The future of the tree-grass ratio in the lowveld savanna

Global Change and the Kruger National Park

Bob Scholes

CSIR-Natural Resources and Environment

KNP Network meeting 14 March 2006

our future through science

Outline

- What is known about environmental changes coming in this century?
- How are they likely to impact on biodiversity?
  -species diversity
  -ecosystem function
- How will biodiversity adapt to the changes?
- How can we help biodiversity to persist?
  -Conservation planning tools
  -Active management

‘Global Change’ is a syndrome of linked changes

- Land cover change
- Biogeochemical change
- Climate change
- Biodiversity change

At the same time, there are many social, economic and political changes going on, not least in South Africa

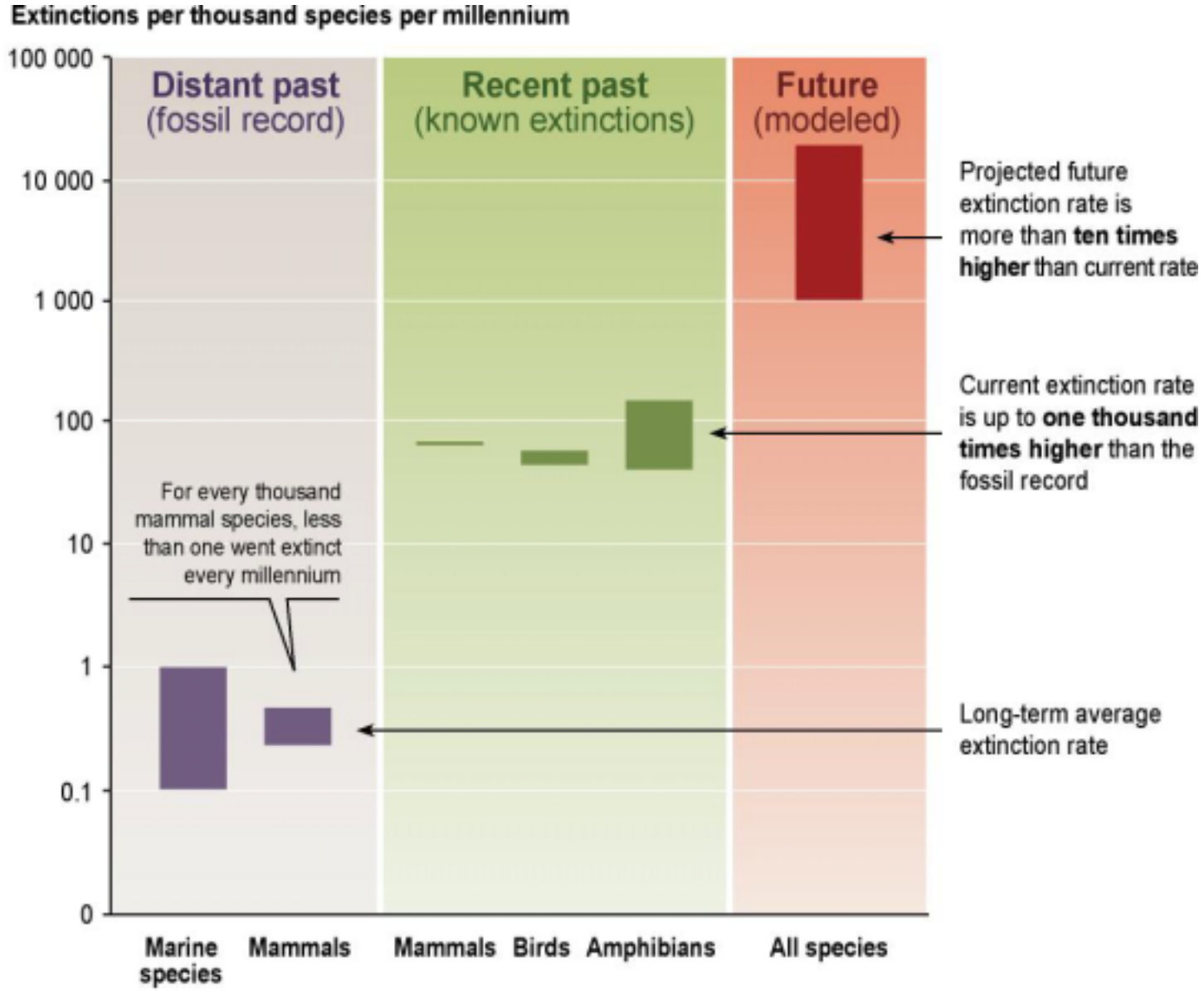
The lowveld in the 21st Century

