Assessing the Potential Impacts of Climate Change on Dipterocarpus Species and Conservation Adaptation in Peninsular Thailand

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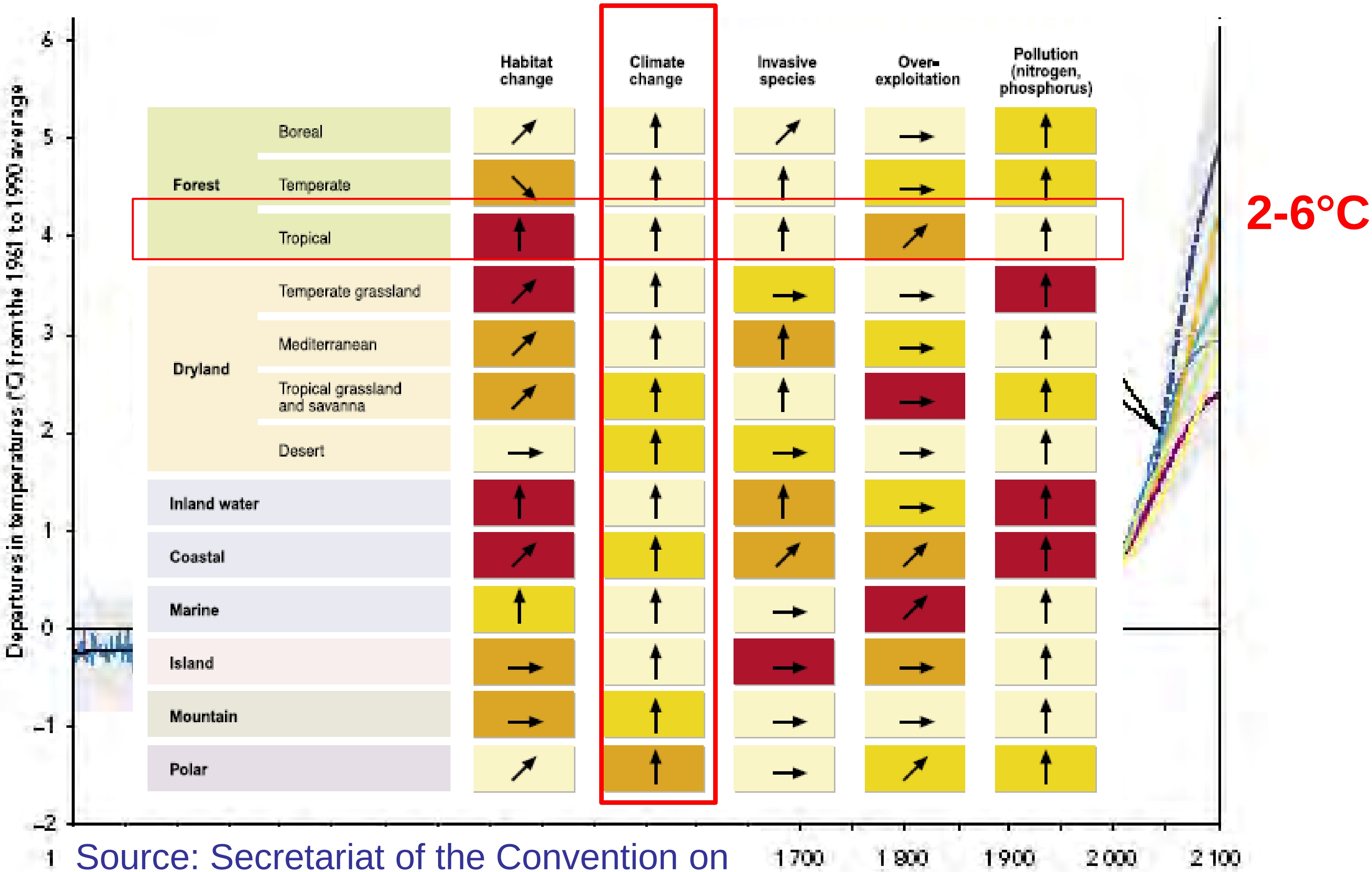

Source: Secretariat of the Convention on Biological Diversity (2006)

Source: Mann et al., 1999 (last 1 000 years); IPCC, 2001a (projection for the next 100 years).

