Einsatz der Fernerkundung in der Ökologie: Beispiele, Synergien und mögliche Verknüpfungen

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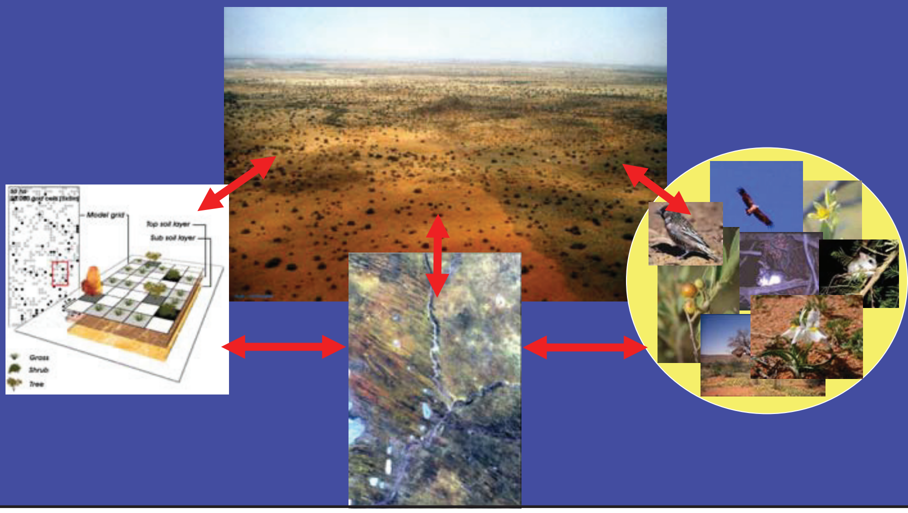
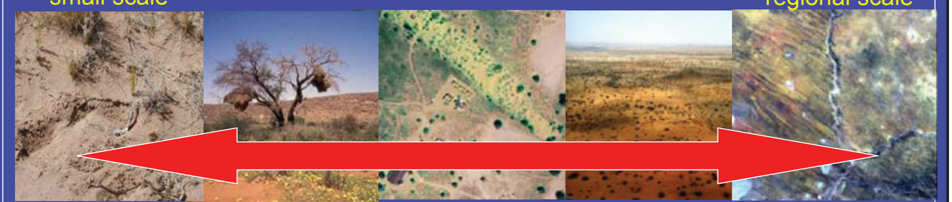


The problem of scaling in Ecology and Nature Conservation

small scale

regional scale



soil processes ↻ vegetation processes ↻ management ↻ conservation …. ↻ policy

Understanding of mechanisms

Decision making

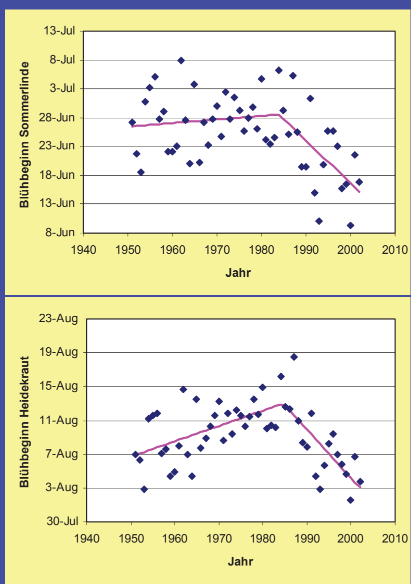
How to identify mechanisms?

S. Levin 1992: ‚The identification of mechanisms underlying observed **patterns** is the key to understanding and prediction‘

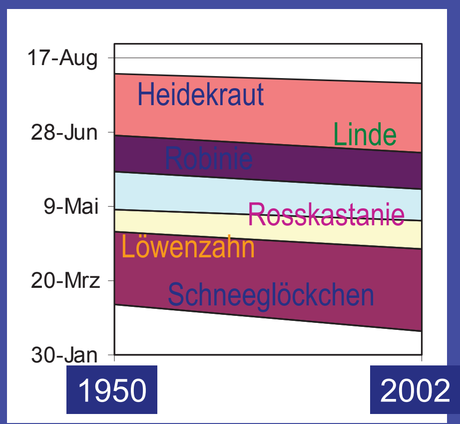
Pattern ⟺ process

A few brief examples from ecology

Trends im Blühbeginn



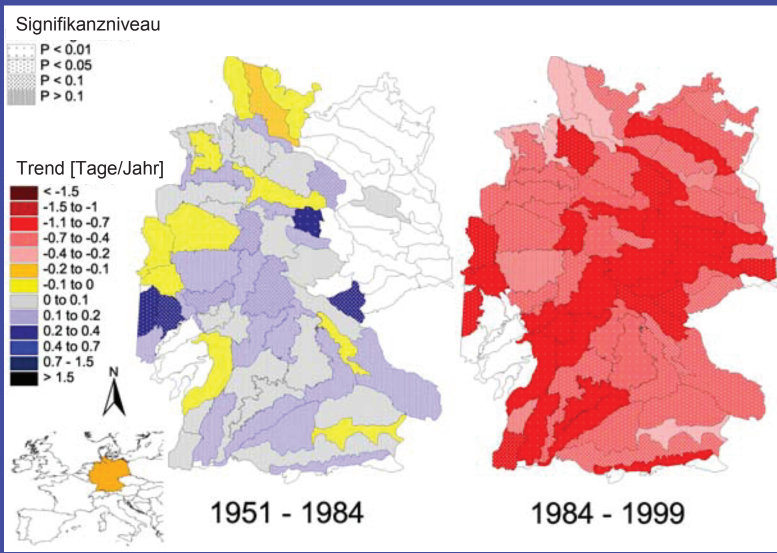
s. Tagfalterphänologie in Döberitzer Heide (Poster – Kühling et al.)