Intergovernmental Panel on Climate Change

- CO_2 will rise to 550-700 ppm (now 380, preindustrial 270ppm)
- N deposition and ‘global dimming’ will rise (and then fall?)
- The contrast between protected areas (both statutory and private) and human settlements will become stronger
- The annual mean temperature will rise by 3 to 5ºC. The nighttime temperatures will rise somewhat more, and daytime temperatures proportionately less; winter temperatures will rise more than summer temperatures.
- 2 to 13% reduction in mean annual rainfall?
- Changes in vapour pressure deficit? (more or less humid?)
- Soil moisture duration decrease?

Impacts of Global Change on biodiversity

Millennium Ecosystem Assessment Findings



Source: Millennium Ecosystem Assessment

Adaptation of biodiversity

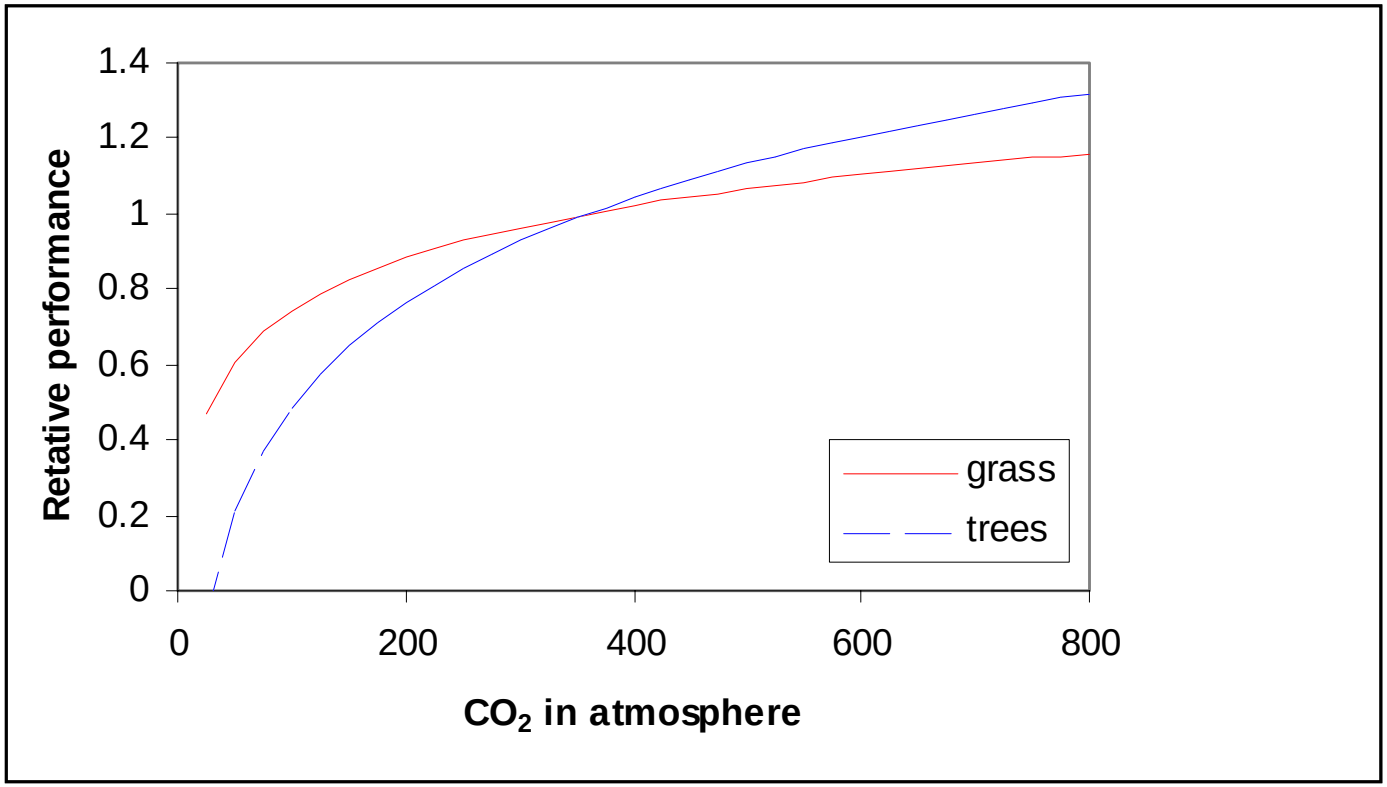
Assessment of Impacts and Adaptation of Climate Change

