From land use to vegetation and biodiversity changes – linking models and data

N. Blaum[1], E. Rossmanith[1], D. Lohmann[1], S. Meyfarth[1], M. Schwager[2], S. Domptail[3], E. Nuppenau[3], U. Geßner[4], M. Keil[4], A. Petersen[5], A. Gröngröft[5], M. Strohbach[6] & F. Jeltsch[1]

(1) University of Potsdam, (2) University of Mainz, (3) University of Gießen, (4) German Aerospace Center (DLR), (5) University of Hamburg (6) NBRI Namibia

"Biodiversity of Africa - Observation and Sustainable Management for our Future!"
International Congress, 29 September – 3 October 2008, at Spier, RSA

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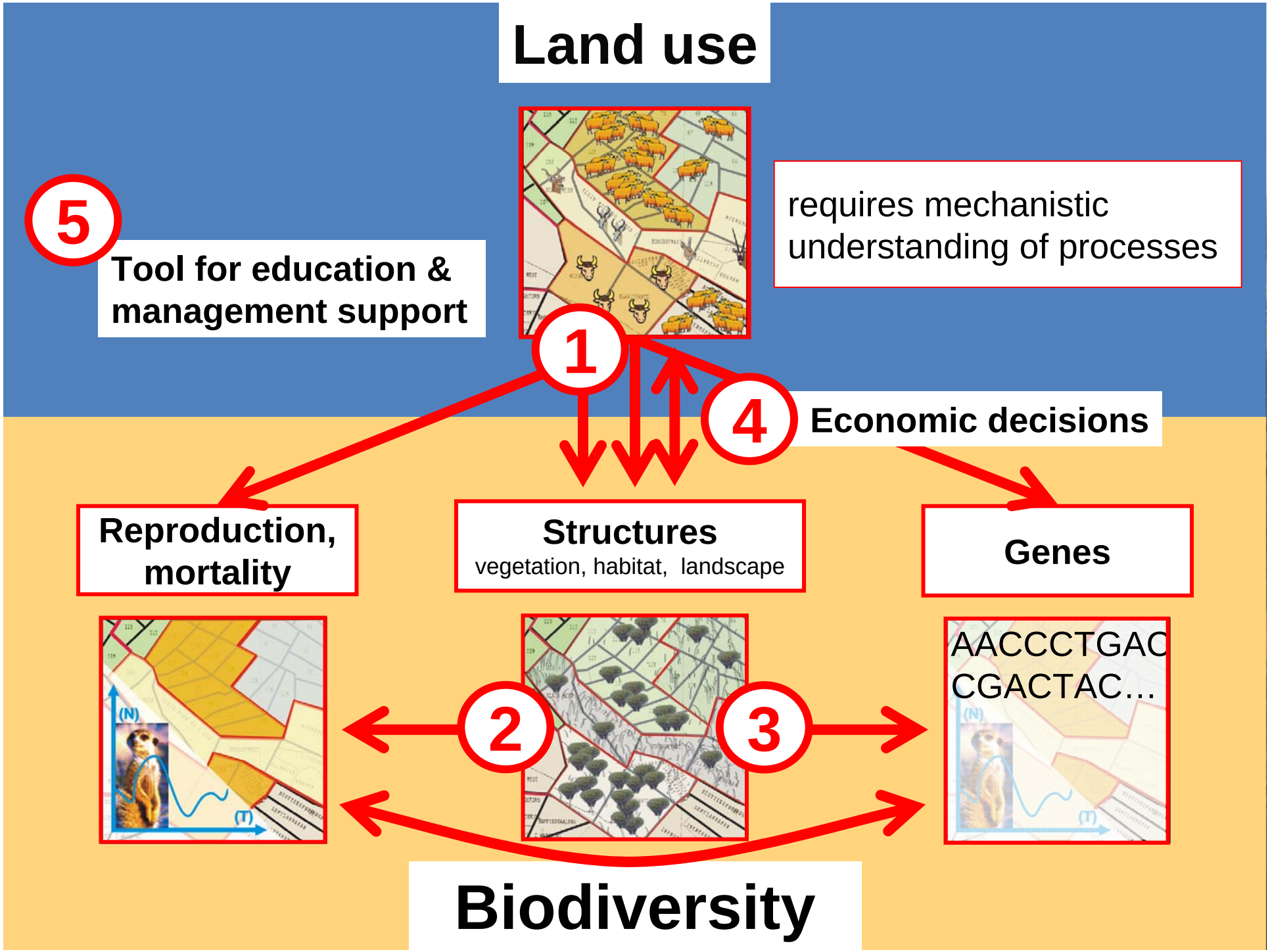
→ Major threat for biodiversity

(Sala et al. 2000, Science 287)

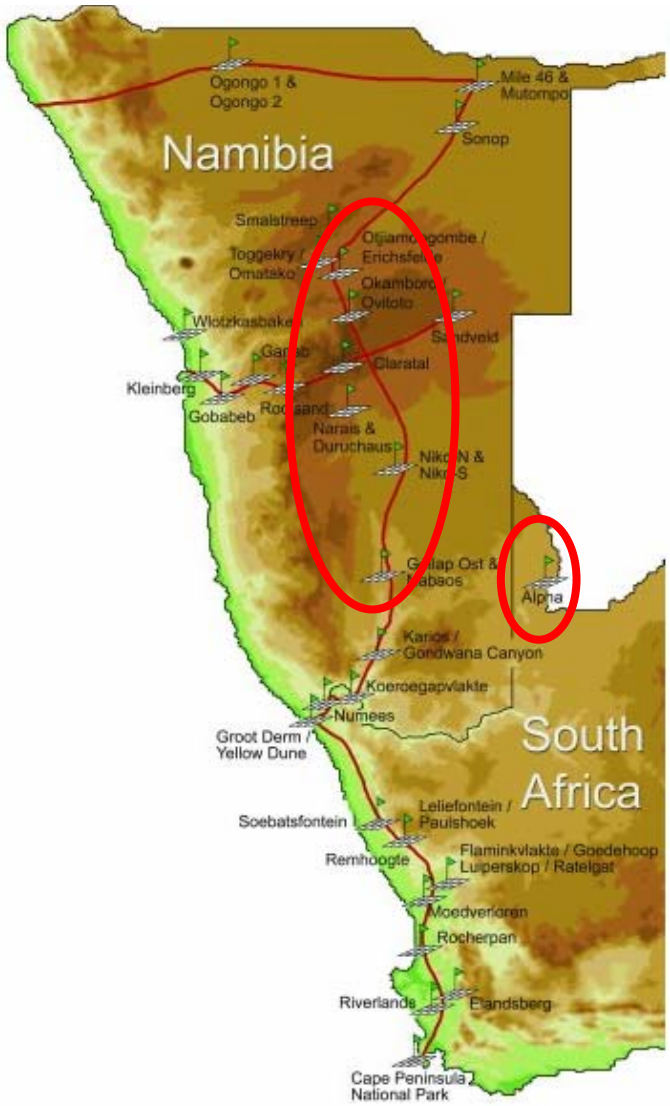
→ **leads to habitat loss, fragmentation and degradation**

Ecological implications (e.g. Lindenmayer&Fischer 2007, TREE 22)

- changes in demographic and genetic structure
- reduction of population fitness
- increase in extinction risk


Land use
requires mechanistic understanding of processes
5
Tool for education & management support
1
4
Economic decisions
Reproduction, mortality
Structures
vegetation, habitat, landscape
Genes
AACCCTGAC
CGACTAC…
2
3
Biodiversity

Focal study areas:



rainfall gradient

Annual rainfall: ~ 350 mm

Annual rainfall: ~ 150 mm

BIOTA savanna sites in Namibia & South Africa

Example 1

Effects of livestock grazing on savanna vegetation dynamics

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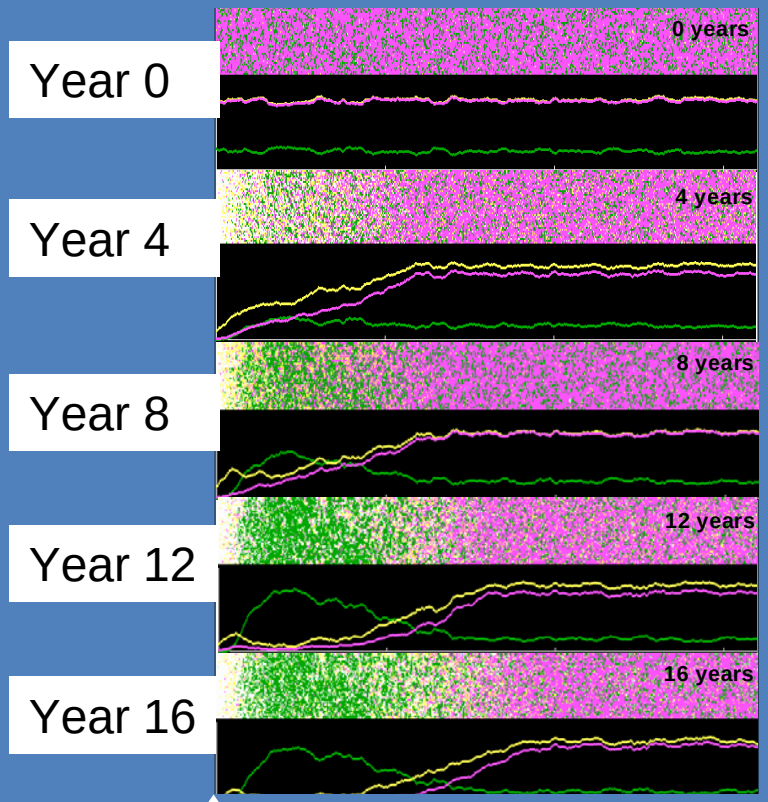
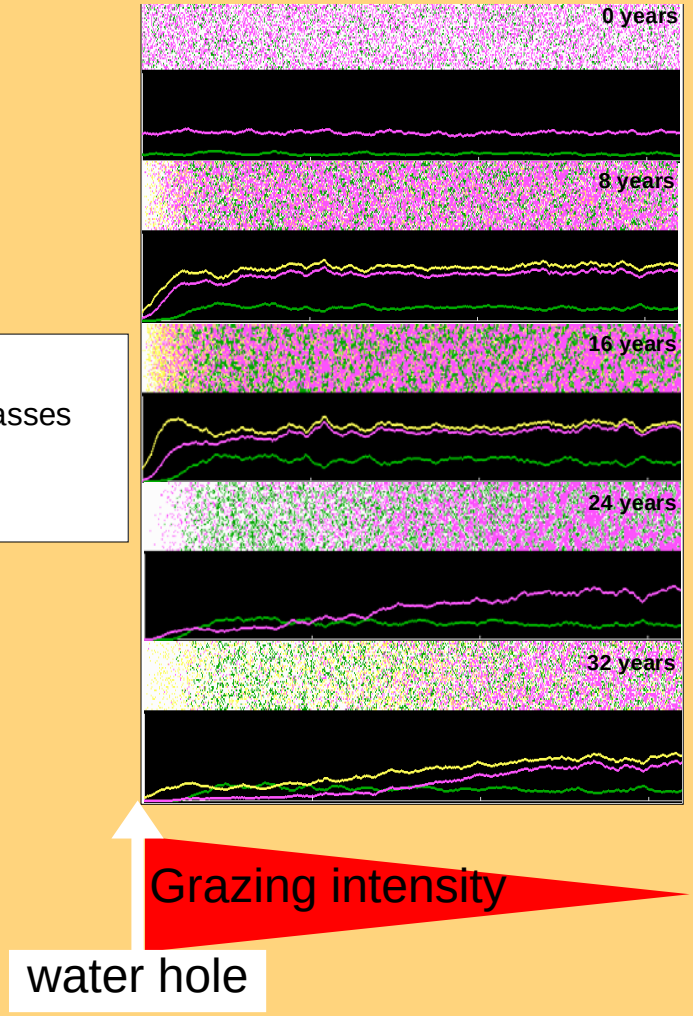
Computer models: Heavy grazing affects vegetation dynamics

Scenario 1: humid savanna



→shrub encroachment

Scenario 2: dry savanna



→ loss of vegetation, soil erosion

Example 2:

Effects of land degradation on species diversity: risk assessment across animal taxa

Blaum et al. (accepted) *Biodiversity & Conservation*
Wasiolka et al. (in press) *Acta Oecologica*
Blaum et al. (2008) *Wildlife Research* 35: 72-79
Blaum et al. (2007) *Basic & Applied Ecology* 8: 552-564
Blaum et al. (2007) *Journal of Mammalogy* 88: 194-200
Blaum et al. (2007) *Acta Oecologica* 31: 86-92

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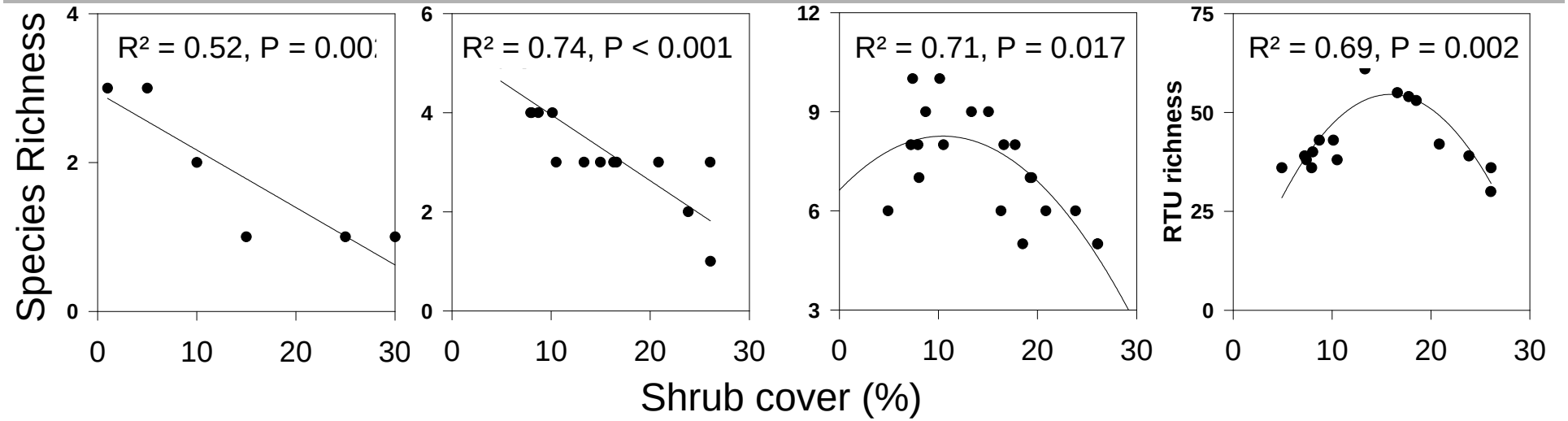
Biodiversity monitoring across a land use gradient

Reptiles	Rodents	Carnivores	Arthropods



Sensitivities of animal diversity to shrub encroachment varies between taxa
Note: diversity is low in shrub dominated areas across taxa

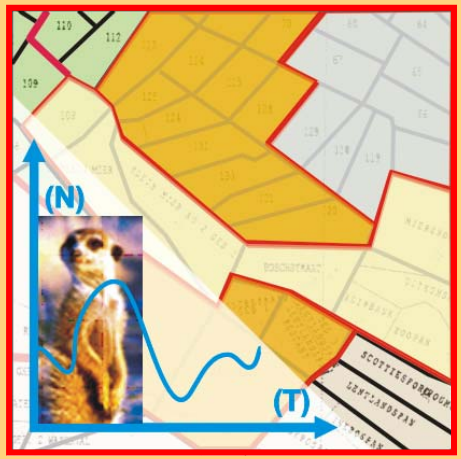
Wasiolka et al. (in press)	Blaum et al. (2007)	Blaum et al. (2007)	Blaum et al. (accepted)
Acta Oecologica	*J Animal Ecology*	*Basic & Applied Ecology*	*Biodiversity & Conservation*

Modelling: Integrating small scale processes and scaling up

Future land use

?

Animal diversity



Predicting changes in diversity under different land use scenarios

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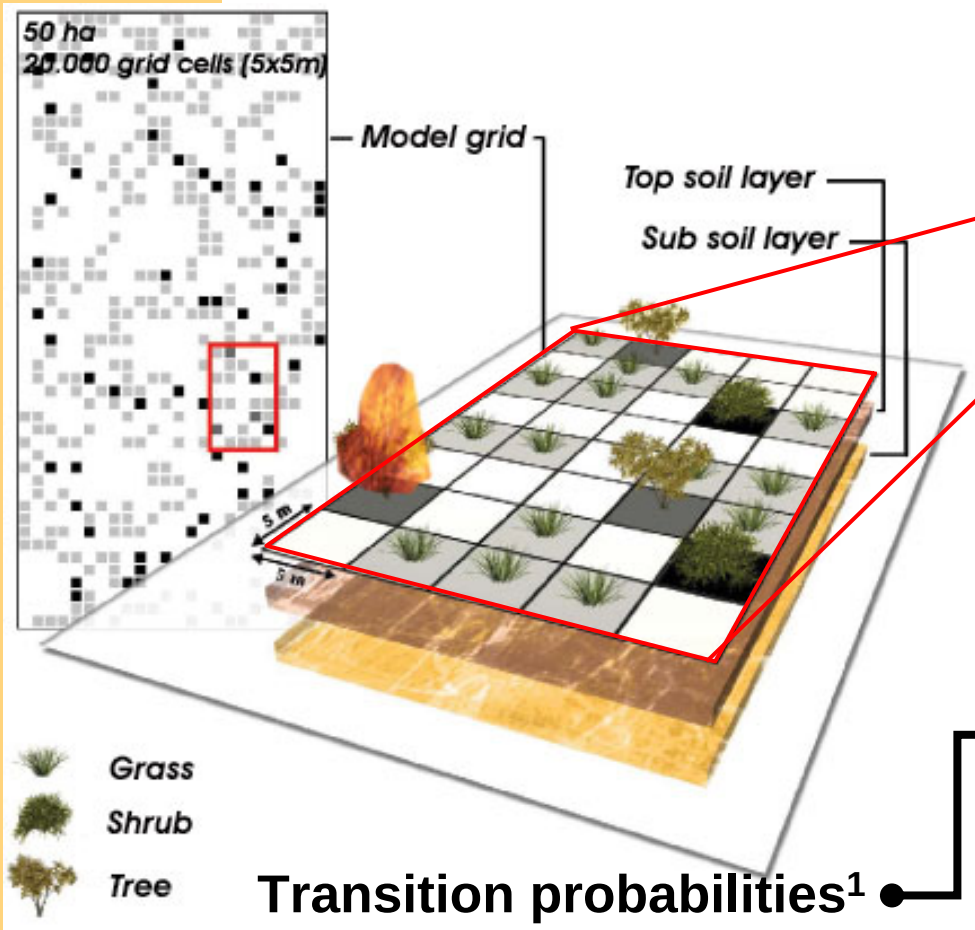
Regional vegetation state and transition model