Perspektiven:

- Fernerkundung von dominanten Blühphasen
- Korrelation mit Aktivität von Bestäubern

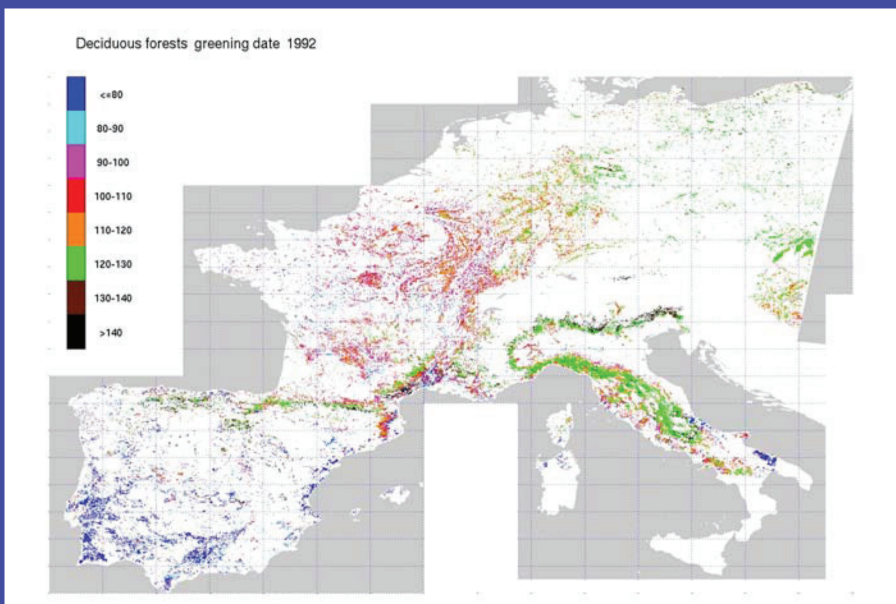
Trends in Deutschland: späte Frühjahrsphase



Perspektiven:
- höhere Auflösung räumlicher Muster in Studiengebieten

Schaber & Badeck (2005)
Reg. Environ. Change 5

„Grüne Welle" – aus dem All beobachtet



Badeck et al. (2004) New Phytologist 162

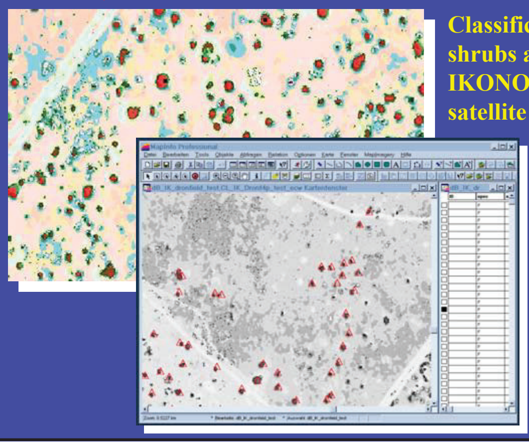
1. How to detect pattern? Remote sensing!

e.g. tree distributions in the southern Kalahari

Aerial Photos
1940, 1964,
1984, 1993

IKONOS Satellite

Techniques for quantification of present and historical landscape structures, using high resolution satellite images and aerial photographs



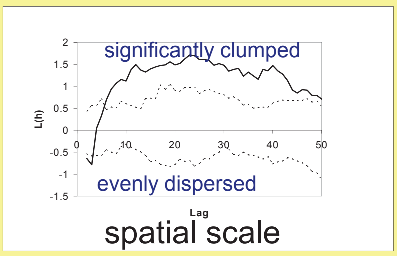
Classification of trees, shrubs and grassland with IKONOS multispectral satellite image

Automatic Tree Detection (Software)

Müller, Marburg

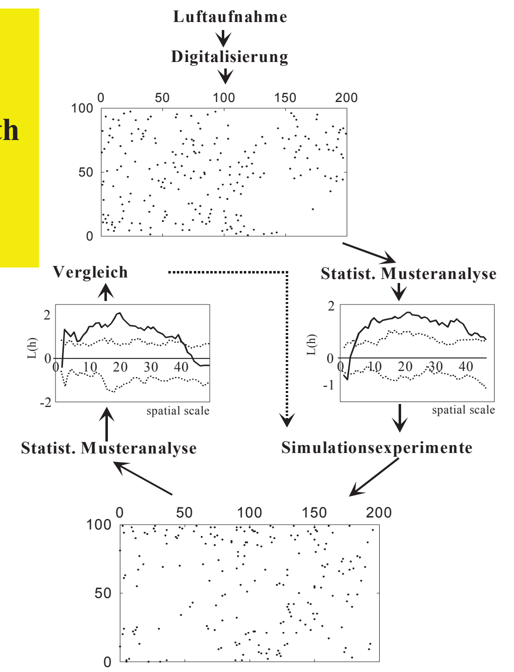
2. How to identify and quantify pattern?

