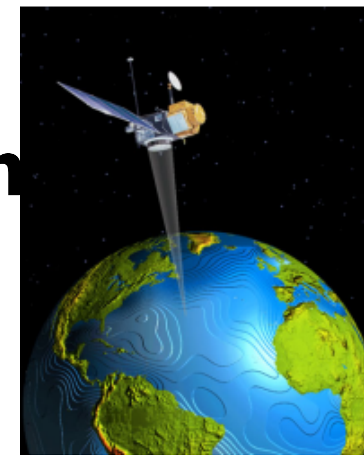
Trends of Geo-informatics for **Biodiversity Monitoring in Thailand**

Yongyut TRISURAT
Kasetsart University, Thailand
Email: fforyyt@ku.ac.th



Landscape Ecology, Biodiversity and GIS Modeling

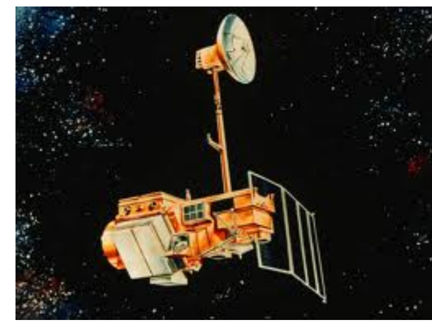
OUTLINE

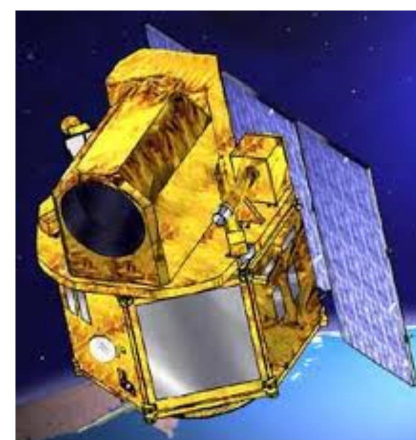
- **Progress of RS & GIS implementation**
- **Relevant researches related to GEO-BON concept (terrestrial)**
  - **Status, distribution and condition**
  - **Drivers**
  - **Ecosystem services**
- **Future Directions & Conclusions**

RS & GIS Benchmarks

- 1930 Aerial photos first introduced by RTSD
- 1961 RFD used aerial photos for forest mapping
- 1973 RFD used Landsat- MSS for forest mapping
- 1979 Remoting Sensing Div./NRCT
- 1981 Ground Receiving Station (MSS/Landsat)
- 1985 **GIS introduced** by WB for land policy analysis
- **1989 Commercial logging banned**
- 1991 Developed digital provincial GIS database
- 2000 Establishment of GISTDA
- 2008 Launched THEOS-1

Uses for various purposes!!!





Essential Global Information of Terrestrial

Category	Dataset	Progress
Status, distribution and condition (ecosystem & species)	**Coarse ecosystem map**	**H**
	Ecosystem condition and composition (FCD)	**M**
	Fine ecosystem map (e.g. forest plantation)	**M**
	Species distribution	**L**
Drivers	**Land use change**	**H**
	Farmland intensity	**M**
	Climate change	**L**
	Desertification	**L**
	Human encroachment	**H**
	Pollution	**L**
	Urbanization	**M**
Ecosystem services	**Carbon sequestration**	**M**
	Fire regime	**M**
	Water clcle regulation	**L**
	Timber provision	**L**
	Crop production	**M**

Future

high

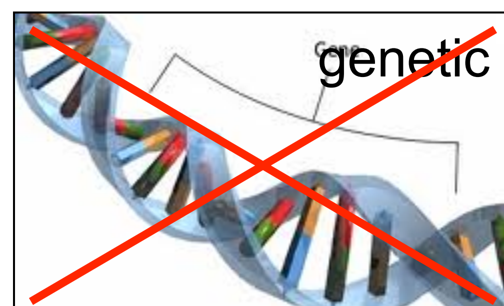
mod.

low

GEOBON concept doc. (2008)

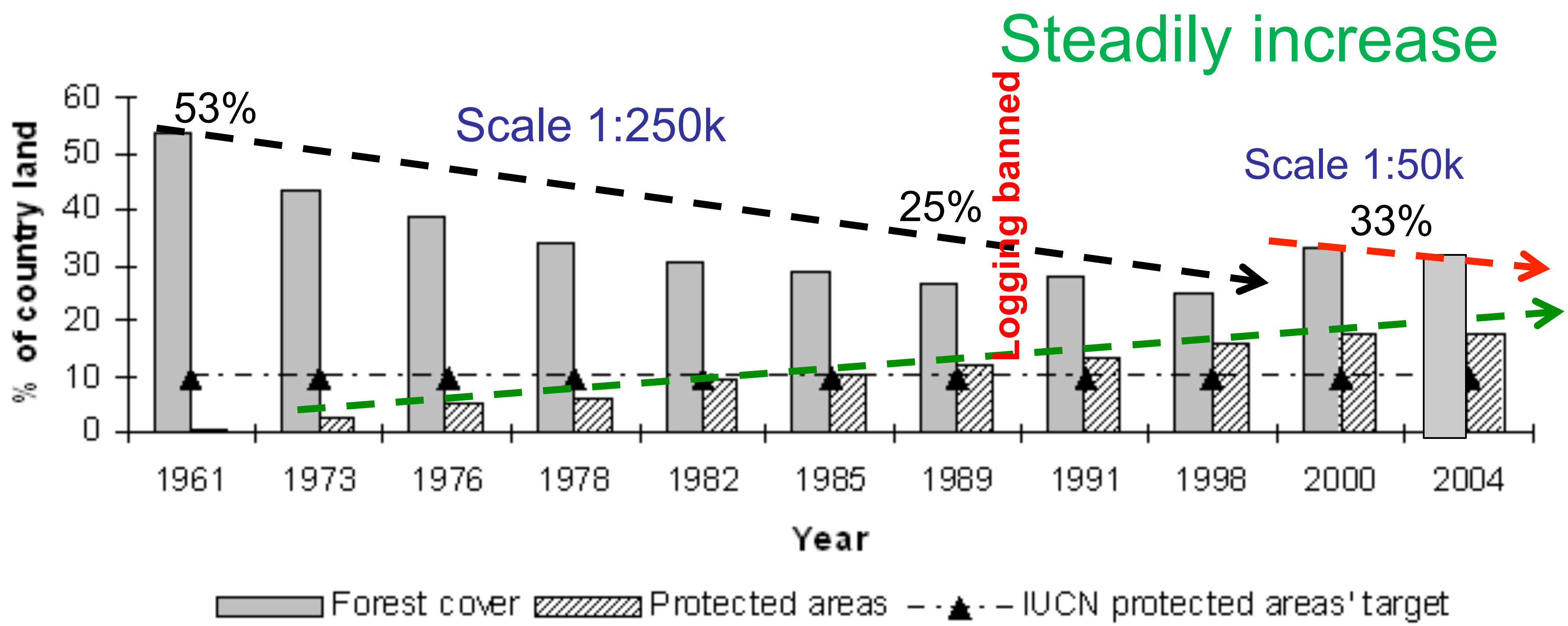
Status and Distribution: Ecosystem & Species

Biodiversity hierarchy

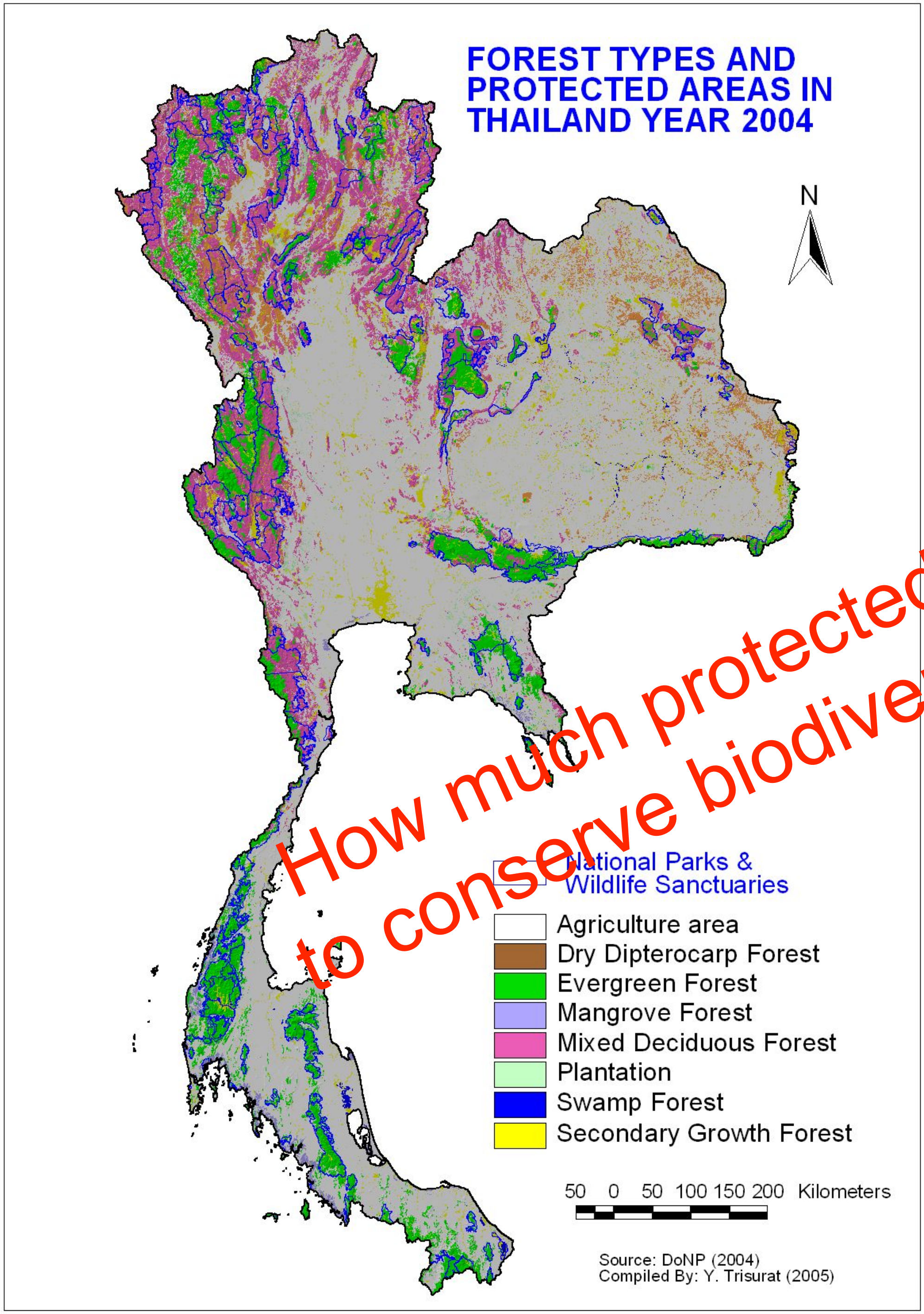


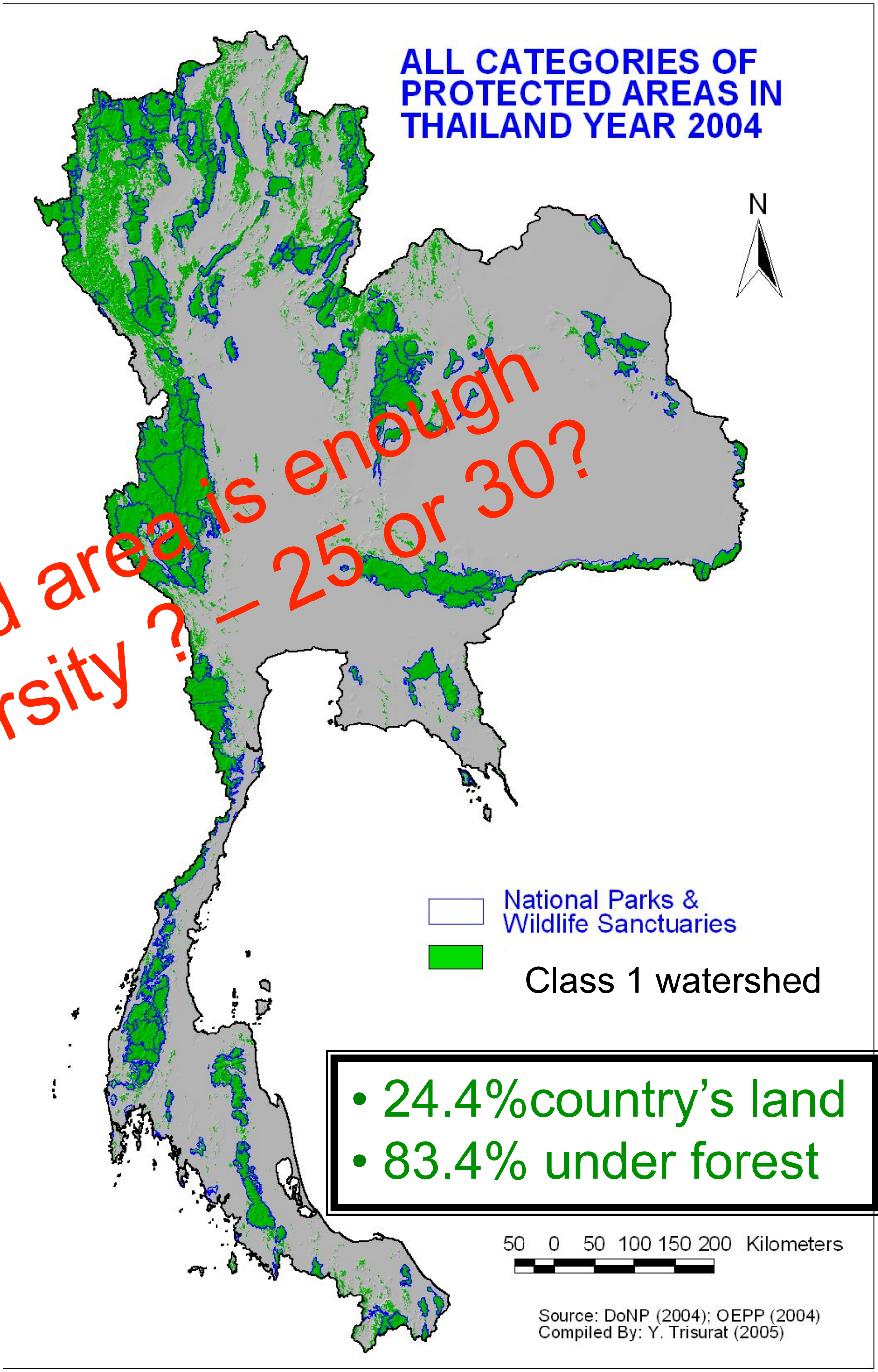
Forest Cover & Protected Areas

Rapidly decrease & quite stable after 2000



It is a matter of scales and classification!