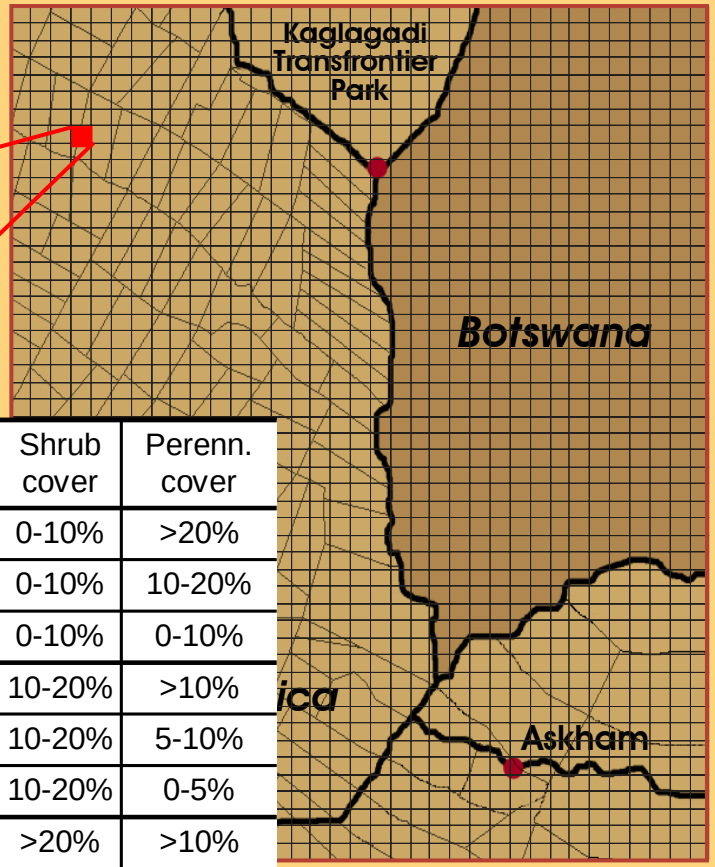
State & transition model



Transition probabilities[1]
- Vegetation states

BIOTA observatory ‚Alpha'

Study are = 70 x 100km

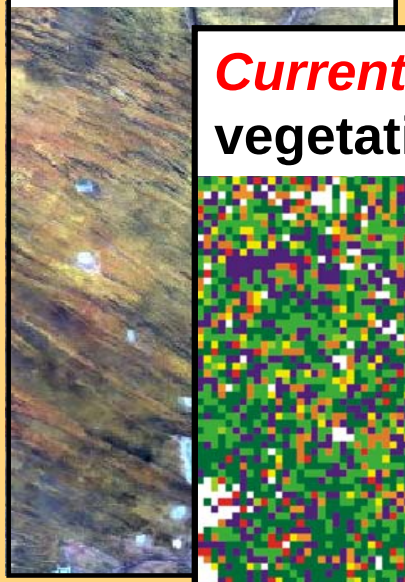


Veg. state	Shrub cover	Perenn. cover
1	0-10%	>20%
2	0-10%	10-20%
3	0-10%	0-10%
4	10-20%	>10%
5	10-20%	5-10%
6	10-20%	0-5%
7	>20%	>10%
8	>20%	5-10%
9	>20%	0-5%

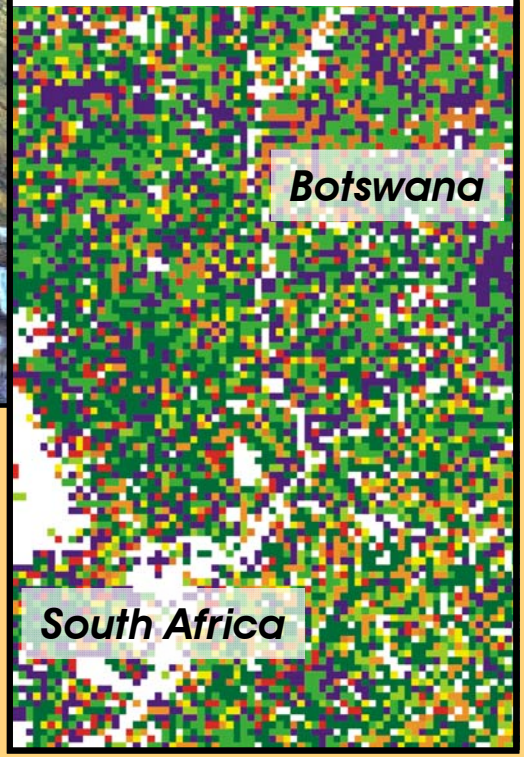
[1] Based on small-scale vegetation model: Jeltsch et al. (2000) *Oikos*

Model initialisation

LandSat image



***Current* pattern of vegetation states**



Veg. state	Shrub cover	Perenn. cover
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4	10-20%	>10%
5	10-20%	5-10%
6	10-20%	0-5%
7	>20%	>10%
8	>20%	5-10%
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Classification of vegetation states by LandSat image

Example Scenario:
20% increase in grazing intensity for 20 years

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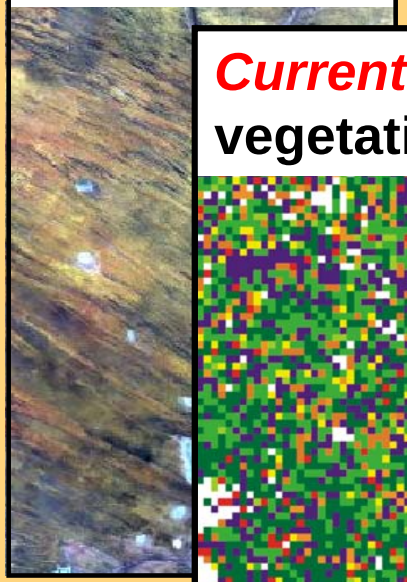
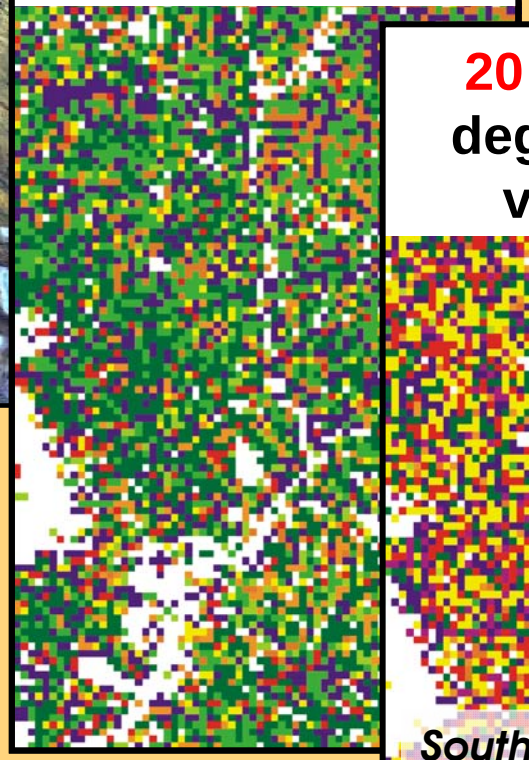
Scenario: 20% increase of grazing intensity