E.g. point pattern analysis

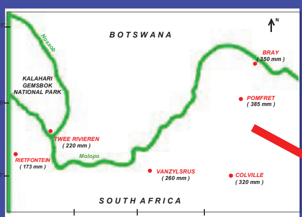


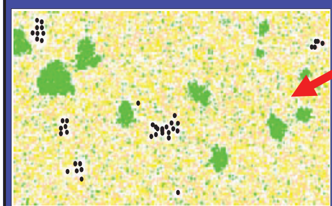
3. How to identify mechanisms?

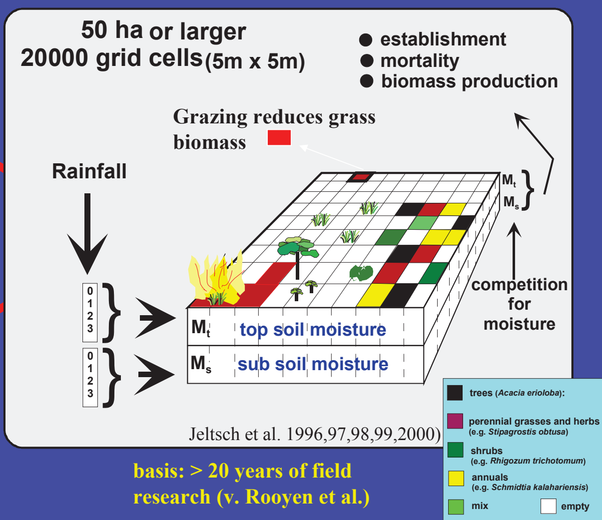
Compare real pattern with patterns produced in controlled simulation experiments!



Example: spatially-explicit, grid based simulation model → vegetation dynamics in the southern Kalahari







basis: > 20 years of field research (v. Rooyen et al.)

timeseries, pattern, abundances, soil moisture classes, grass cover, fire sequence

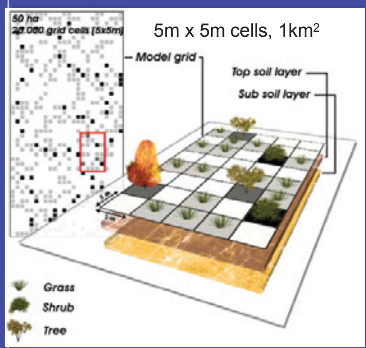
- Mechanisms of long term tree-grass coexistence (Jeltsch et al. 1996, 1998, 2000)
- Dynamics of shrub encroachment (Jeltsch et al. 1997a,b, Weber et al. 1998, 2000, Tews et al. 2004, in press)

Integrating small-scale processes and scaling up

Farm level

?

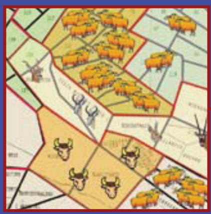
Regional level



Single farm

High resolution process model

Integrating small-scale processes and scaling up



Mosaic of
land use types

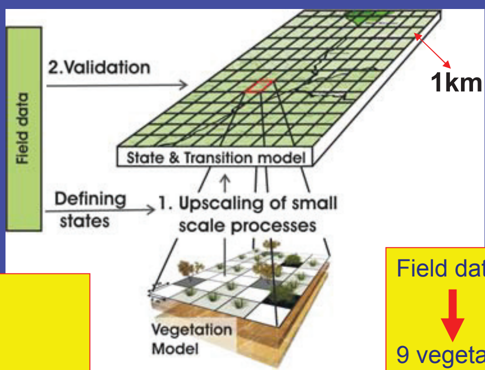
Mosaic of vegetation
states and structures

Population dynamics
of species, diversity




Method of scaling up

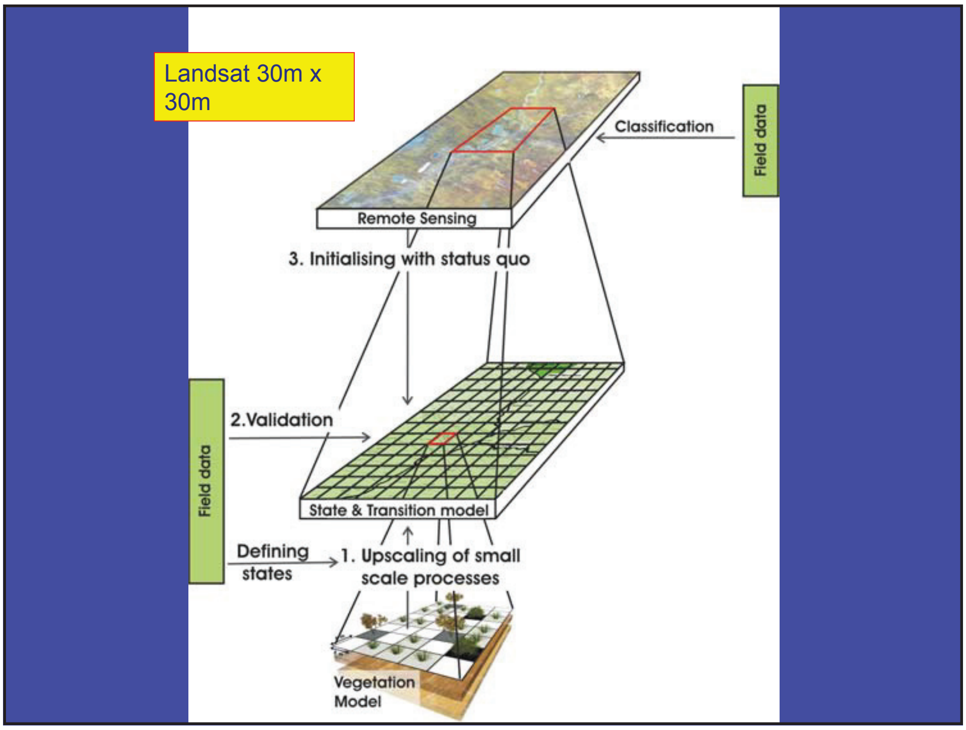
Large scale,
process-based
state &
transition
model



