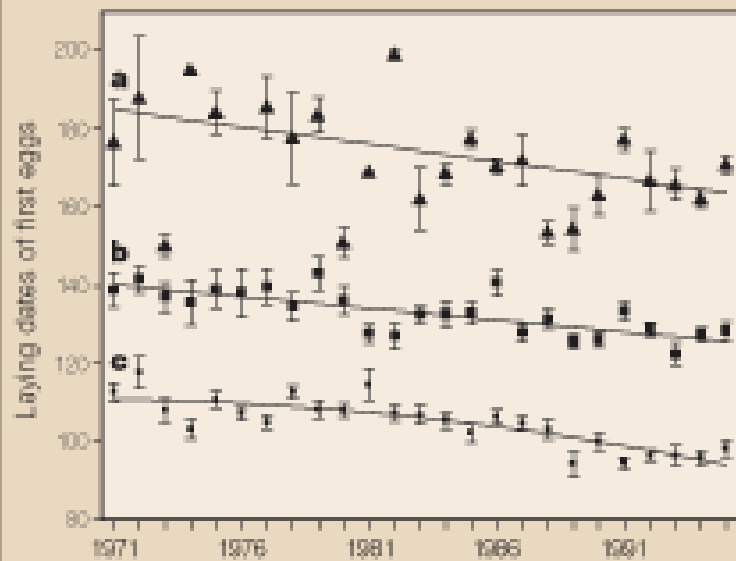
Global Warming Projections





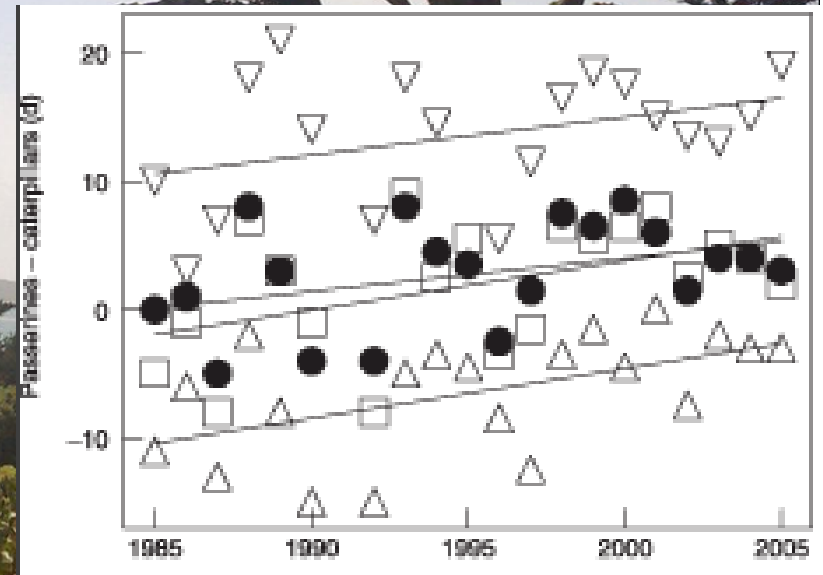
Effect on conservation

- Scale and speed of change in the physical environment
- Can expect some adaptation by organisms through phenotypic plasticity and evolution



Crick et al 1997

Laying dates in UK birds getting earlier (c3/4 days per decade) But mismatch between peak food demand and peak food availability is increasing



Both et al 2007

Effect on conservation

- Intervention will be needed to avoid loss of biodiversity and ecosystem services
- But what should be done?
- We need to know what will be the likely impact of the predicted physical changes
- We need to know what (if anything) we can do to facilitate adaptation