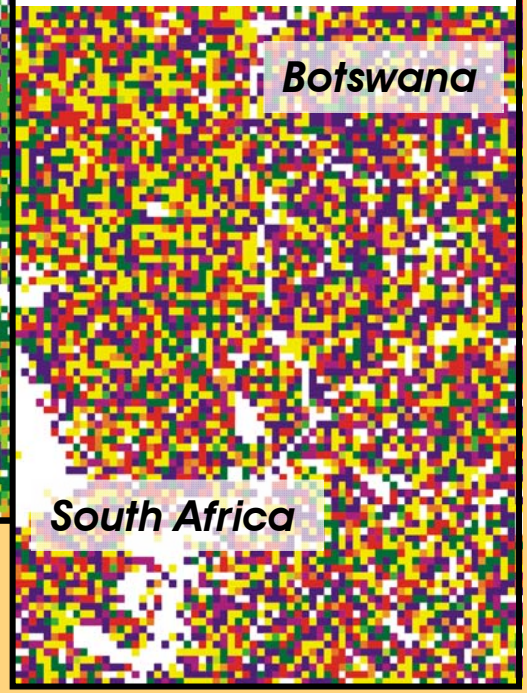
LandSat image



***Current* pattern of vegetation states**



20 years later: degradation of vegetation



Linking
regional vegetation model & statistical models

Reduction of carnivore diversity by 12%

Veg. state	Shrub cover	Perenn. cover
1	0-10%	>20%
2	0-10%	10-20%
3	0-10%	0-10%
4	10-20%	>10%
5	10-20%	5-10%
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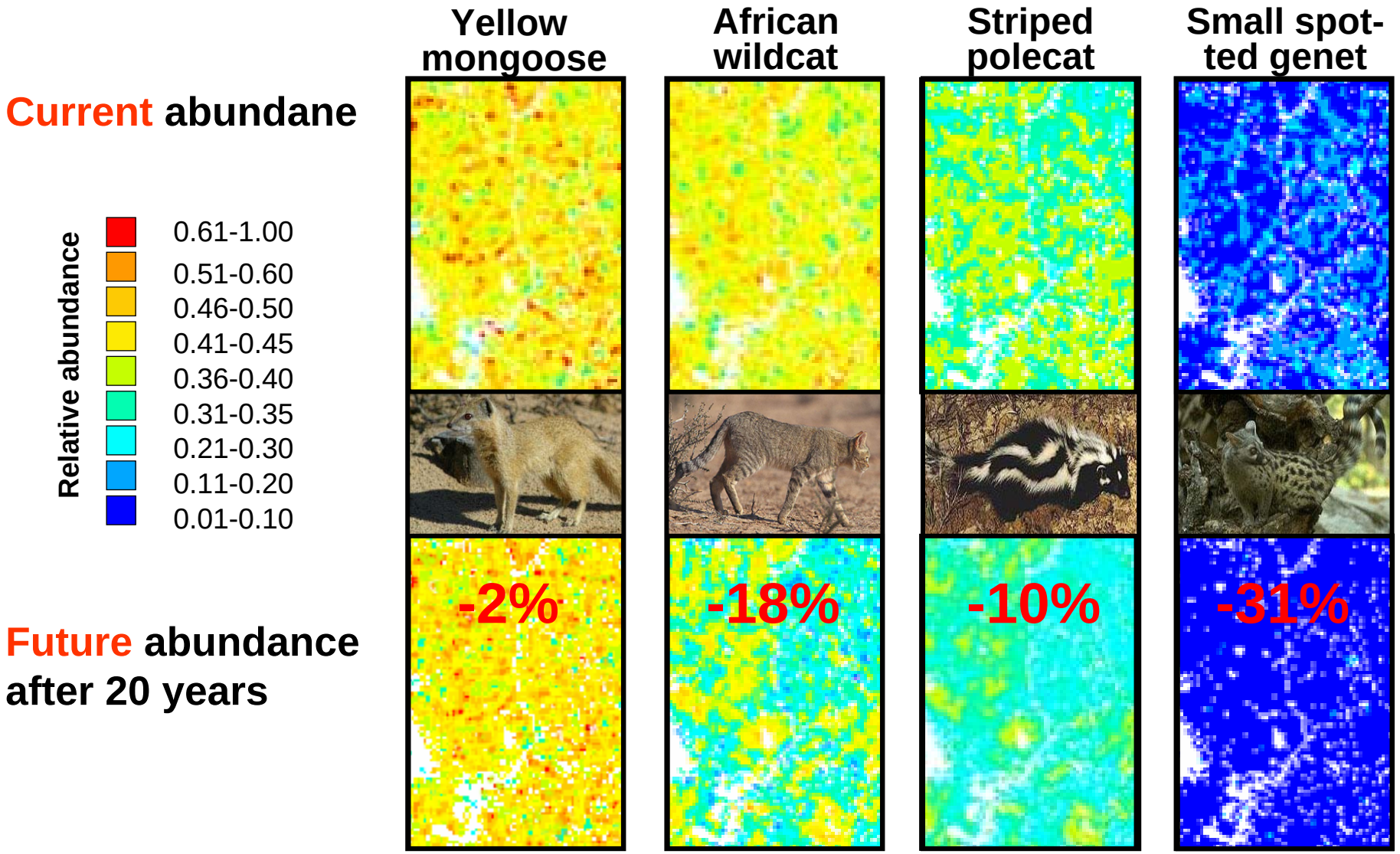
9	>20%	0-5%

Testing land use scenarios to predict species diversity



Linkage with process based models

Animals

Tawny eagle
Wichmann et al. 2003 (Oikos)

Sociable weaver
Schwager et al. 2008 (Oikos)

Yellow mongoose
Popp et al. 2007 (Ecological Modelling)

Hairy footed gerbil
Blaum & Wichmann 2007 (J Animal Ecology)

Plants

Camelthorn
Jeltsch et al. 2000 (Oikos)

Raisin bush
Tews et al. 2004 (J Vegetation Science)

Devil's Claw → Poster

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Example 3:

Gene flow in fragmented savannas: Combined effects of land use and climate

Blaum et al. (2007) *Afr. J Ecology*
Blaum & Wichmann (2007) *J Animal Ecology*

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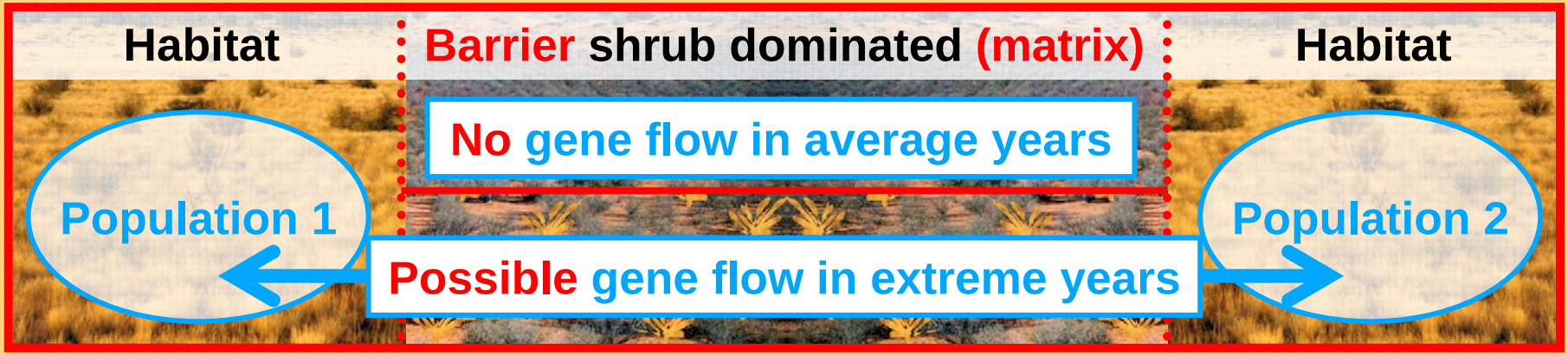
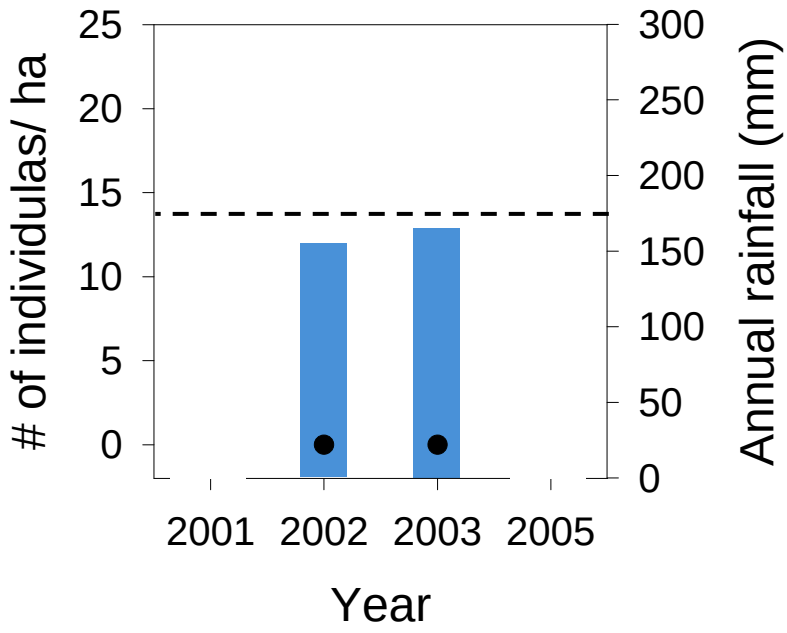
Model organism: the hairy-footed gerbil



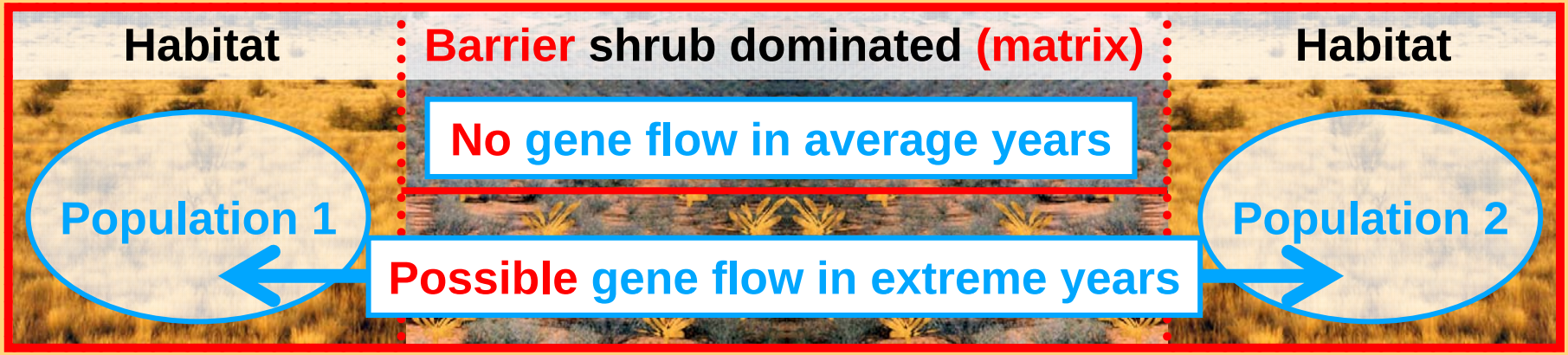
Hairy-footed gerbil
(Gerbillurus paeba)

Field study in shrub matrix (n=30)



Blaum & Wichmann 2007, J Animal Ecology 76

Model organism: the hairy-footed gerbil



Hairy-footed gerbil
(Gerbillurus paeba)

Key question:
What is the impact of extreme rainfall on gene flow ?