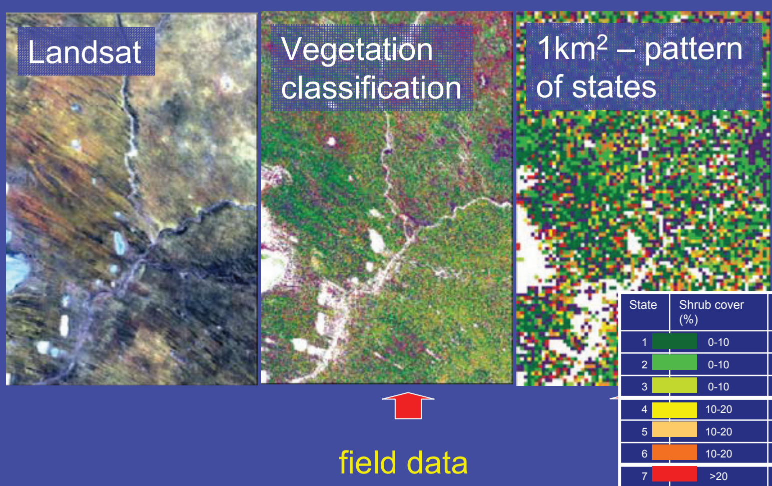
1km x 1km

Land use
↓
state-transition
matrix: 1 km^2

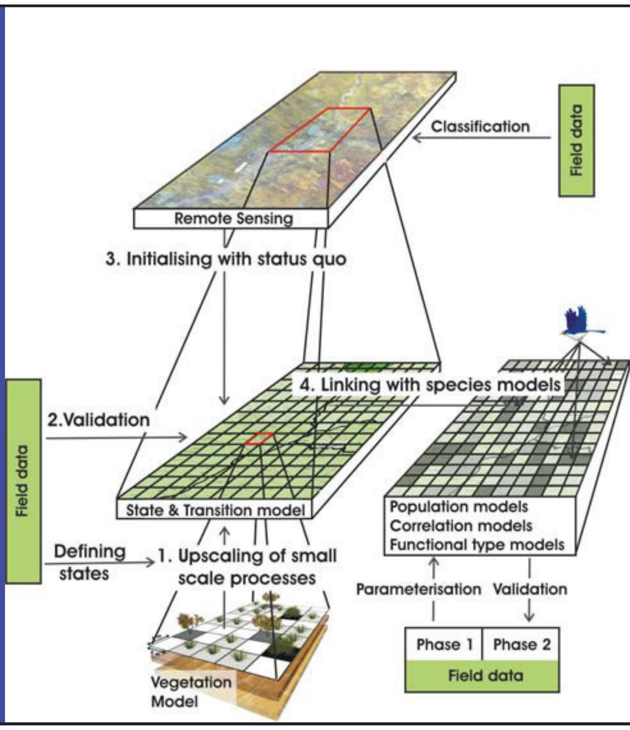
Field data
↓
9 vegetation states
% shrub cover
% peren. grasses & herbs



Current status based on remote sensing



State	Shrub cover (%)	Perennial grass 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

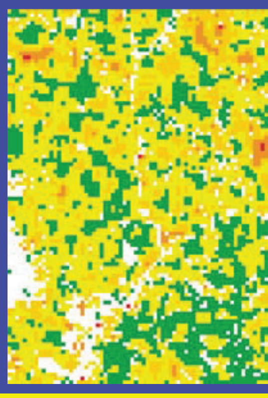


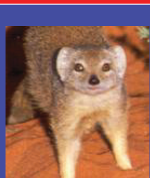
Sample application: small carnivore diversity

Field data: State-diversity correlations (Blaum 2004, Blaum et al. subm.)