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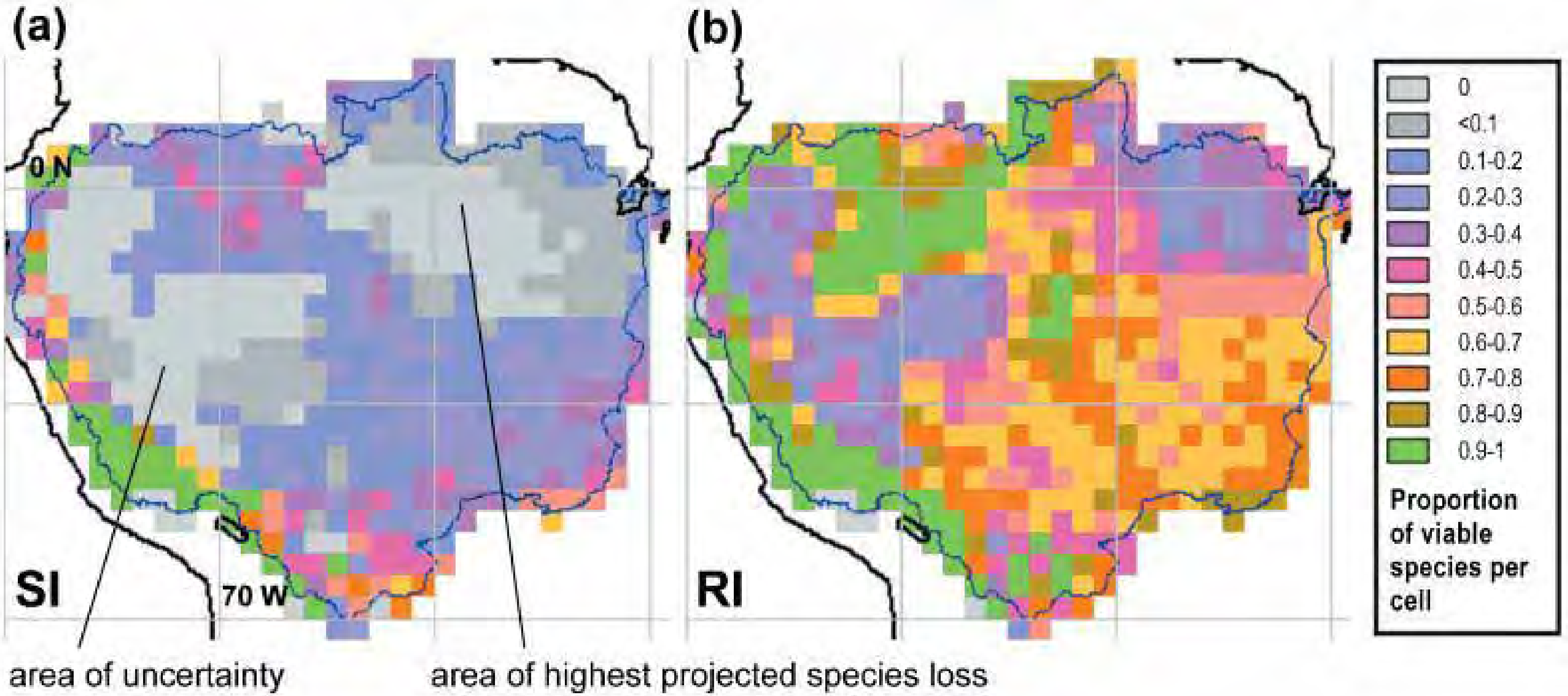