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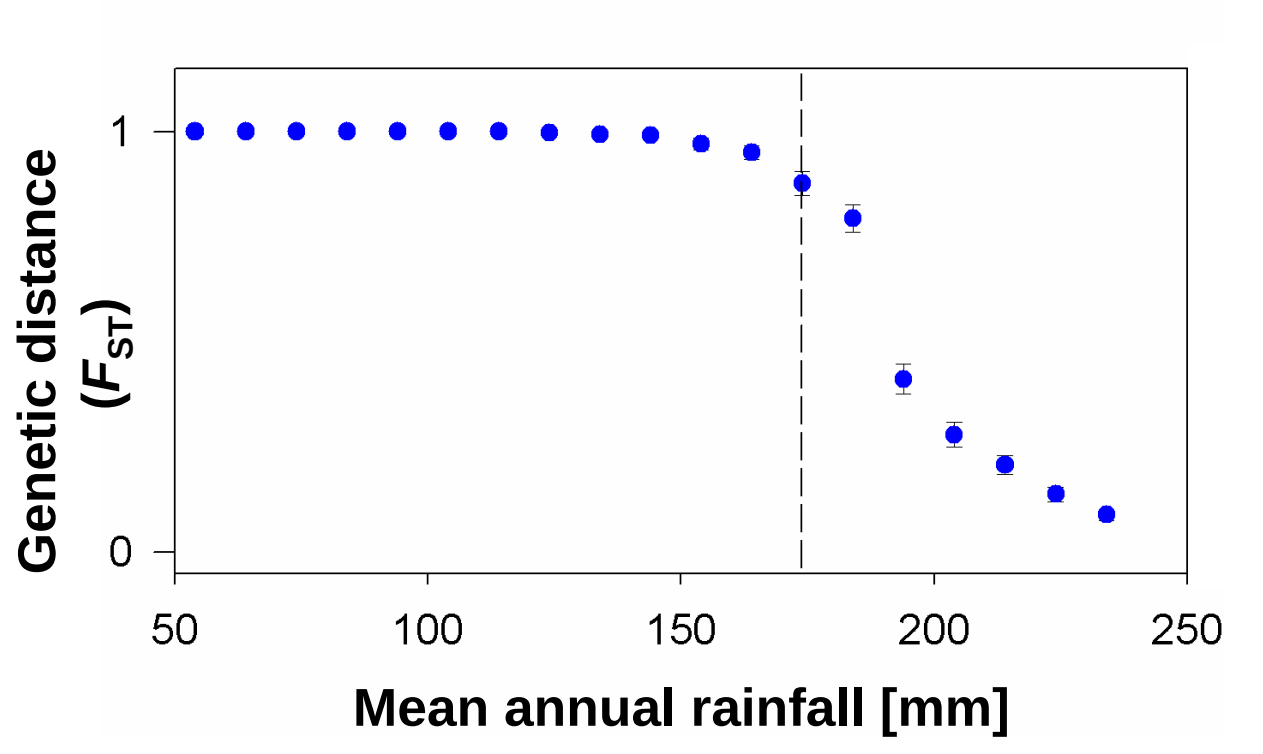
Results: **Gene flow under natural rainfall**



1. Increasing average rainfall reduces genetic distance.

2. Under natural rainfall the model suggests gene flow.

Blaum & Wichmann (2007). *J Animal Ecology*

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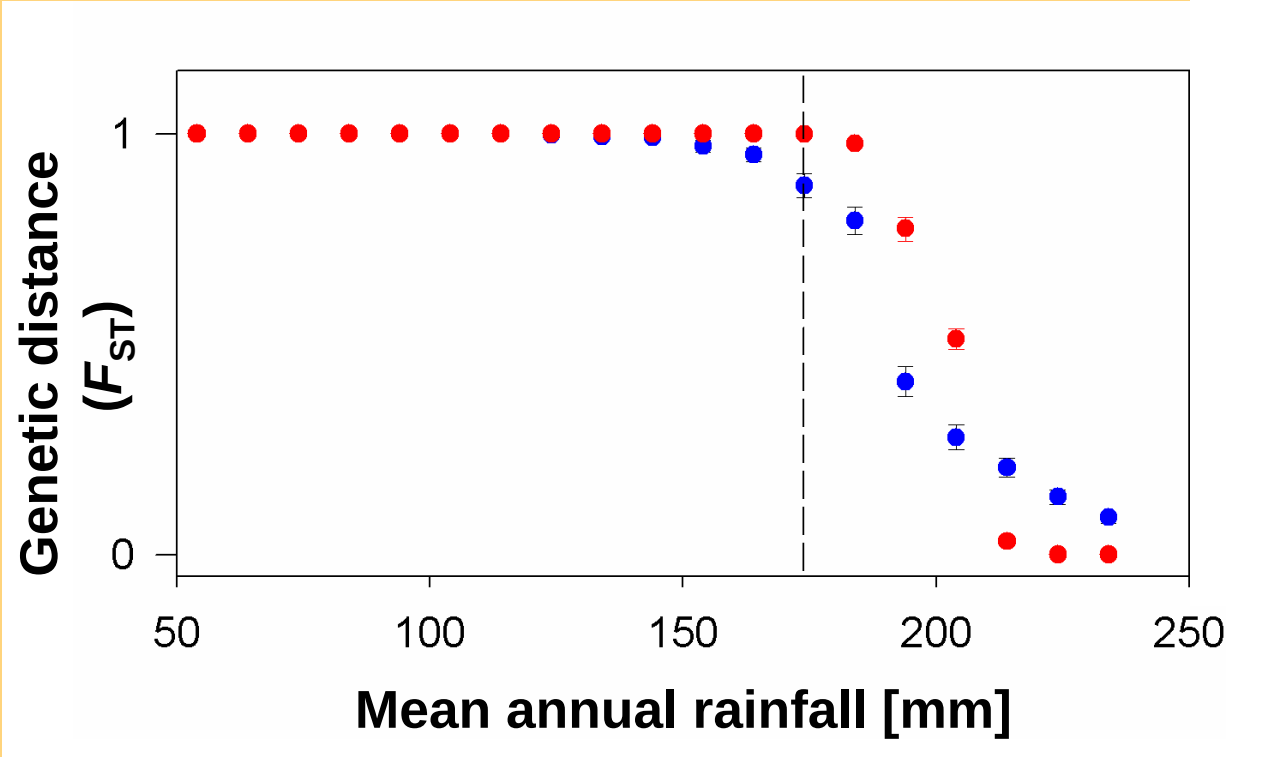
Results: **Gene flow under modified rainfall**



Climate is important driver for gene flow!

Blaum & Wichmann (2007). *Journal of Animal Ecology*

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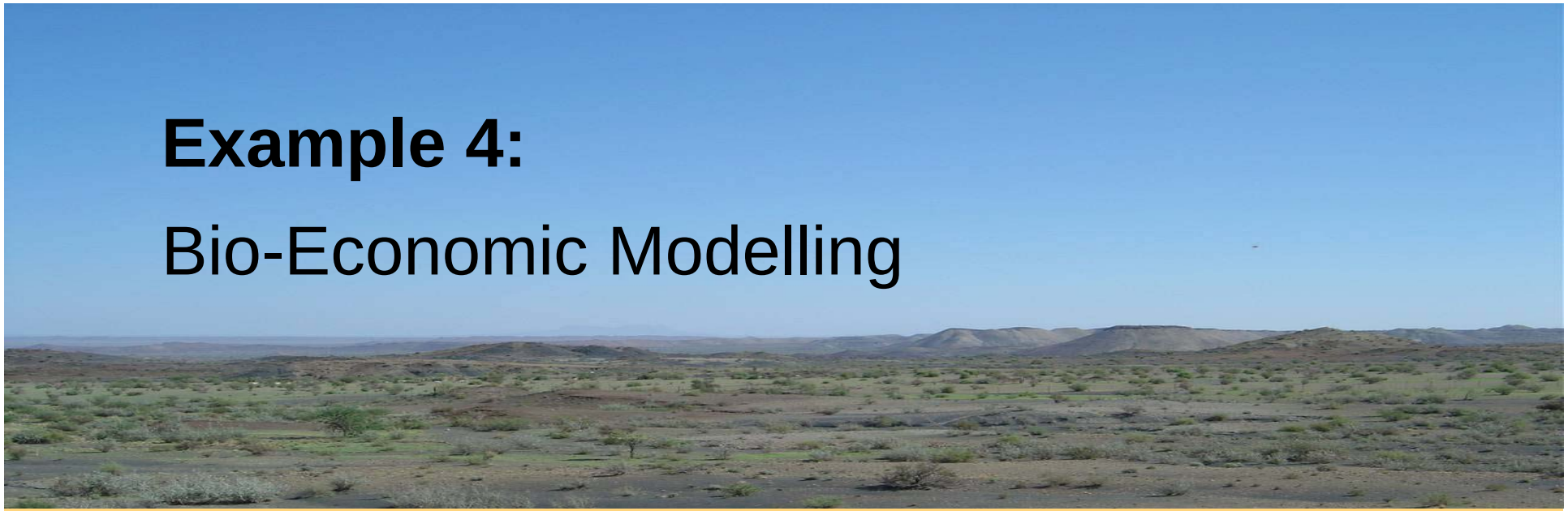
What is missing ? **- the farmer!**

Until now:
static land use scenarios

But:
farmers decisions are dynamic
- ecological-economic feed backs
- ecological-economic trade offs



Example 4:

Bio-Economic Modelling

Key question:

What are the best management strategies for sustainable use of natural resources and the conservation of biodiversity?