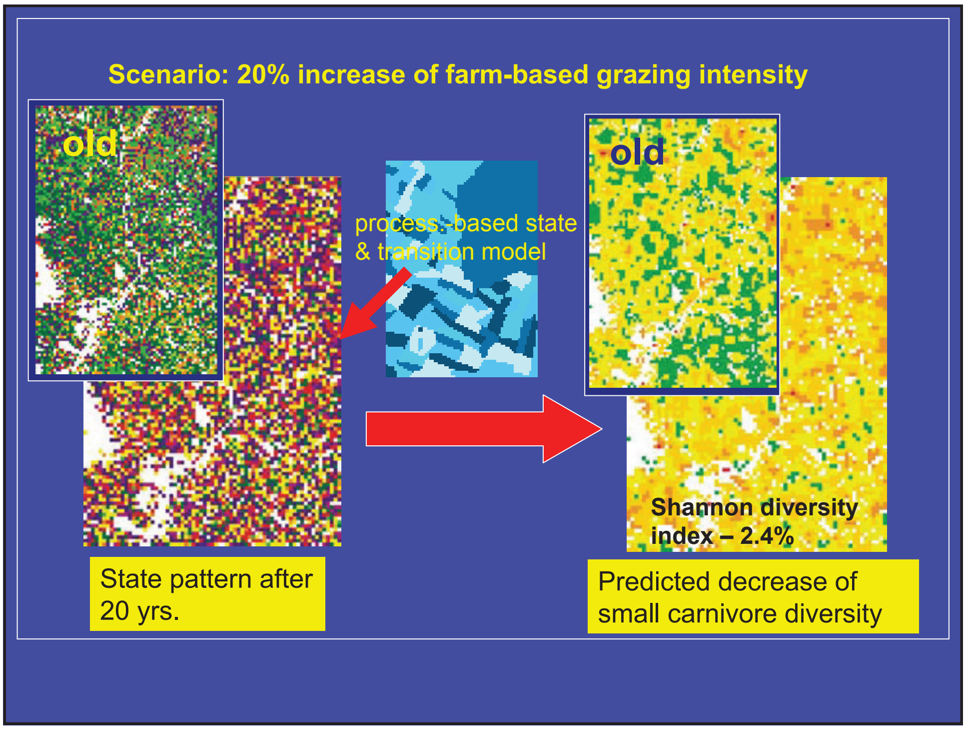
Shannon
Diversity Index

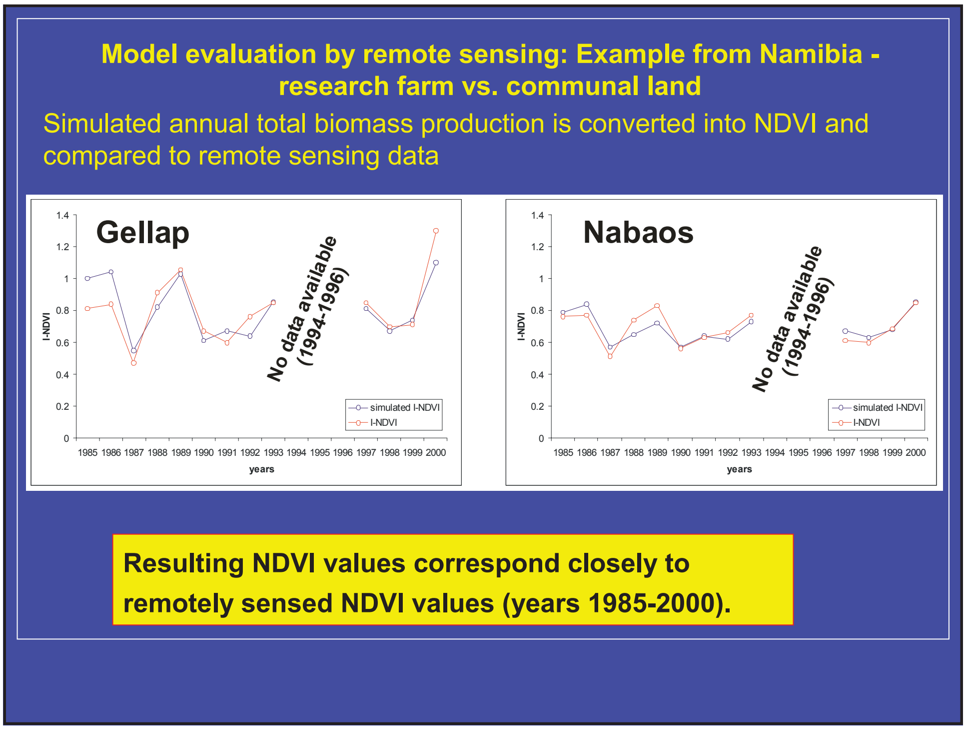
- 0.46-0.50
- 0.51-0.55
- 0.56-0.60
- 0.61-0.65
- 0.66-0.70





Current pattern of small carnivore diversity


Scenario: 20% increase of farm-based grazing intensity
old
process-based state & transition model
old
Shannon diversity index – 2.4%
State pattern after 20 yrs.
Predicted decrease of small carnivore diversity