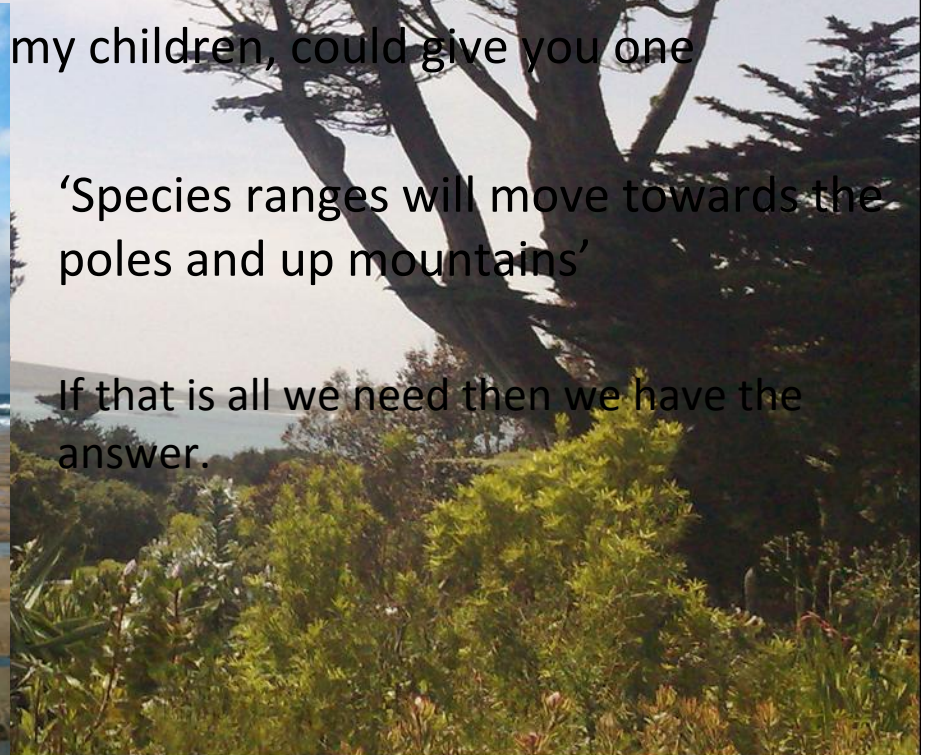
What should be done?

- The answer will depend on what the impact we believe climate change will have on the biological world?

Almost anyone, including my children, could give you one answer.

‘Species ranges will move towards the poles and up mountains’

If that is all we need then we have the answer.



Overly simple answers don't help



We need to know more than the species range will move north.

How far?

To what habitat?

How will it move?

Will we need to help?

Modeling and environmental change

- Ecologists make predictions about the systems of interest using models
- Typically this would be a model based on assumed causal relationships derived from data statistically
- Such models are great at telling us what happened but poor at predicting the behaviour of systems in novel situations