- ‘Autonomous adaptation’
  - Adjustment of population size (therefore community composition)
  - Behavioral adaptation (eg resting in the shade)
  - Physiological adaptation (eg changing temperature optimum)
  - Dispersal to more favourable environments
  - Evolutionary adaptation (selection for more fit genotypes)
- ‘Facilitated adaptation’
  - Ensure that dispersal pathways exist
  - Ensure some degree of protection exists in new habitats
  - Physically move populations or communities
- ‘Rescue’ through *ex situ* conservation
  - Last resort activity
  - As an insurance in case autonomous or facilitated adaptation fail

Structural and functional adaptation

- Will the lowveld become more or less dominated by trees?
- Will the carrying capacity for different guilds of herbivores change?

Effect of CO_2 on plant production

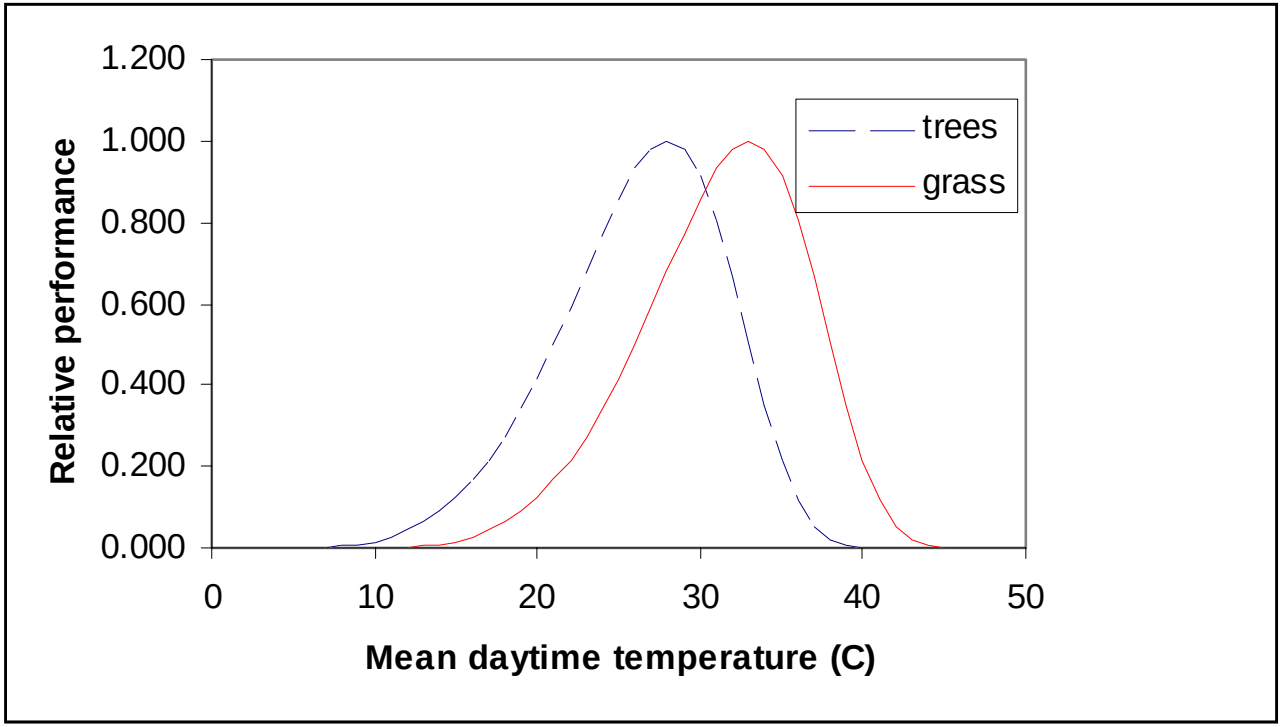


$$F(CO_2) = 1 + \beta \ln([CO_2]/[CO_{2ref}])$$

$\beta \sim 0.4$ for trees, 0.2 for grass

$[CO_{2ref}] = 360$ ppm

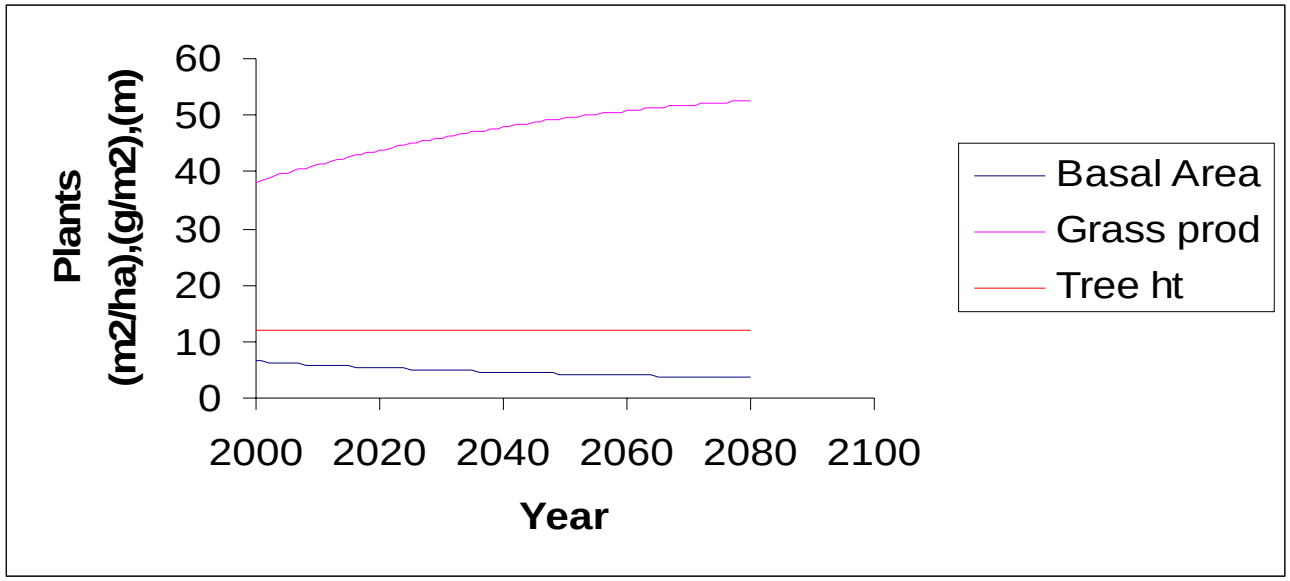
Effects of temperature on plant production



