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Biodiversity Monitoring and Research in Chinese Ecosystem Research Network (CERN)

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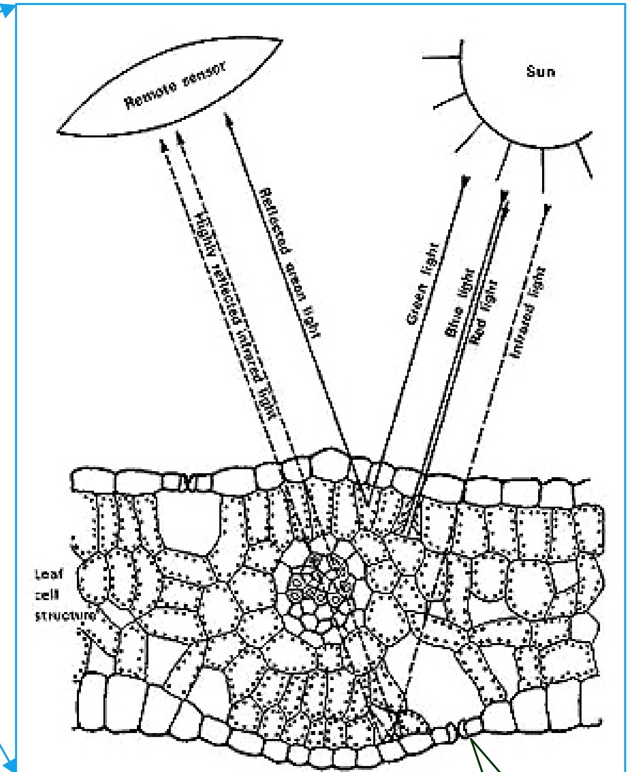
Chinese Academy of Sciences

How to upscale the plot-based biodiversity monitoring to regional assessment?

- Based on plant biophysical and biochemical laws
- High precision if the variables are exactly measured
- To many variables! Upscaling uncertainty

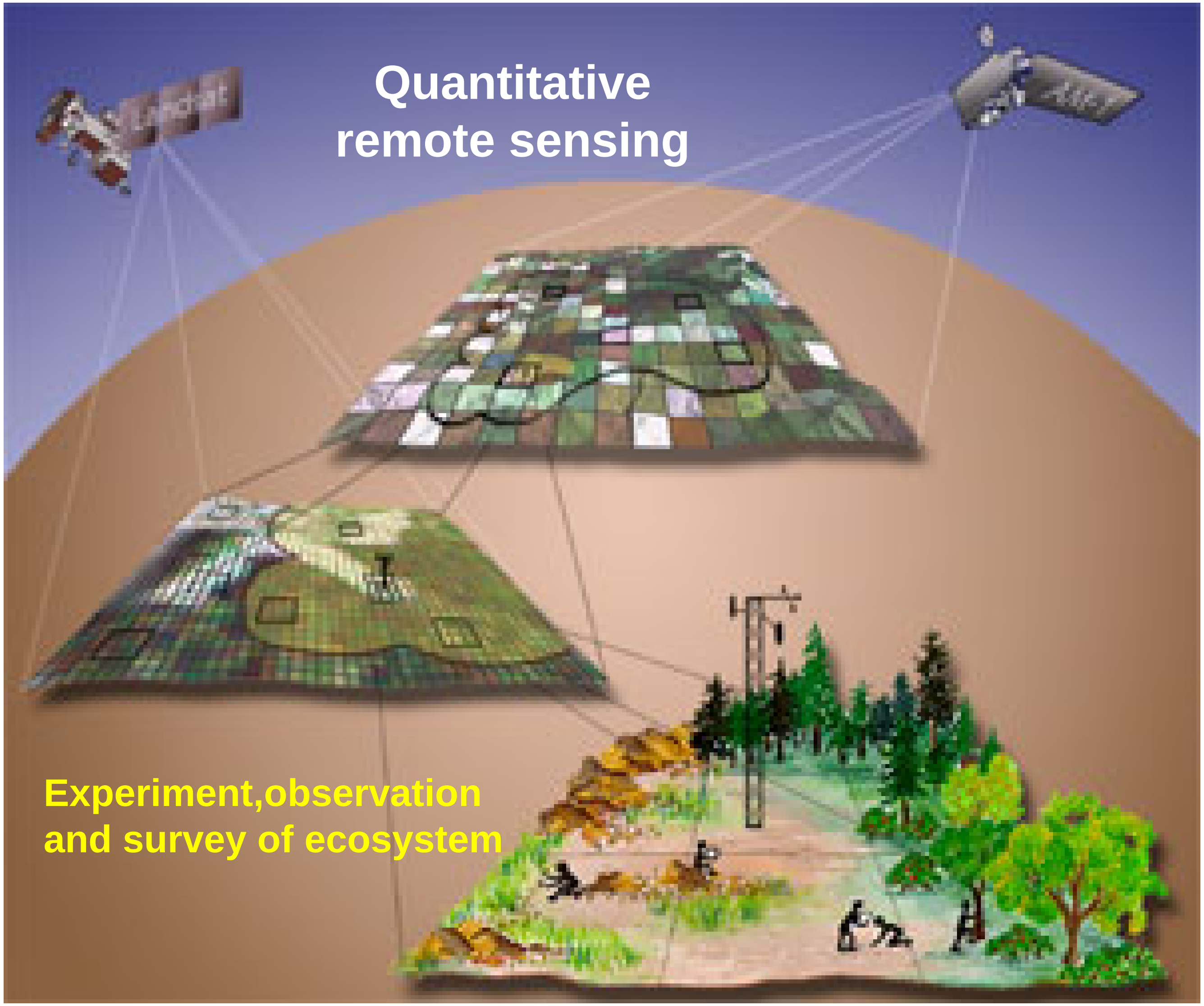


Leaf structure

stoma

From site to regional?
What variables?

How to integrate the in-situ monitoring with remote sensing monitoring?



Source: Big foot, USA

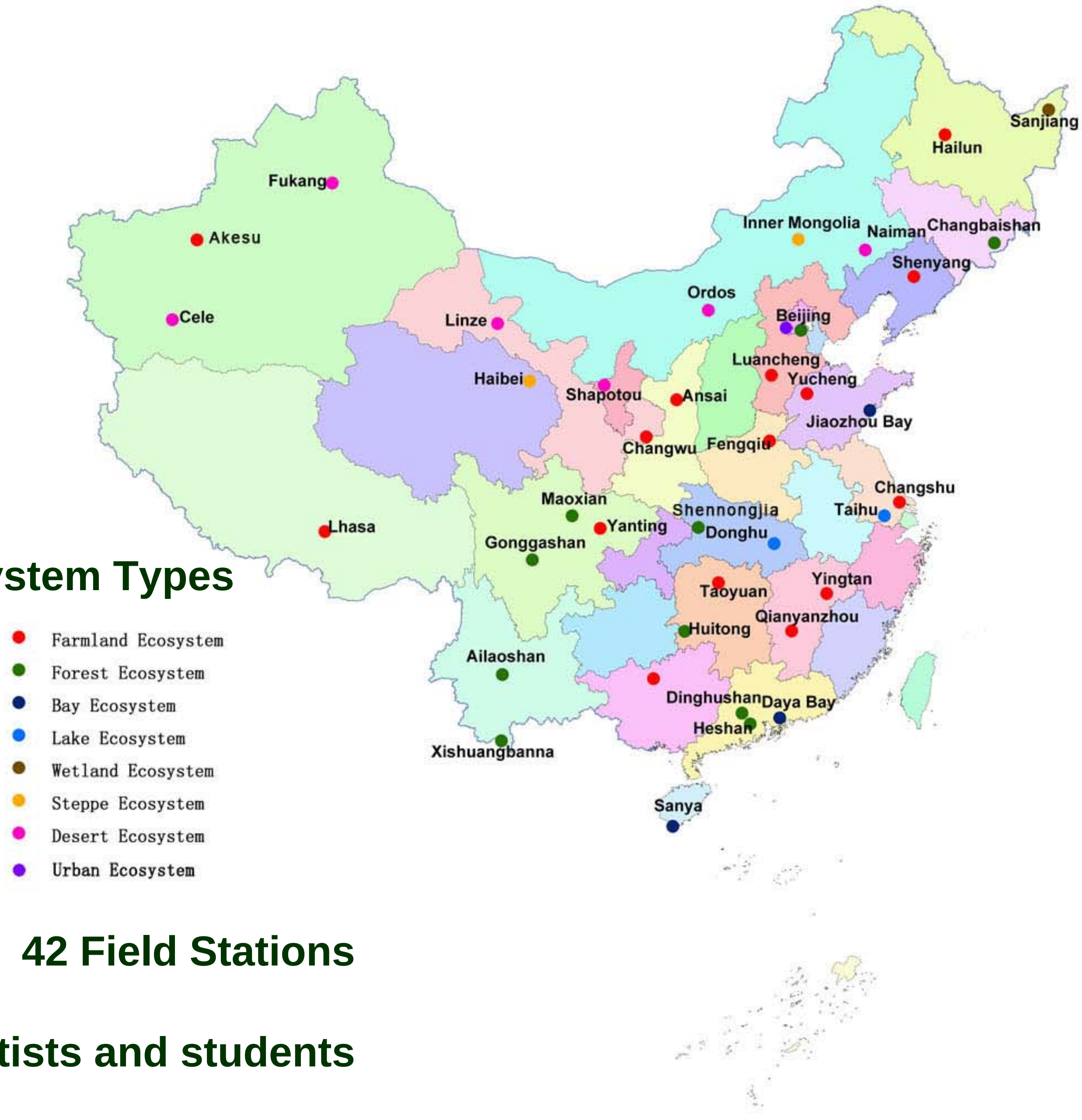
Outline of Presentation

1. CERN Functions and Examples of Biodiversity Monitoring and Research
2. Linkage between Land Use Changes and Biodiversity
3. Upscaling the Plot-based Biodiversity Monitoring to Regional Biodiversity Assessment
4. Conclusions

Part I

CERN FUNCTIONS AND EXAMPLES OF BIODIVERSITY MONITORING AND RESEARCH

Distribution Map of Ecological Stations of CERN



8 Ecosystem Types

42 Field Stations

1200 scientists and students

Publications

Year	SCI
2003	263
2004	373
2005	358
2006	399
2007	412
2008	469
2009	626
2010	741
2011	860

Function 1: Monitoring

- Meteorological and atmospheric conditions
- Soil physiochemical characteristics
- Biological features: biomass, LAI, DBH, community structure
- Hydrological processes