Modeling and environmental change



Modeling and environmental change



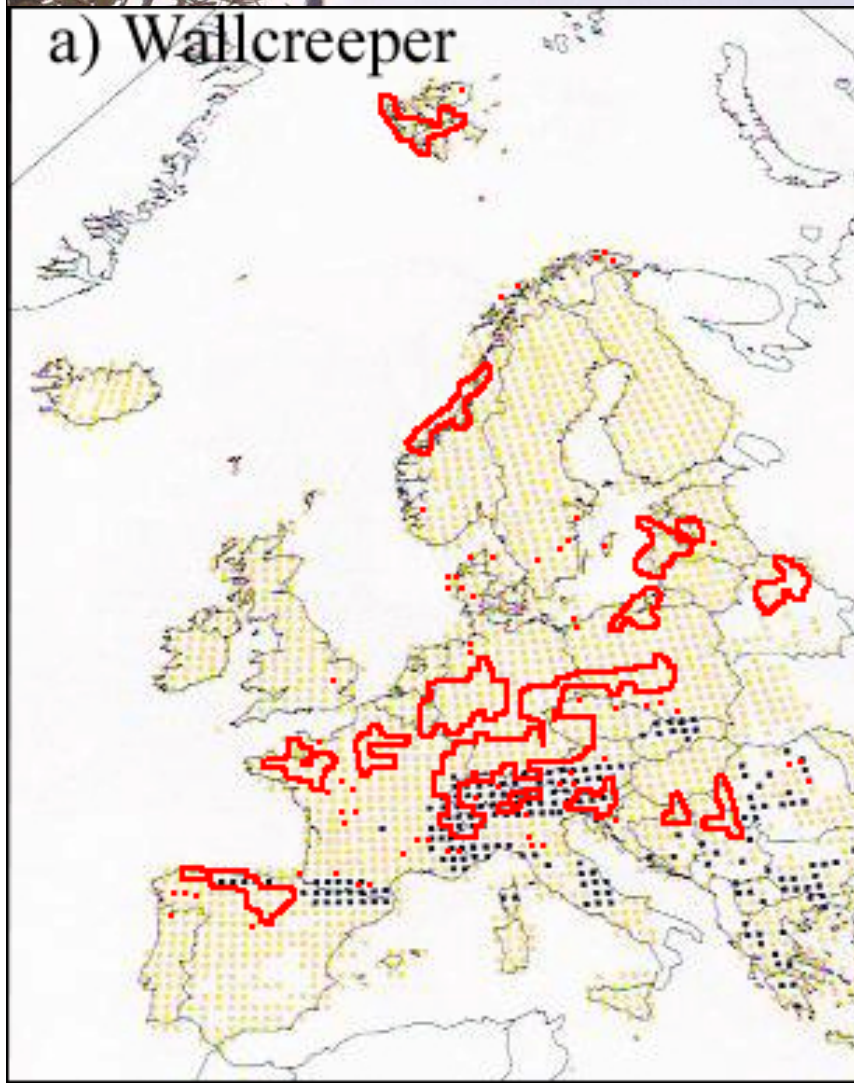
Modeling and environmental change

- Mark Twain (1883) provided an excellent illustration of the problems of extrapolating outside the range of observed data in 1883:
- 'In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles. That is an average of a trifle over one mile and a third per year. Therefore, any calm person, who is not blind or idiotic, can see that in the Old Oolitic Silurian Period, just a million years ago next November, the Lower Mississippi River was upwards of one million three hundred thousand miles long, and stuck out over the Gulf of Mexico like a fishing-rod. And by the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three-quarters long, and Cairo and New Orleans will have joined their streets together, and be plodding comfortably along under a single mayor and a mutual board of aldermen. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.'

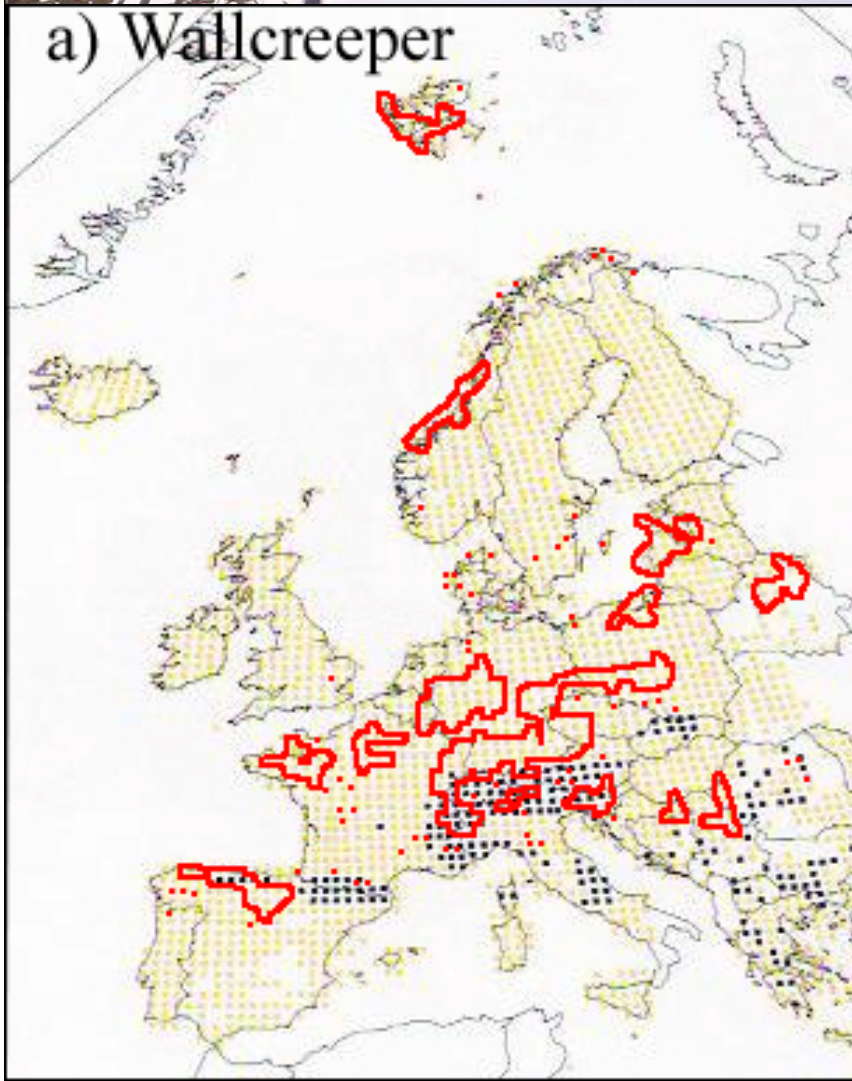
What happens when we use existing methods?



Why can't we use existing methods?