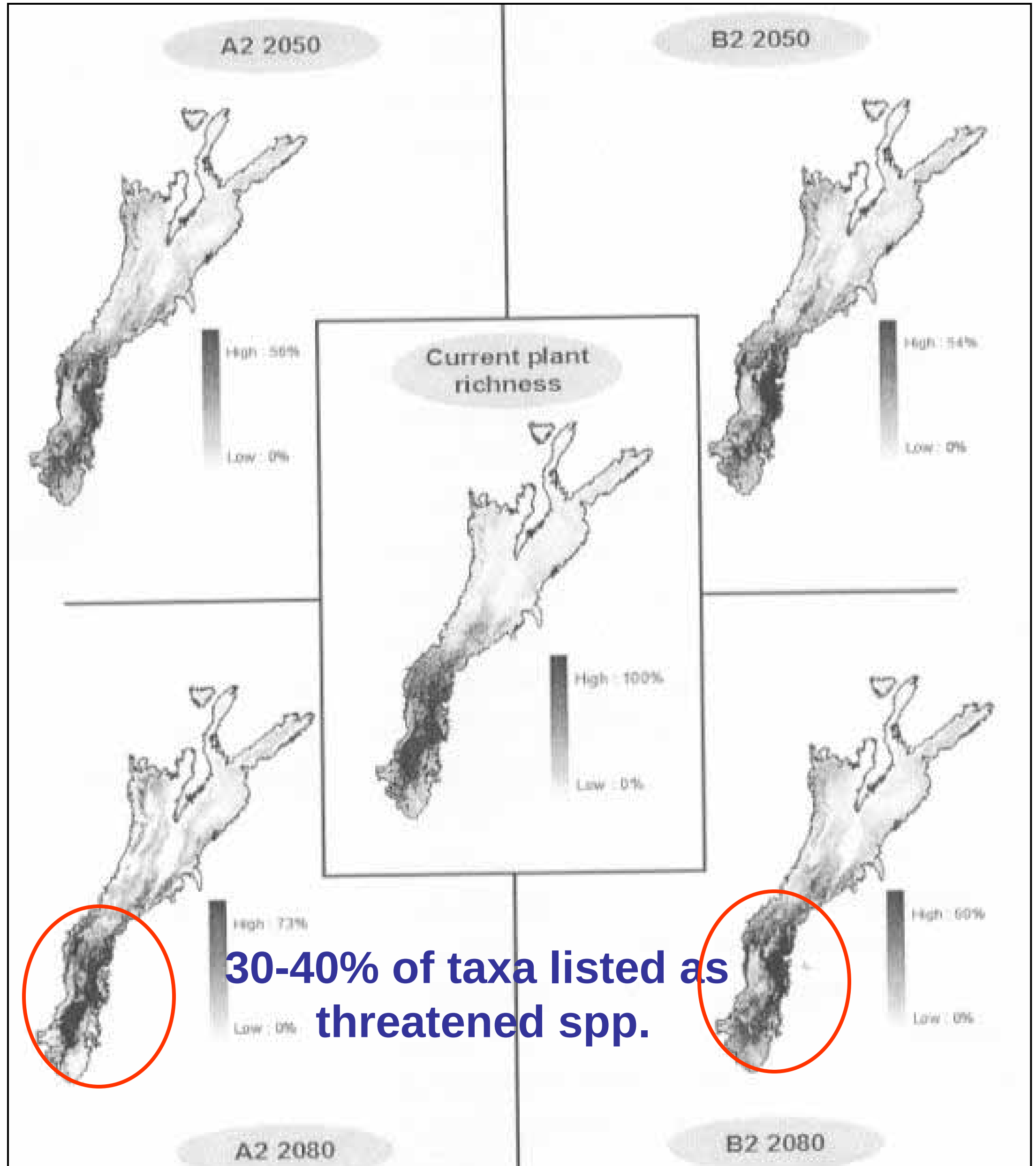
In Amazonia, up to 43% of plant species could become non-viable by 2100