Long term ecological monitoring in the field

Function 2: Research

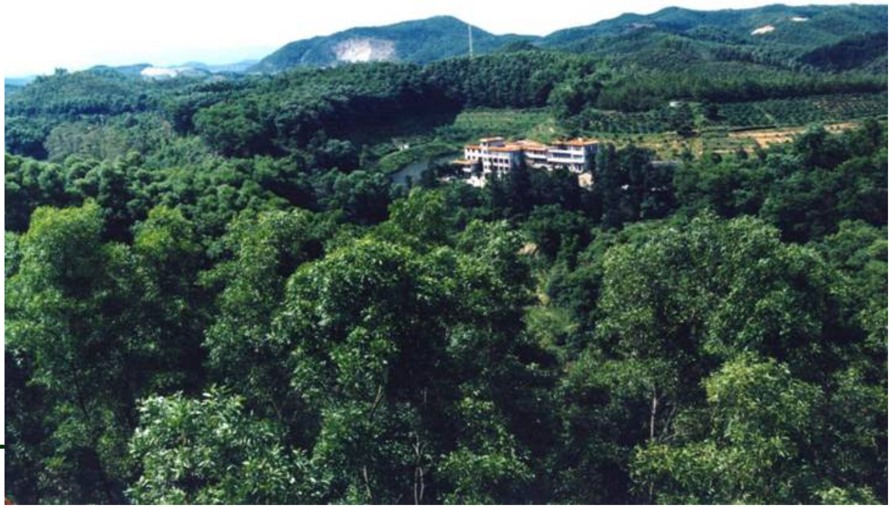
Core research areas

1. Ecosystem biogenic elements and water cycle process
2. Response and adaptation of ecosystems to global climate change
3. Biodiversity conservation and use of biological resources
4. Ecosystem restoration and sustainability
5. Impacts of human activities on ecosystem structure and functions
6. Application of ecological monitoring, modeling and eco-informatics

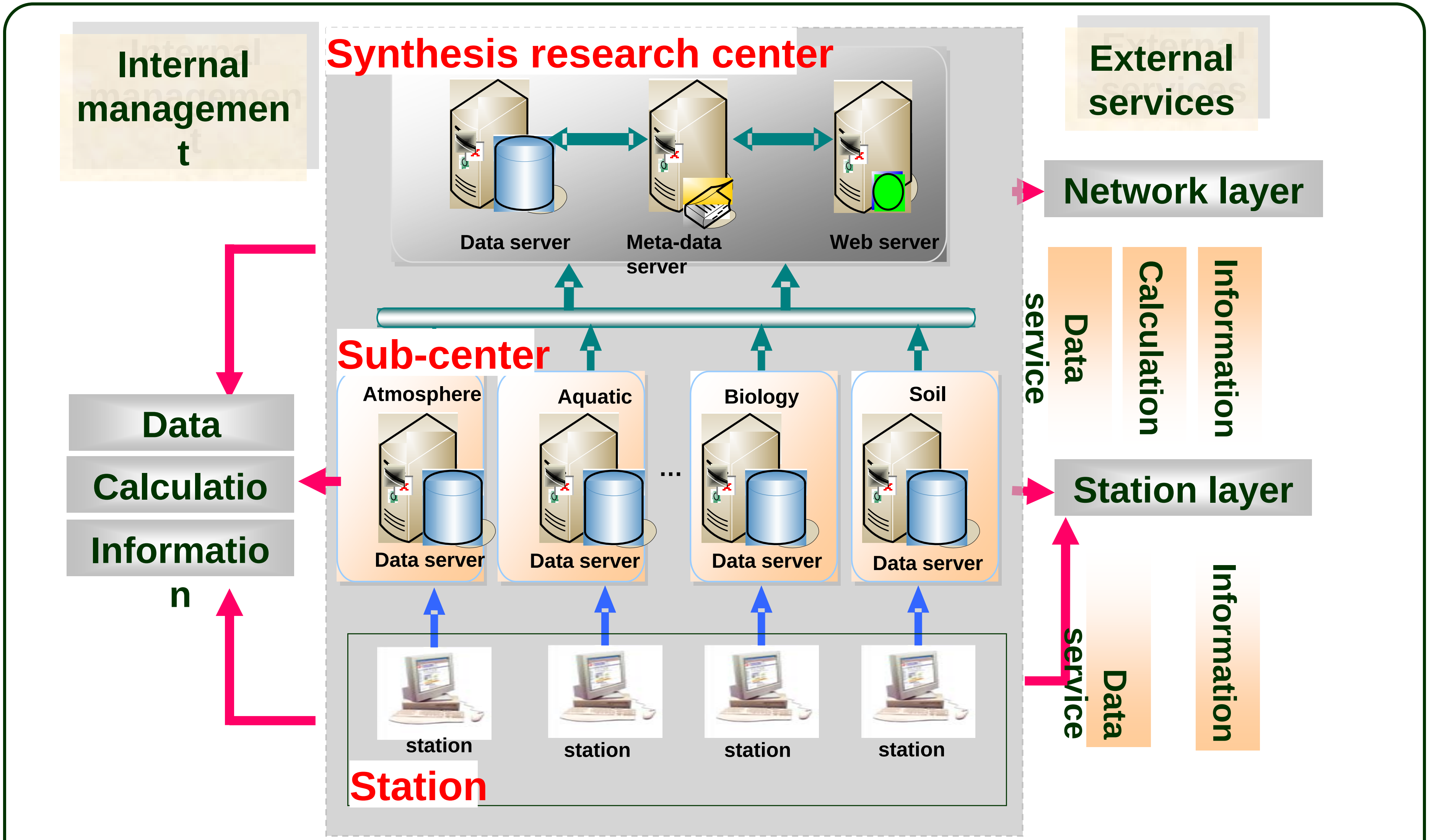
Function 3: Demonstration

- Best Practices in Ecosystem Management
- Practical Technology and Approaches (i.e. structural & biological measures)
- Vegetation coverage, soil erosion control, and income generating

Some 20 demonstration models developed in CERN Stations



Function 4: Data management and sharing

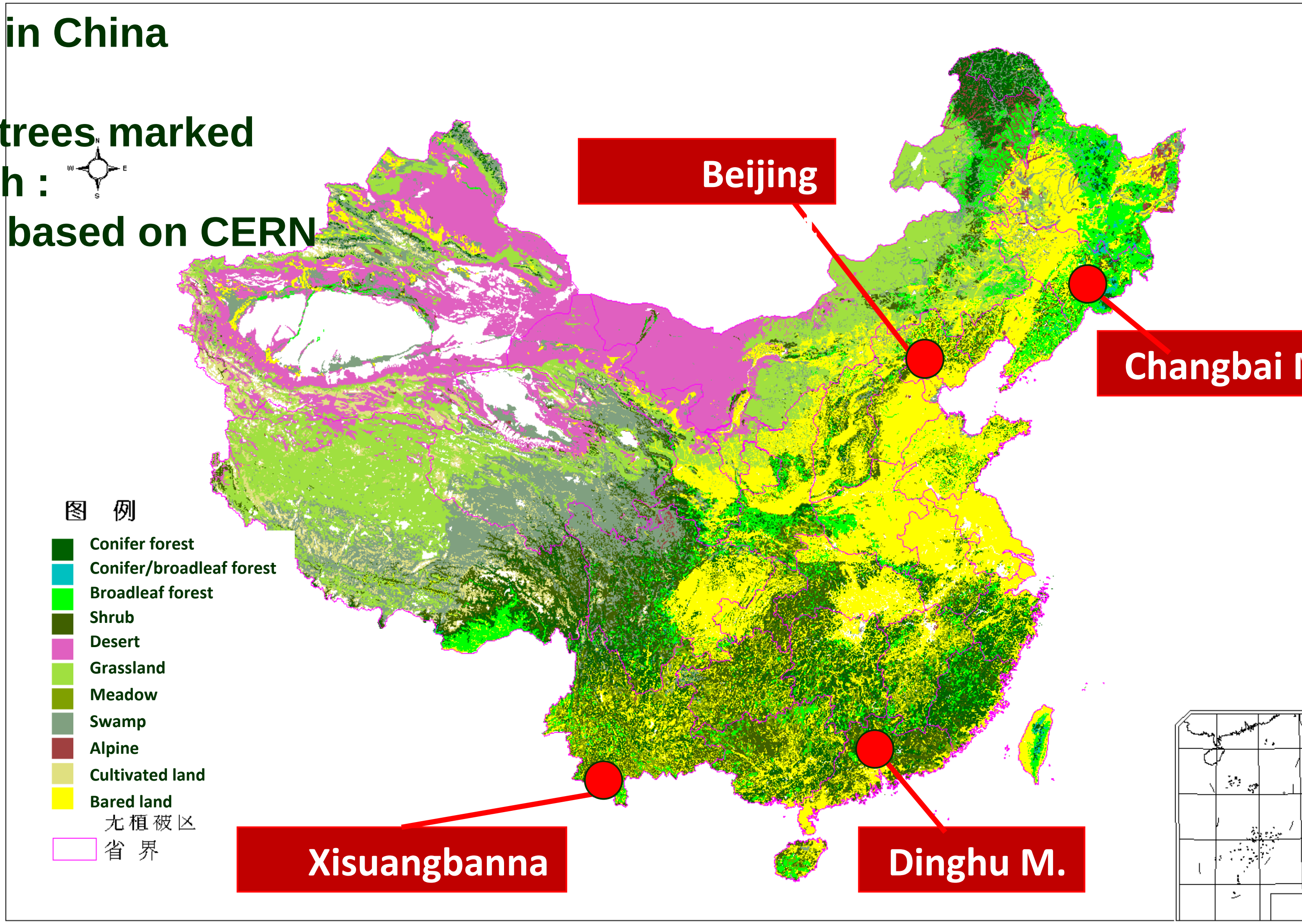


Centralized metadata, distributed storage of data

China Forest Biodiversity Monitoring

CASE 1

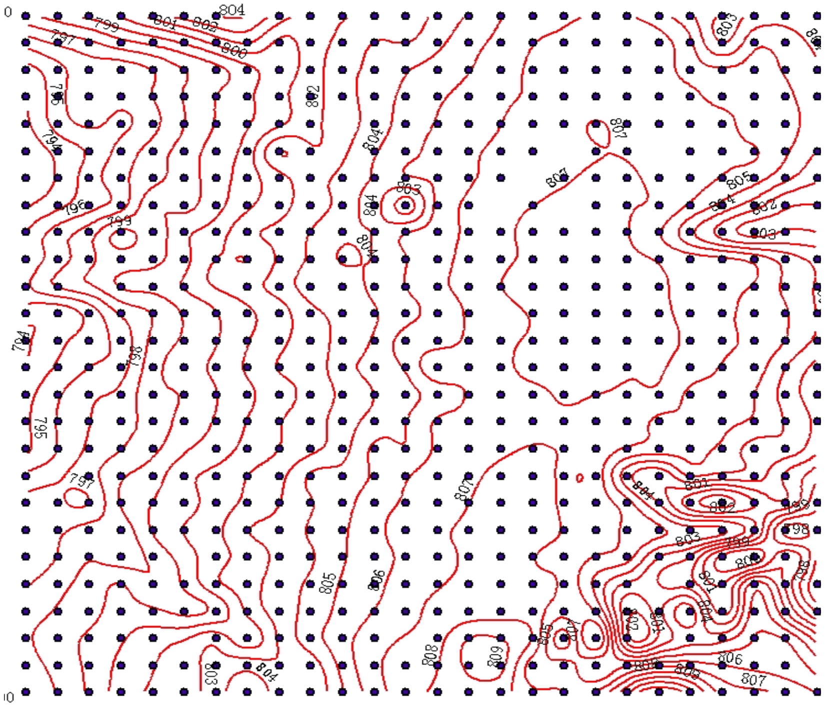
8 plots in China
>20 ha
600,00 trees marked
in which :
4 Plots based on CERN



Courtesy: Keping Ma, 2012

Changbai Mountain Forest Plot

CASE 1



Elvation: 801.5 m   Area: 25ha   Trees: 38,901

Some publications

CASE 1

Journal of Ecology

Journal of Ecology 2011, **99**, 1382–1393 doi: 10.1111/j.1365-2745.2011.01857.x

Spatial patterns of tree species richness in two temperate forests

Xugao Wang[1], Thorsten Wiegand[2], Amy Wolf[3], Robert Howe[3], Stuart J. Davies[4] and Zhanqing Hao[1]*

[1]State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110164, China; [2]Department of Ecological Modelling, UFZ Helmholtz Centre for Environmental Research-UFZ, D-04301 Leipzig, Germany; [3]Department of Natural and Applied Sciences, University of Wisconsin-Green Bay, Green Bay, WI 54311, USA; and [4]Center for Tropical Forest Science, Arnold Arboretum, Harvard University and Smithsonian Tropical Research Institute, Boston, MA 02131

Summary

1. The relative contribution of external vs. internal clustering me nity structure and its manifestations has been the subject of a co have been made to examine their single and joint effects in a com

Research

Oikos 000: 001–009, 2011
doi: 10.1111/j.1600-0706.2011.19428.x

Subject Editor: Stefano Allesina. Accepted 5 May 2011

Separating the effect of mechanisms shaping species-abundance distributions at multiple scales in a subtropical forest

Jiajia Cheng, Xiangcheng Mi, Karin Nadrowski, Haibao Ren, Jintun Zhang and Keping Ma

J. J. Cheng, X. C. Mi (mixiangcheng@ibcas.ac.cn), H. B. Ren and K. P. Ma, State Key Laboratory of Vegetation and Environmental Change, Inst. of Botany, Chinese Academy of Sciences, 20 Nanxincun, Xiangshan, Beijing 100093, PR China. – J. J. Cheng and J. T. Zhang, College of Life Science, Beijing Normal Univ., Beijing 100875, PR China. – K. Nadrowski, Inst. Biologie I - Special Botany and Functional Biodiversity, Univ. of Leipzig, Johannisallee 21-23, DE-04103 Leipzig, Germany.