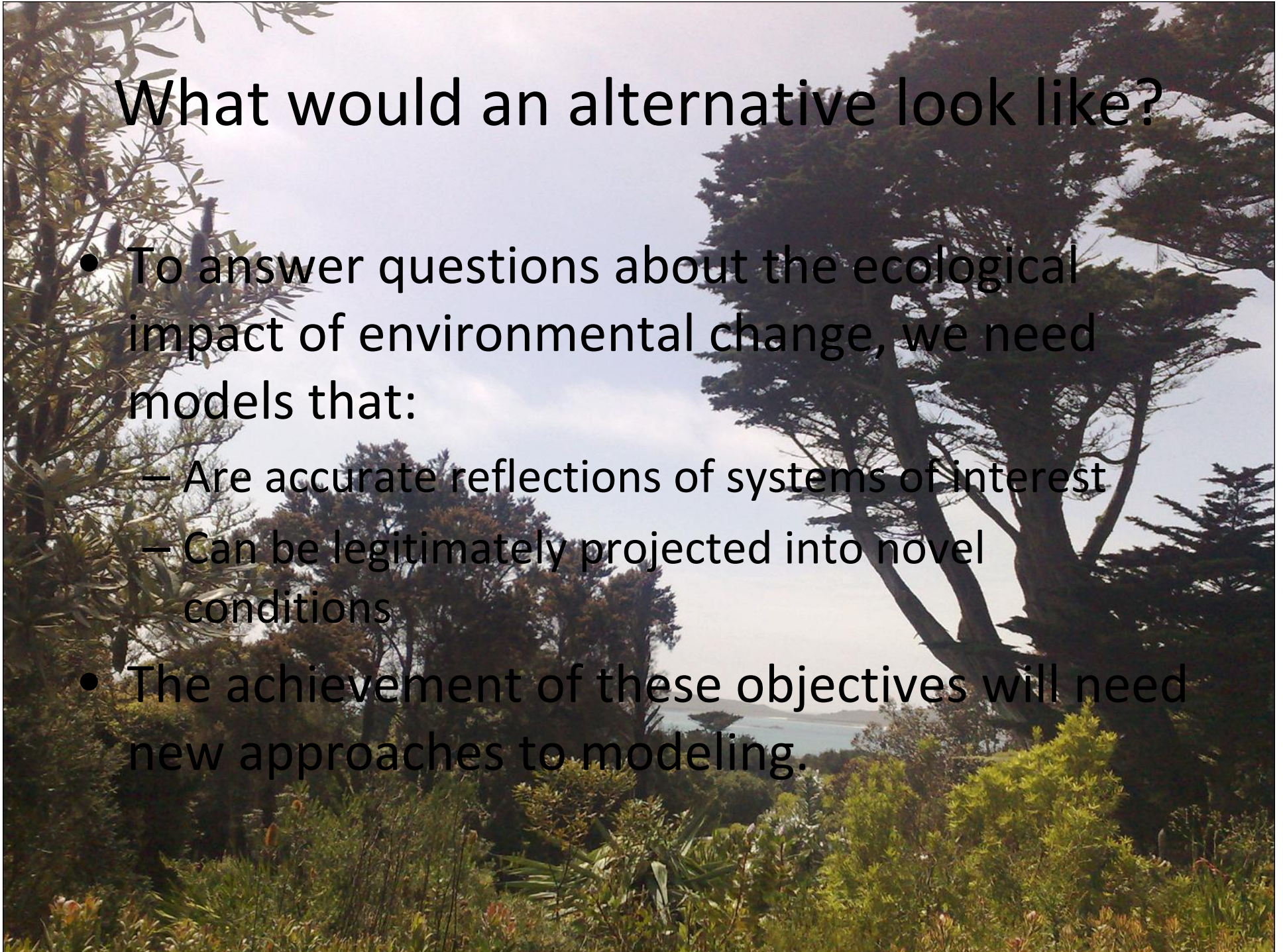


Why can't we use existing methods?



What would an alternative look like?

- To answer questions about the ecological impact of environmental change, we need models that:
 - Are accurate reflections of systems of interest
 - Can be legitimately projected into novel conditions
- The achievement of these objectives will need new approaches to modeling.