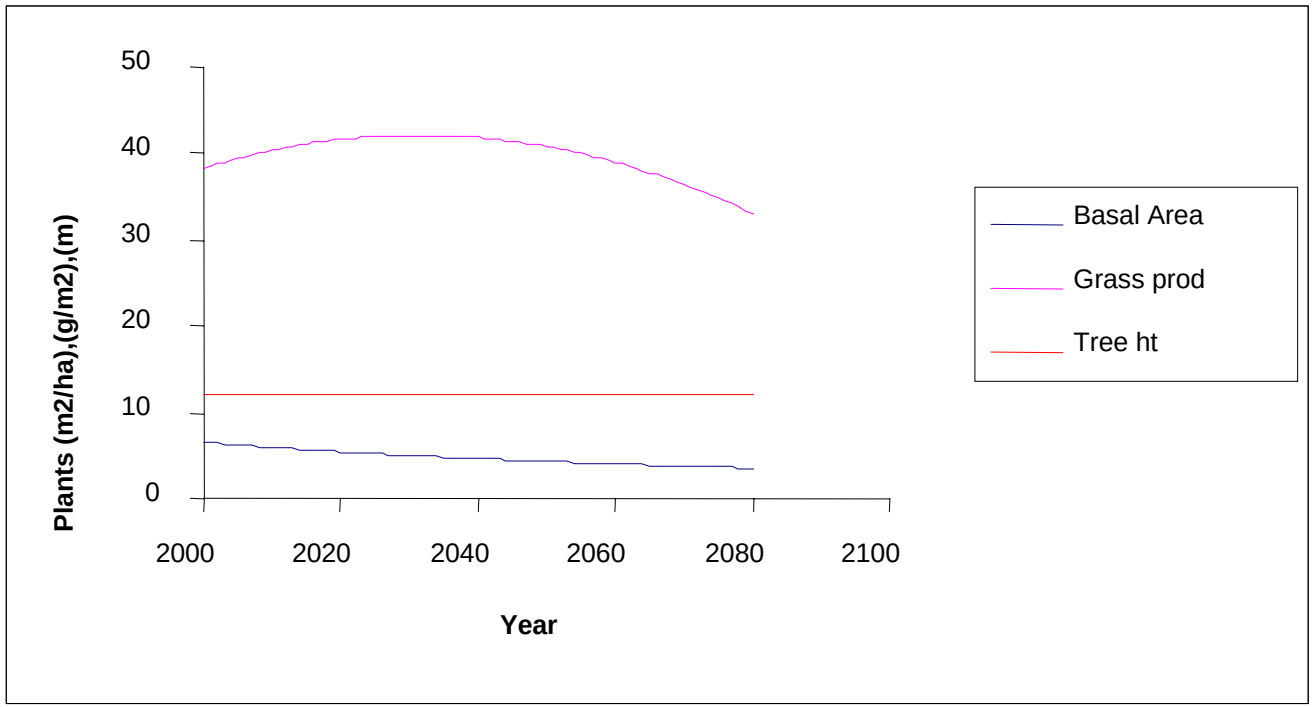
$$f[T] = e^{c*(1-\{[(b-T)/(b-a)]^{\wedge}d\}/d} * (b-T)/(b-a)^c$$

a = position of optimum ~ 28°C for trees, ~33°C for grasses
b =temperature below which no growth occurs ~5C trees, 10C grass
c = steepness of curve below optimum ~3
d = steepness of curve above optimum ~7