Species abundance distributions (SADs) play an important role in the current dispute over mechanisms shaping community assembly. Niche theory assumes differential occurrence of species in different habitats while neutral theory emphasizes stochastic events and dispersal. The previous tests of niche and neutral models shaping SADs lead to the claim that SADs are not informative for inferring underlying processes. Using spatial statistical models in a fully mapped 24-ha subtropical forest in China, we first demonstrate that one can not distinguish between the effect of habitat heterogeneity and dispersal limitation on SADs by inspecting whether the observed SADs fall within 95% confidence intervals of the simulated SADs.

Scientific findings

CASE 1

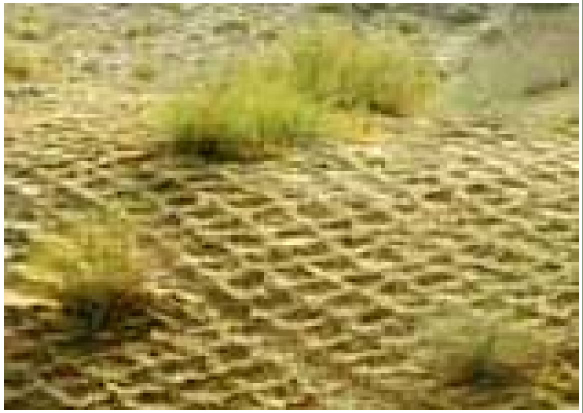
- The sub-tropical forests are generally density dependent after analyzing the mechanism of species co-existence of forest ecosystems with the large amount of measured data;
- Methodology was developed to separate the contribution of different mechanisms on species co-existence, in particular the methodology to estimate the relative contributions of intensity dependent and ecological niche;
- Contributions of intensity dependent and ecological niche to vegetation co-existence was quantified the mechanism of maintaining biodiversity;

Restoration of desertified grassland in arid western China in the last 50 years

CASE 2

1.Shifting dune

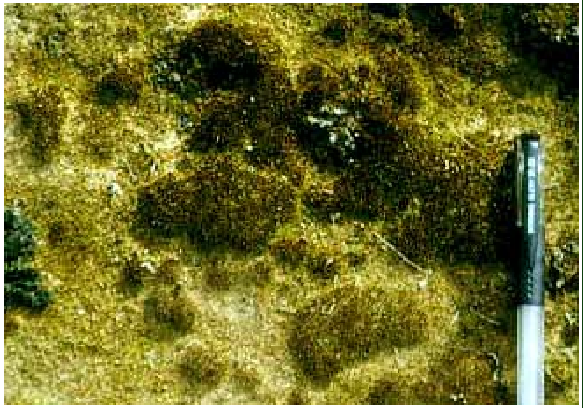
2. Dune fixed by straws



3. Dune fixed by bushes

4. Planted shrub

5. Naturally restored herbage



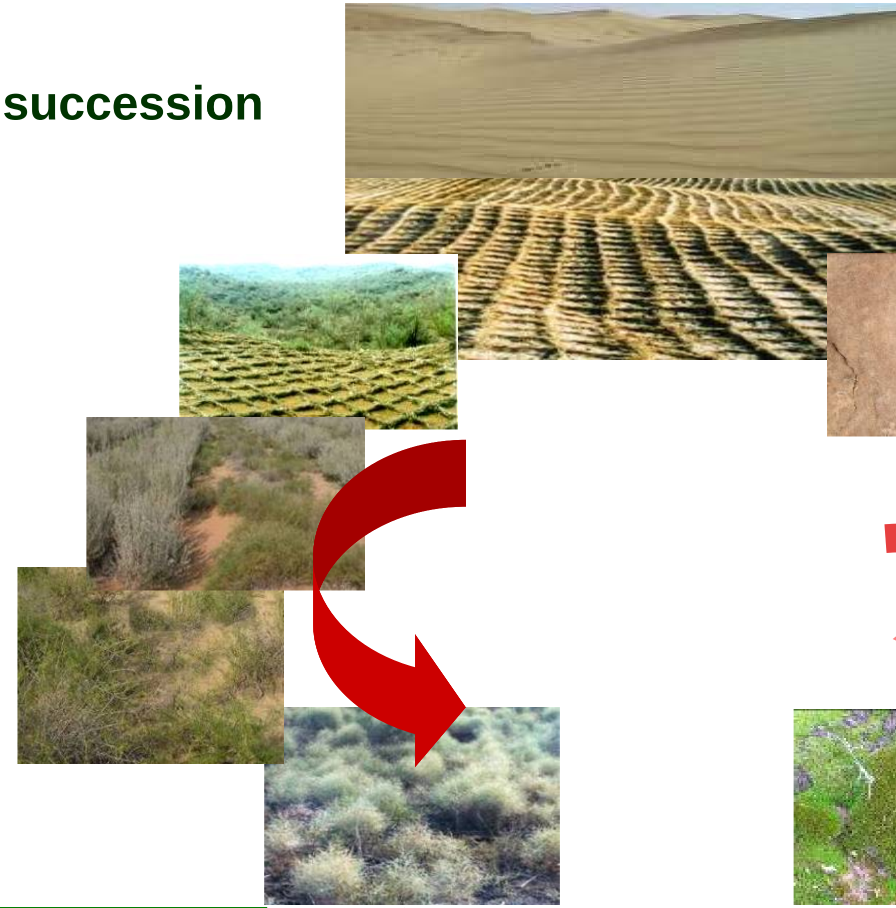
6. Microbe, lichen, moss

Changes in soil and vegetation following stabilisation of dunes

CASE 2

Plant succession

Biological soil crusts determine vegetation changes



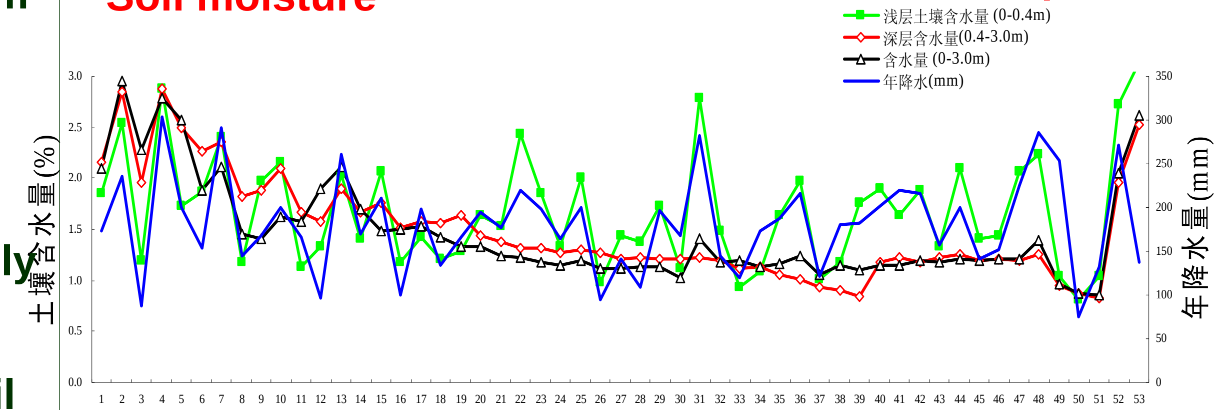
Sand dune vegetation → Shrub community → cryptogam herbage shallow root subshrub

CASE 2 Response pattern of artificial sand-fixation vegetation onto water cycling evolution

- Based on 53-year long-term observation, it has been found that the water content of soil in the shallow layer was positively correlated with the annual precipitation, while the soil moisture in the deep layer had been declining and reach the balanced in the 40th year.
- Species richness: the coverage of shrubs has been falling, while that of the herbaceous plants has been rising

Soil moisture

Precepitation

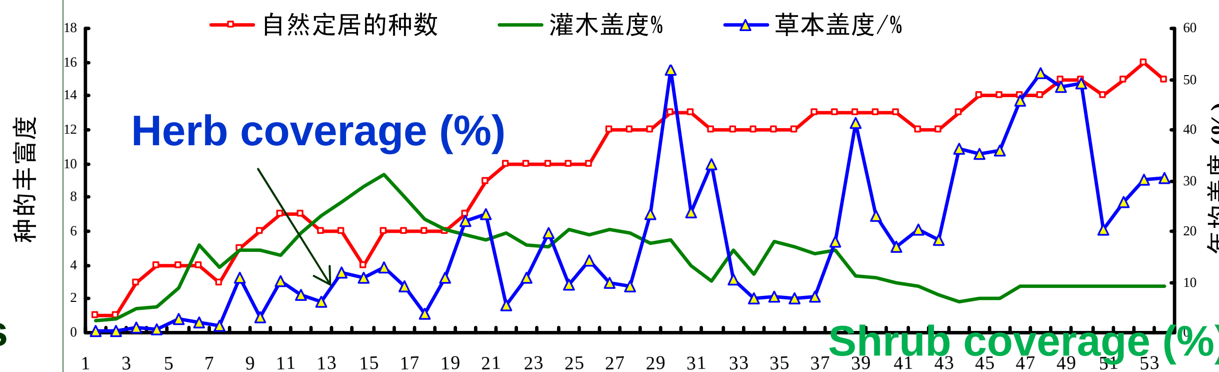


Years after the sand due fixation

Species richness

Vegetation coverage

Herb coverage (%)



Shrub coverage (%)