Source: Miles et al. (2004)

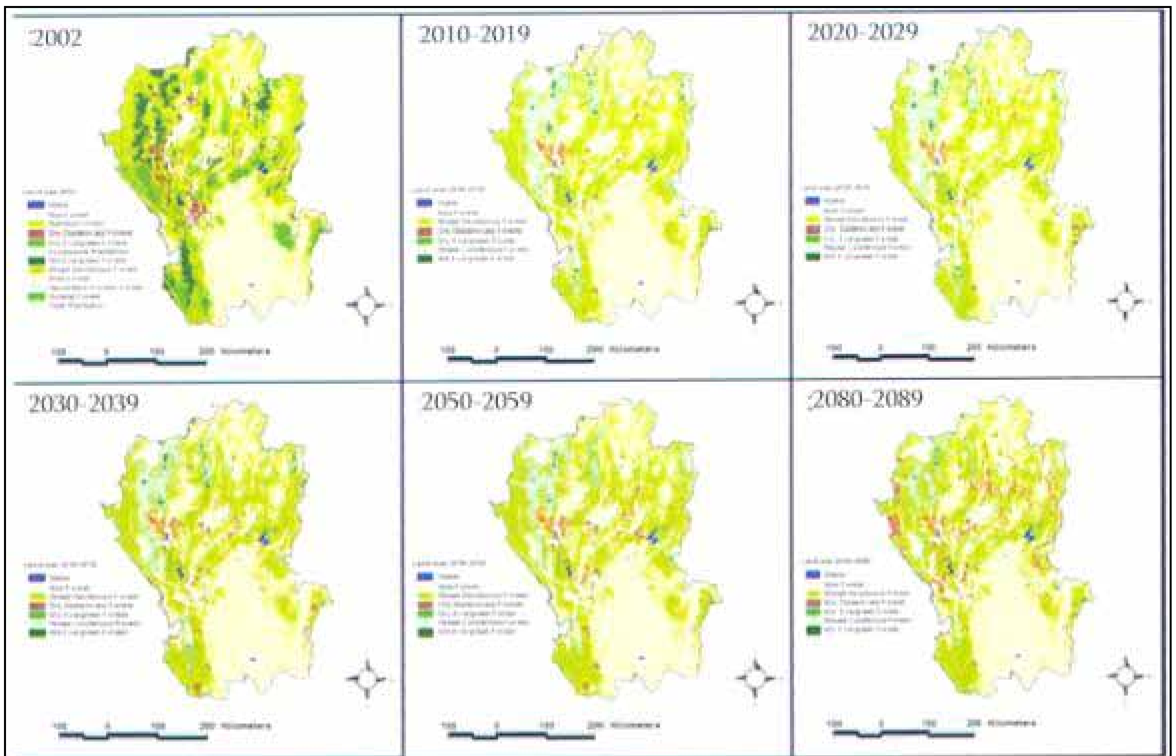
The Northern Andes



Previous study (0.5 ° or 45 km resolution)

- increases temp. of 1.5-2.0 °C in 2100
- high rainfall intensity and long drought

Boonpragob and Santisirisomboon (1996)

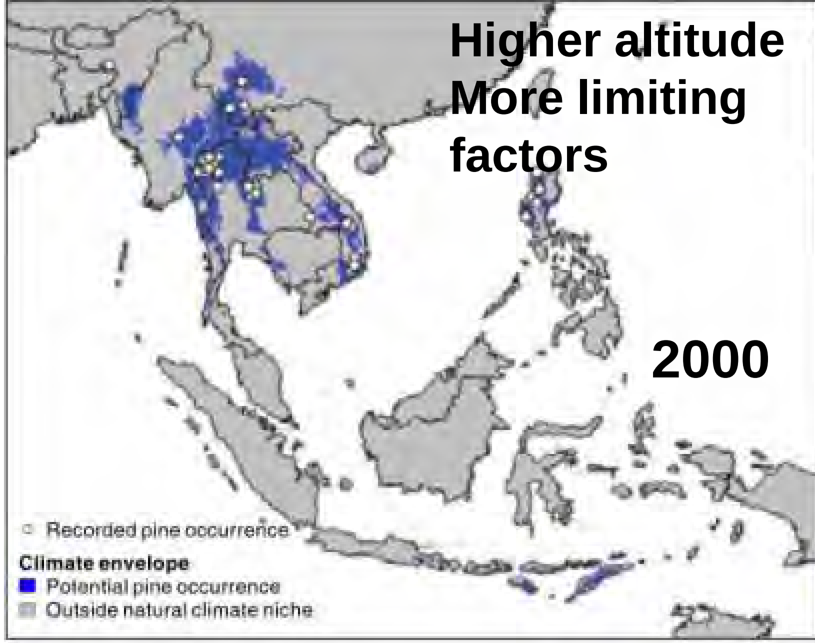


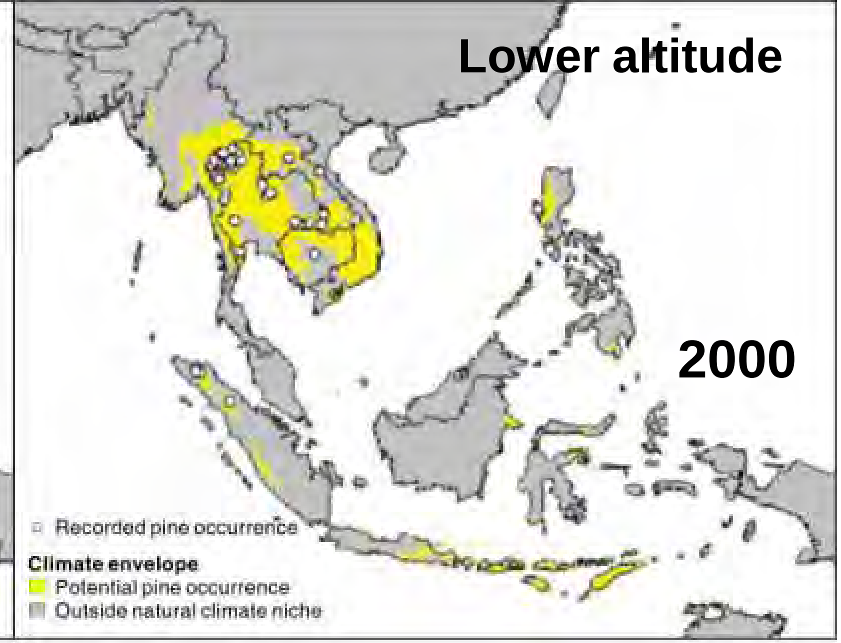
Derived from Fuzzy model

- deciduous forest expands 20-50%
- evergreen forest declines 45-80%

Pumijumnong and Techamahasaranont (2009)

- species distribution?
- adaptation?