Some model projections



B2 scenario
Community climate model



A2 scenario
Hadley model

Conclusions regarding functional and structural changes in the lowveld ecosystem

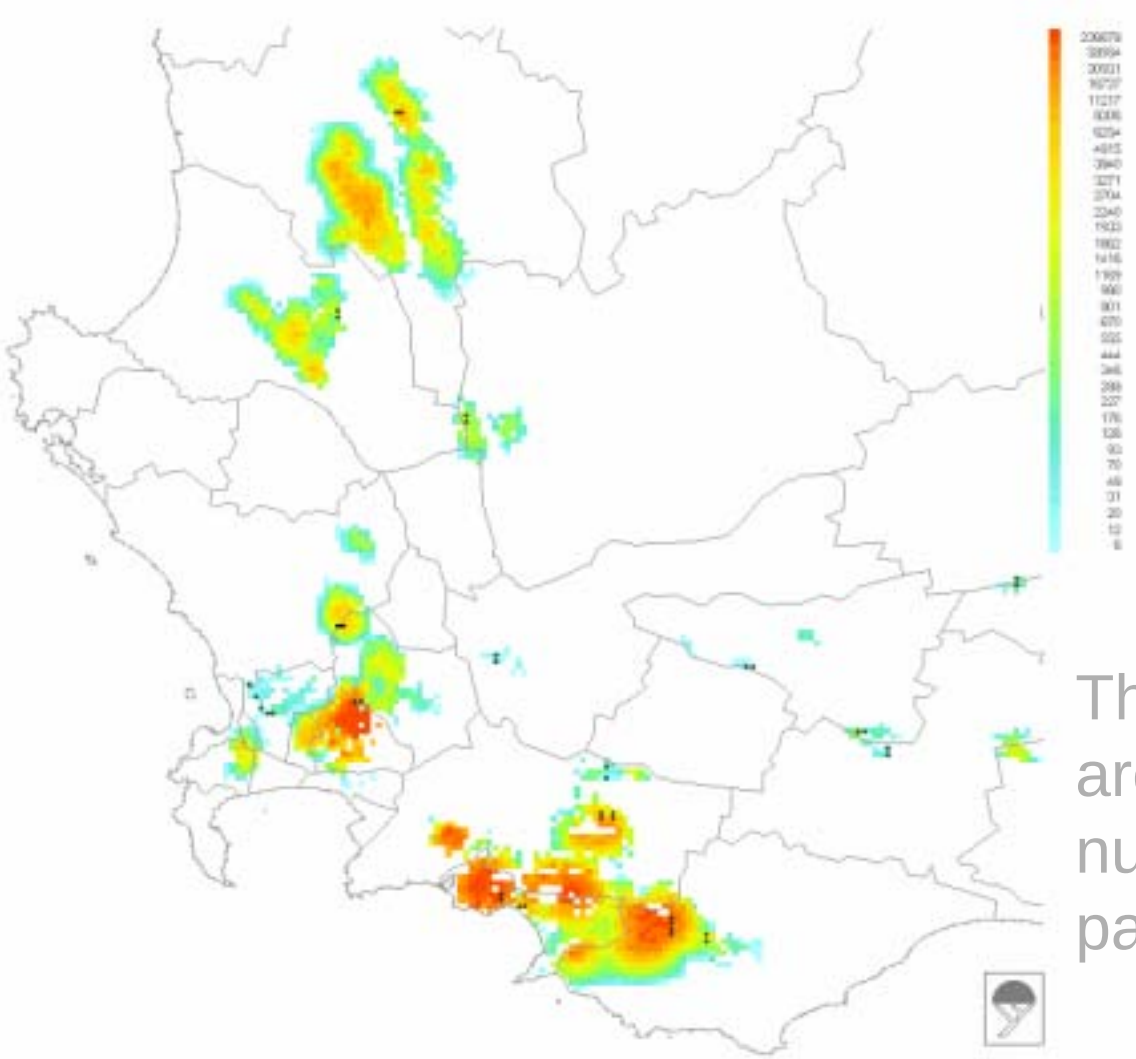
- It is likely that plant production will initially rise slightly, then decline due to excessive temperatures
- It is not a forgone conclusion that trees will out-compete grass
- The structural outcome depends on how the ecosystem is managed: elephants and fire

Managing for reduced vulnerability

- Systematic Conservation Planning in a non-constant environment
  - Robustness: Must repeat the analysis for optimal distribution of protected areas for several tome periods, and using a range of models and scenarios
- Must be willing to consider radical changes in conservation procedures
  - Introduction of species into places that they did not historically occur
  - Allow certain populations to become locally extinct
- Ensuring that the between-park matrix is biodiversity-friendly
  - Little scope for major reorientation of protected areas
  - Most biodiversity (abundance) is outside protected areas
  - Negotiated payments for biodiversity services is a cost-effective protection strategy