Years after the sand due fixation

Biodiversity and Ecosystem Function Experiment in Inner Mongolia Grassland

CASE 3

CASE 3

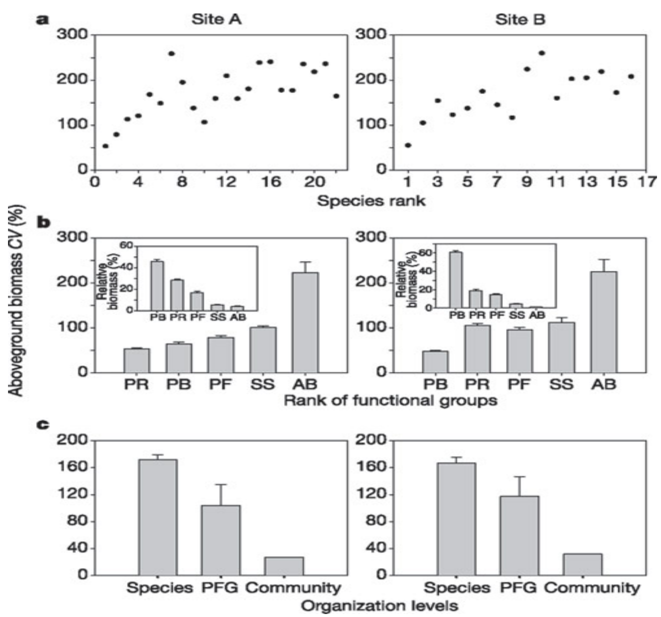
Relationship between biodiversity and stability in grassland ecosystem

Based on 25 years' measurement at Inner Mongolia grassland site:

- ✓ **Ecosystem stability according to biomass variation increased with structure grade**
- ✓ **Community stability depended on the compensation between species and functional groups**
- ✓ **A contribution to ecology theory and a guidance to restoration and management of degenerated grassland**


letters to nature

Ecosystem stability and compensatory effects in the Inner Mongolia grassland



Source:Bai et al., Nature, 2004

Nitrogen addition and biodiversity

CASE 3

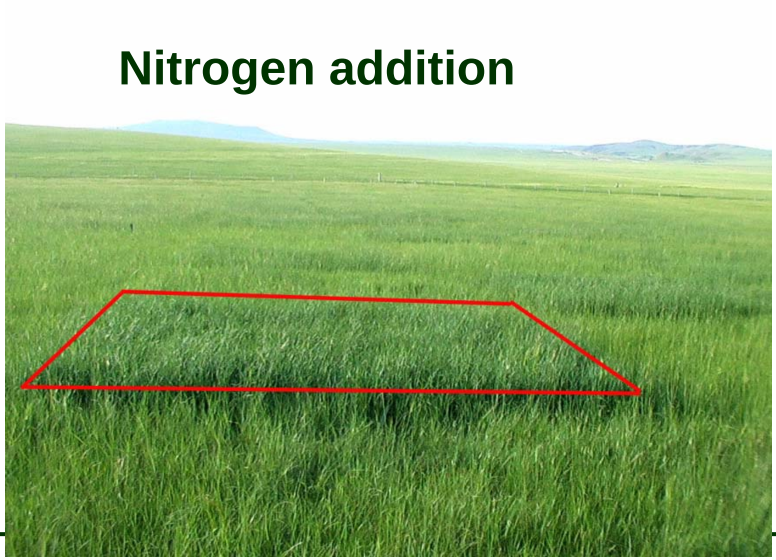
Global Change Biology

Global Change Biology (2010) **16**, 358–372, doi: 10.1111/j.1365-2486.2009.01950.x

Tradeoffs and thresholds in the effects of nitrogen addition on biodiversity and ecosystem functioning: evidence from inner Mongolia Grasslands

YONGFEI BAI*, JIANGUO WU*†, CHRISTOPHER M. CLARK†, SHAHID NAEEM‡, QINGMIN PAN*, JIANHUI HUANG*, LIXIA ZHANG* and XINGGUO HAN*

**State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing 100093, China, †School of Life Sciences and Global Institute of Sustainability, Arizona State University, Tempe, Arizona 85287-4501, USA, ‡Department of Ecology, Evolution and Environmental Biology, Columbia University, New York, NY 10027, USA*



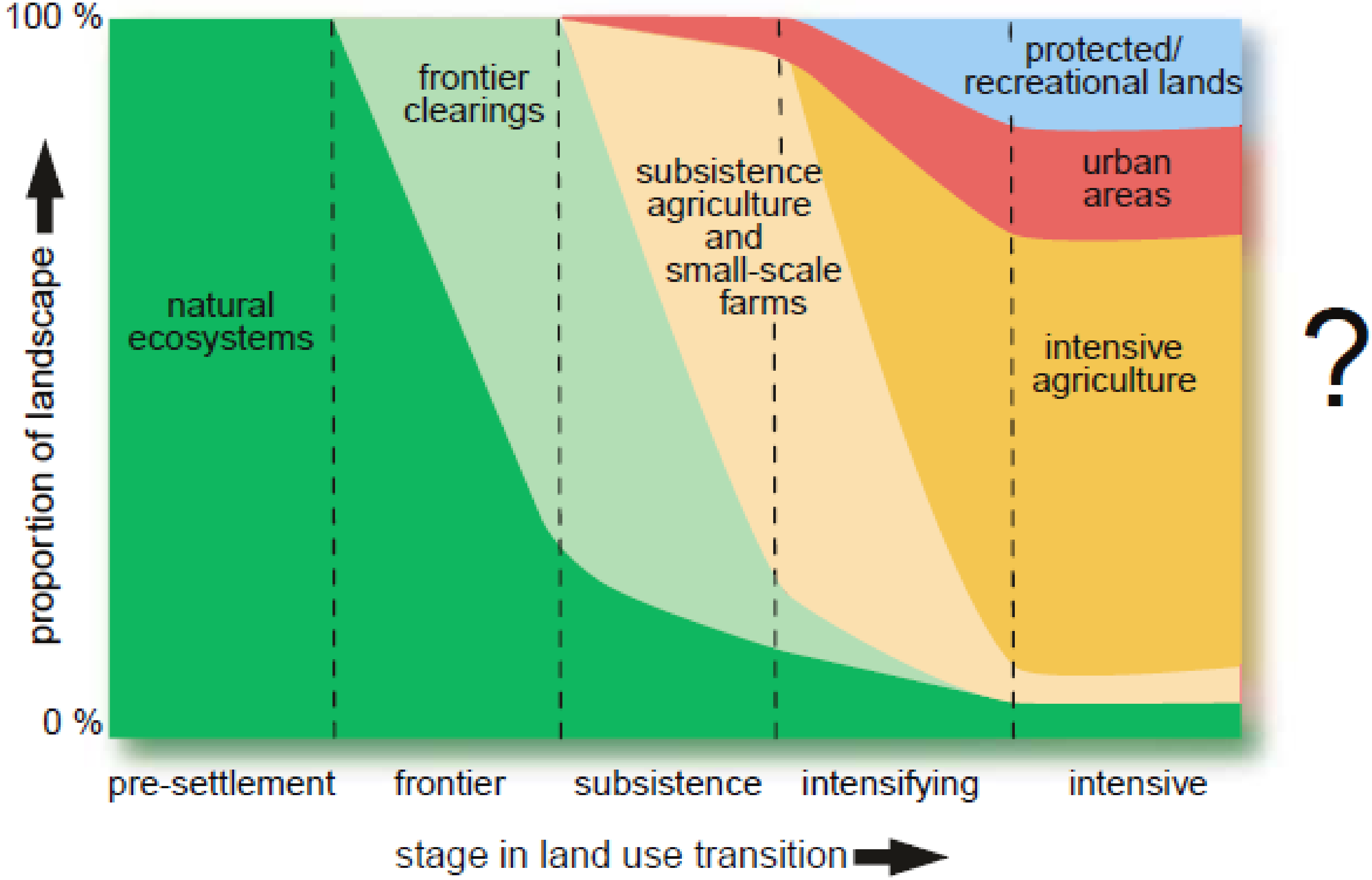
Lessons learned

- The CERN biological monitoring, 5-years' biological survey and information system is helpful for biodiversity analysis at plot scale.
- Approaches of China Forest Biodiversity Monitoring developed to be applied to other ecosystem types (such as shrub, mangrove) and other regions.
- The CERN plot-based monitoring and research are valuable to understand the reasons for biodiversity changes with long-term datasets.

Part 2

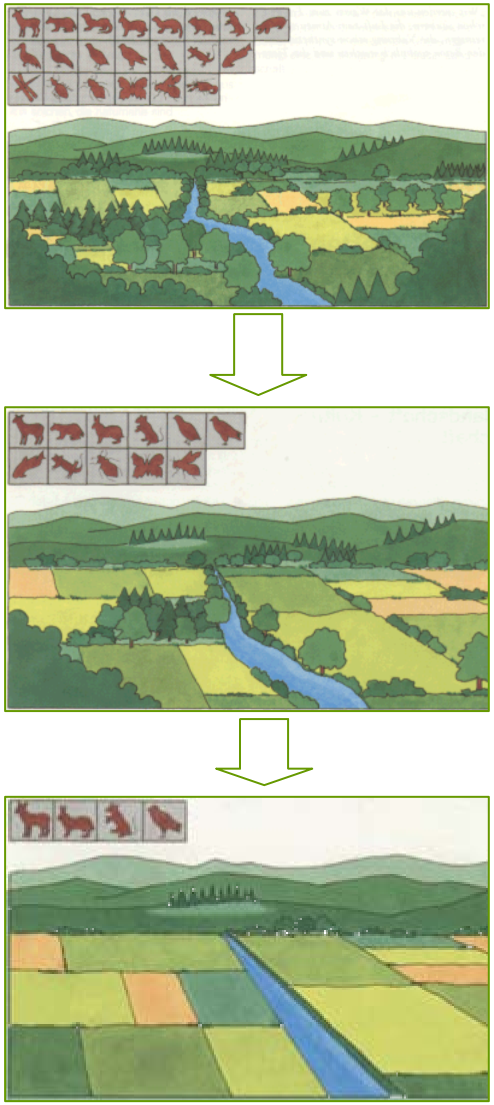
LINKAGE BETWEEN LAND USE CHANGES AND BIODIVERSITY

Global Consequences of Land Use



www.sciencemag.org SCIENCE VOL 309 22 JULY 2005

Landscape change and biodiversity



- Agricultural landscapes cover vast areas of land
  - Mosaic of ecosystems, used and unused
  - Home of rich biodiversity, in some countries: of almost all biodiversity
  - “Cultural landscapes”
- Landscape changes have led to biodiversity decline
  - Agricultural fields
  - Agricultural practices
  - Non-point pollution
- Biodiversity decline:
  - Red-list-species
    - “ typical“ species endangered