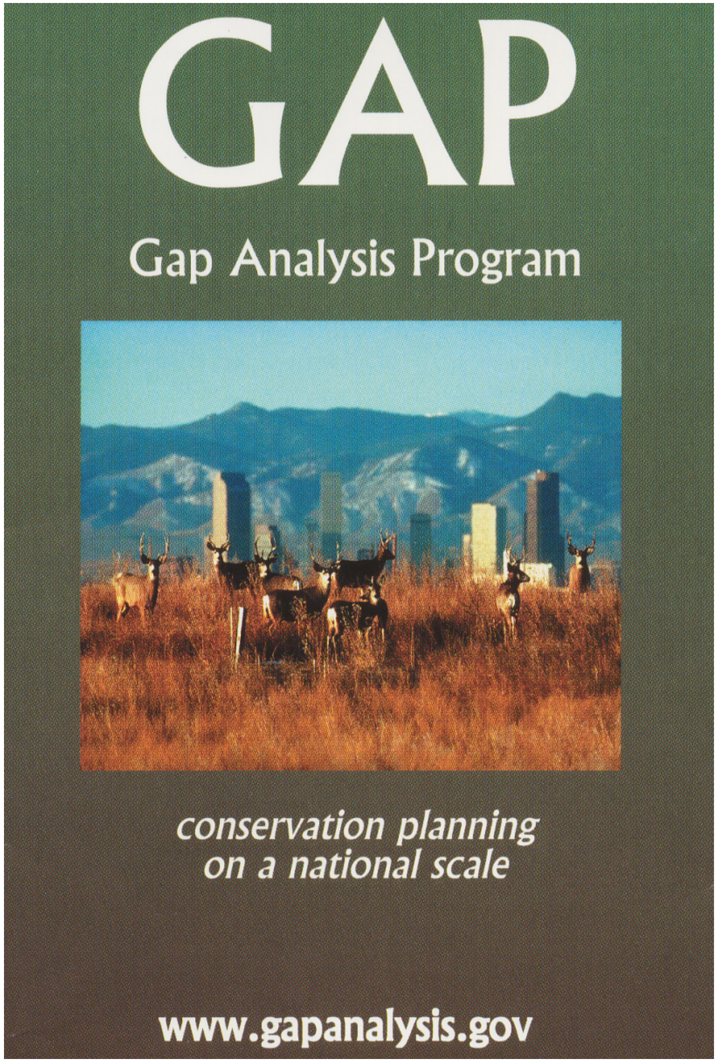


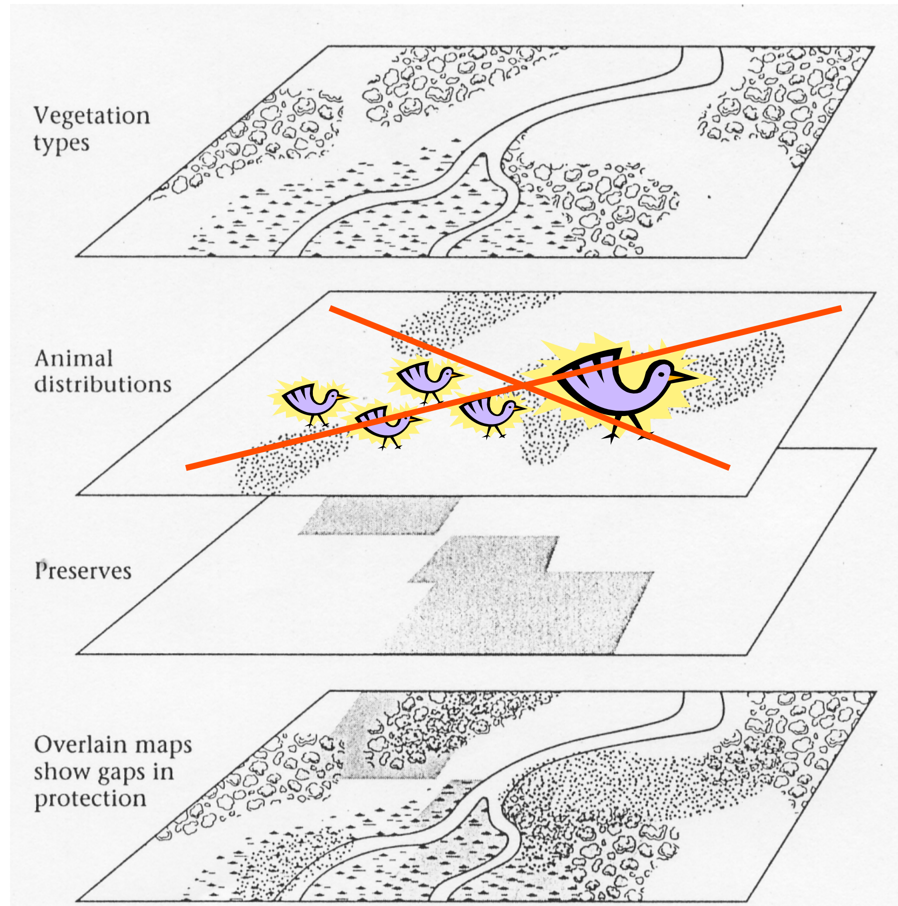


How much protected area is enough to conserve biodiversity ? – 25 or 30?

- 24.4%country's land
- 83.4% under forest

Identify biodiversity “gap” in existing protected areas





Representativeness

- Forest types and natural land system (veg. + alt)

1) Protected area system (PAs)

national park (NP), wildlife sanctuary (WS)

2) Conservation area (Con)

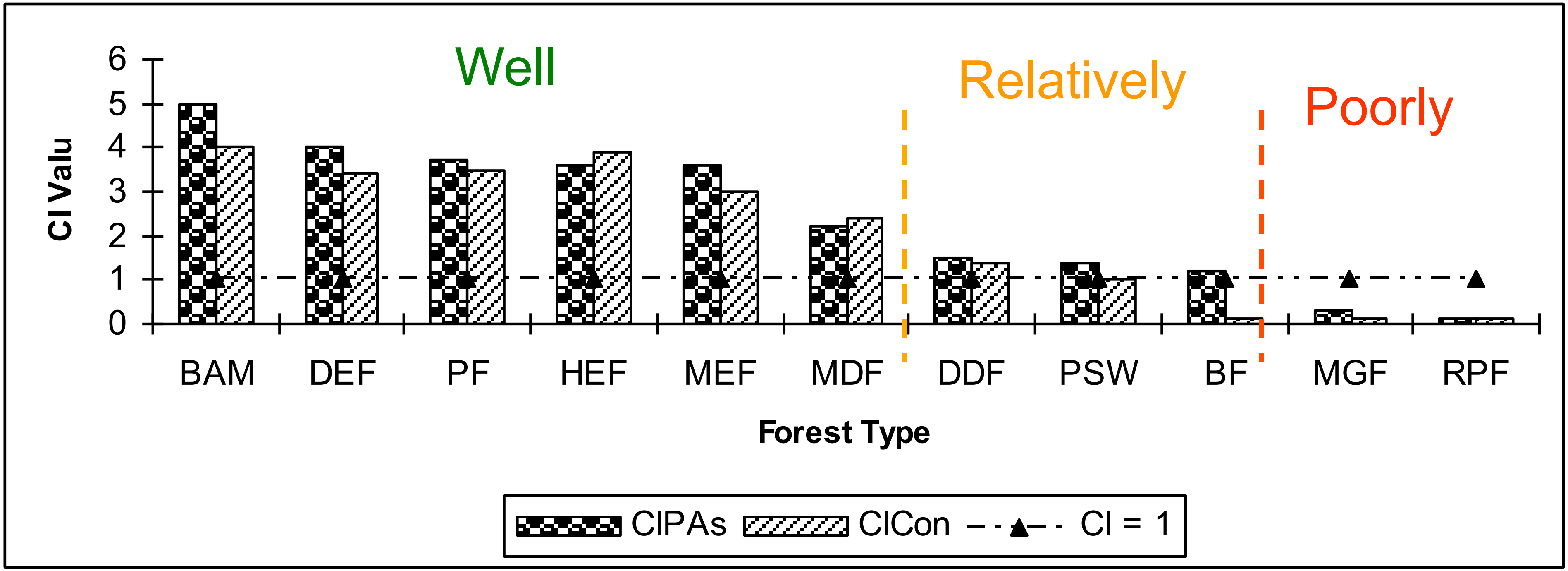
NP + WS + Class 1 Watershed

Comparison Index (CI) – proportion rep.

$$CI = \frac{\text{\% ecosystem in protection}}{\text{\% ecosystem in country's land area}}$$

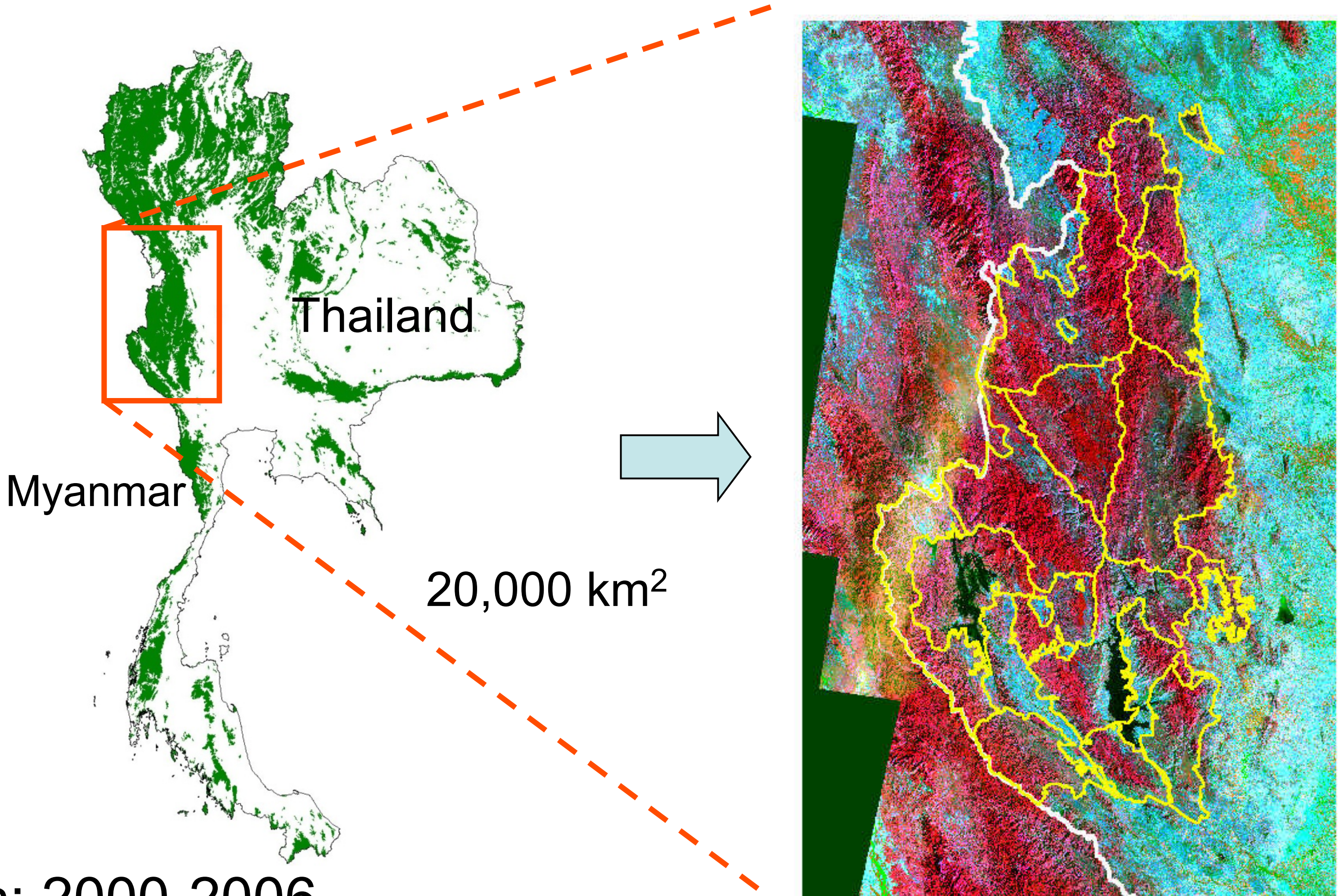
1, well represented; < 1 poorly represented

Forest Types – year 2000 (1:50K)



Trisurat (2007). *Env. Mgt.*

Ecosystem management: Species Distribution and Improving Viability of large mammal in **WEFCOM**