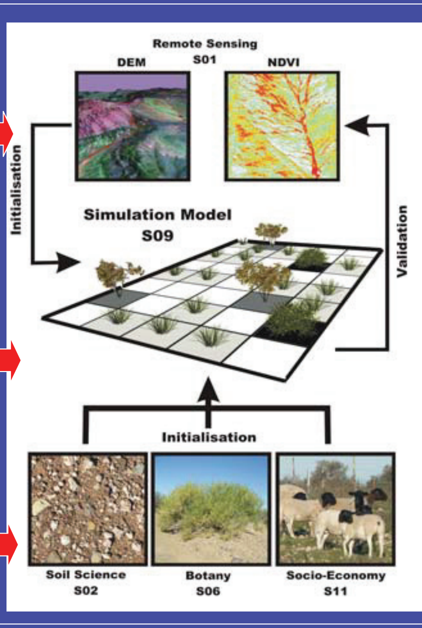

Model evaluation by remote sensing: Example from Namibia - research farm vs. communal land
Simulated annual total biomass production is converted into NDVI and compared to remote sensing data
Gellap
No data available (1994-1996)
simulated I-NDVI
I-NDVI
I-NDVI
years
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000
Nabaos
No data available (1994-1996)
simulated I-NDVI
I-NDVI
I-NDVI
years
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000
Resulting NDVI values correspond closely to remotely sensed NDVI values (years 1985-2000).

Process integration and scale transition

landscape initialization and model validation based on remote sensing

Integration in a high resolution, process-based simulation model

data, processes and small scale mechanisms



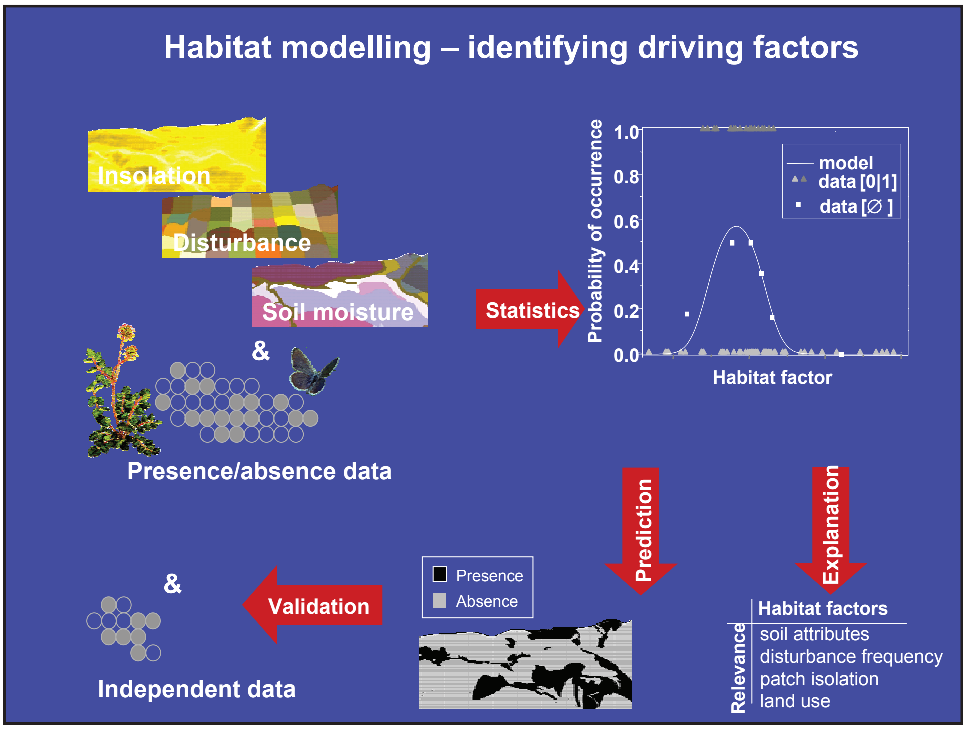
Powerful tools for mechanism-based forecasts of global change effects