Courtesy: Ulrich Stachow, **2011.**

Linkage between land use and the biodiversity

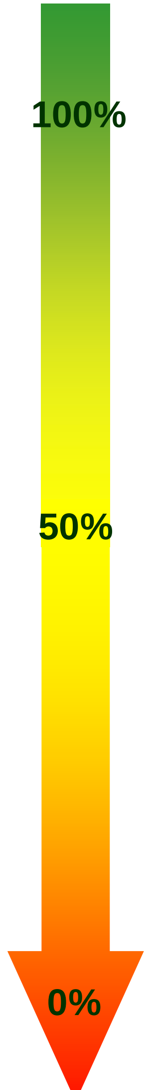
Primary forest

Selective logging

Secondary vegetation

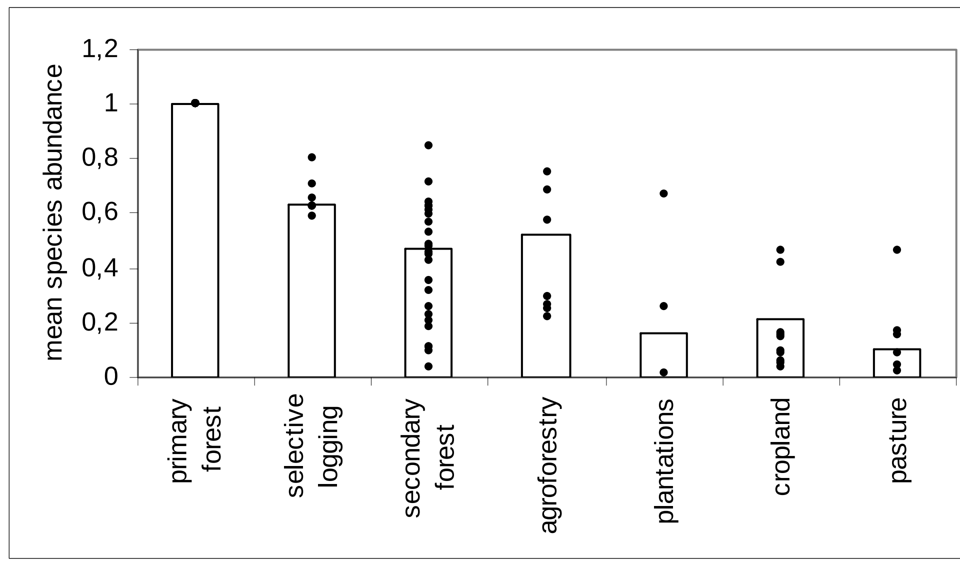
Plantation

Degraded



Dose response relations and MSA

MSA



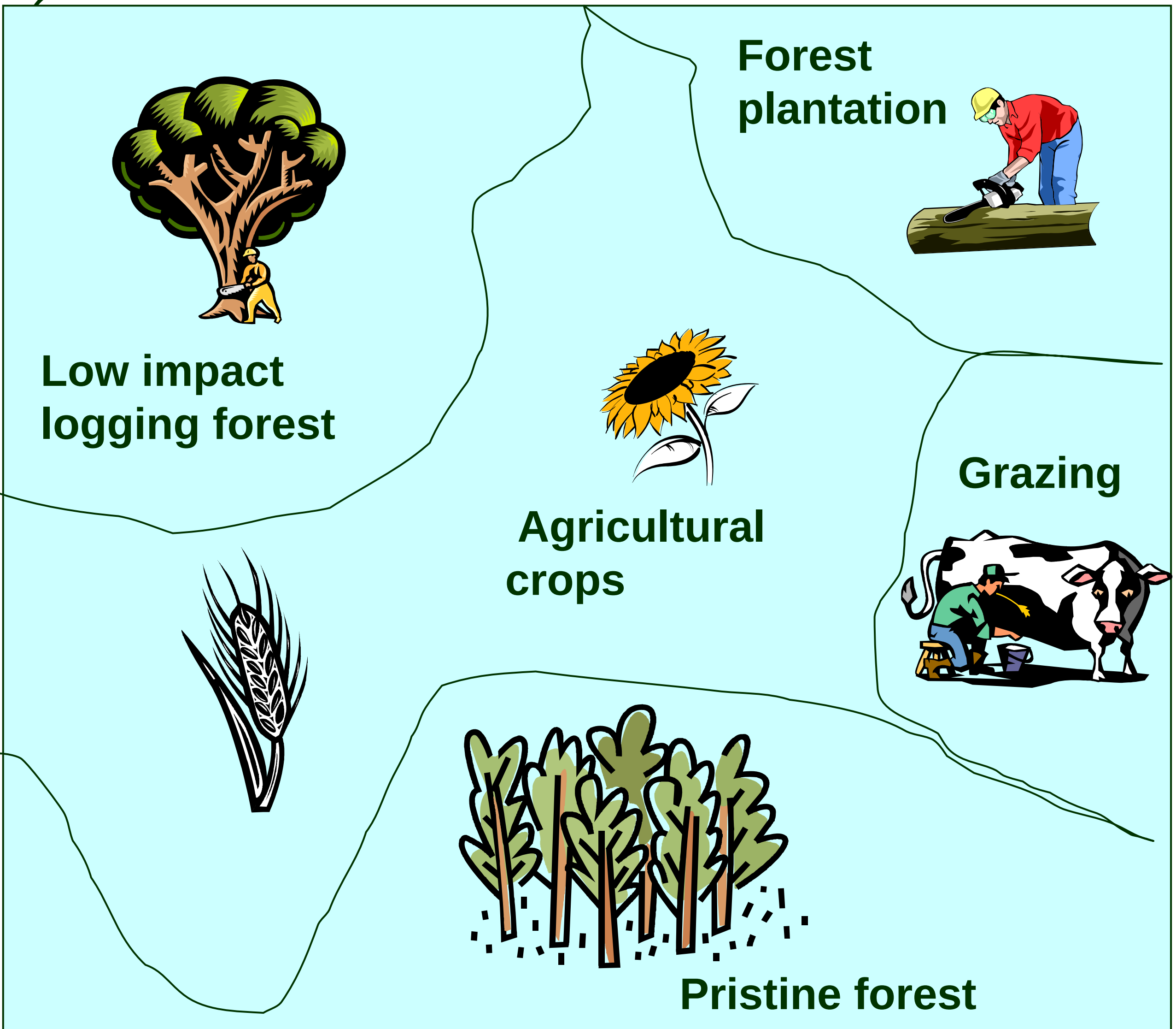
Courtesy: Eric Arets, 2010

Generic land use <> MSA table

- **Biodiversity values (MSA) are derived for a set of generic land use types**
- **The model is not limited to these generic classes, but added relations have to have scientific basis too!**

Land-use class	MSA value
Primary forests	1.0
Forest plantations	0.2
Secondary forests	0.5
Light used primary forests	0.7
Agro forestry	0.5
Extensive agriculture	0.3
Irrigated intensive agriculture	0.05
Intensive agriculture	0.1
Perennials & bio fuels	0.2
Natural grass & shrub lands	1.0
Man made pastures	0.1
Livestock grazing	0.7
Natural Bare, rock & snow	1.0
Natural inland water	null
Artificial water	null
River/stream	null
Built up areas	0.05

Biodiversity loss by Land use changes



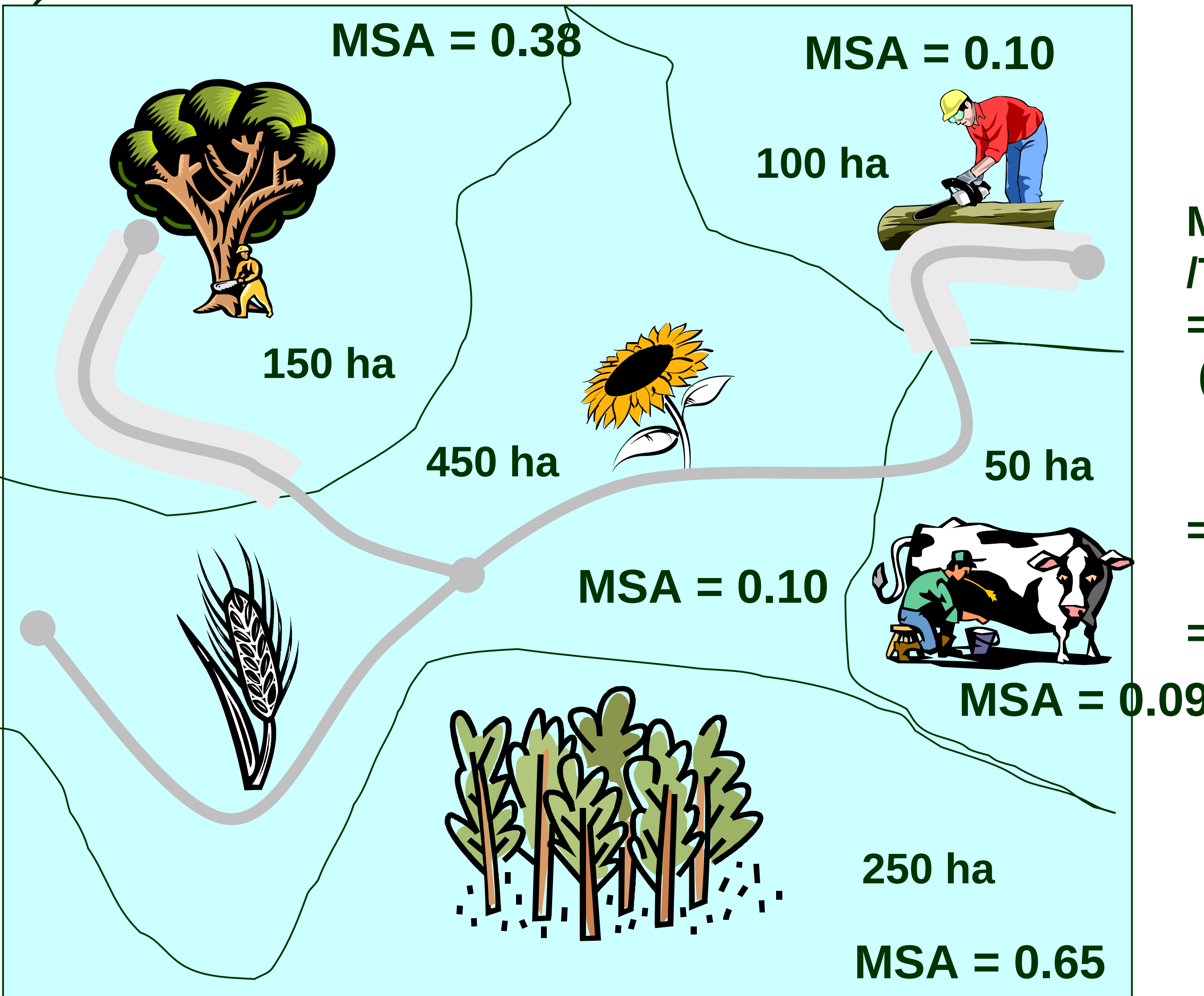
MSA_{LU}

Pressures on nature:

Land-cover / land use

- Forest
- Grassland
- Agriculture

MSA calculation: Overall biodiversity

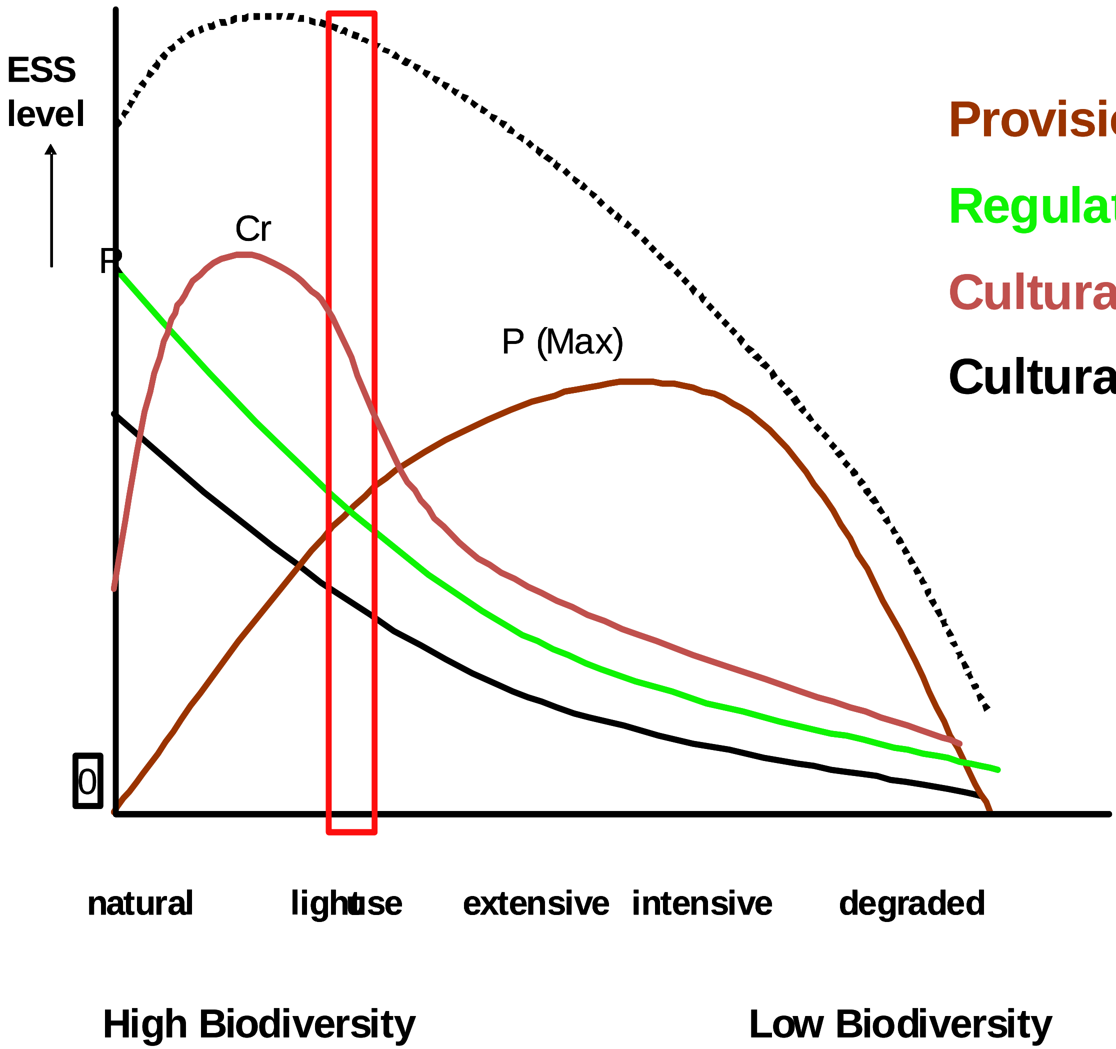


Total MSA

MSA = Σ (Area x MSA) /Tot Area
=
(150 * 0.38 + 100 * 0.1 + 450 * 0.1 + 50 * 0.09 + 250 * 0.65) / 1000
= 0.28

= 28% of original biodiversity is left

Linkage of Land Use Changes, Biodiversity vs. Ecosystem Services



Provisioning services (P):

Regulating services (R):

Cultural – recreation services (Cr):

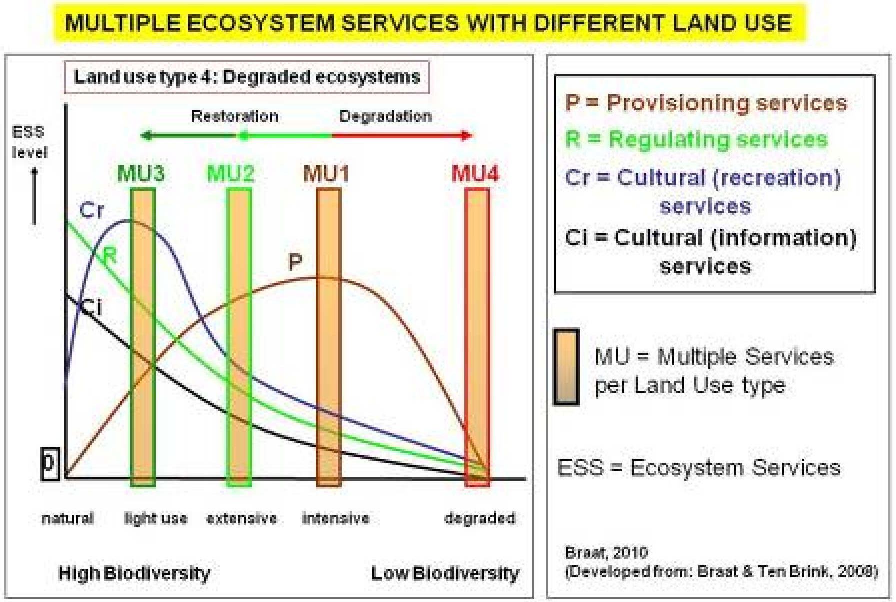
Cultural – Information services (Ci):

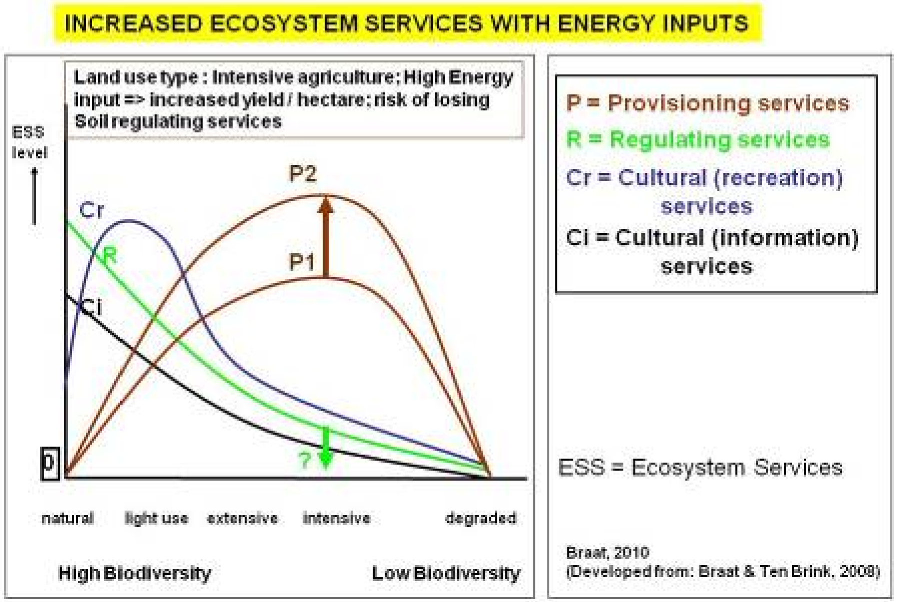
Multiple Services Per Land Use type

Management of ecosystem services

❖Restoration

❖Increased inputs





Implications for future work

- Land use changes are easier to detect than the land use itself by the remote sensed data, so the remote sensed data are more useful to monitor the biodiversity changes, rather than the biodiversity itself.
- More documentation and database are needed to link the land use changes and mean species abundance (MSA).
- The ecosystem services could be managed through reducing the threats and increasing input, but not necessarily increasing the biodiversity.

Part 3

LINKAGE BETWEEN LAND USE CHANGES AND BIODIVERSITY

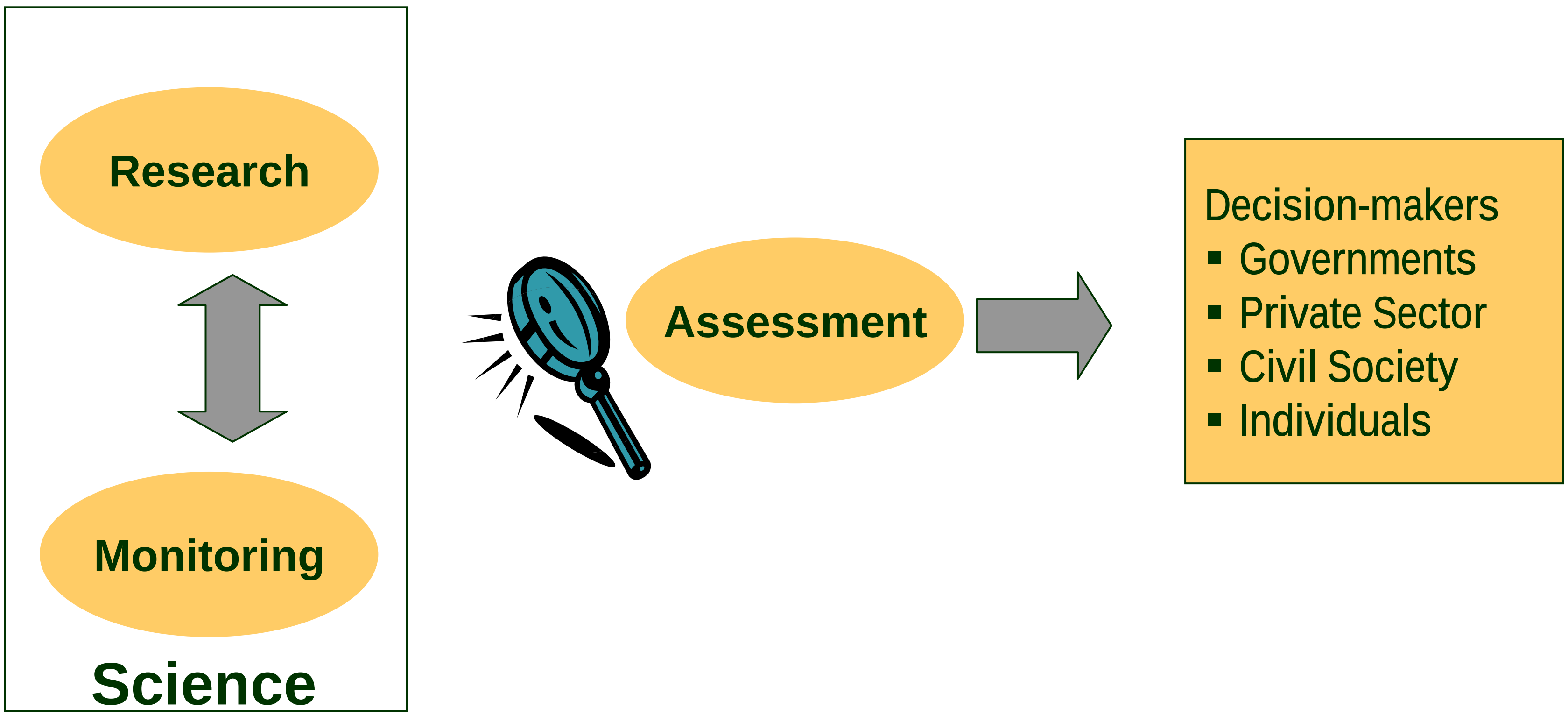
CERN Strategic Plan 2020

Core area 3: Biodiversity conservation and use of biological resources

- To study the role of biodiversity in maintaining ecosystem functions, address the mechanism of maintaining biodiversity, and study the ecological mechanism of species evolution in key areas and the technologies of conserving genetic resources.
- To answer the questions (1) How the land use changes impact the biodiversity changes? (2) How the biodiversity changes impact the ecosystem functions and services?