Years: 2000-2006

Species Targets & Methods



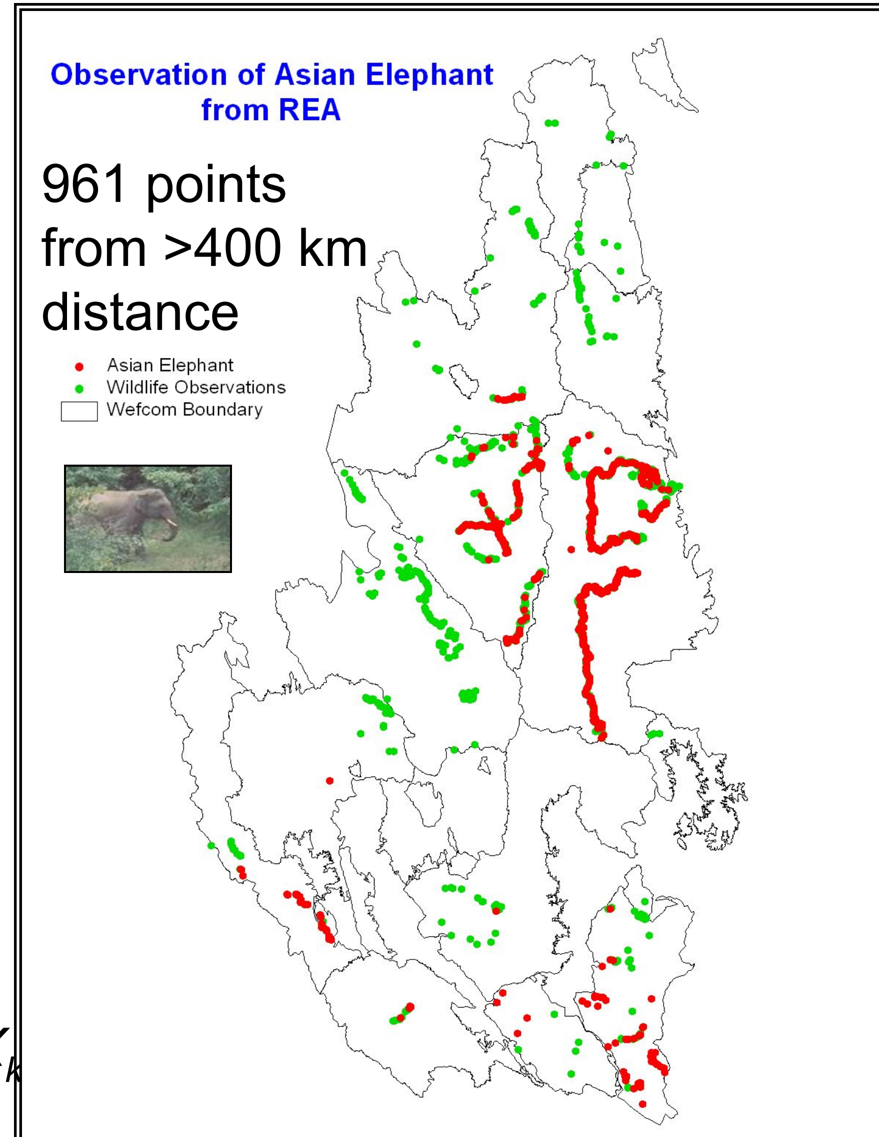


Logistic Regression Model

$$Prob.\ (event) = \frac{1}{1 + e^{-z}}$$

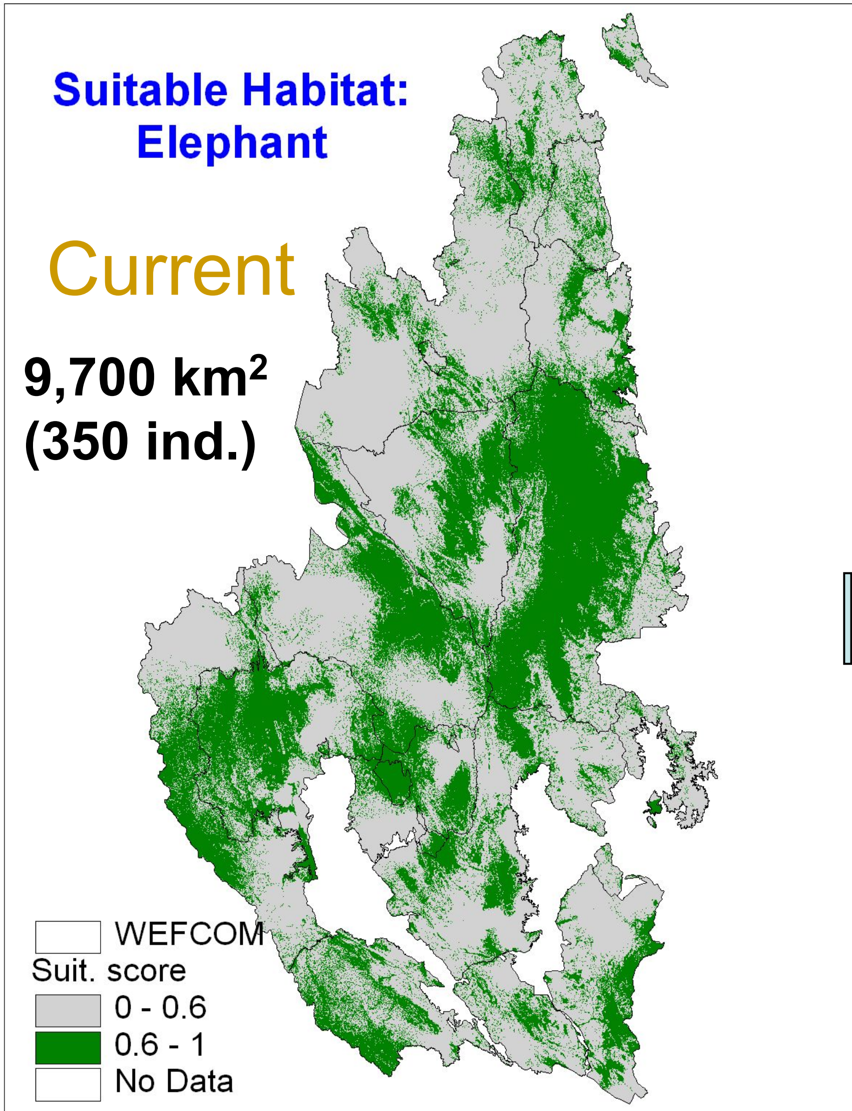
$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k$$

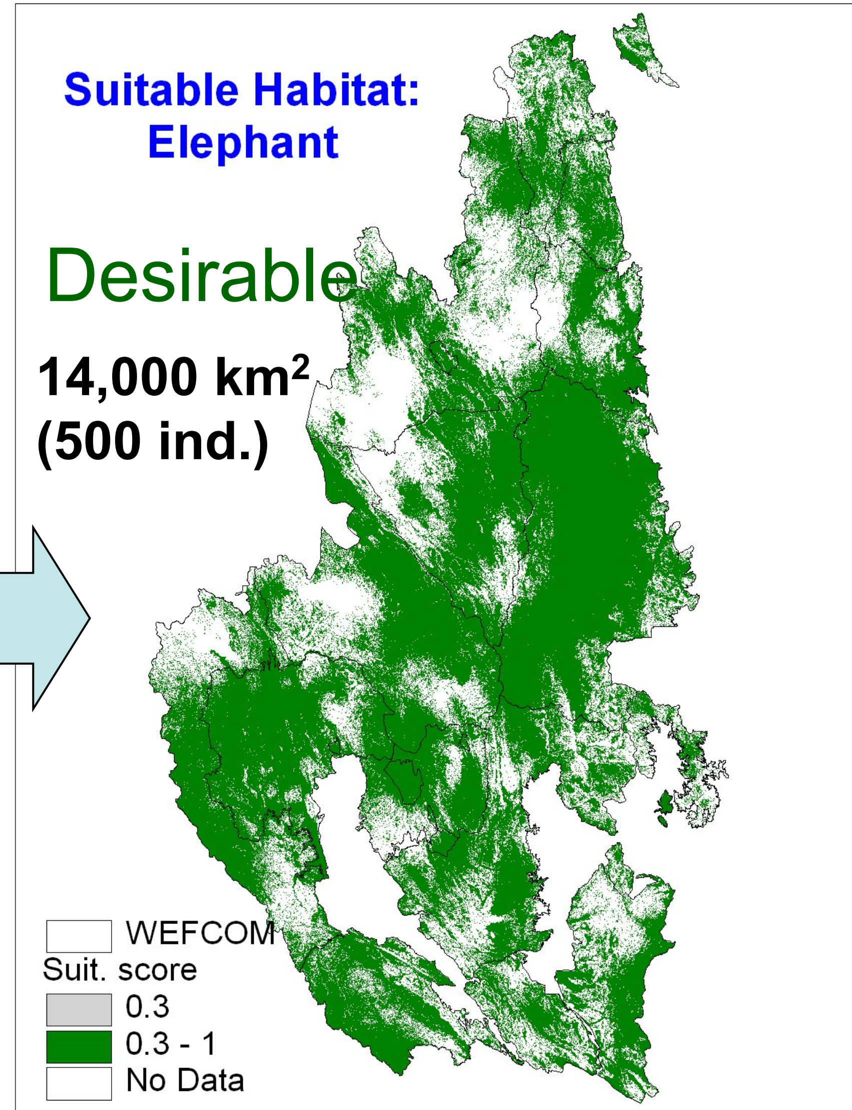
Z = presence/absence
X_i = habitat factors



Trisurat et al. (2010) Wildlife Research

Improving Pop. Viability

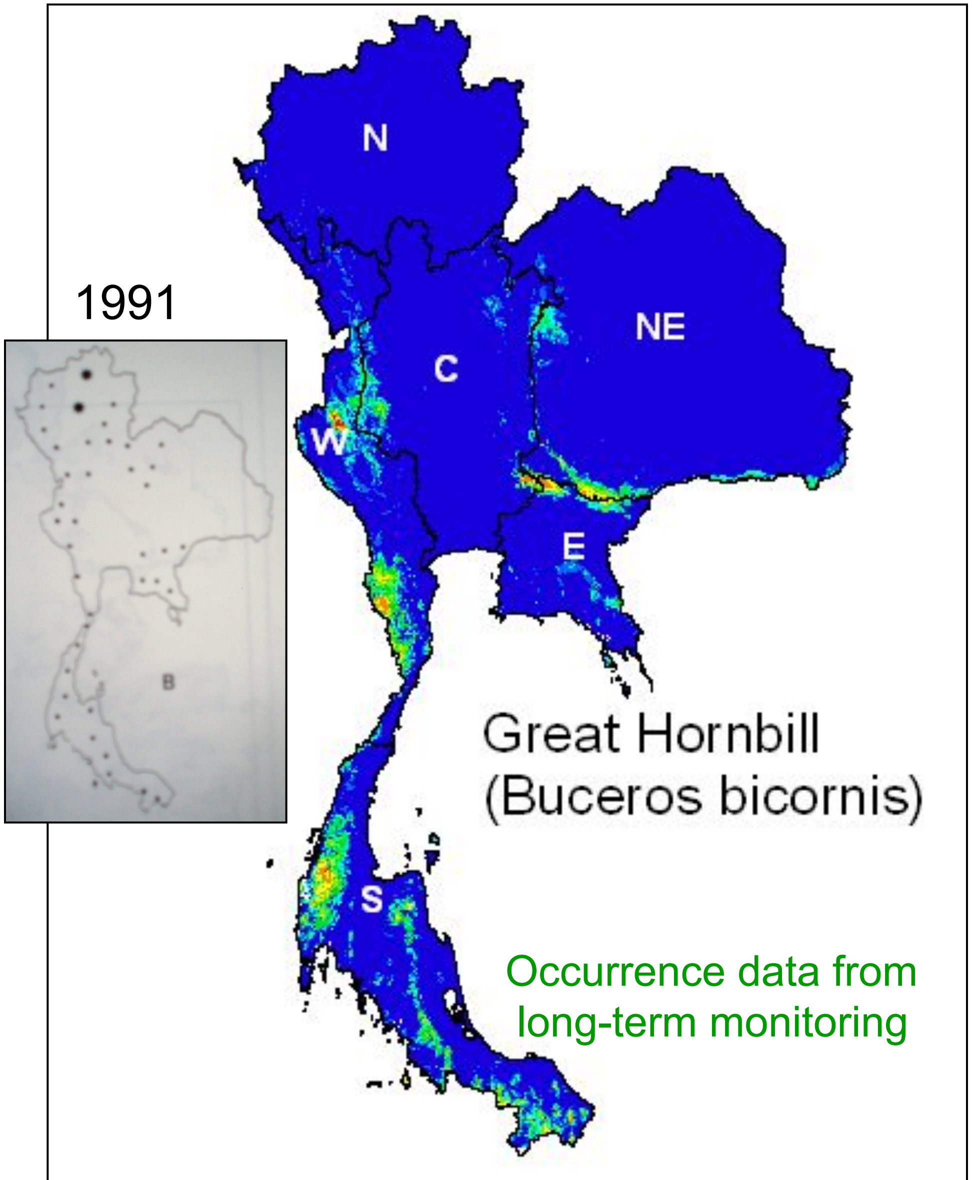




Trisurat et al. (2010) *Wildlife Research*

Studies on Hornbill Distribution and Conservation Status

Distribution and Concentration



Maxent (Phillips et al., 2006)

Region

Probability of distribution

0.0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1.0

National level

- 36,131 km^2; 7.05%

PAs

- 13,053 km^2; 36%

Trisurat et al. (in press). *Oryx*

Revised Conservation Status of Hornbills

(B1 criterion – extent of occurrence)

Common name	Conservation Status		
	Global	National	Findings
1. Rufous-necked H.	Vulnerable	Endangered	Endangered
2. Tickell's Brown H.	Near threatened	Vulnerable	Endangered
3. Rhinoceros H.	Near threatened	Endangered	Endangered
4. Austen's Brown H.	Near threatened	Vulnerable	Endangered
5. Helmeted Hornbill	Near threatened	Endangered	Endangered
6. Bushy-crested H.	Least concern	Vulnerable	Vulnerable
7. White-crowned H.	Near threatened	Vulnerable	Vulnerable
8. Oriental Pied H.	Least concern	Least concern	Least concern
9. Wreathed H.	Least concern	Vulnerable	Near threatened
10. Great H.	Near threatened	Vulnerable	Near threatened

3 species not evaluated (data insufficient)

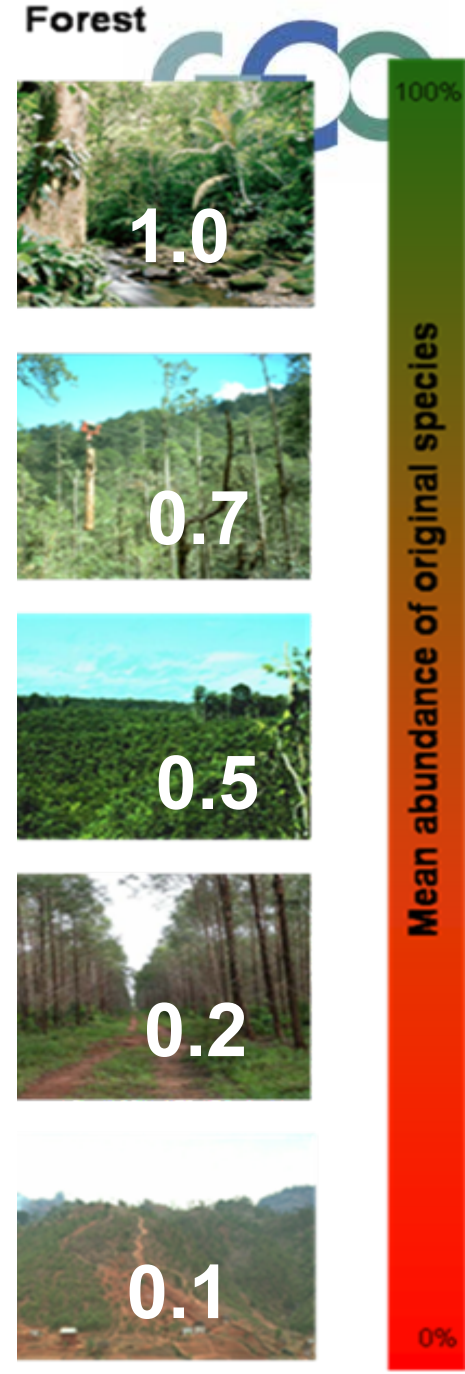
Trisurat et al. (in press) *Oryx*

Overall Biodiversity

$$MSA = MSA_{LUC} * MSA_{CC} * MSA_{N} * MSA_{I} * MSA_{F}$$

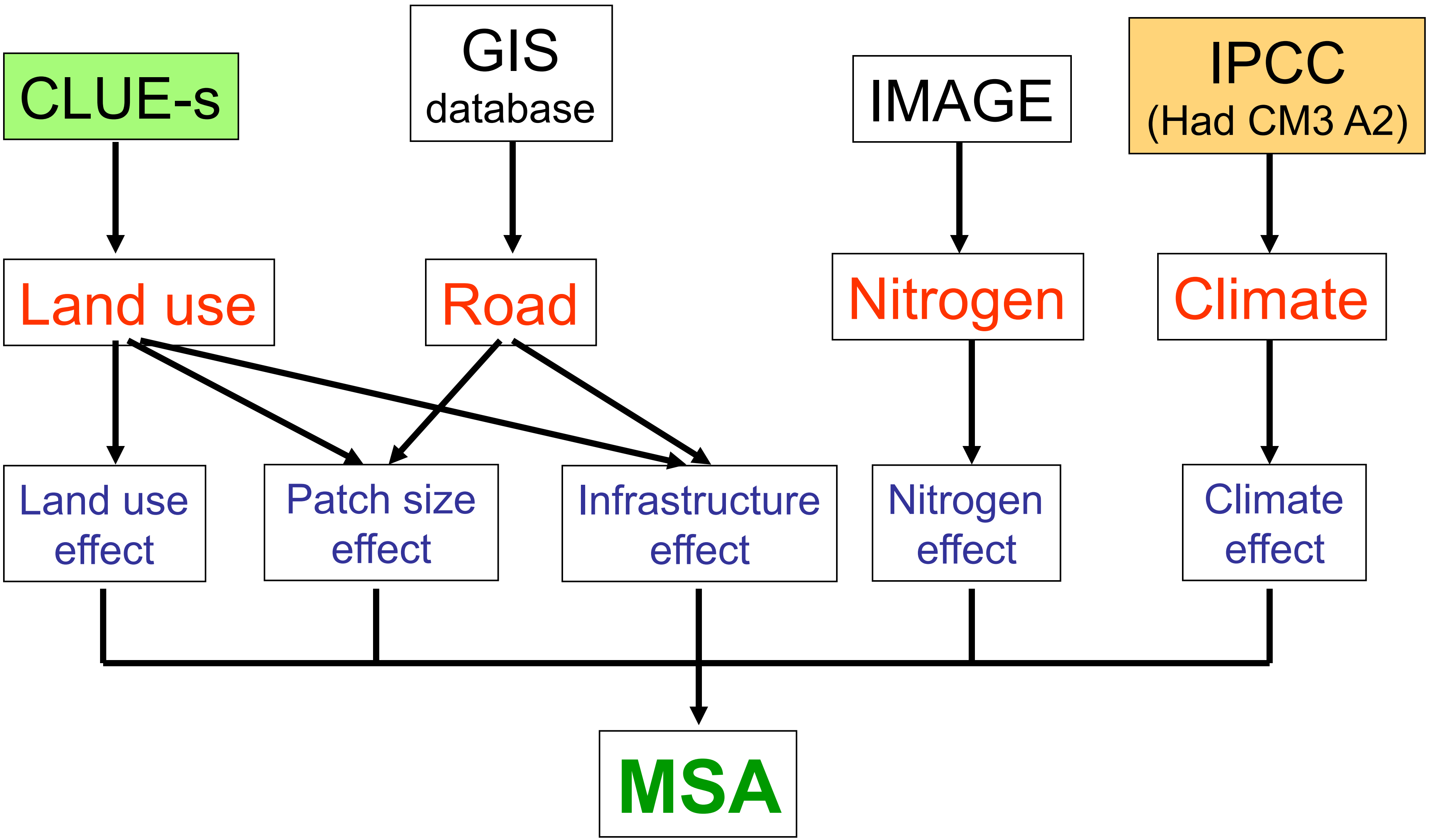
MSA = Mean Species Abundance (relative to pristine stage)