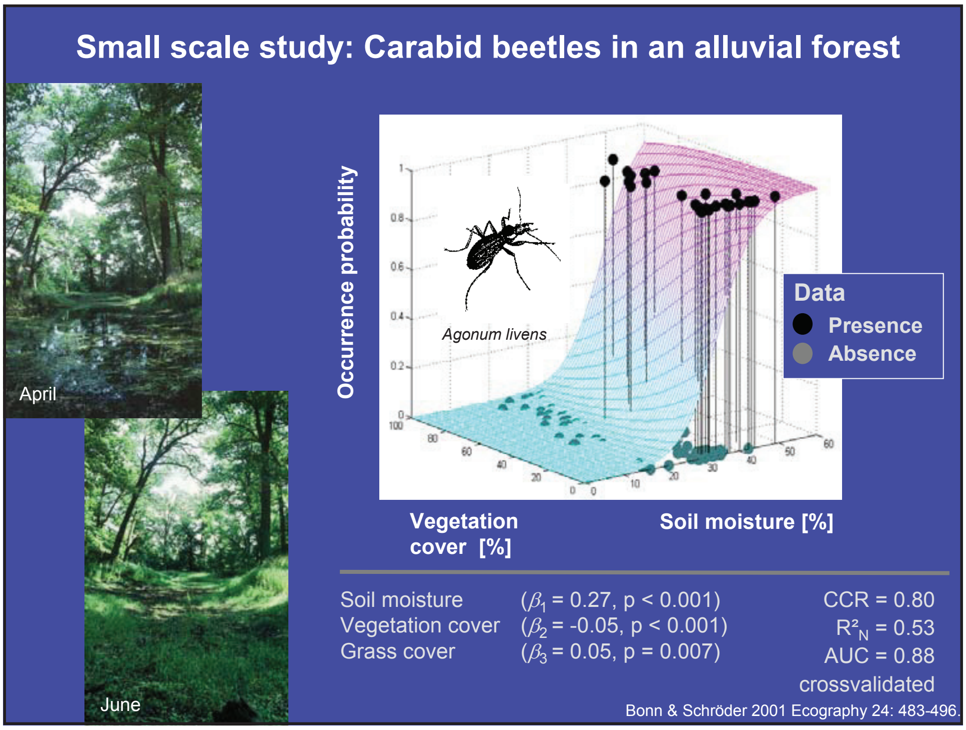
Pattern **Process**

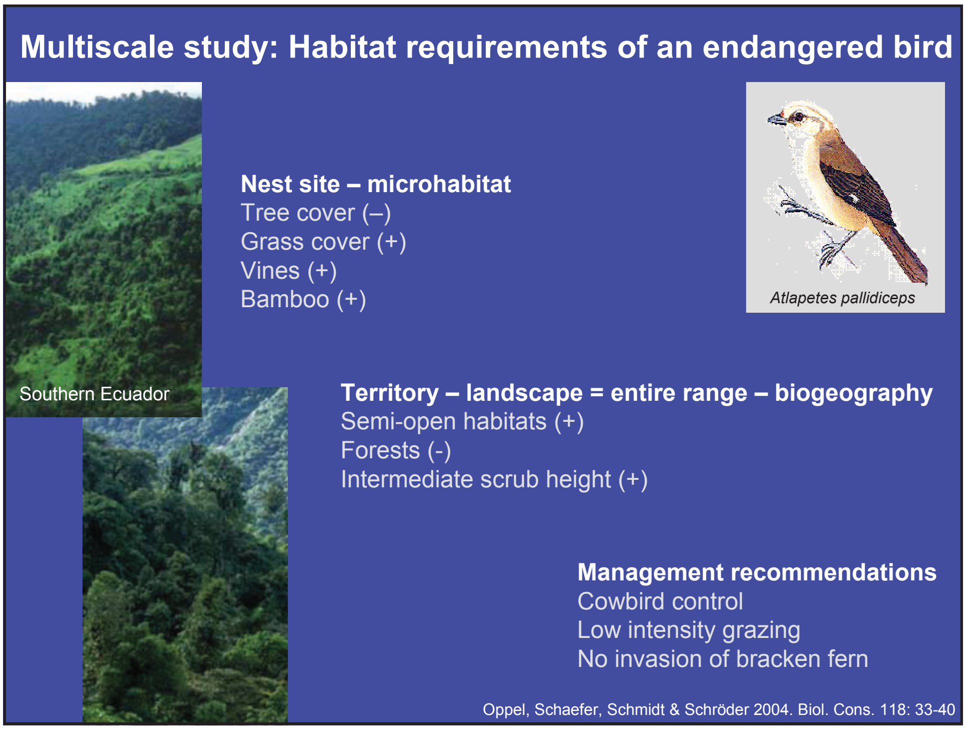
Spatial distribution of species
– understanding & prediction
– mulitple scales

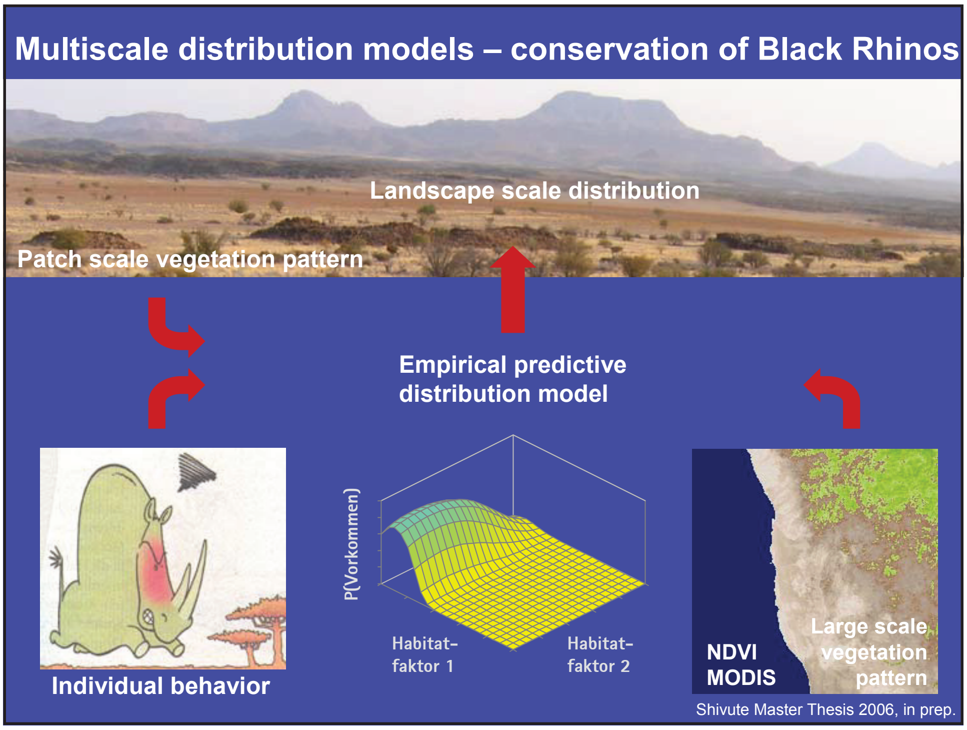
Driving factors
– identification
– integrated modelling