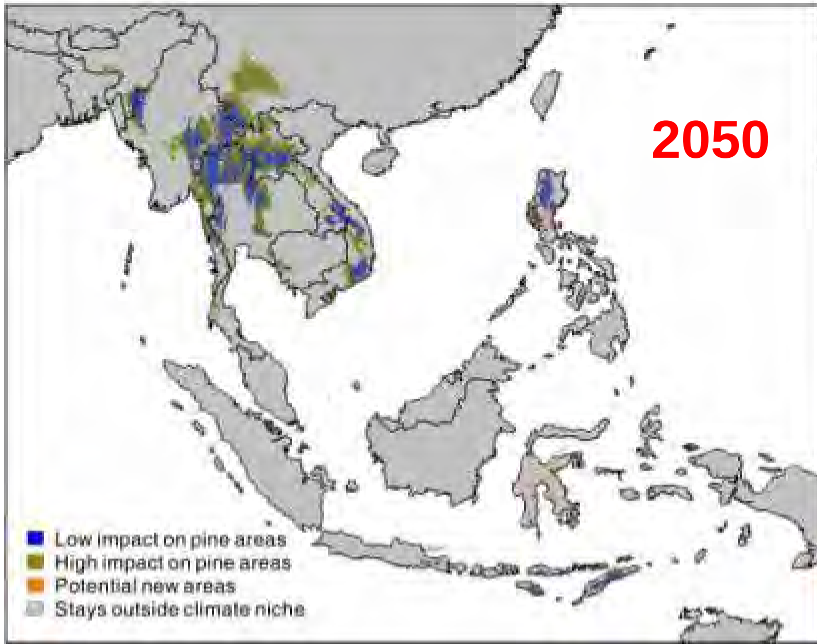
1
Recorded and potential occurrence of Pinus kesiya

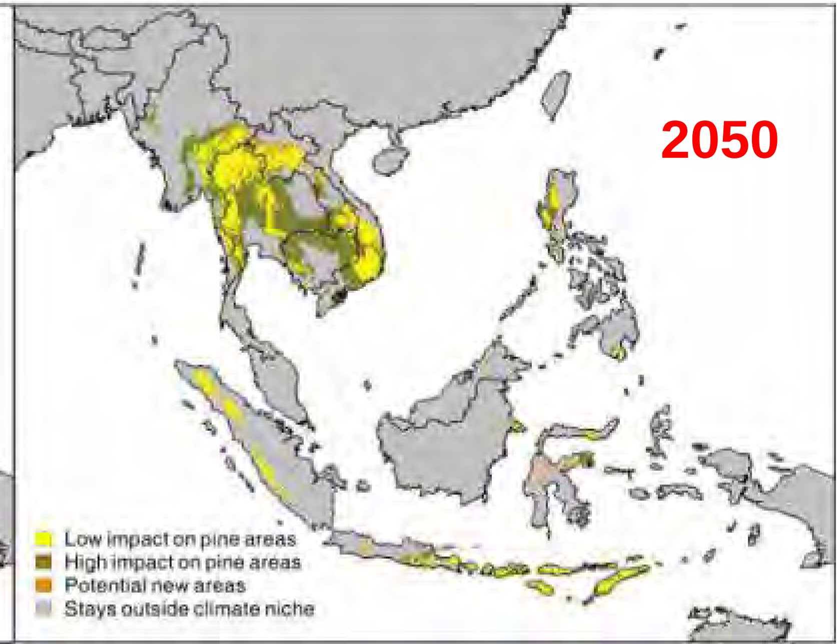
Pinus kesiya

2
Recorded and potential occurrence of Pinus merkusii

Pinus merkusii

van Zonneveld,et al (2009)





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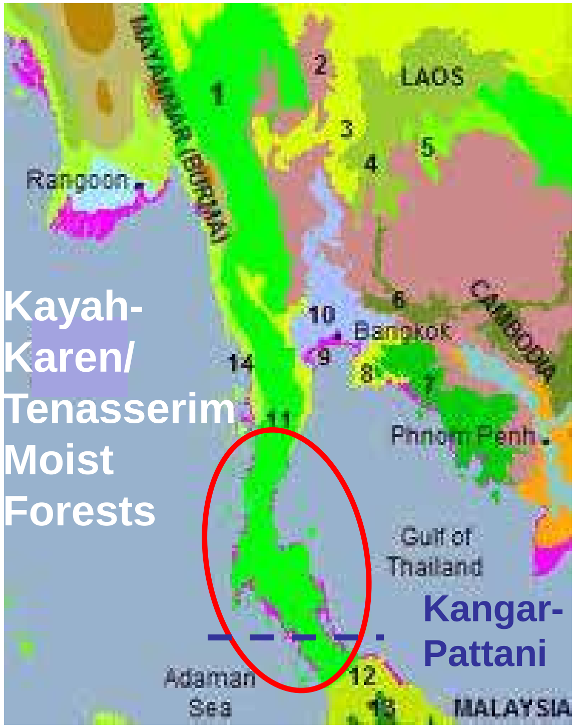
Peninsular Thailand