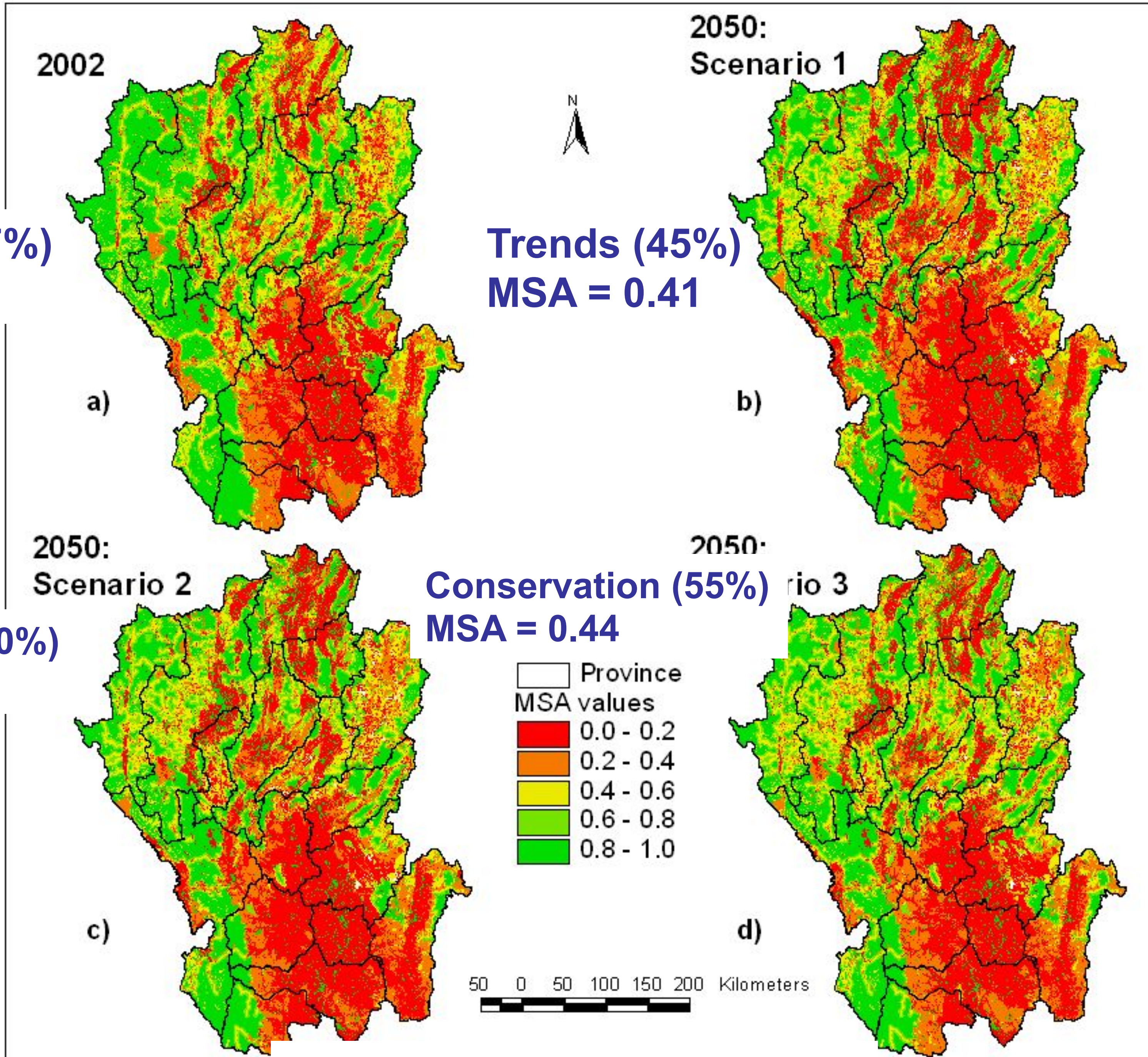
MSA_{LUC} = Remaining MSA for land use change
MSA_{I} = Remaining MSA for infrastructure
MSA_{F} = Remaining MSA for fragmentation
MSA_{CC} = Remaining MSA for climate change
MSA_{N} = Remaining MSA for nitrogen pollution



Netherlands Environmental Assessment Agency

GLOBIO 3 Model

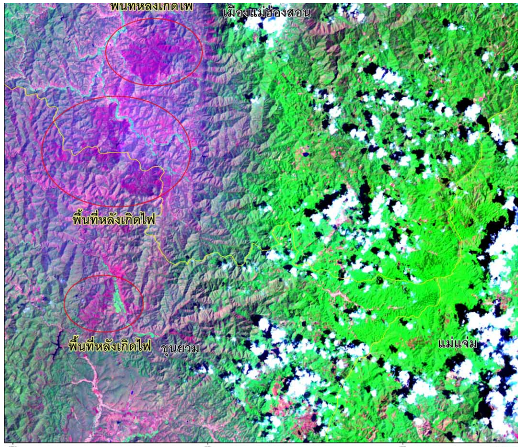


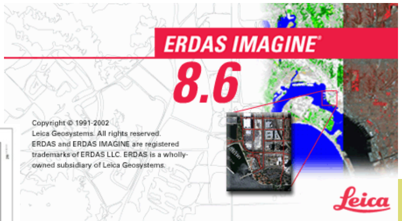


Source: Trisurat et al. (2009). *Env. Mgt*.

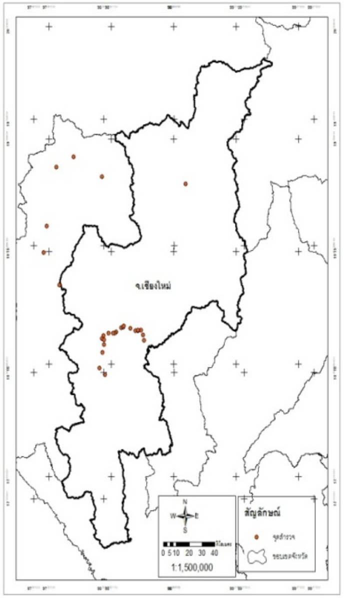
Forest Canopy Density - FCD (Ecosystem condition)

- LANDSAT 5 TM
- Erdas imagine
- FCD Mapper (HemiView)





Chiang Mai Province

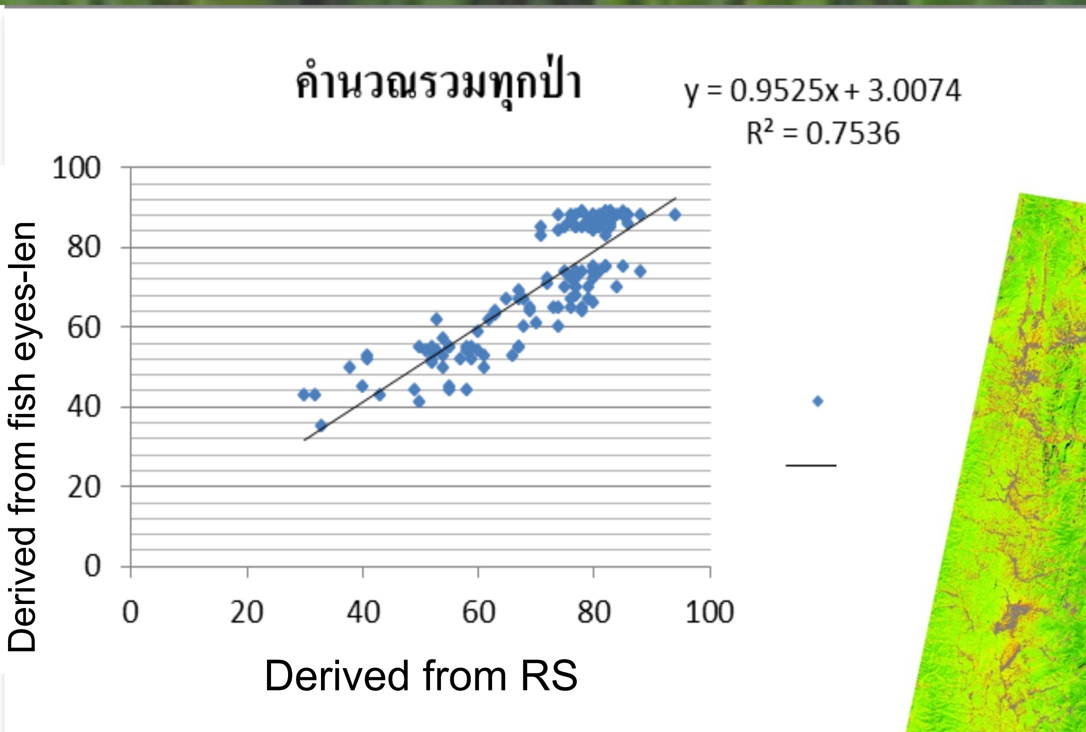


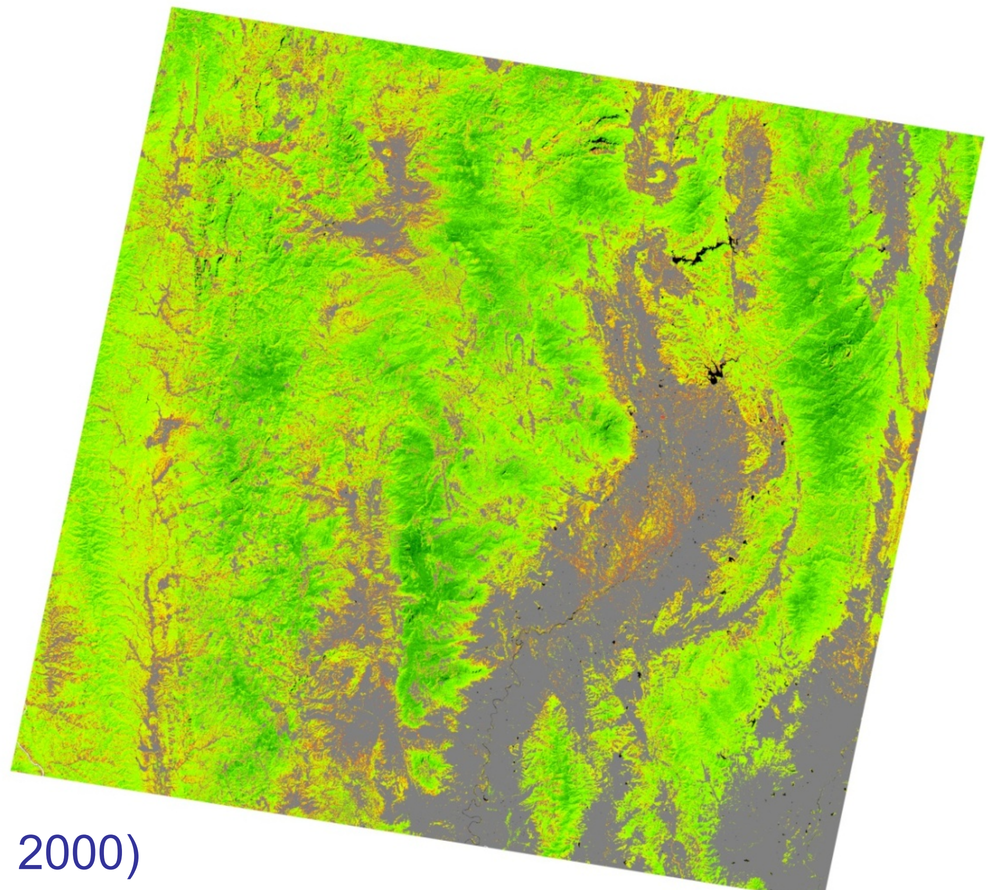
Rangsipanich (2012)

Rikimaru et al. (1999)