Popp et al. (in press) *Basic & Applied Ecology*

Popp et al. (accepted) *Ecological Modelling*

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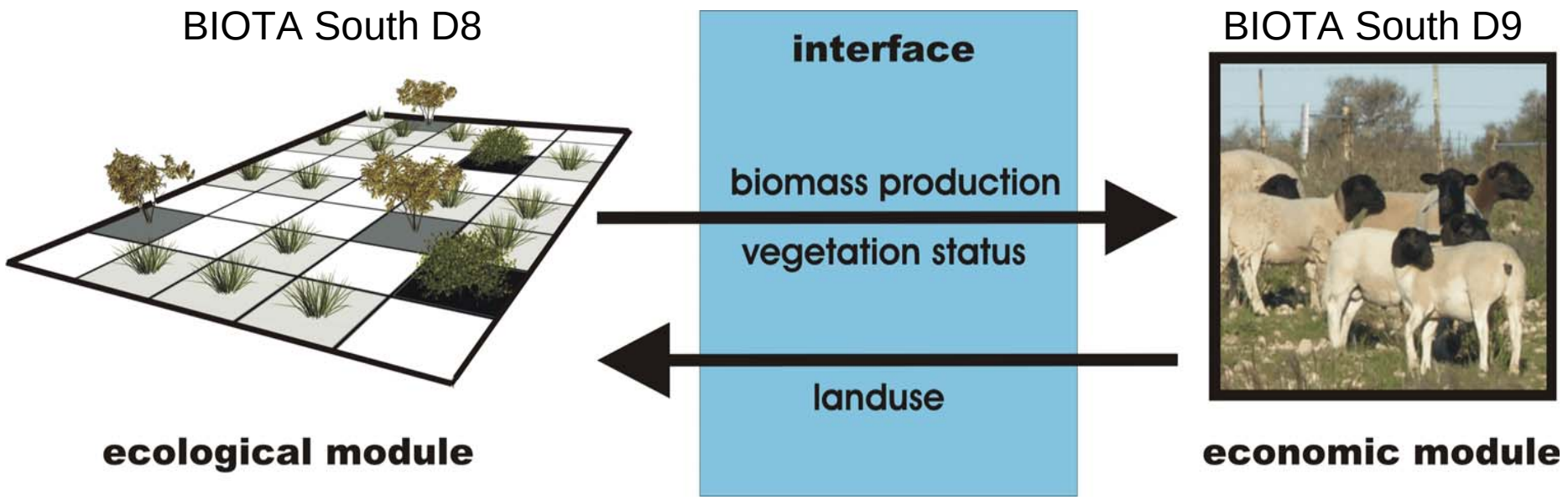
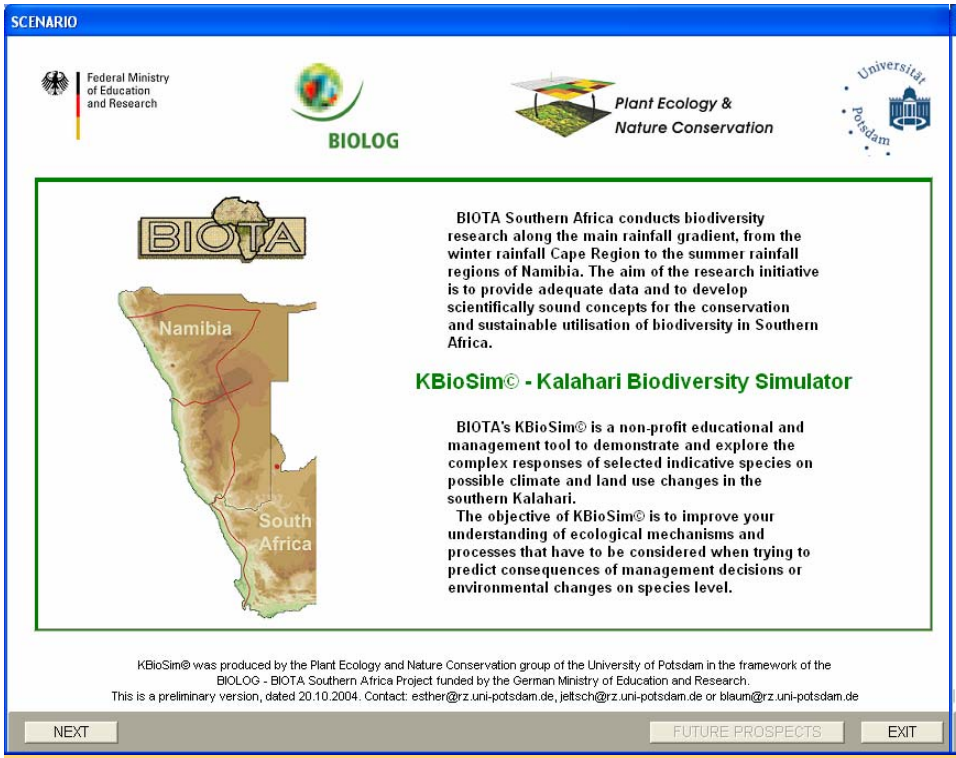
Bio-economic Modelling

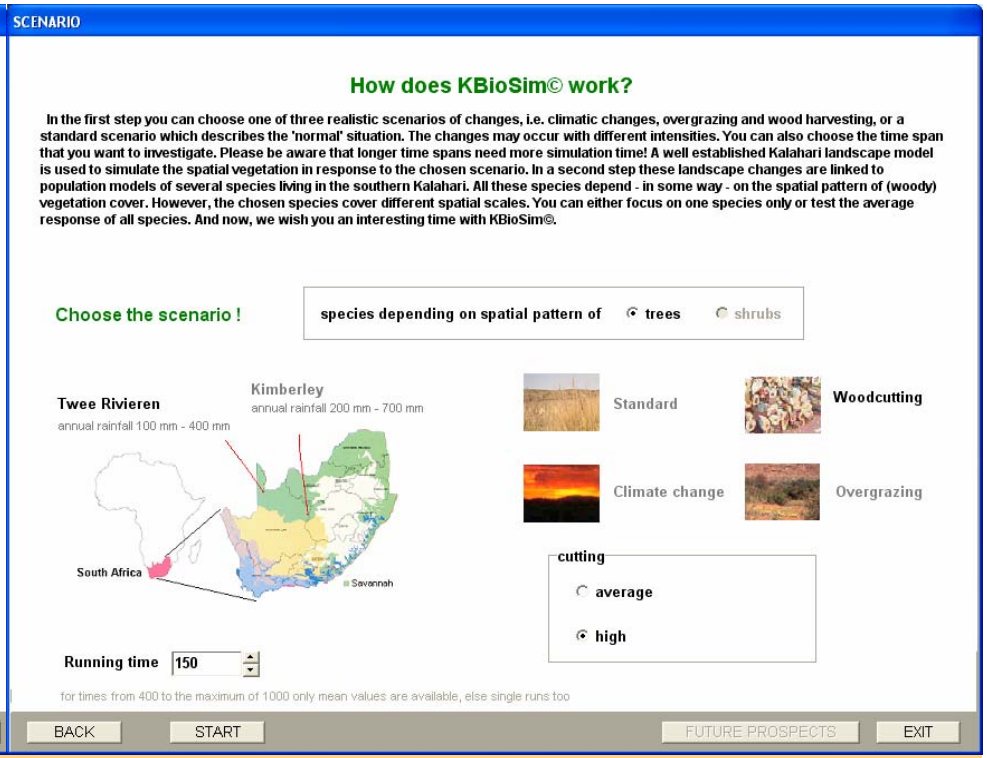


→ **Talk** of Stephanie Domptail et al., Thursday, 8.30

→ **Posters** of Dirk Lohmann et al. and Alex Popp et al.

Popp et al. (in press) *Basic & Applied Ecology*
Popp et al. (accepted) *Ecological Modelling*





Example 5:

Computer models as educational & management tools:
The BIOTA **Ka**lahari **Bio**diversitäts **Sim**ulator

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Selection of scenario

SCENARIO

How does KBioSim© work?

In the first step you can choose one of three realistic scenarios of changes, i.e. climatic changes, overgrazing and wood harvesting, or a standard scenario which describes the 'normal' situation. The changes may occur with different intensities. You can also choose the time span that you want to investigate. Please be aware that longer time spans need more simulation time! A well established Kalahari landscape model is used to simulate the spatial vegetation in response to the chosen scenario. In a second step these landscape changes are linked to population models of several species living in the southern Kalahari. All these species depend - in some way - on the spatial pattern of (woody) vegetation cover. However, the chosen species cover different spatial scales. You can either focus on one species only or test the average response of all species. And now, we wish you an interesting time with KBioSim©.

Choose the scenario !

species depending on spatial pattern of ◉ trees ○ shrubs

Twee Rivieren
annual rainfall 100 mm - 400 mm

Kimberley
annual rainfall 200 mm - 700 mm

Standard

Woodcutting

Climate change

Overgrazing

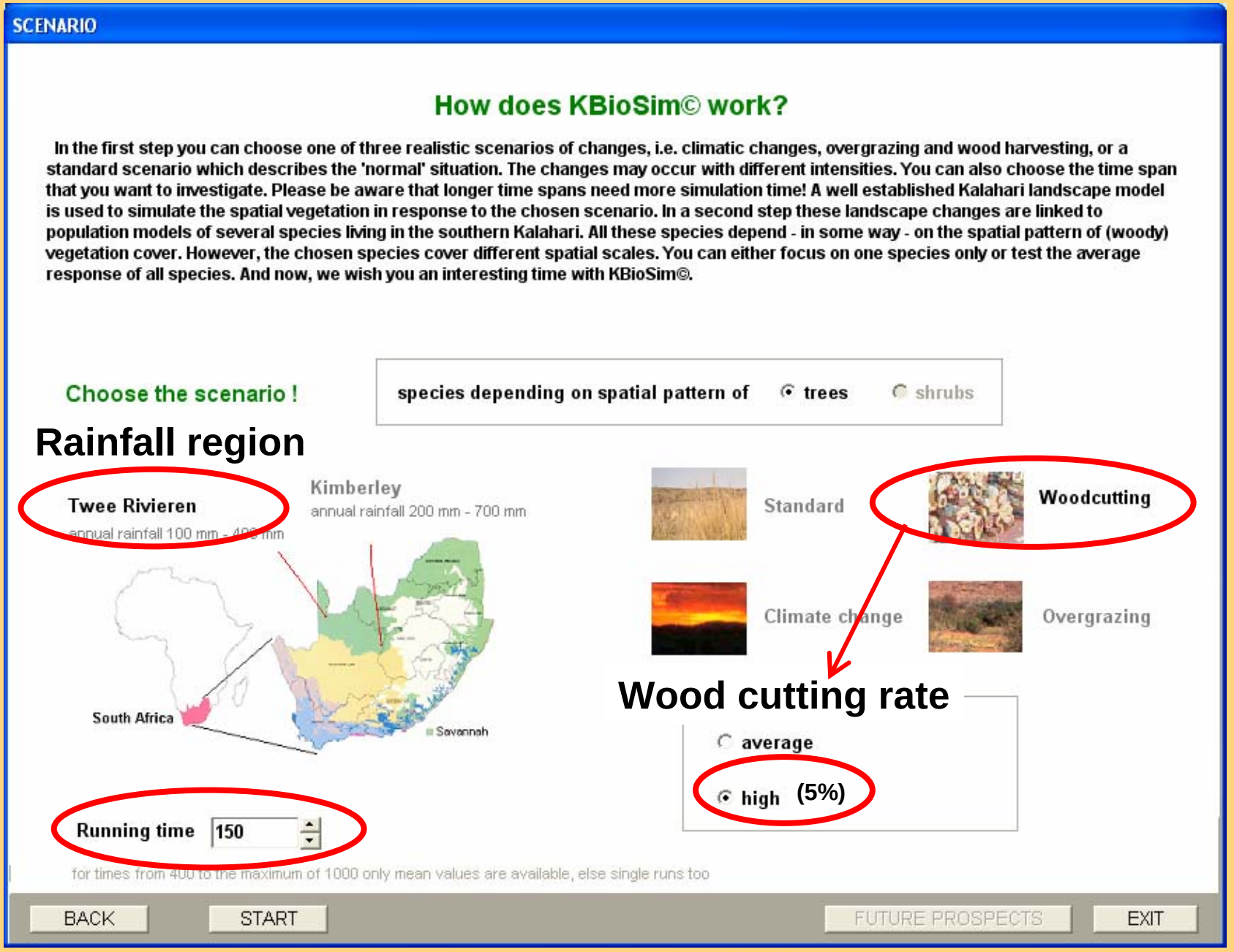
cutting
○ average (0.5%)
◉ high (5%)