Modeling and environmental change

- All ecological systems are collections of individual organisms
- A population is not an entity, it's characteristics depend on how well the individuals within it breed/survive/emigrate
- If the individuals within a population breed and/or survive well then population growth emerges
- If the interactions between individuals within a population could be modeled appropriately then population dynamics would be an emergent property of the system
- Similarly communities and ecosystems are composed of individual organisms

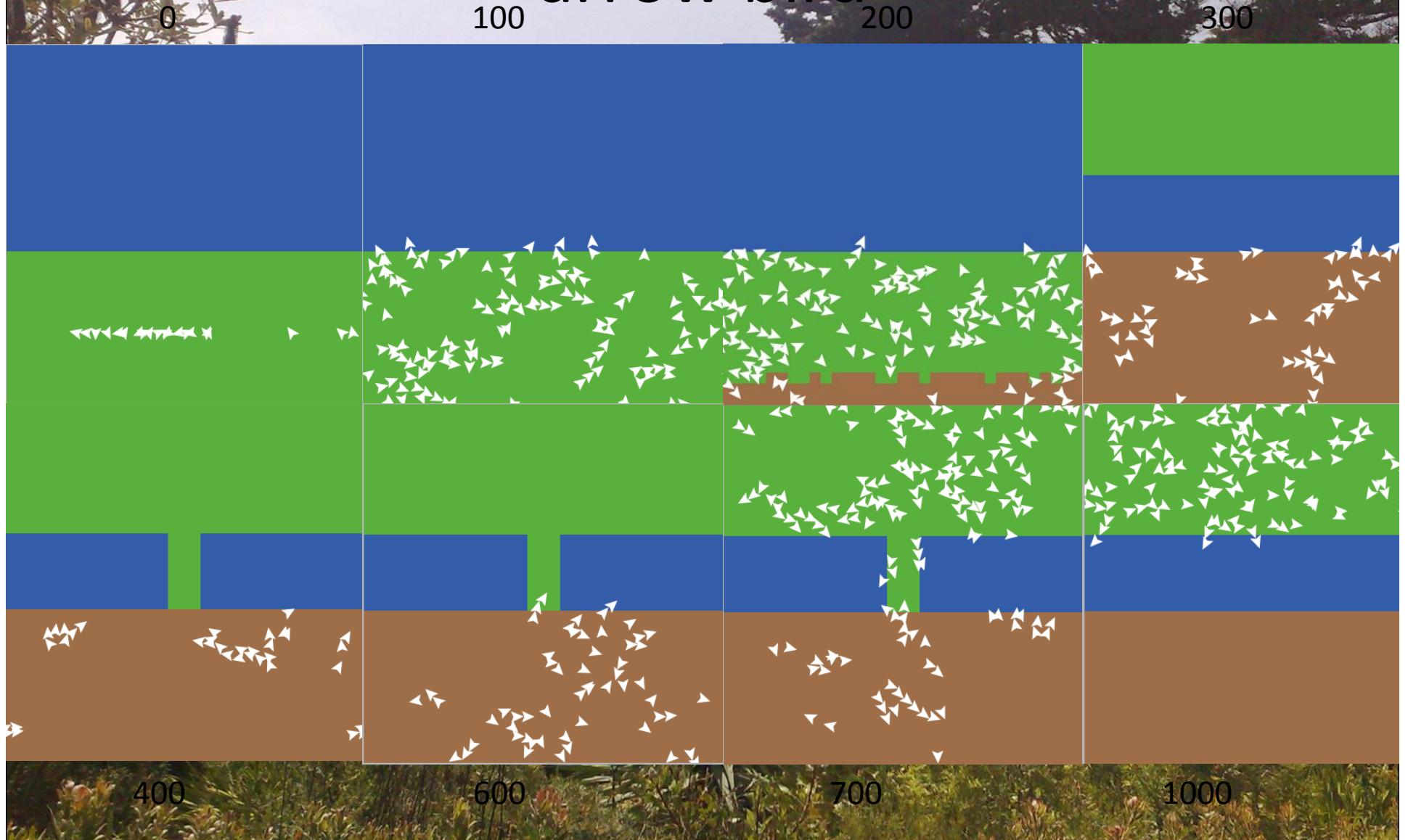
Modeling and environmental change

- Yes this is complicated, but no this is not a new idea
- Climatologists faced with the problem of predicting the impact of rising CO₂ emissions on world temperatures
- Systems biologists trying to understand how proteins and genes interact to produce cell metabolism

An example

- The white arrow bird (demography = wren)
- Limited to a reserve surrounded by unsuitable habitat
- Environment starts to deteriorate (reduces 0-1 year survival by 10%)
- Population declines
- Reserve created to the north
- Natural colonisation doesn't occur
- Population declines, conservation corridor built