Field observation

FCD Map

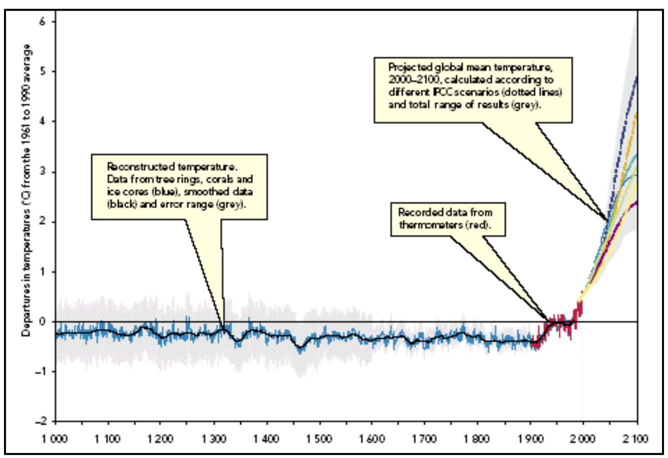


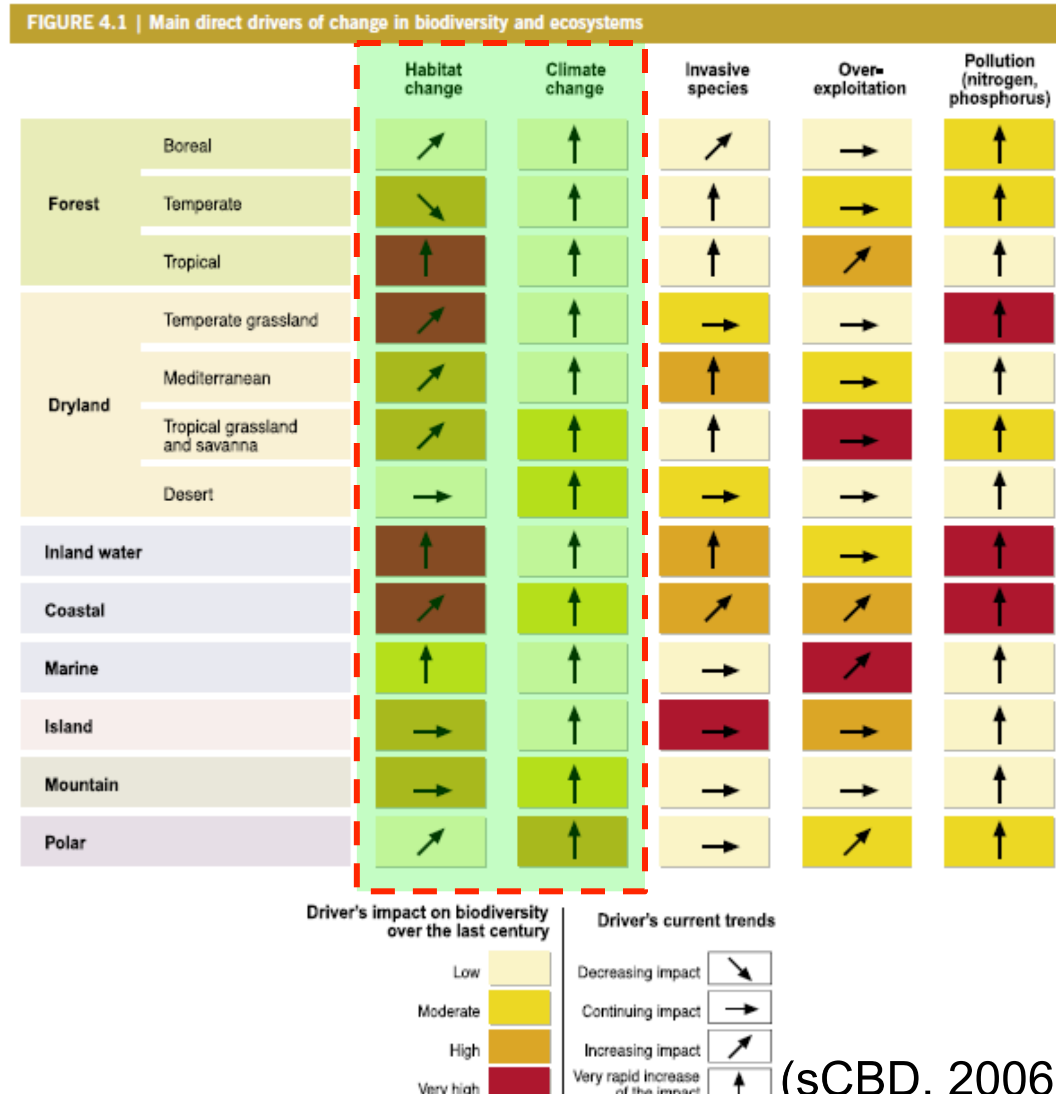


Rangsipanich (2012)

+ mangrove forest (Rattanasermpong, 2000)

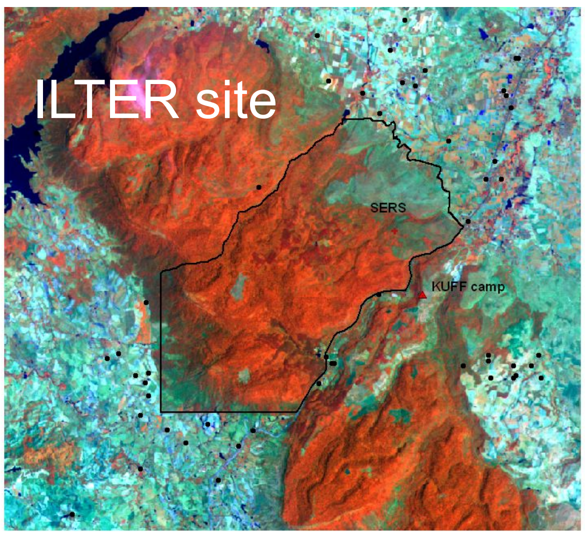
Drivers to Biodiversity





(sCBD, 2006)

Consequences of Land Use Change On Bird Distribution: *Sakaerat Environmental Research Station*



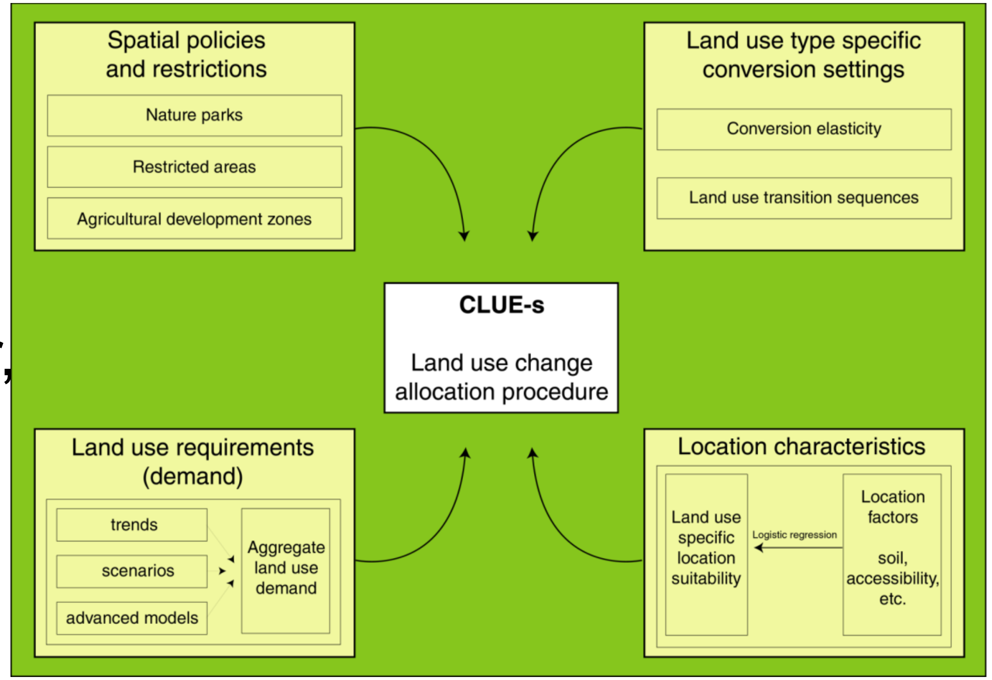
Black-crested Bulbul
(*Pycnonotus melanicterus*)

Trisurat and Duengkae (2011).
Journal of Ecology and Field Biology

Land use variables for CLUEs

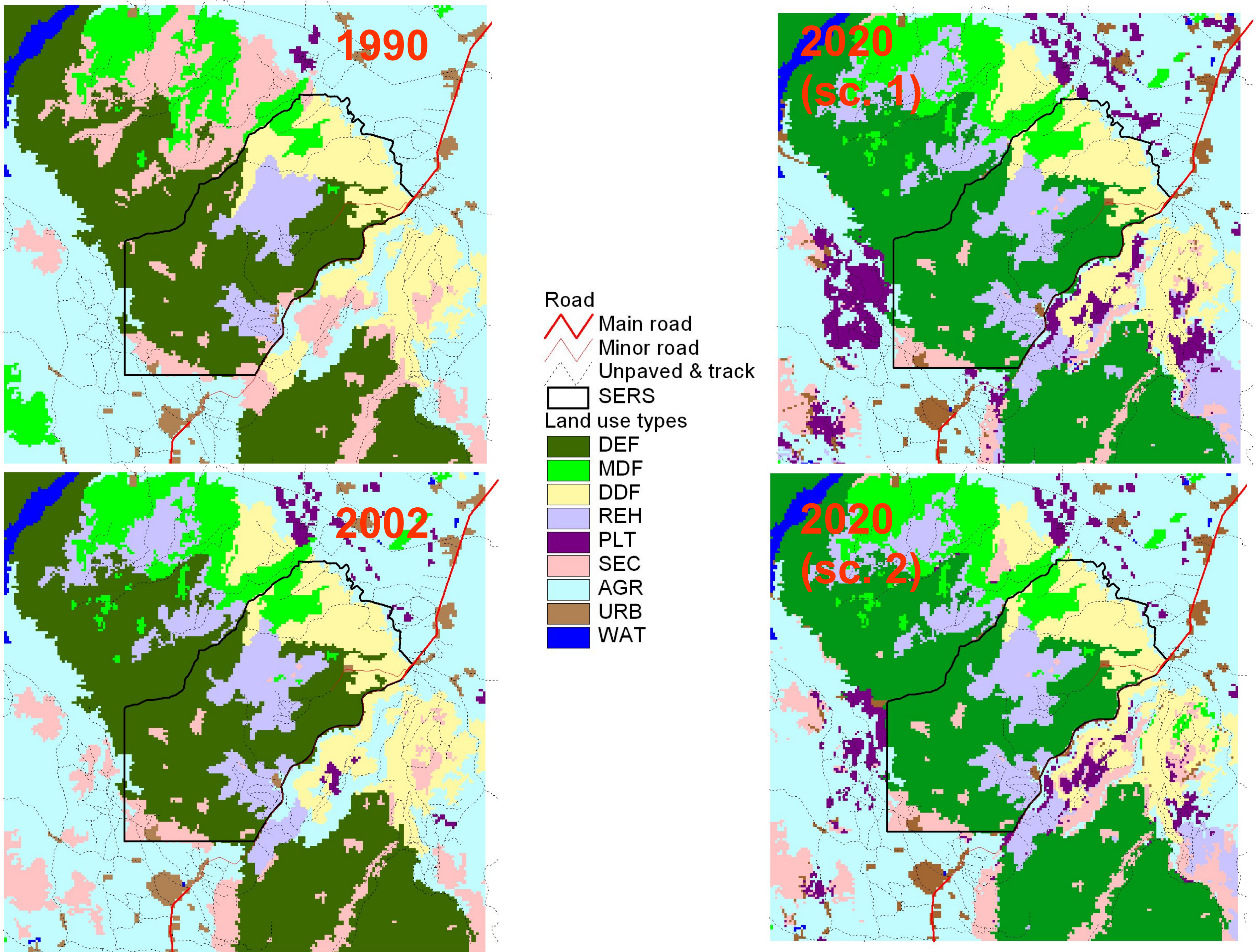
Physical factors
- altitude
- slope
- distance to available water,
- soil characteristics (texture, drainage, depth, fertility).

Socio-economic factors
- distance to village
- distance to main road.



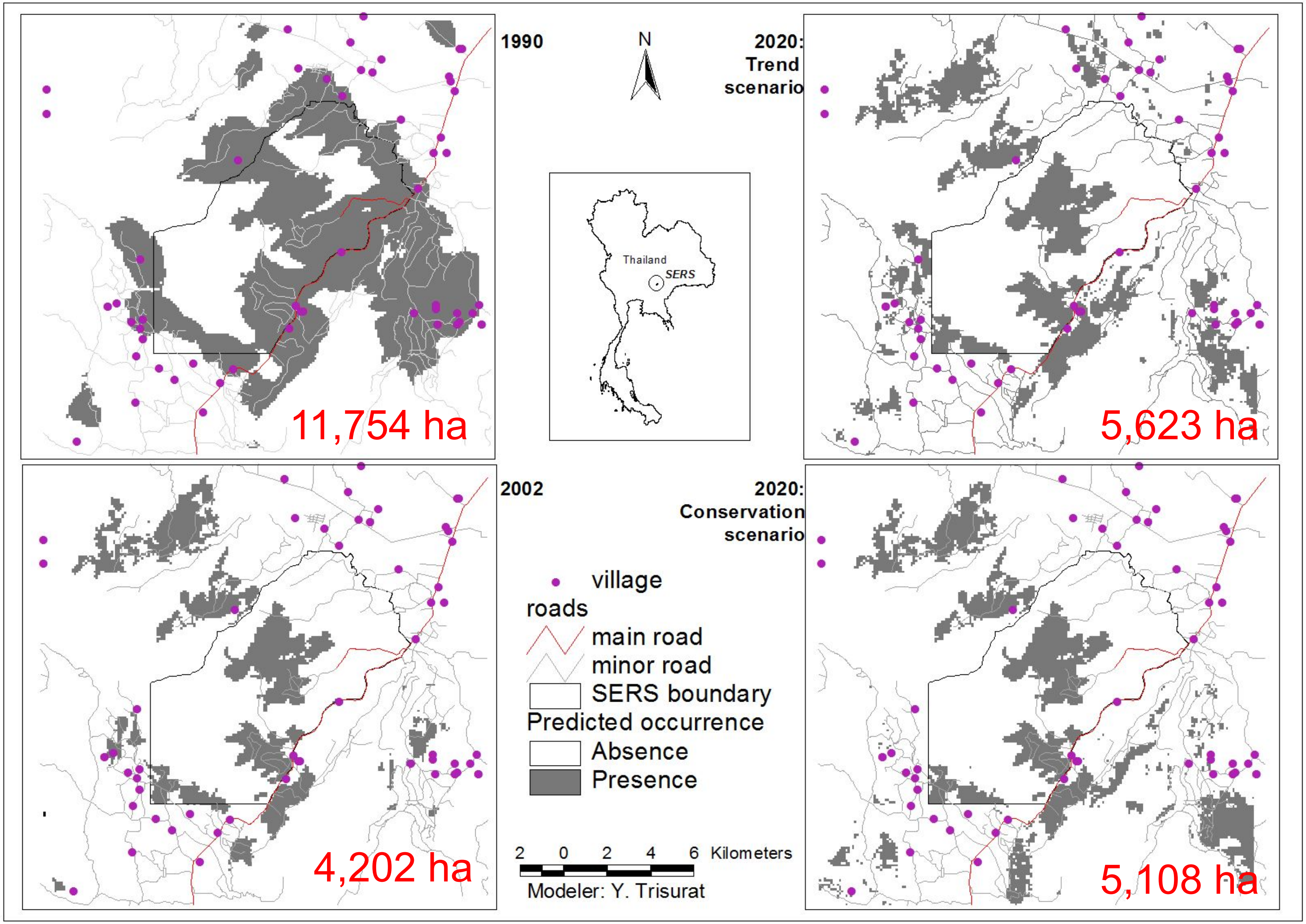
Future land use
1. Trends
2. Conservation

Verburg et al (2002)



1990
2020
(sc. 1)
2002
2020
(sc. 2)
Road
Main road
Minor road
Unpaved & track
SERS
Land use types
DEF
MDF
DDF
REH
PLT
SEC
AGR
URB
WAT

Predicted Bird Distribution
(niche modeling – Maxent)