Running time 150

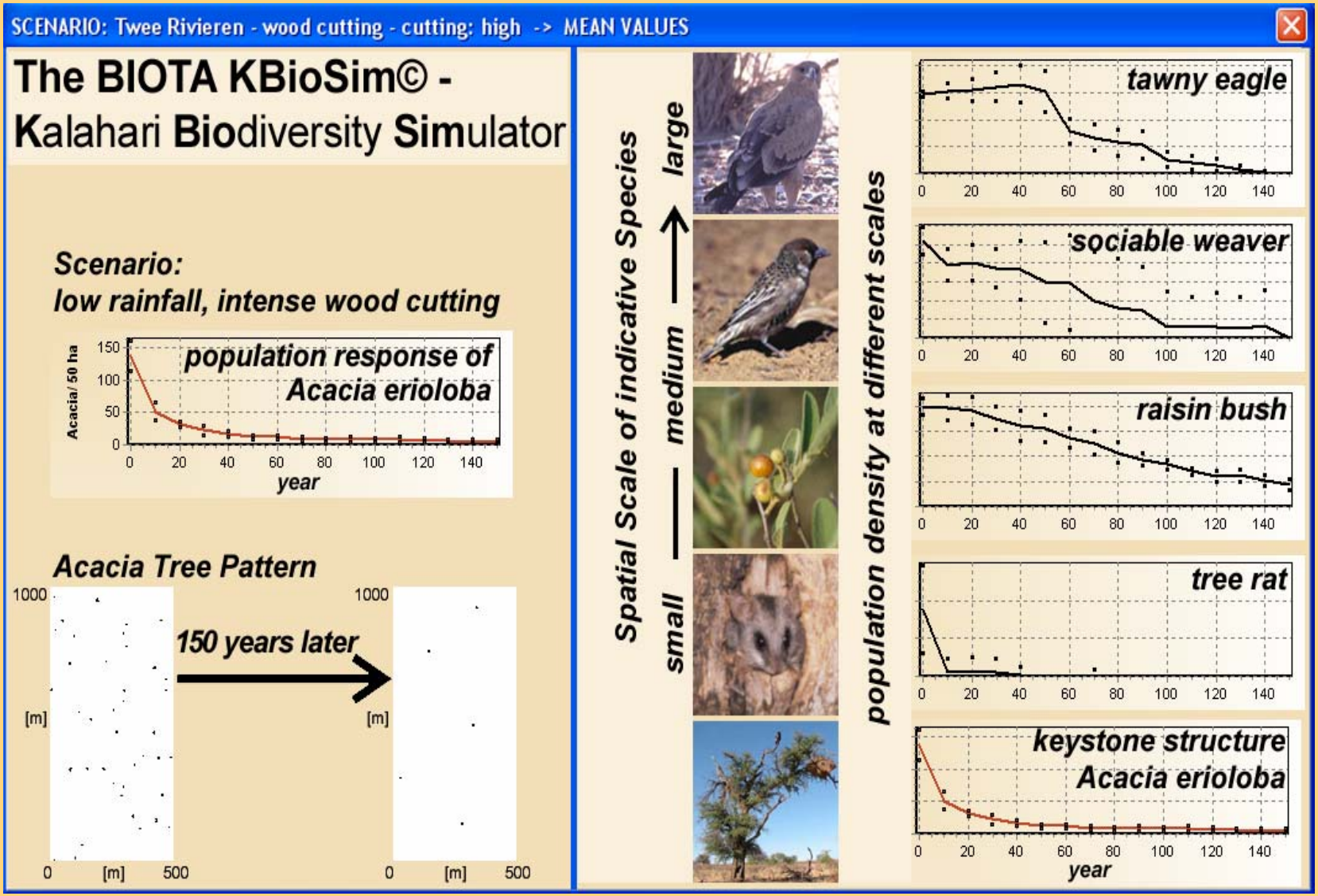
for times from 400 to the maximum of 1000 only mean values are available, else single runs too

BACK START FUTURE PROSPECTS EXIT

Example scenario: Wood cutting (annual rate 5%)

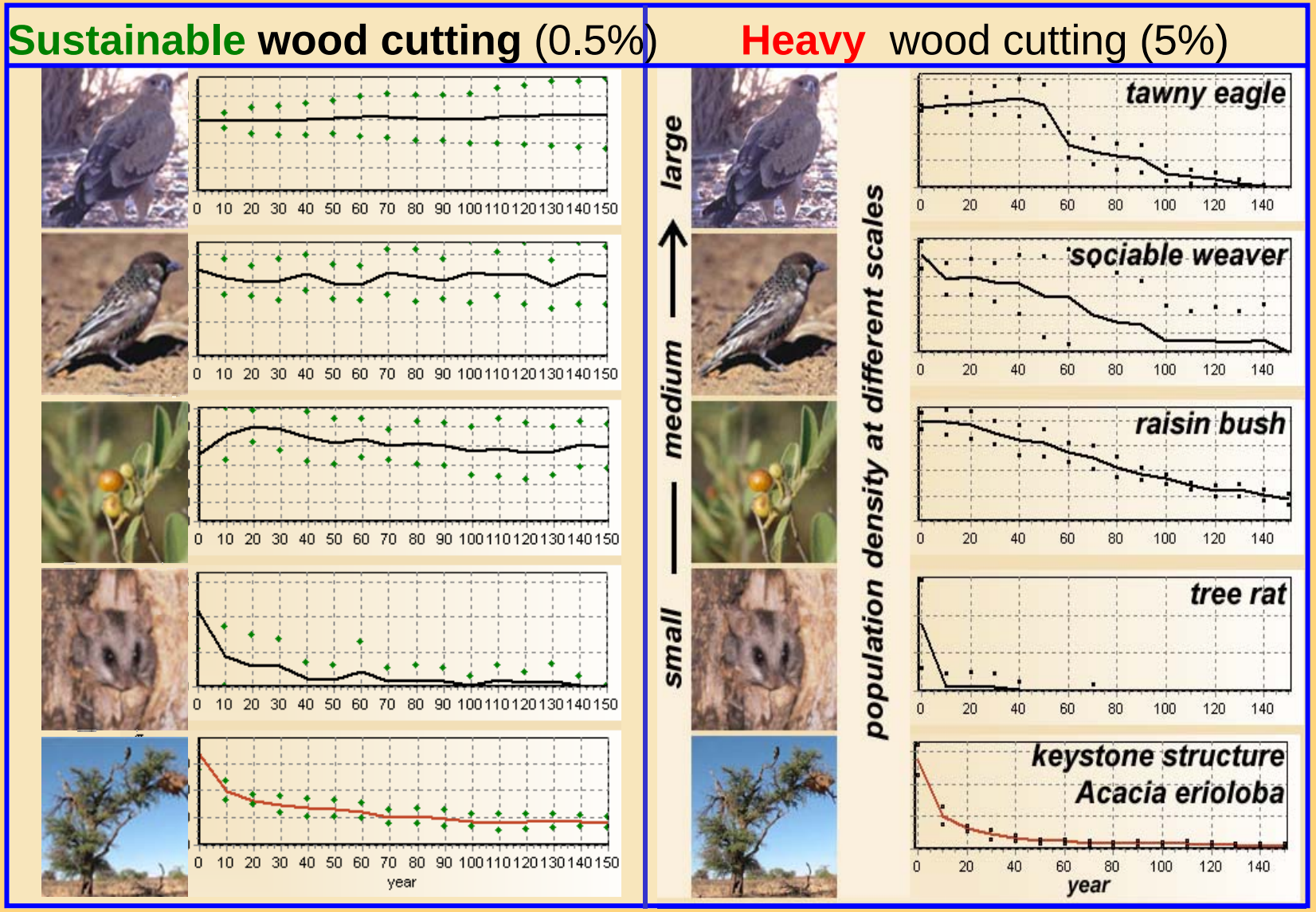


Lesson 1: Wood cutting (annual rate 5%)



Heavy wood cutting: negative impacts across indicative species!