Identifying critical dispersal chains

Guy Midgley and Greg Hughes, SANBI



The red locations are on the largest number of critical paths

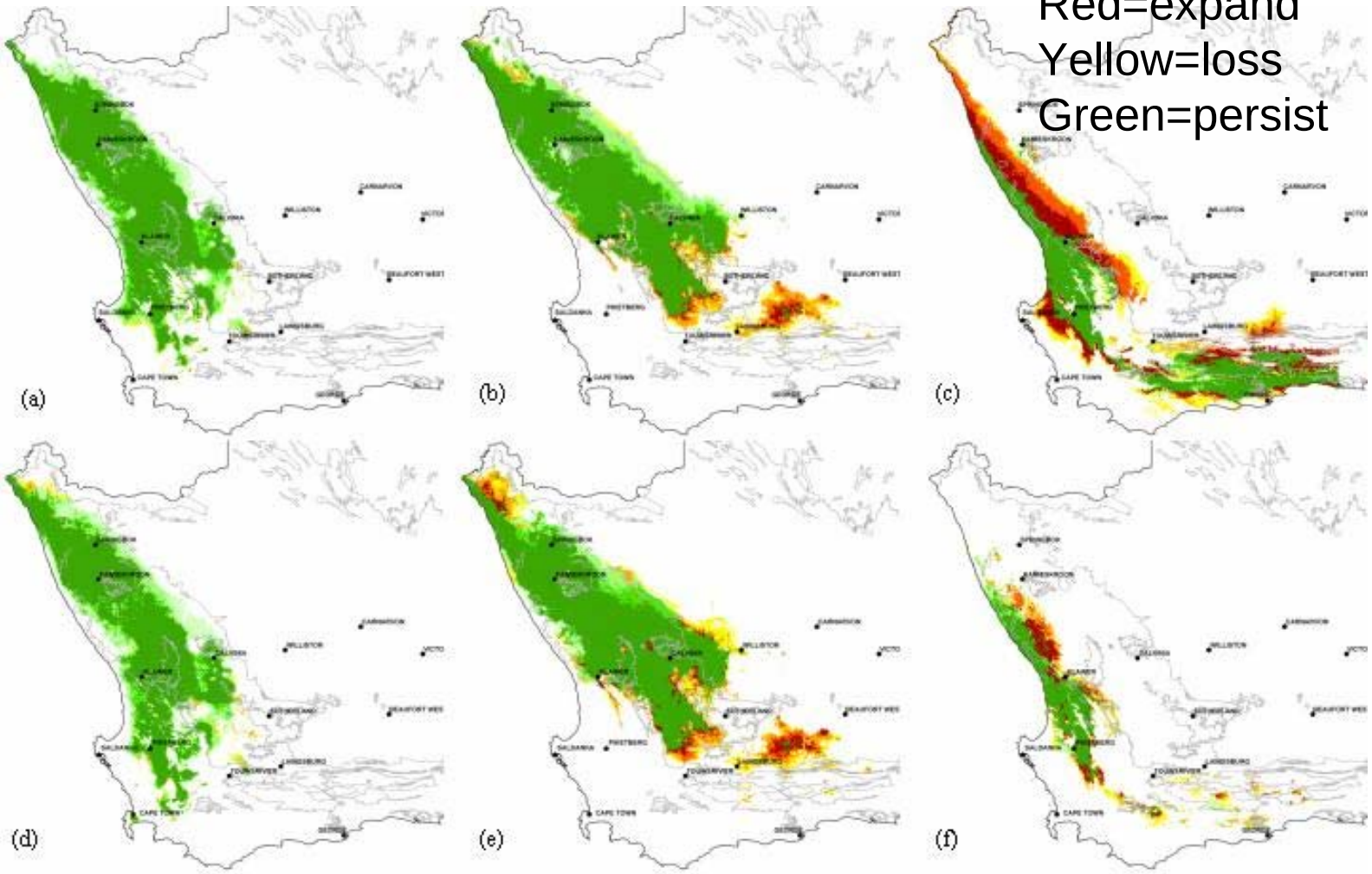
Modelling species and their food supply

Guy Midgley and Greg Hughes, SANBI

Red=expand
Yellow=loss
Green=persist

Tortoises alone

Tortoises and food



Homopus sinatus *H.s. sinatus* *H.s. cafer*

Remaining research challenges

- Better prediction of soil moisture trends
- Understanding of feedbacks and thresholds
- Production responses and adaptations to high temperatures
- The movement of communities
- Social and economic mechanisms for supporting biodiversity in landscapes that are primarily used for other purposes

Global change is not the end of the world! But it could be the end of quite a lot of species

(And this is the end of my talk!)

Dr Bob Scholes

bscholes@csir.co.za

+27 12 841 2045

CSIR-NRE

PO Box 395

Pretoria

0001

our future through science