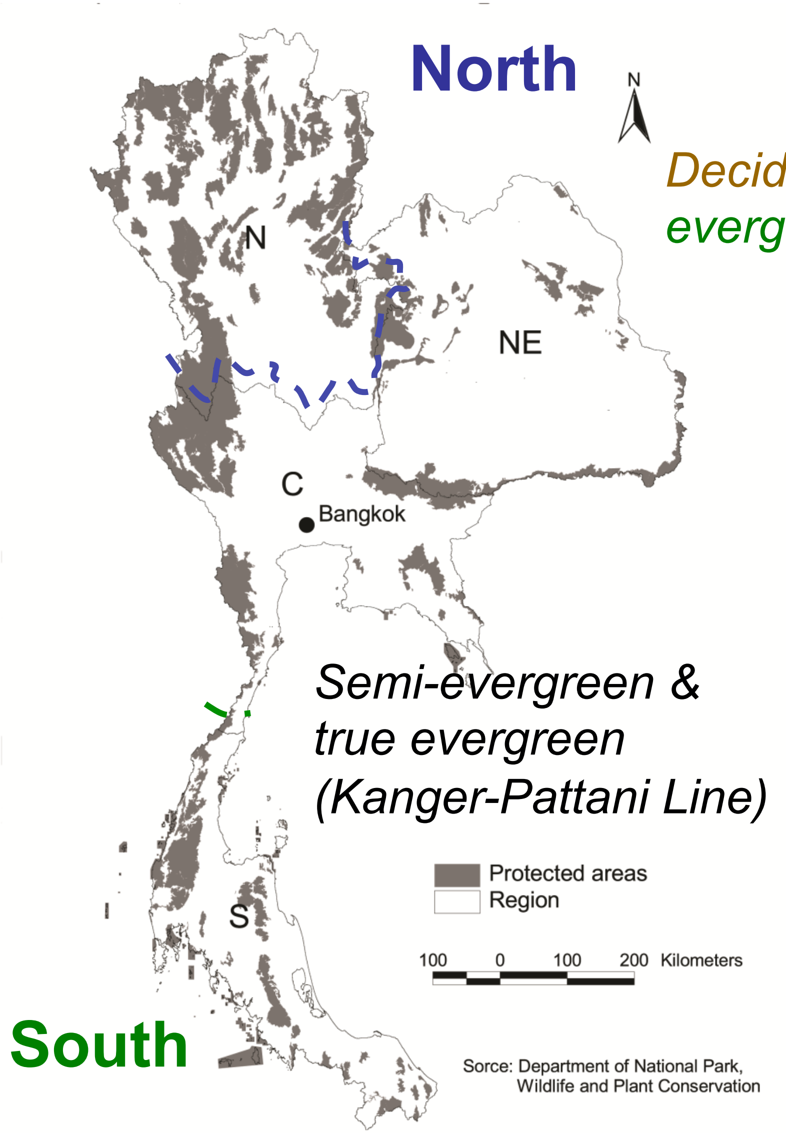


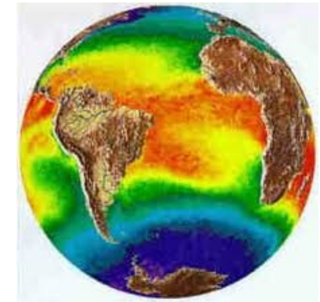
Landscape Structure Change *(Fragstats)*

Landscape indices of suit. niche	1990	2002	2020: trend scenario	2020: conservation scenario
Total area (ha)	11,754	4,202	5,623	5,108
Number of patches	10	28	119	87
Mean patch size (ha)	1175	150	47	59
Largest patch index	28.2	2.6	2.6	2.6
Total edge length (km)	212.6	261.4	429.2	353.0
Mean core area (ha)	895	56	14.4	20.4
Total core area (ha)	8,952	1,577	1,716	17,77
Connectance index (1-km radius)	11.1	5.5	4.8	4.1

LU/LC change severely affects the distribution of Black-crested Bulbul.

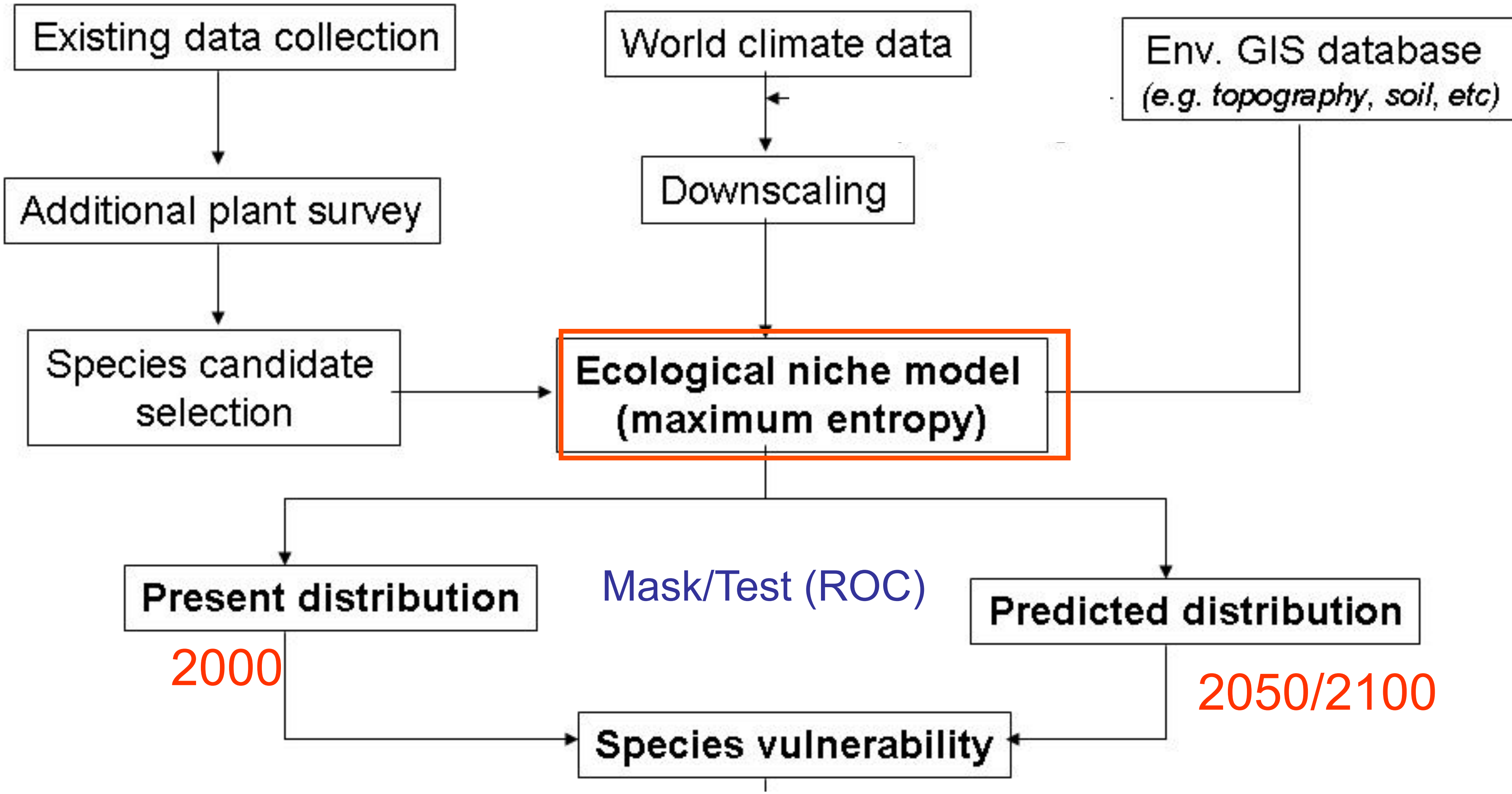
Trisurat and Duengkae (2011).
Journal of Ecology and Field Biology





RESPONSE OF TROPICAL FOREST TREES TO CLIMATE CHANGE

Methodology Framework

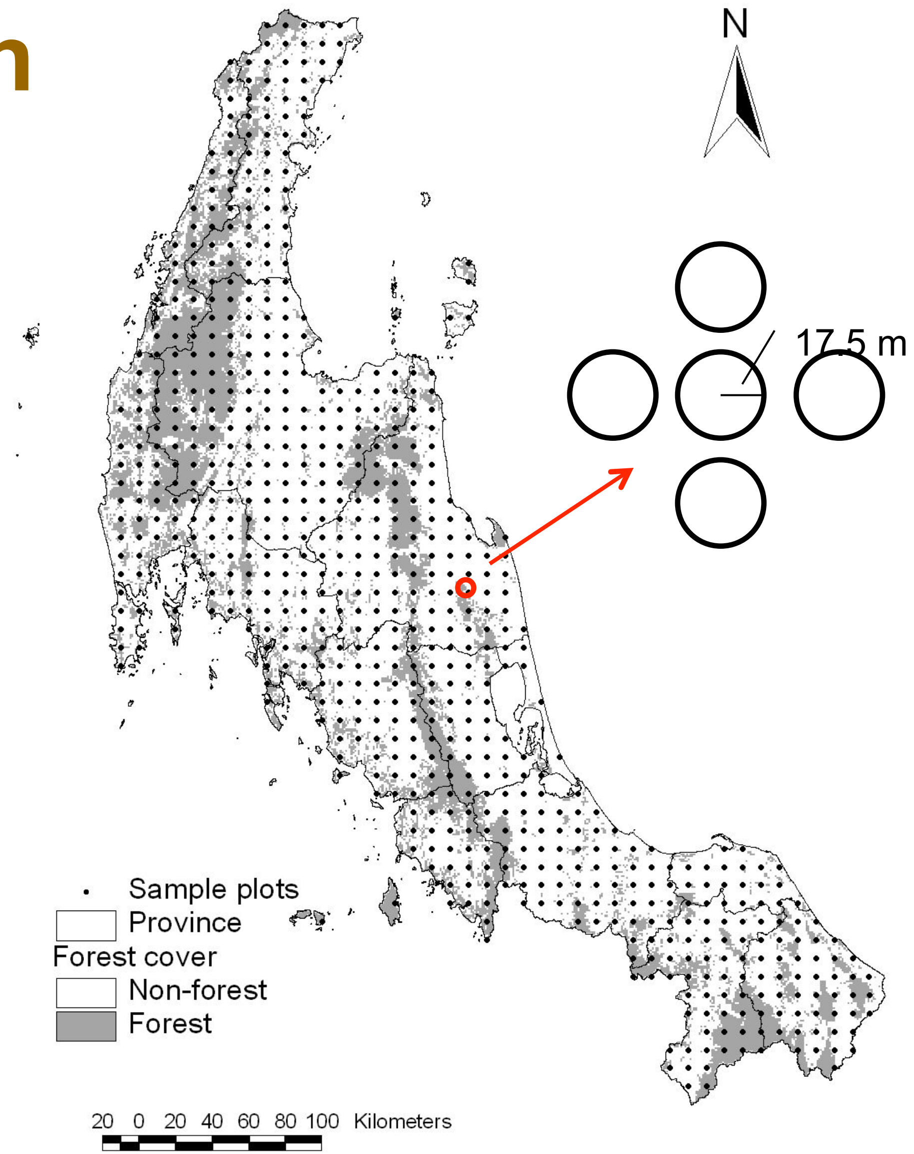


Species Selection

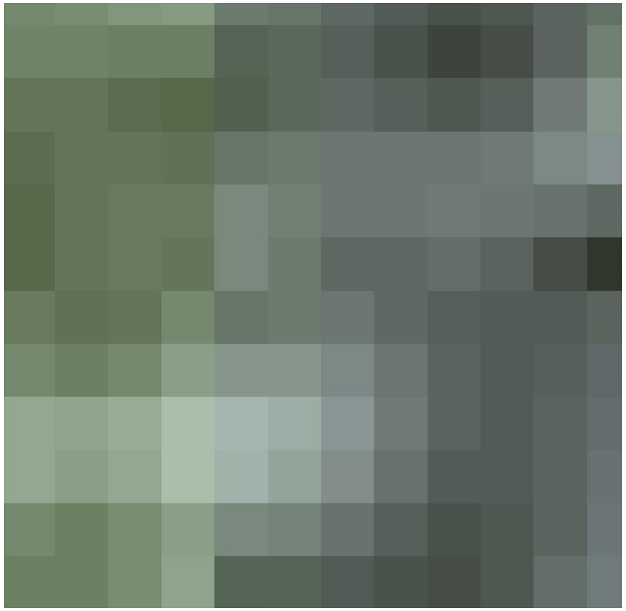
Criteria for selection

- Forest trees DBH>4.5 cm
- Presence > 20 records
- Representatives of family and genus
- Conservation important

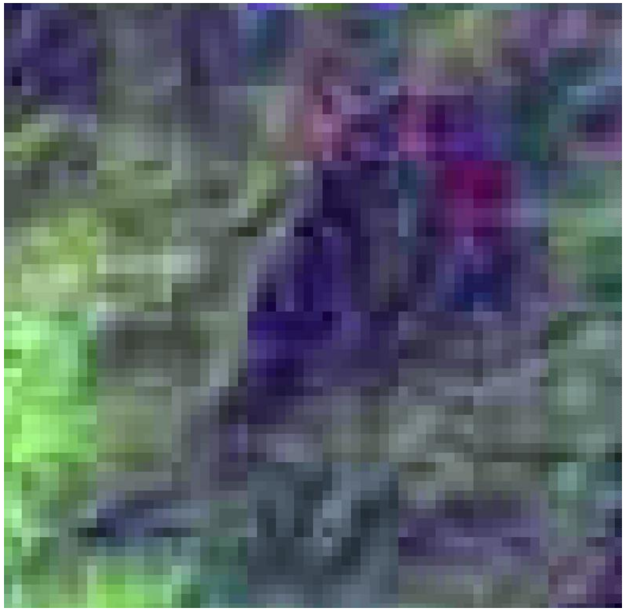
National forest inventory plots:
a uniform fixed grid of 10 x 10 km
(ITTO/RFD, 2003)



Downscaling Global Climate Data (Hadley CM3)



0.5° or 45 km



1 km

$$\text{Bio1\_th} = a - b_1\text{Alt} + b_2\text{Slp} + b_3\text{Asp} + b_4\text{Lat} + b_5\text{Long} + b_6\text{Bio1}$$

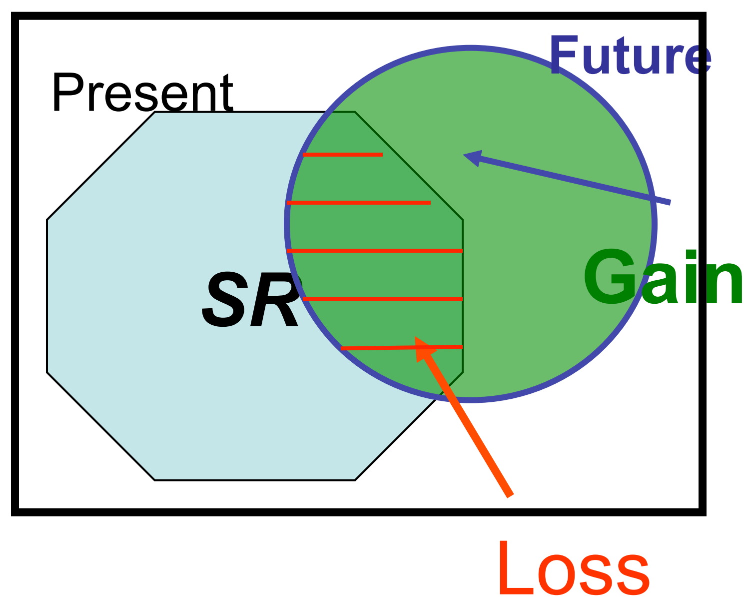
Bio1 = global climate monthly data

Impacts Assessment

Individual species

- Species gain (new arrival)
- Species loss (disappearance)
- Turnover rate (change from original range)