- Influenced by Burmese (N) and Malaysian flora (S) (Rares and Van Welzen, 2009)
- Santisuk *et al*. (1991): 2 sub-types
  - Peninsular Wet Seasonal Evergreen Forest (north of the Kangar-Pattani Line)
  - Malayan Mixed Dipterocarp Forest
- Fam. **Dipterocarpaceae** – dominant



Ecoregion Map (WWF, 2008)

Limitations (Malayan Dip.)

- less drought tolerant (Baltzer et al., 2007)
- less desiccation tolerant leaves (Baltzer *et al*., 2008) at the seedling recruitment stage (Kursar et al., 2009)

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OBJECTIVES

- To assess the distributions (ecological niches) of selected Dipterocarpus species in peninsular Thailand (present & future)
- To evaluate the potential impacts of climate change on shifting in distributions and their vulnerability
- To recommend adaptive measures to mitigate CC impacts

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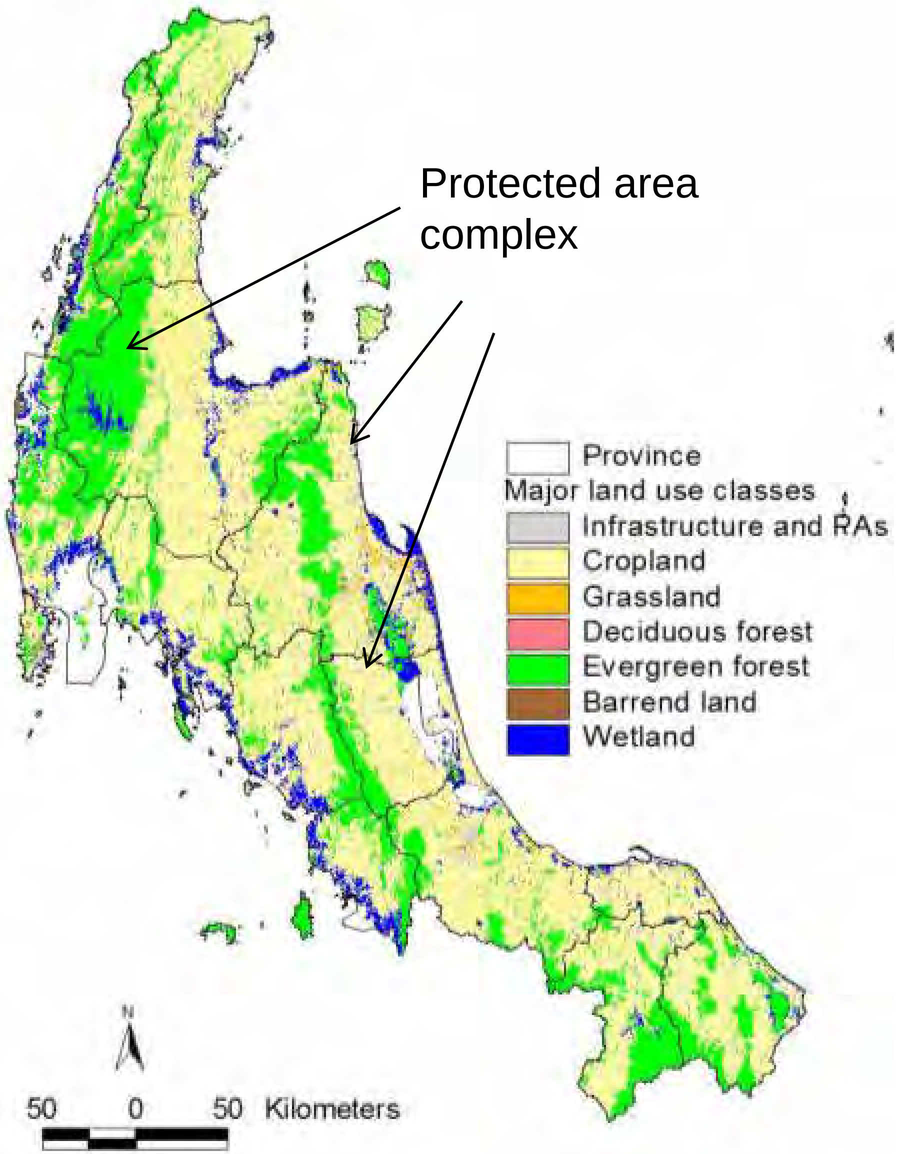