A silly simple example – the white arrow bird



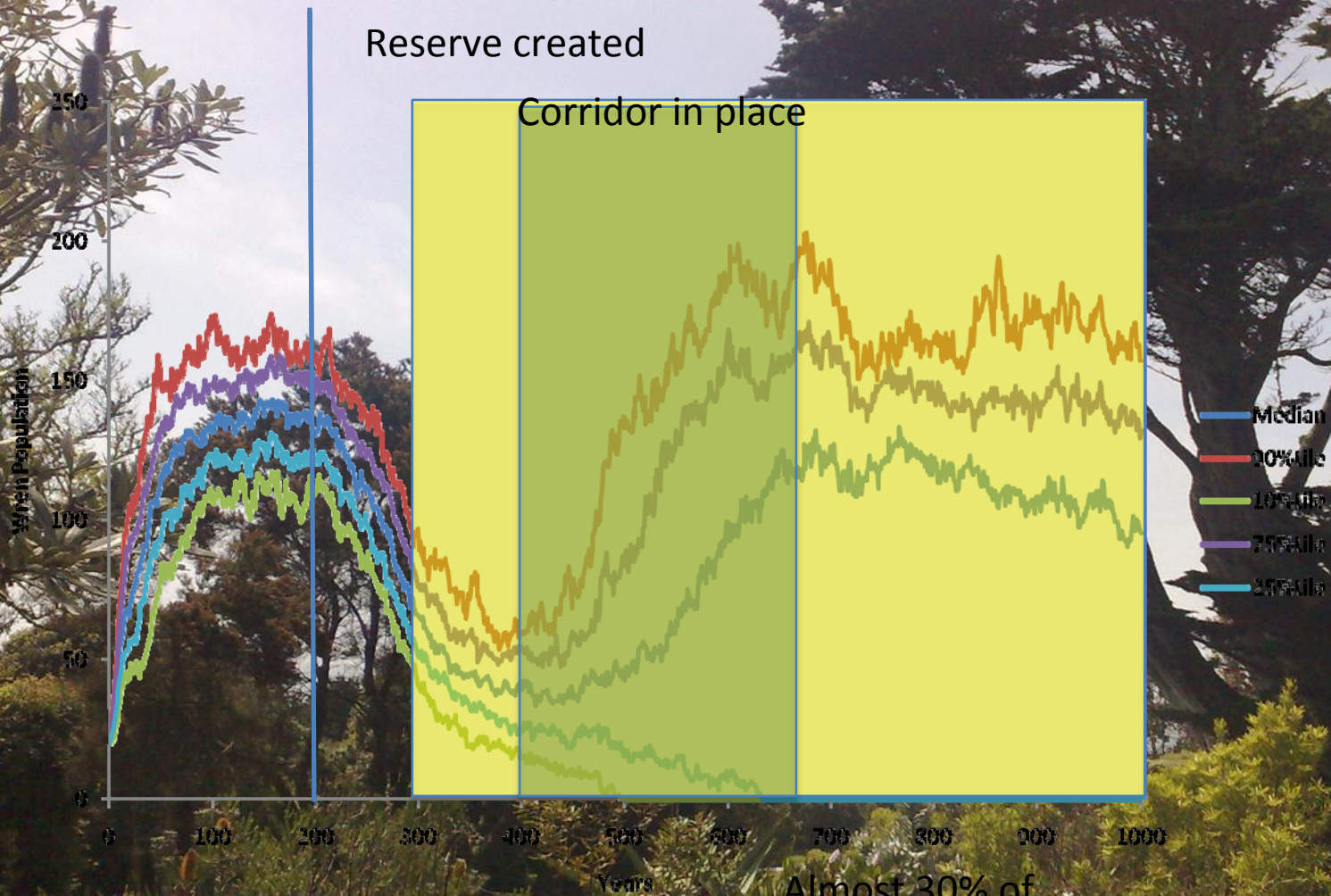
The white arrow bird a conservation success

Environment starts to deteriorate

success

Reserve created

Corridor in place



Almost 30% of runs end in extinction

Action

- Ecologists need to start modelling realistic, specific examples
- These models are likely to be process-based systems models, incorporating individual-level biology
- Conservationists need to demand answers for systems for which they are concerned
- This forecasting effort will be difficult but is tractable and is sufficiently important to command resources similar to those currently used to forecast the physical changes in climate