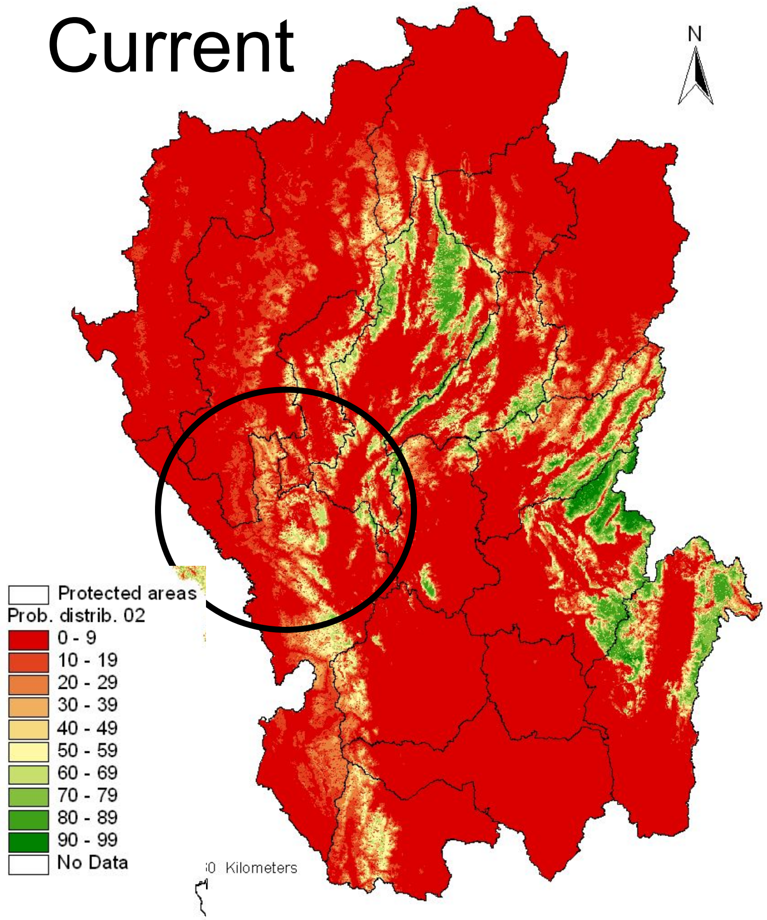
$$T = 100 \times \left[\frac{(G+L)}{(SR+G)}\right]$$



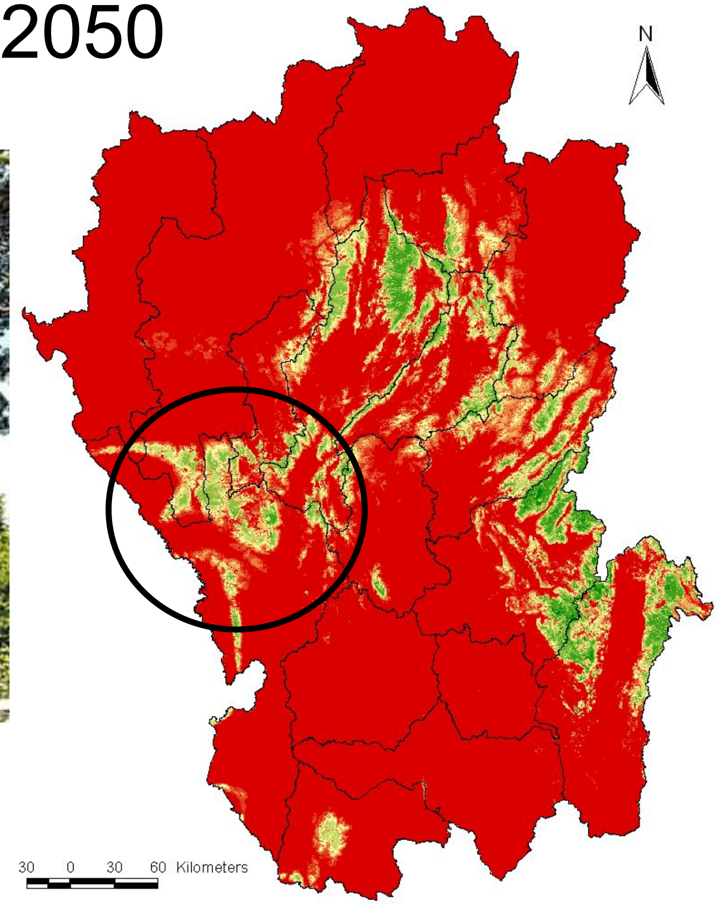
Species richness
- total area
- fragmentation

Dipterocarpus alatus

Current



2050

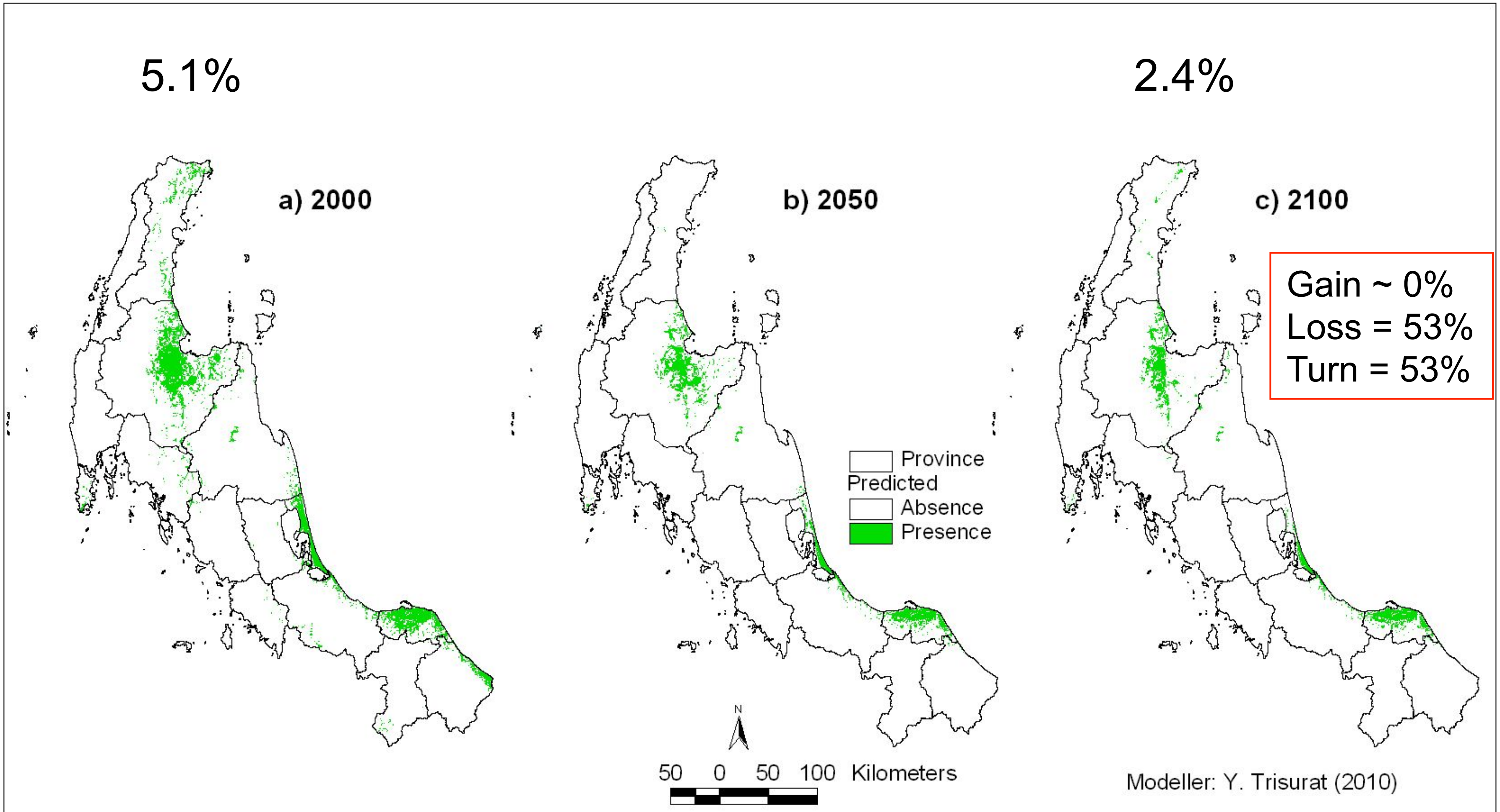


By: Y. Trisurat (2008)

G = 27%; L = 75%; T = 80%

Trisurat et al. (2009)

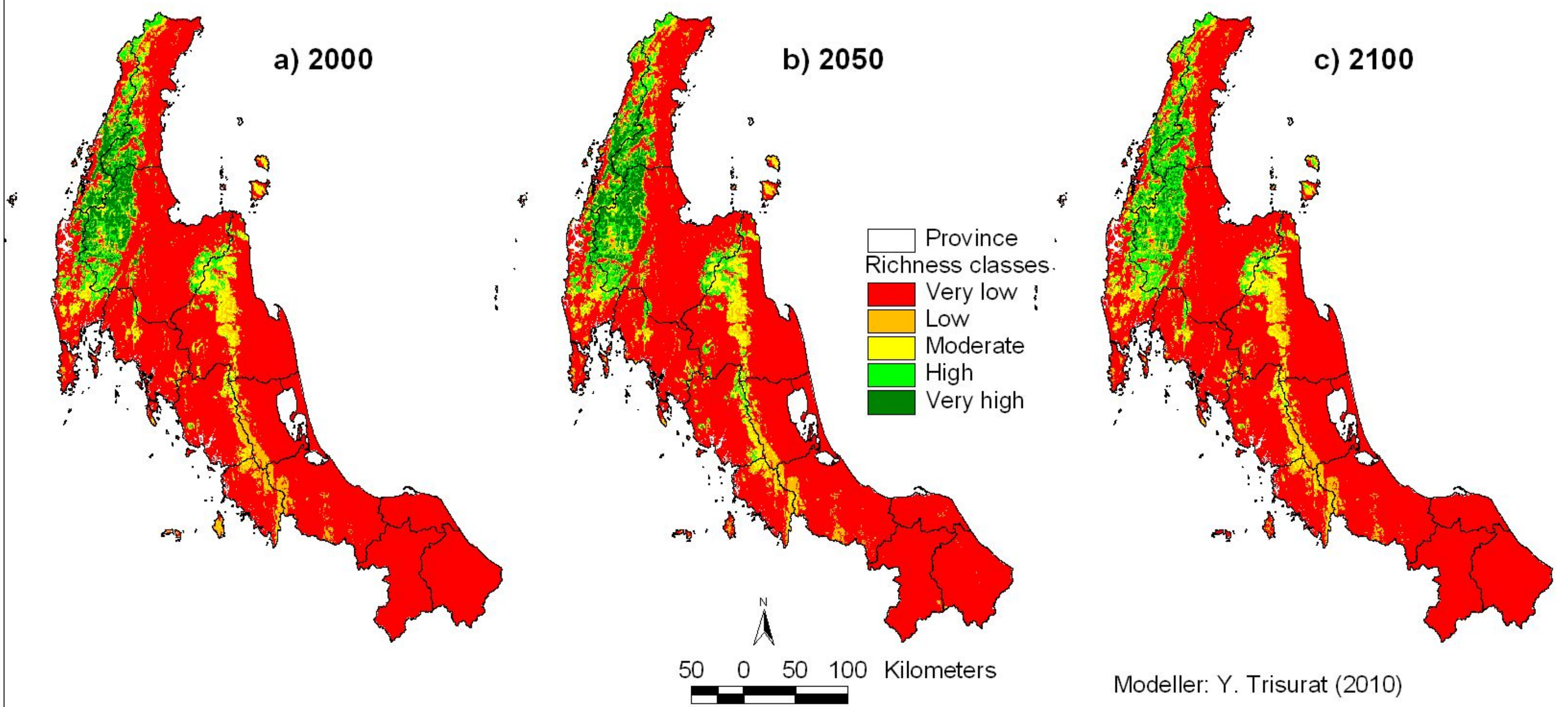
Dipterocarp grandiflorus



Low abundance >> **very low** abundance

Plant Richness (66 spp.)

8.4% **8.7%** **8.1%**



Very low = 1-12; Low = 13-24; Moderate = 25-36; High = 37-48; Very high = > 48

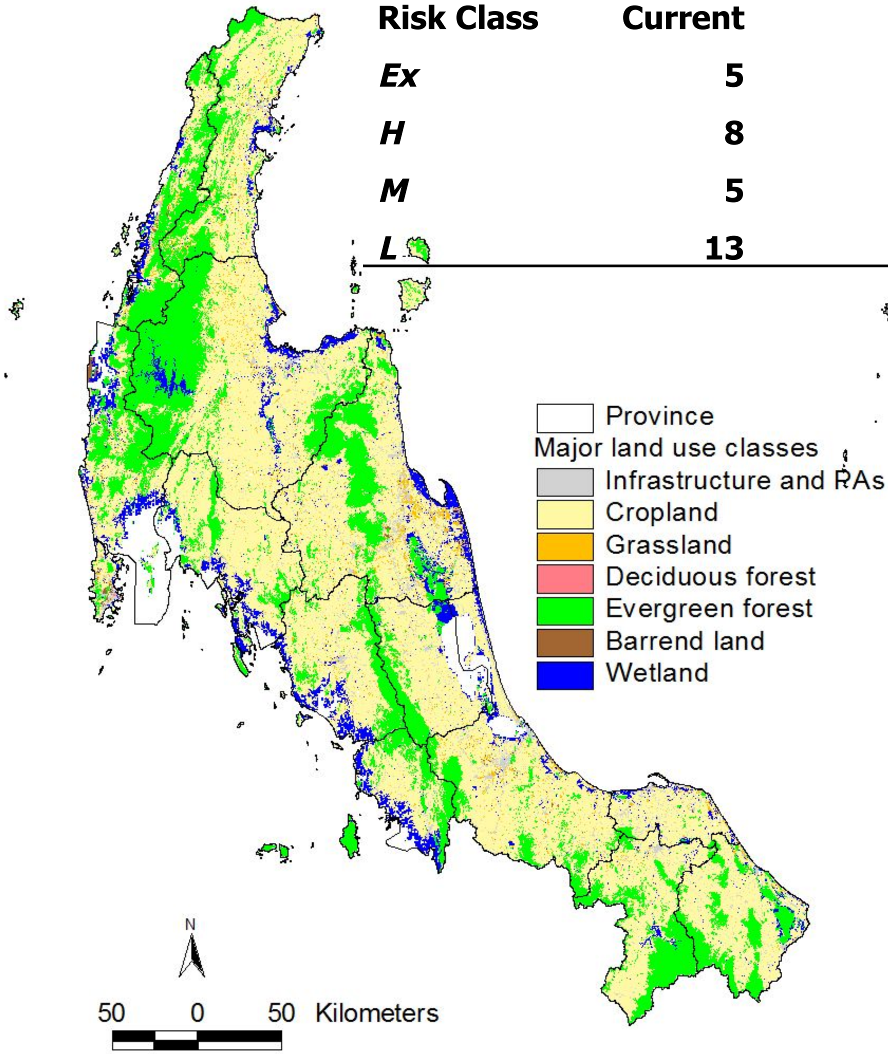
Trisurat et al. (2011). *Appl. Geo*.