From in-situ monitoring to regional assessment

A social process designed to bring the findings of science to bear on the needs of decision-makers



Plot-based Biodiversity Monitoring& Research → Regional biodiversity Assessment → Policy options

From in-situ biodiversity monitoring to regional biodiversity assessment

- **Plot-based approaches**

  Design the plots to match Remotely sensed data resolution

- **Transect-based approaches**

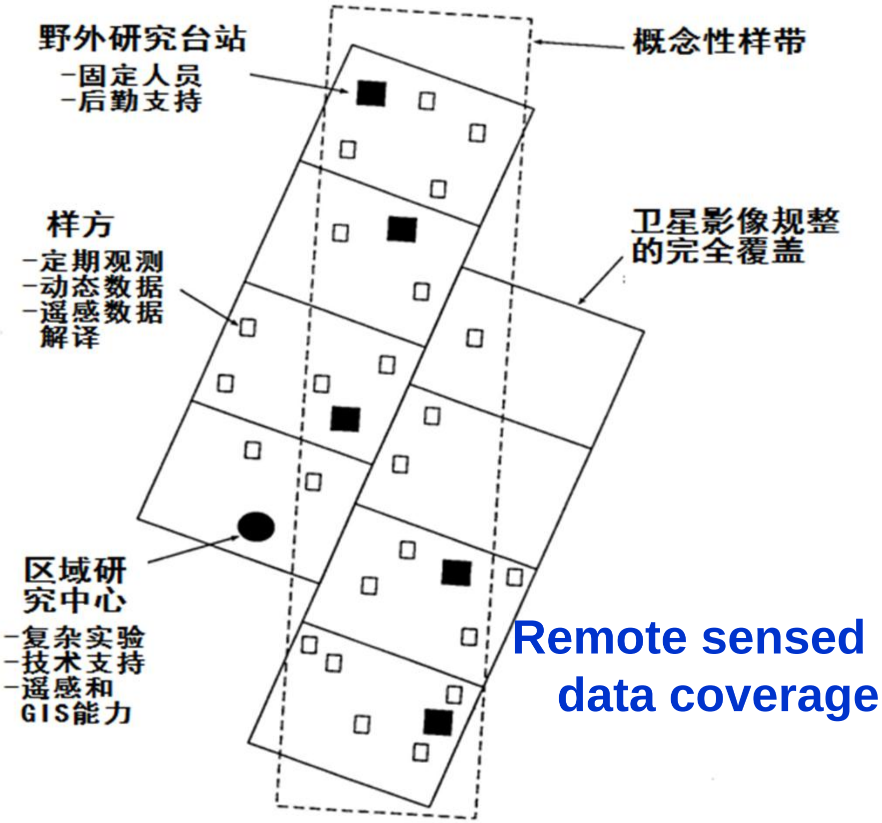
  Relate biodiversity abundances with environment gradients

- **Nationwide biodiversity and ecosystem survey**

  Biodiversity and habitat mapping to link plots to regions

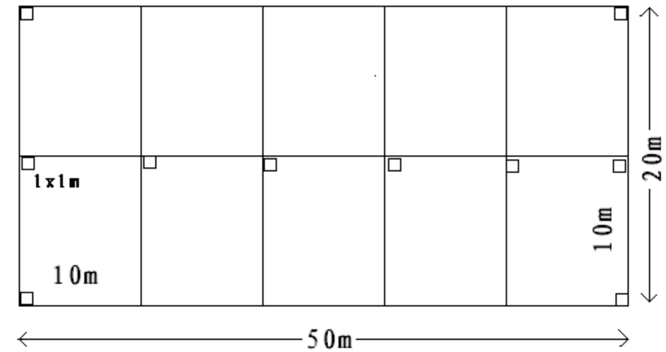
Design the plots to match remote sensed data resolutions

Conceptual Transect



陆地样带研究设计图

(概念性样带约长1000km，宽数百km)