Peninsular Thailand (Southern Region)

- Latitude: 5 ° 37’ - 11 ° 42’ N
- Size: 70,700 km^2
- Mean temp: 26.6 °C
- Rainfall: 2,000 – 3,000 mm
- Forest cover:
  - 42% (1961)
  - 30% (2008)
- Protected areas: 14.8%
- Threats: rubber & oil palm

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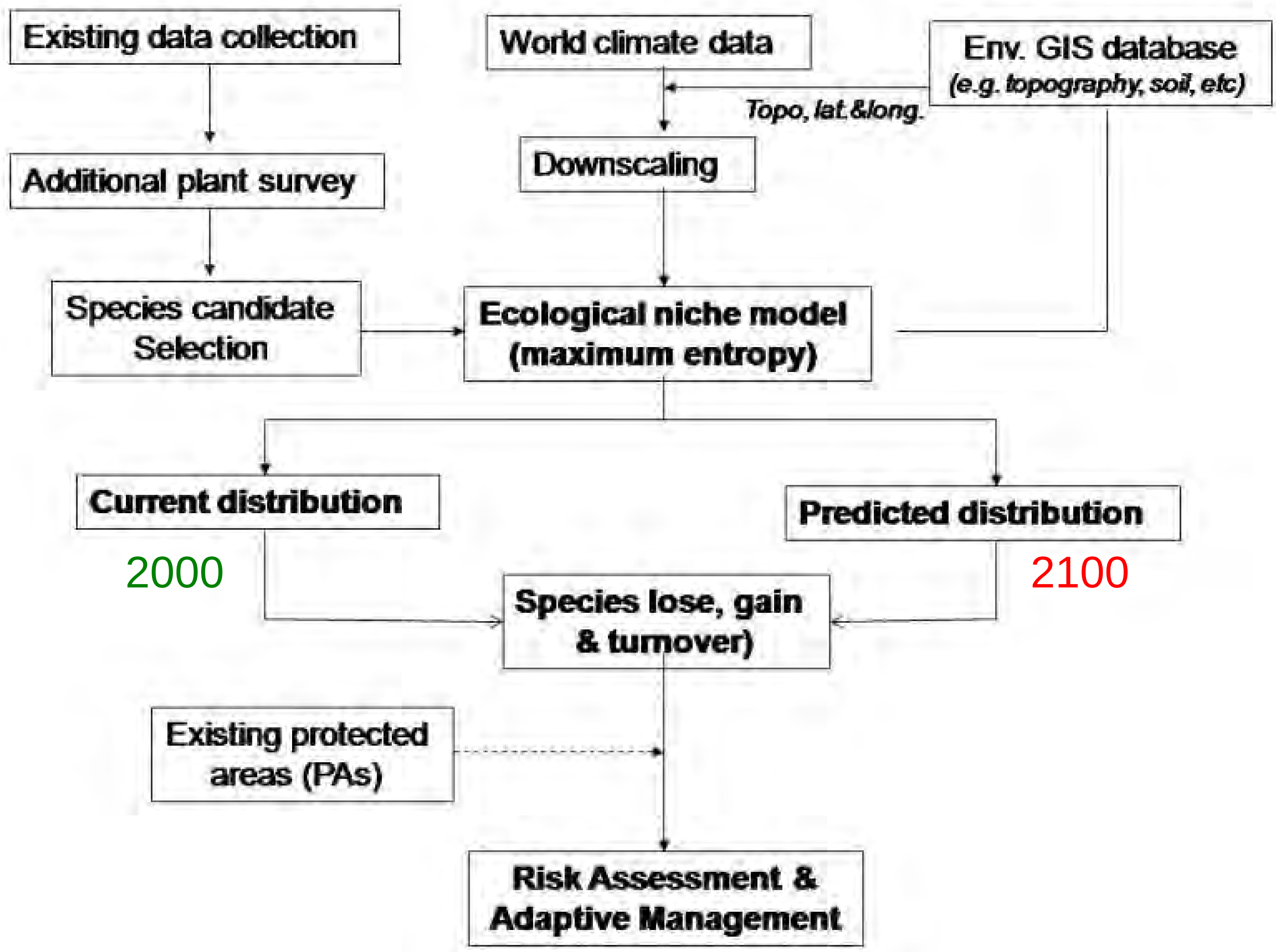
Methodology Framework