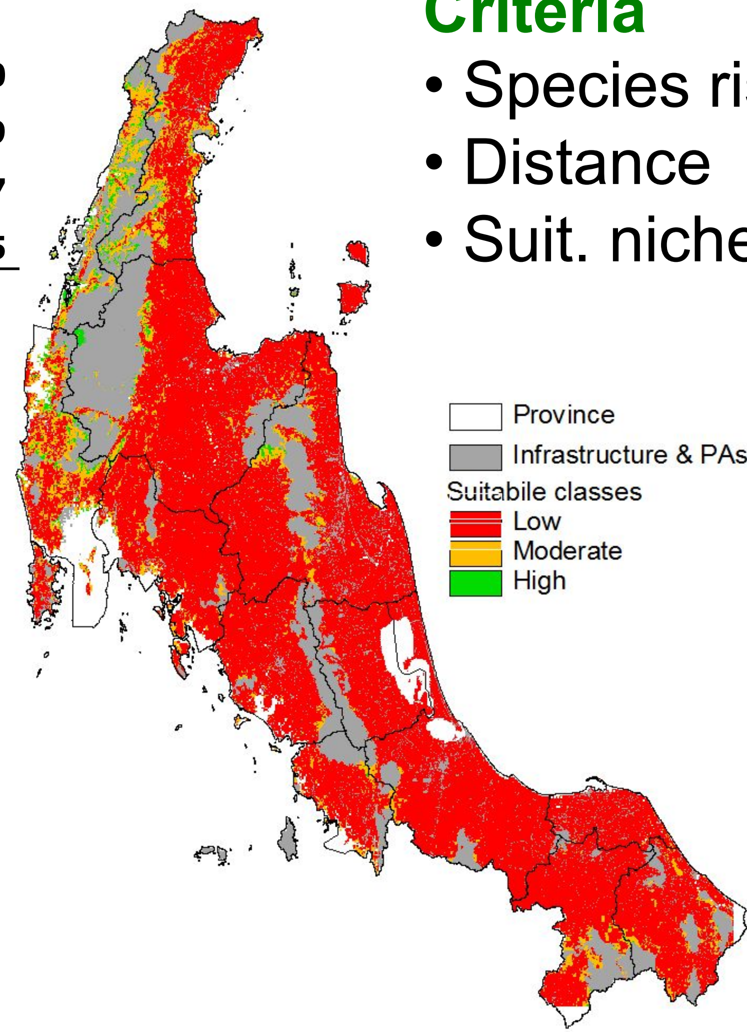
Priority areas for additional Conservation Areas

Risk Class	Current	New Pas
Ex	5	0
H	8	9
M	5	7
L	13	15

Criteria

- Species risk
- Distance
- Suit. niches





surat (2011)

Risk Assessment & Gravity Model

Ecosystem Services

มหาวิทยาลัยแม่โจ้ Maejo University

Allometric Equations

$$Ws = 0.0396(D^2H)^{0.9326}$$

$$Wb = 0.006003(D^2H)^{1.0270}$$

$$Wl = (28.0/Wtc+0.025)^{-1}$$

$$Wr = 0.0264(D^2H)^{0.7750}$$

Whereas, Ws = Stem biomass (kg)

Wb = Branch biomass (kg)

Wl = Leaf biomass (kg)

Wr = Root biomass (kg)

Wtc = Stem+ Branch biomass (kg)

Ogawa et al. (1965)

Tsutsumi et al. (1998)

Un-destructive measurement data of a tropical lower montain forest at Doi Inthanon National Park

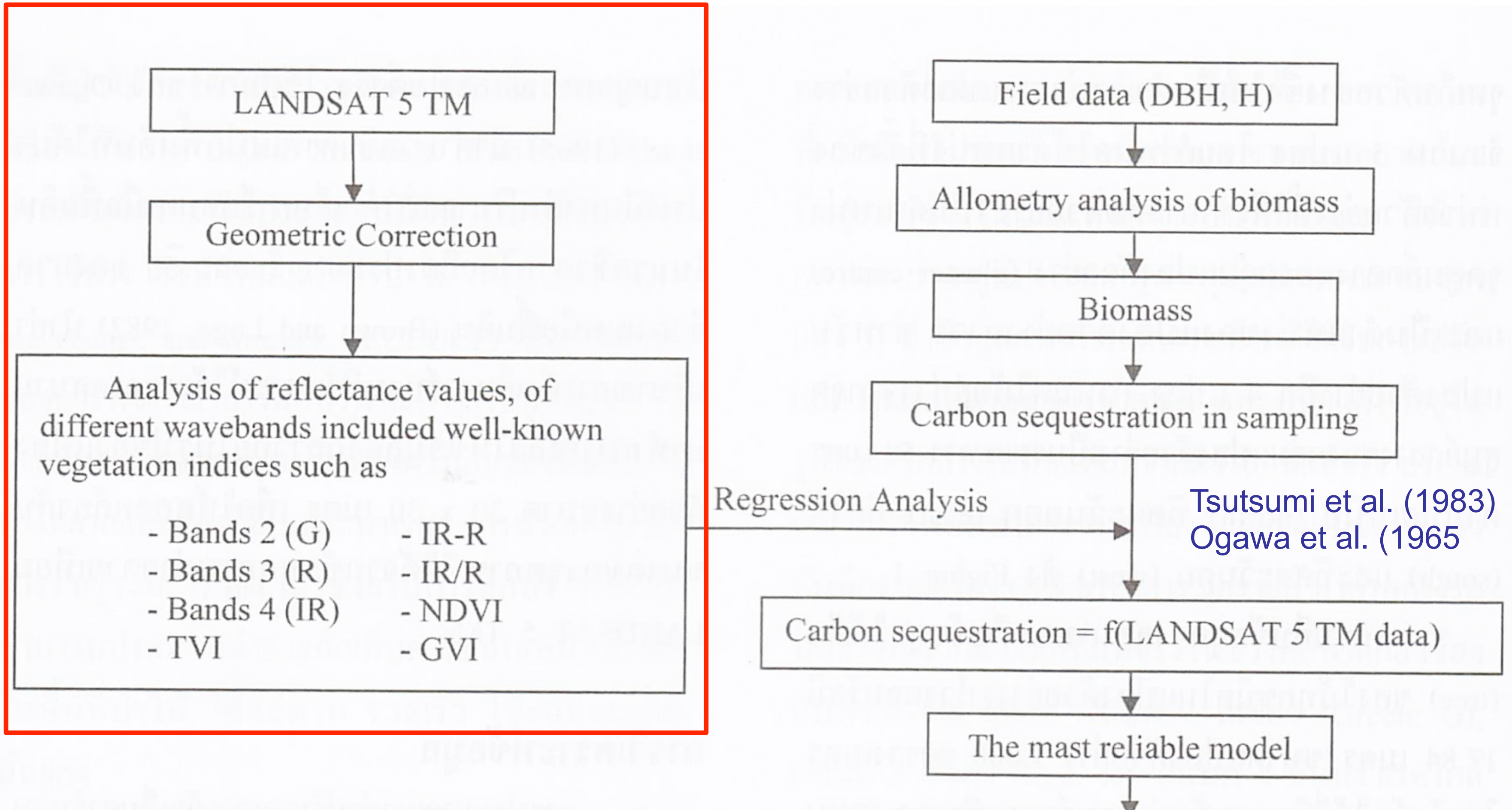
Methods	W_S	W_B	W_L	Biomass ($Mg.ha^{-1}$)
Yamakura *et al.* (1986)	$0.0290(D^2H)^{0.9813}$	$0.119 (Ws)^{1.059}$	$0.095 (Ws+Wb)^{0.726}$	391
Sungpalee *et al.* (2010)	$Vs \times \rho$	$0.1489 (Ws)^{1.035}$	$0.1101 (Ws)^{0.730}$	277
Chave *et al.* (2005)	$\rho \times \exp(-1.499+2.148 \ln(D)+0.207(\ln(D)^2 - 0.0281(\ln(D))^3)$			374
Chave *et al.* (2005)	$\exp(-2.977 + \ln(\rho D^2H))$			392

W_s = stem biomass (kg)
W_B = branch biomass (kg)
W_L = leave biomass (kg)
H = total height (m)
D = d.b.h. (cm)
Vs = stem volume (m^3)
ρ = species-specific wood density (kg m^3)

Weakness of Direct Human Induces Estimation

- Labor intensive (cost/ time)
- Ecosystem heterogeneity
- Difficulty to produce field-based inventories at nat., cont. and global scales

Integration of site-based data and RS



Source: Boonsang & Arunpraparat (2011)

Sampling Plots & Equations

Dry evergreen forest: 15 plots

$$C_{DE} = 630.339\,(R) - 74.019,\ R^2 = 0.839$$

Hill evergreen forest: 7 plots

$$C_{HE} = 326.630(IR) - 27.974(IR/R) - 36.188,\ R^2 = 0.854$$

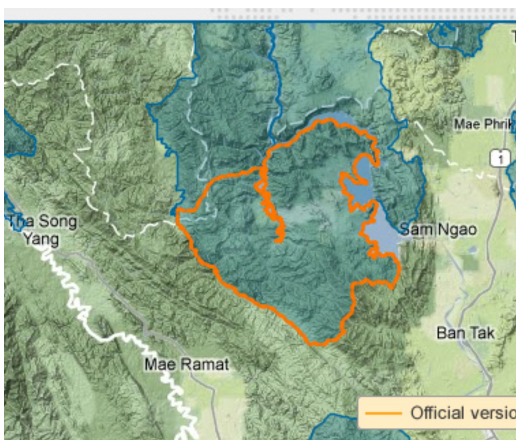
Dry dipterocarp forest: 42 plots

$$C_{DD} = 53.140(IR) - 41.031(TVI) - 194.004(G) + 59.783\ ,\ R^2 = 0.745$$

Mixed deciduous forest: 85 plots

$$C_{MD} = 951.608(IR-R) - 505.367(IR) - 62.406(IR/R) + 134.572,\ R^2 = 0.741$$

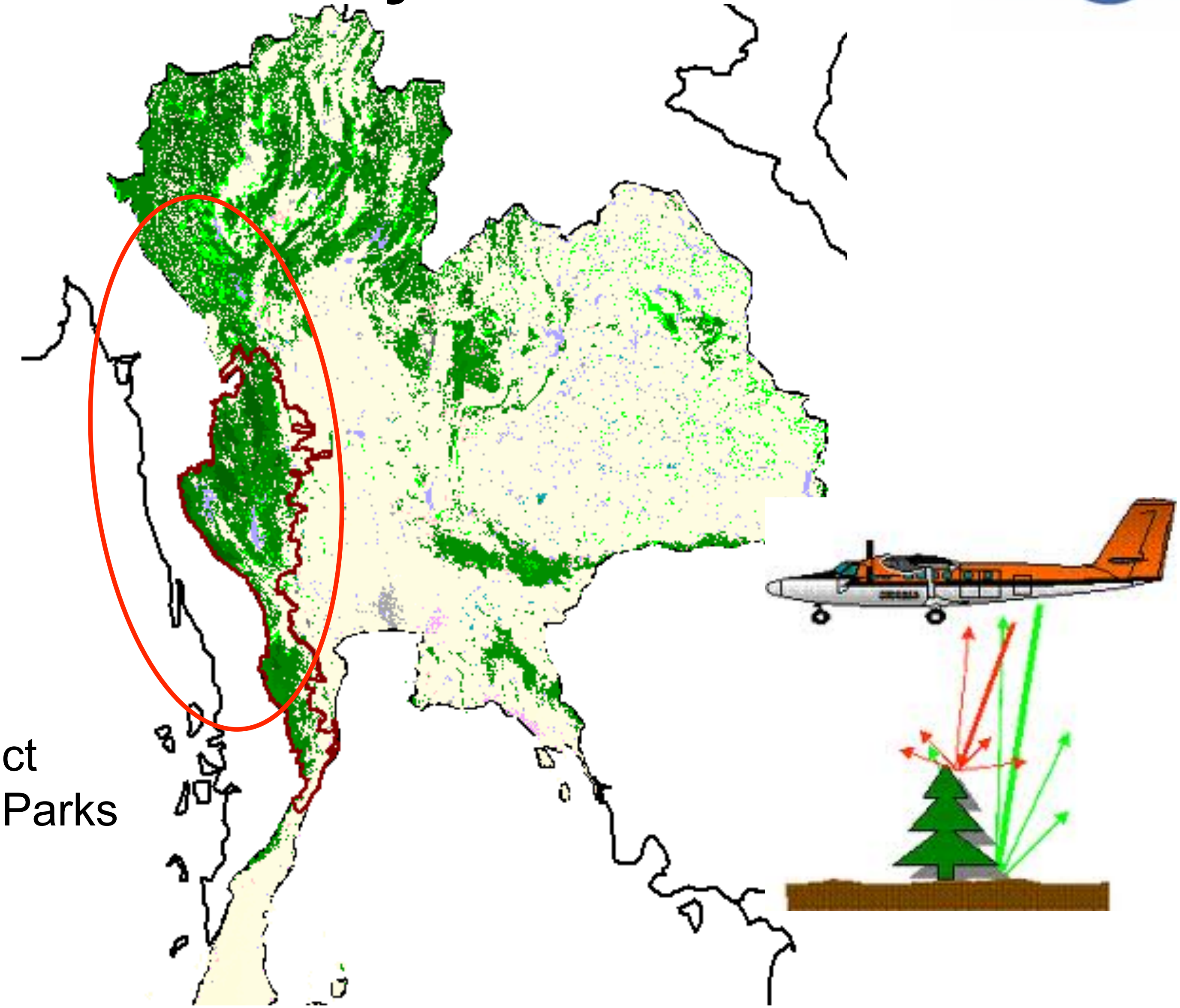
Estimated aboveground carbon sequestration @ Mae Tuen WS



Forest type	Carbon sequestration	
	Carbon (Kt)	Carbon (t/ha)
DEF	**88.0**	**129.0**
HEF	1,564.4	102.4
DDF	2,193.3	54.7
MDF	5,040.8	80.2
Total	8,886.8	-

Source: Boonsang & Arunpraparat (2011)

Intended Activity: LiDAR RS



Collaborative Project
b/w Dept. National Parks
and WWF

Evolution of RS/GIS Applications

Scenarios, global models & site-based data: 2000

Statistic & mat. Modeling: 1990

GIS: 1985

Aerial photo/ Satellite image: 1960

Ecosystem services (carbon and water reg.)

Biodiversity drivers & status

Species distribution

Forest/ LU mapping

Future Direction & Challenge

- **Support international conventions:**
  - **CBD biodiversity targets 2020**
  - **UNFCC Climate change and carbon sto**

- **National agenda and key issues:**
  - **Water cycle regulation and flood predi**
  - **Forest landscape rehabilitation**
  - **Ecosystem services**

- Challenge:
  - **integration of site-based data** and geo-informatics technologies
  - collaborative research at regional level (access & sharing?)

THANK YOU


THE GLOBAL EARTH OBSERVATION
SYSTEM OF SYSTEMS
INFORMATION
FOR THE BENEFIT
OF SOCIETY
Health
Energy
Climate
Agriculture
Biodiversity
Water