惠塔克十分之一公顷样方

Whittaker 0.1ha Plot

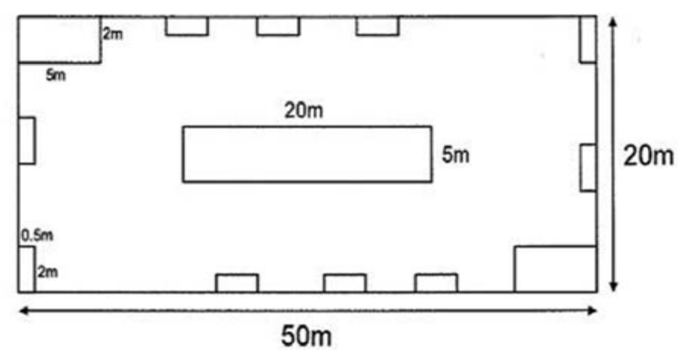


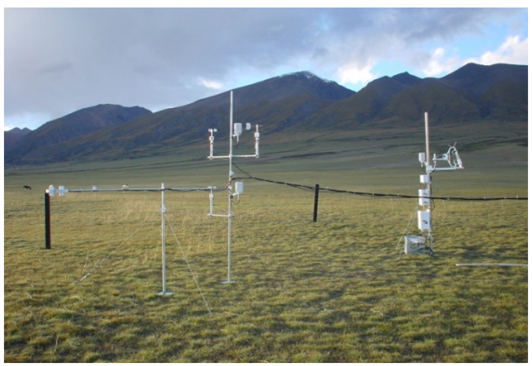
图1 嵌套式植物群落物种调查样方MWP 示意图

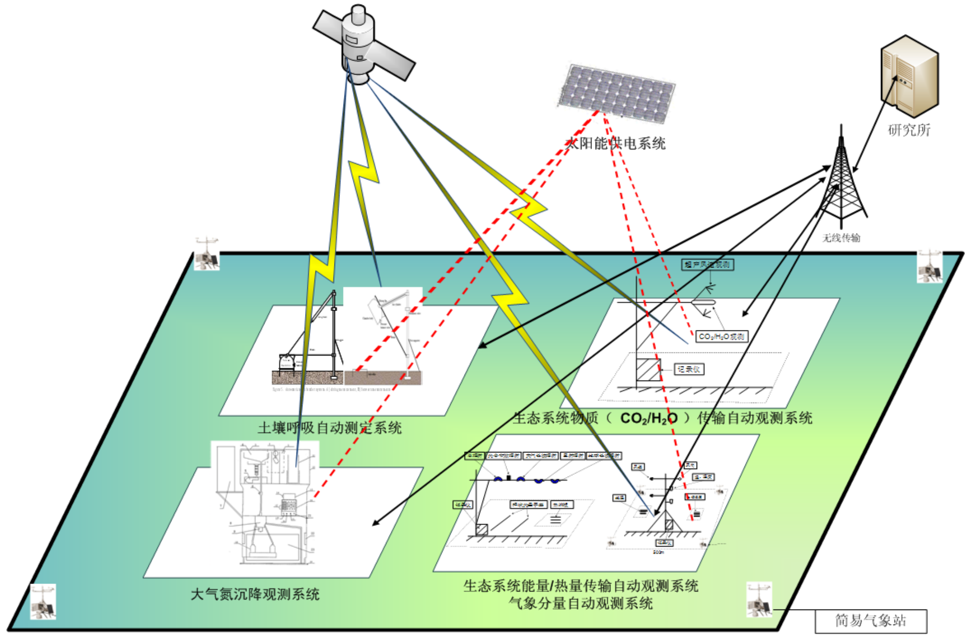
（引自 Stohlgren *et al.*, 1997）

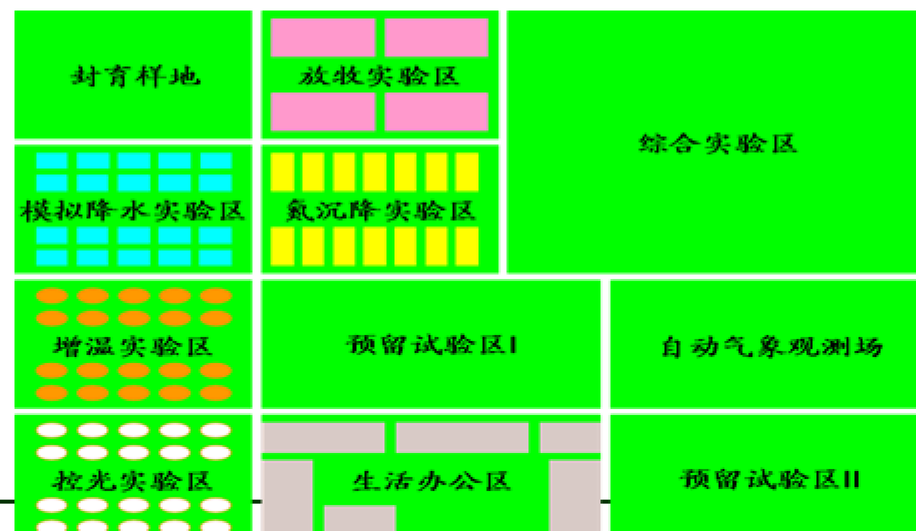
Courtesy: Zhang Xinshi, 20010

Plot-based facility for remote sensing in Tibet Plateau

EXAMPLE

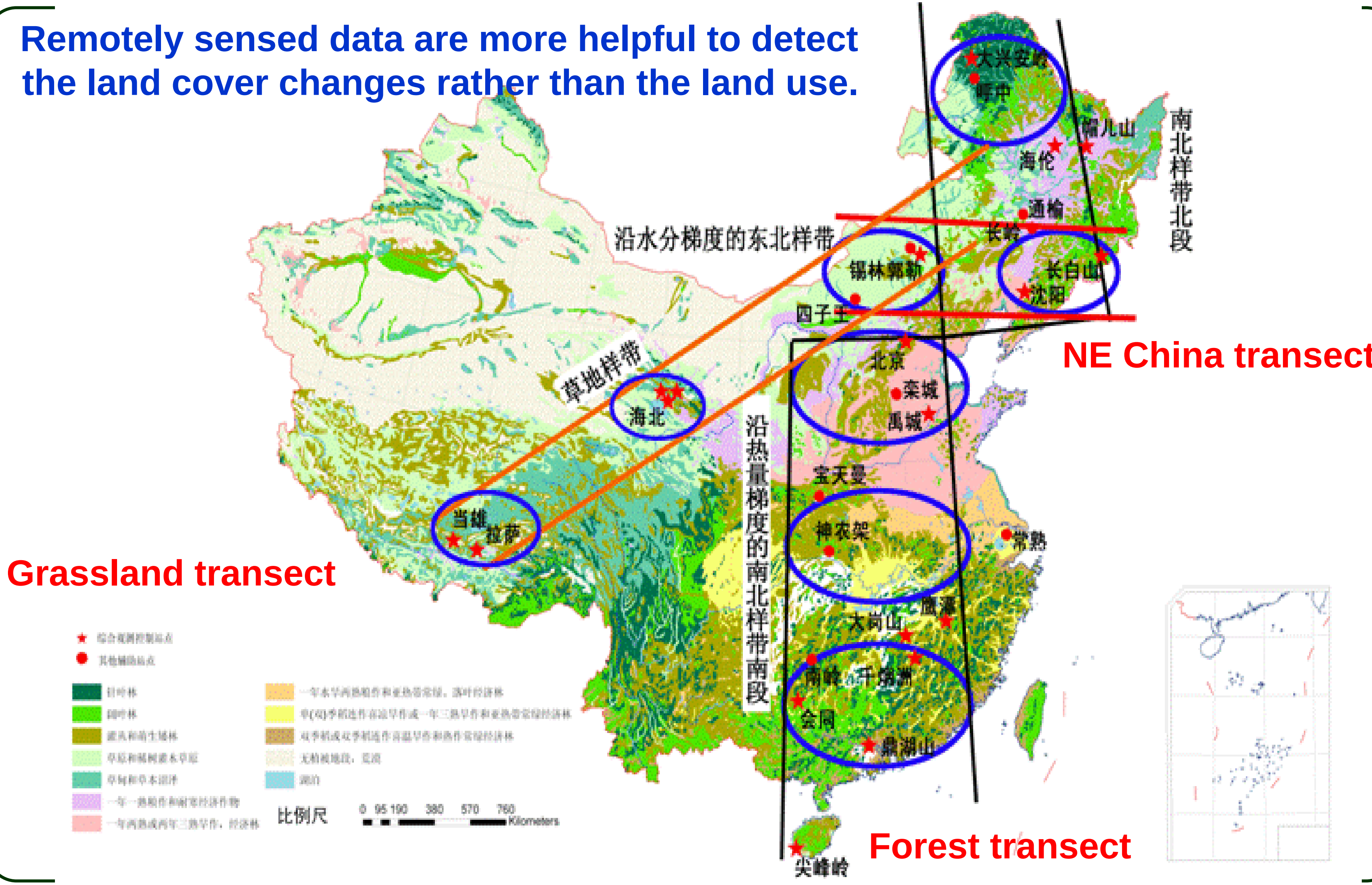


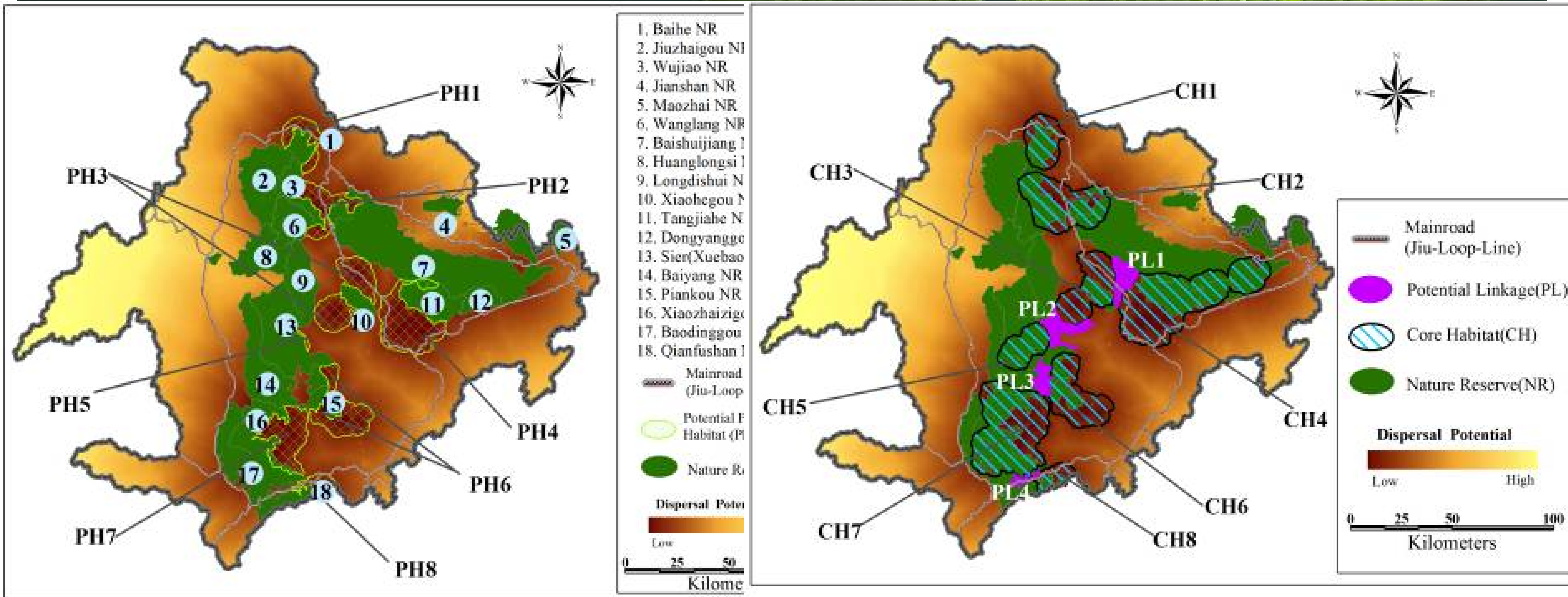




CERN based Transects

Remotely sensed data are more helpful to detect the land cover changes rather than the land use.





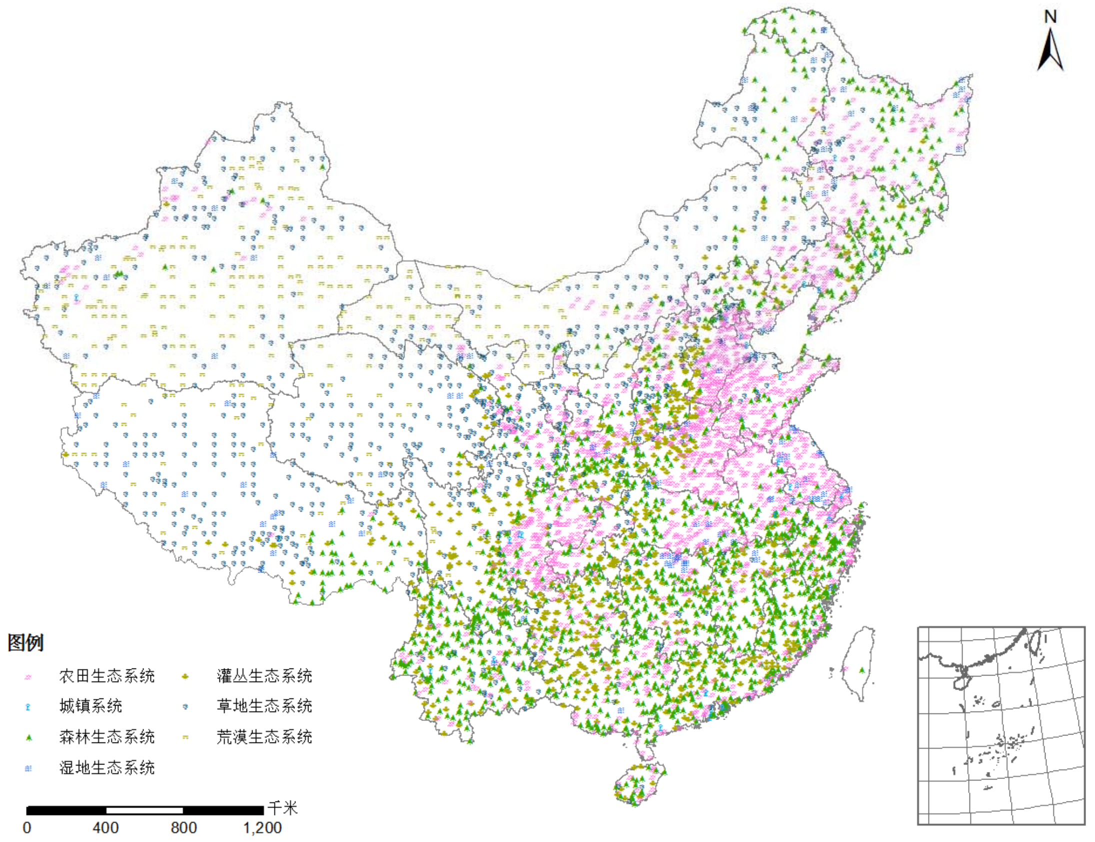
- 45% of the core habitats existed outside the current nature reserves network, 60.9% of NR fail to protected the core habitats.
- Conservation area should aim to ensure habitat retention and connectivity, improve dispersal potential of corridors in face of the natural and anthropogenic dynamics

Conservation Biology, 2008,22 :1144-1153

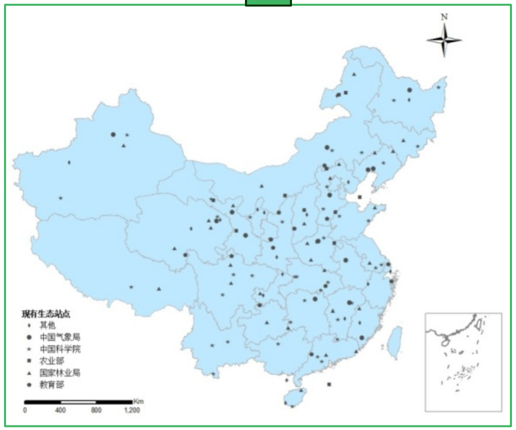
In-situ Biodiversity and Nationwide Survey

Location map for planned plot-based field survey

5000 plots



130 sites



Water bird habitat mapping using remotely sensed data in Poyang Lake, Central Yangtze

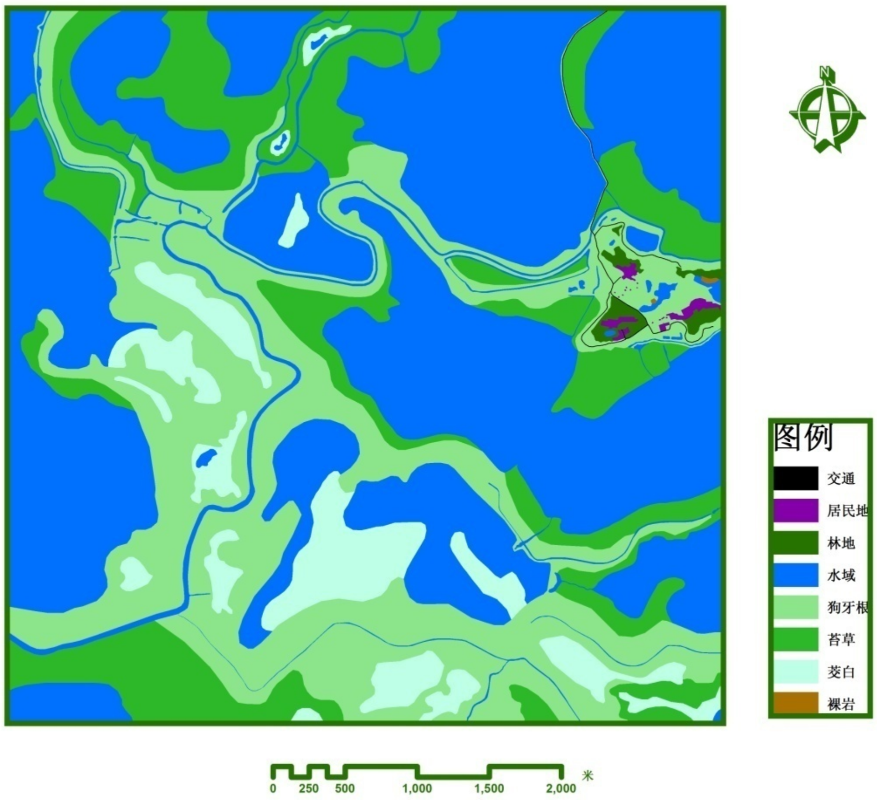
EXAMPLE

Quick bird images

Habitat mapping

南矶山样区5km*5km快鸟影像图
--2009年

南矶山样区生态制图
--2009年



Link the land use changes and MSA

Part 4

CONCLUSIONS

Conclusions

- Monitoring the biodiversity and its changes is a mandate of CERN to answers the questions of how the biodiversity change in a long-term.
- Mean species abundance (MSA) could be a key tool to integrate the plot-based MSA with remotely sensed data at regional scale.
- Design the plots to match the remote sensed data resolution; transect monitoring and survey, as well as nationwide biodiversity survey may contribute to regional biodiversity assessment.
- More studies or experiments are needed to merge the plot-based data and remotely sensed data.

Thanks for your attention

!

- How to combine the long-term biodiversity data combined with remote sensing data?