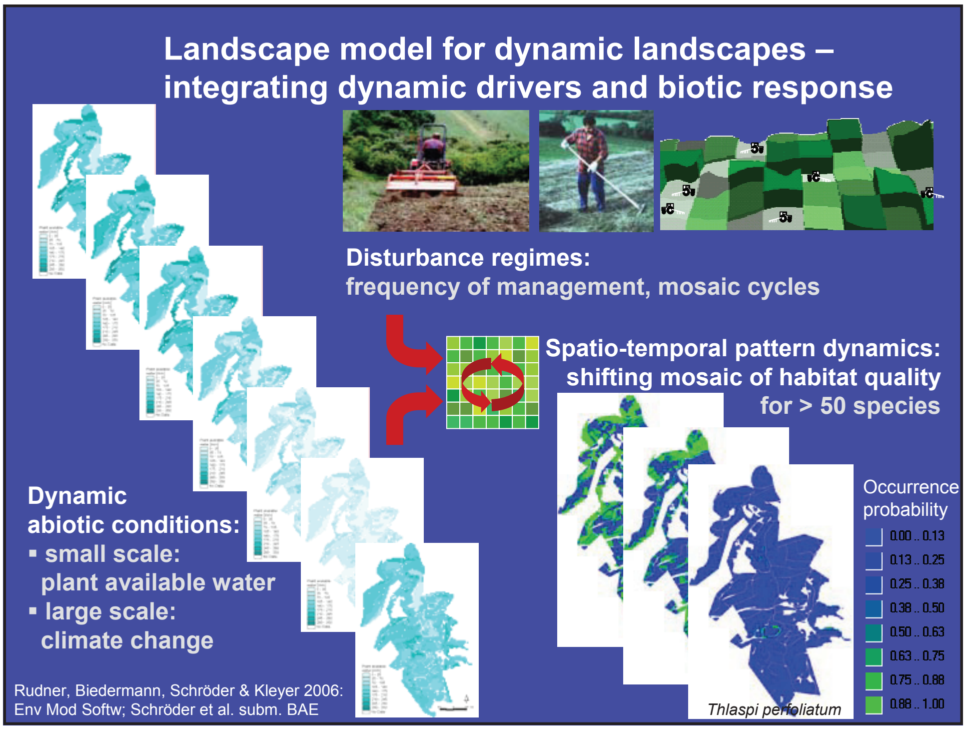
2nd example


Habitat modelling – identifying driving factors
Insolation
Disturbance
Soil moisture
&
Presence/absence data
Statistics
Probability of occurrence
1.0
0.8
0.6
0.4
0.2
0.0
model
data [0|1]
data [∅]
Habitat factor
Prediction
Explanation
&
Validation
Presence
Absence
Independent data
Habitat factors
soil attributes
disturbance frequency
patch isolation
land use
Relevance


Small scale study: Carabid beetles in an alluvial forest
April
June
Occurrence probability
Agonum livens
Data
Presence
Absence
Vegetation cover [%]
Soil moisture [%]
Soil moisture (β_1 = 0.27, p < 0.001)
Vegetation cover (β_2 = -0.05, p < 0.001)
Grass cover (β_3 = 0.05, p = 0.007)
CCR = 0.80
R^2_N = 0.53
AUC = 0.88
crossvalidated
Bonn & Schröder 2001 Ecography 24: 483-496.


Multiscale study: Habitat requirements of an endangered bird
Nest site – microhabitat
Tree cover (–)
Grass cover (+)
Vines (+)
Bamboo (+)
Atlapetes pallidiceps
Southern Ecuador
Territory – landscape = entire range – biogeography
Semi-open habitats (+)
Forests (-)
Intermediate scrub height (+)
Management recommendations
Cowbird control
Low intensity grazing
No invasion of bracken fern
Oppel, Schaefer, Schmidt & Schröder 2004. Biol. Cons. 118: 33-40


Multiscale distribution models – conservation of Black Rhinos
Landscape scale distribution
Patch scale vegetation pattern
Empirical predictive
distribution model
P(Vorkommen)
Habitat-
faktor 1
Habitat-
faktor 2
Individual behavior
NDVI
MODIS
Large scale
vegetation
pattern
Shivute Master Thesis 2006, in prep.



Perspektiven für IMAF

Was liefert die "Biotik"?

- Musterdynamik auf unterschiedlichen Skalen
- dynamische Systeme mit Schwellenwertcharakteristik
- Anwendung ~ Upscaling
- Potential der Fernerkundung & nicht-invasiver Verfahren bei weitem nicht ausgeschöpft

Mögliche IMAF-Kooperationen / Interesse an Fernerkundung

- Erweiterung der Datenbasis & Modell-Inputs, d.h.
  - Verfügbarkeit bisher nicht genutzter Umweltinformationen (z.B. Hyperspektraldaten, Geoelektrik)
  - Ausweitung der räumlichen & zeitlichen Skalen
  - Zugang zu Fernerkundungstechnik & -expertise
- weitergehendes Verständnis der Pattern-Process Interaktionen durch Integration der abiotischen & biotischen Prozesse