Lesson 2: Comparison of wood cutting rates



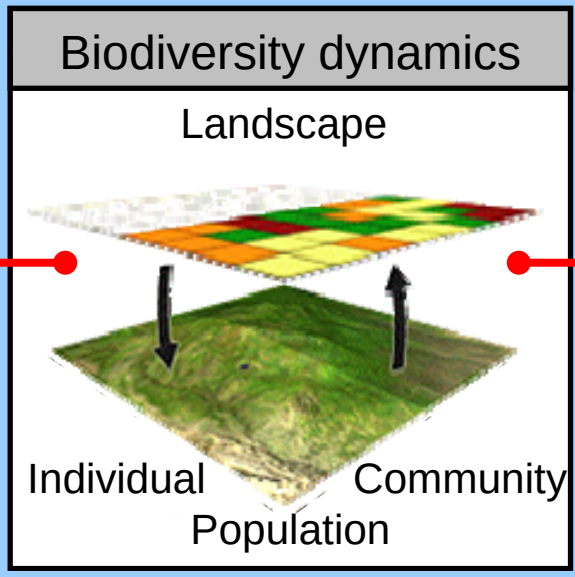
Environmental education by comparing different scenarios

Conclusion

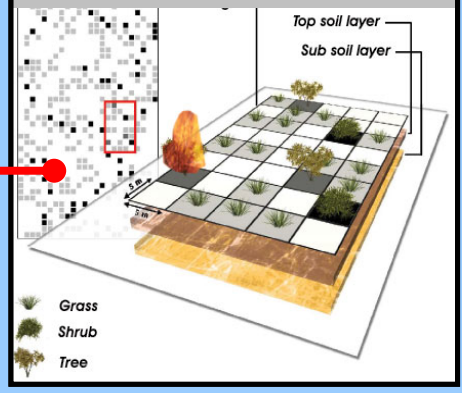
soil science	botany	zoology	remote sensing	ecological modelling	economic modelling

Empirical methods

Biodiversity dynamics



Simulation Models



Understanding of complex interactions (land use & biodiversity dynamics) is possible but requires:

→ Understanding of processes across research disciplines

→ Combination of empirical methods with simulation models

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Conclusion

Results of combined approach allow for…

→ Sustainable management for biodiversity conservation

→ Long term preservation of productivity
& sufficient income for land users

→ Support for decision making, policy

→ Environmental educational tools

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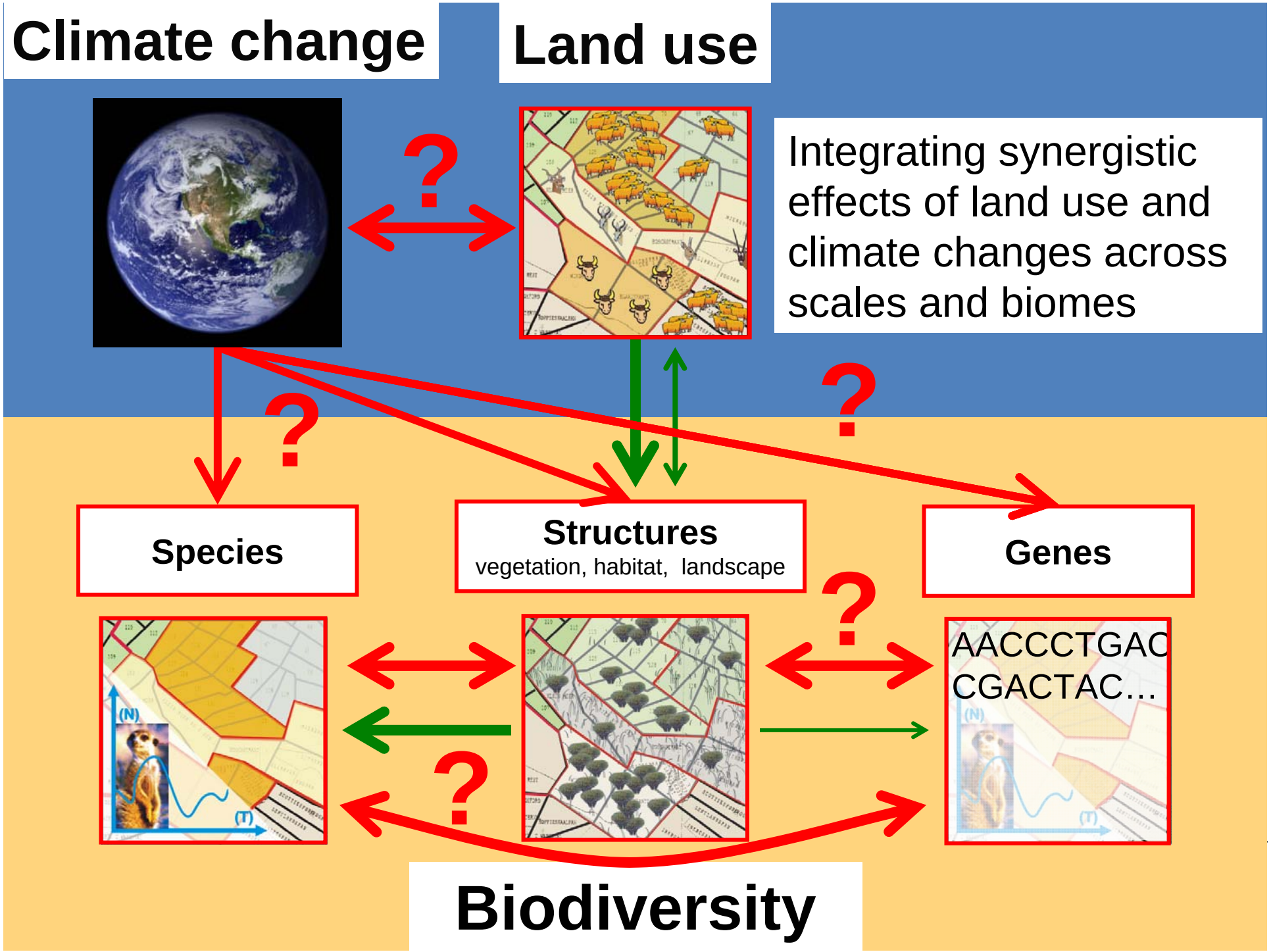

Climate change
Land use
?
Integrating synergistic effects of land use and climate changes across scales and biomes
?
?
Species
Structures
vegetation, habitat, landscape
Genes
?
AACCCTGAC
CGACTAC…
(N)
(T)
?
Biodiversity

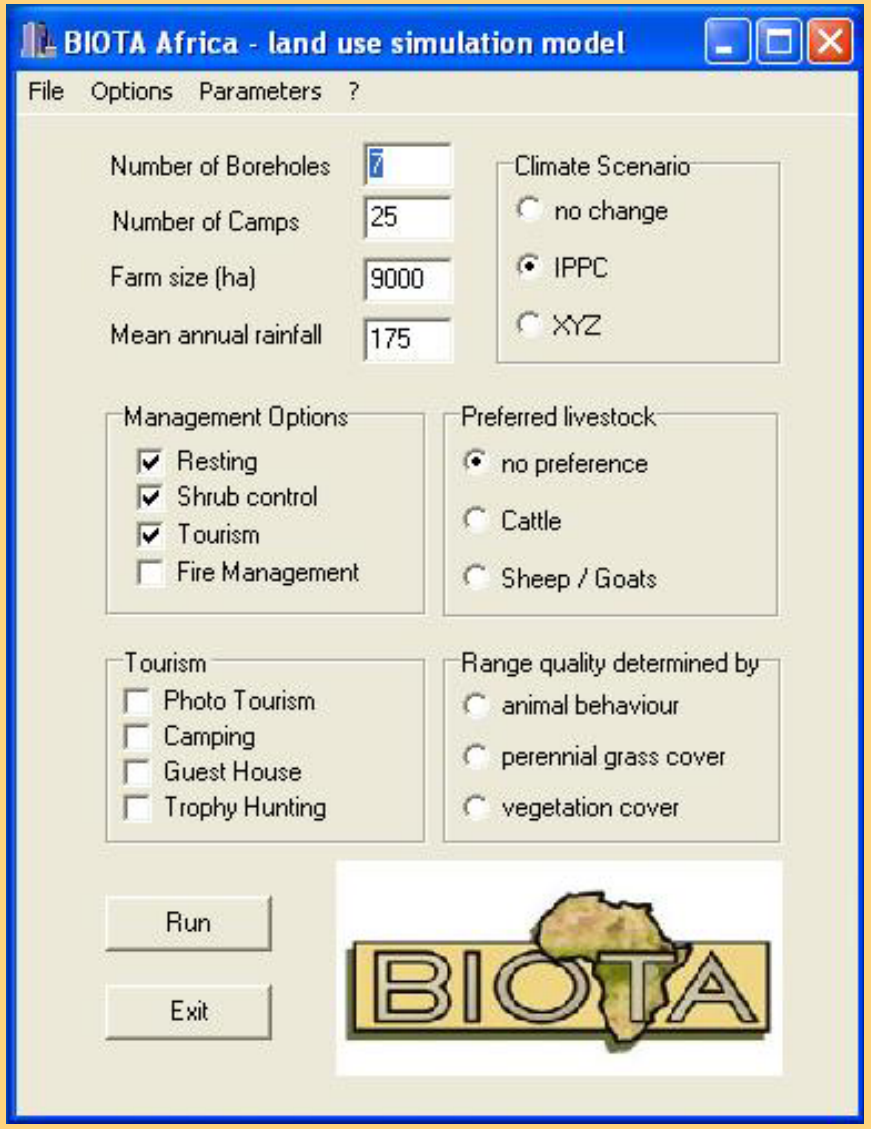
Vision

How can we optimise land use strategies to adapt to climate change?

Towards a management tool for land managers* (under construction)

Considering individual decision making of land users

*Suggestions by potential users are most welcome !



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Thank you for your attention !

Thanks to BMBF & DLR
for funding & support

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