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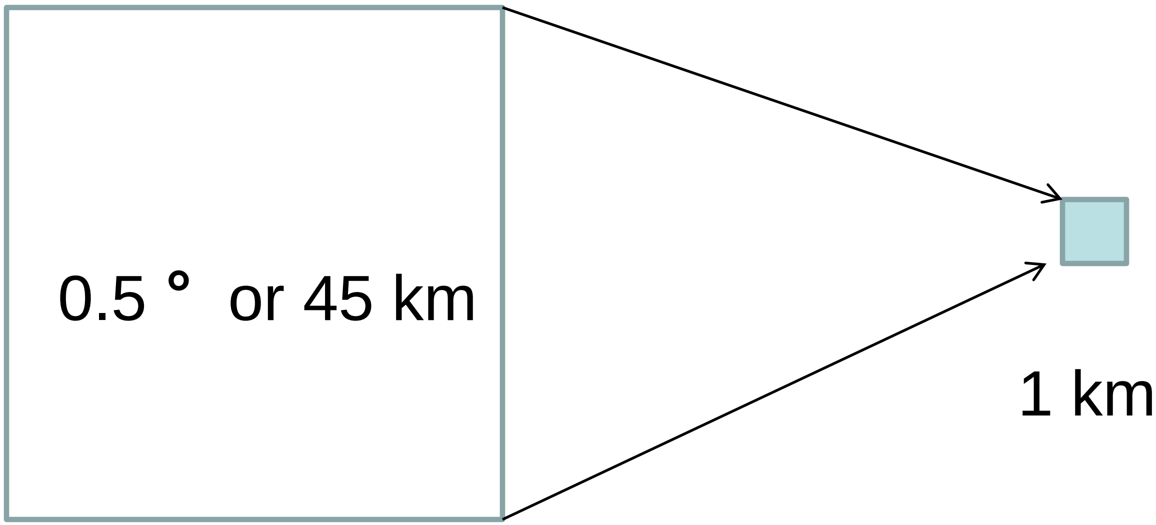
Downscaling Global Climate Data (Hadley CM3 B2A scen.)



- Altitude
- Slope
- Aspect
- Latitude
- Longitude

$$Bioi\_th_{2000} = a - b_1Alt + b_2Slp + b_3Asp + b_4Lat + b_5Long + b_6Bio1_{2000}$$

$$Bioi\_th_{2100} = a - b_1Alt + b_2Slp + b_3Asp + b_4Lat + b_5Long + b_6Bio1_{2100}$$

Bioclimatic variables generated from monthly rainfall and temp.

Code	Description	Code	Description
BIO1	Annual mean temperature	BIO11	Mean temperature of coldest quarter
BIO2	Mean diurnal range (Mean of monthly (max temp – min temp)	BIO12	Annual precipitation
BIO3	Isothermality (Bio2/Bio7)*100	BIO13	Precipitation of wettest month
BIO4	Temperature seasonality	BIO14	Precipitation of driest month
BIO5	Maximum temperature of warmest month	BIO15	Precipitation seasonality
BIO6	Minimum temperature of coldest month	BIO16	Precipitation of wettest quarter
BIO7	Temperature annual range (Bio5-Bio6)	BIO17	Precipitation of driest quarter
BIO8	Mean temperature of wettest quarter	BIO18	Precipitation of warmest quarter
BIO9	Mean temperature of driest quarter	BIO19	Precipitation of coldest quarter
BIO10	Mean temperature of warmest quarter		

More meaningful for ecological study!

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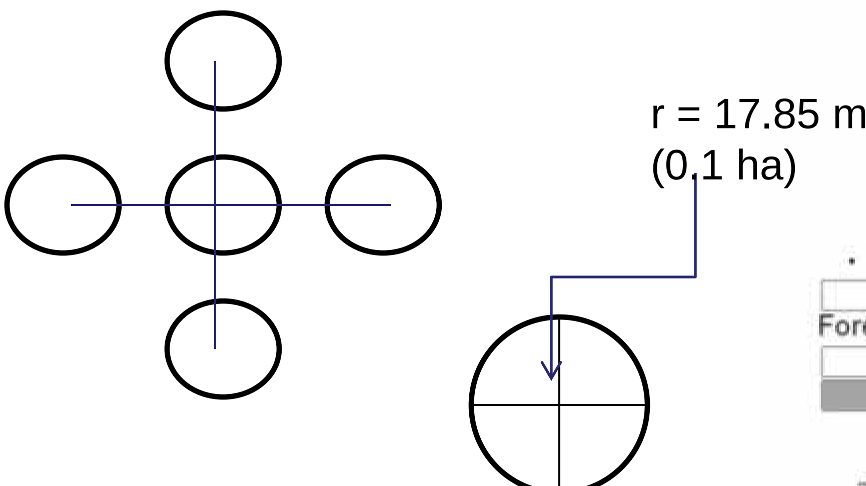
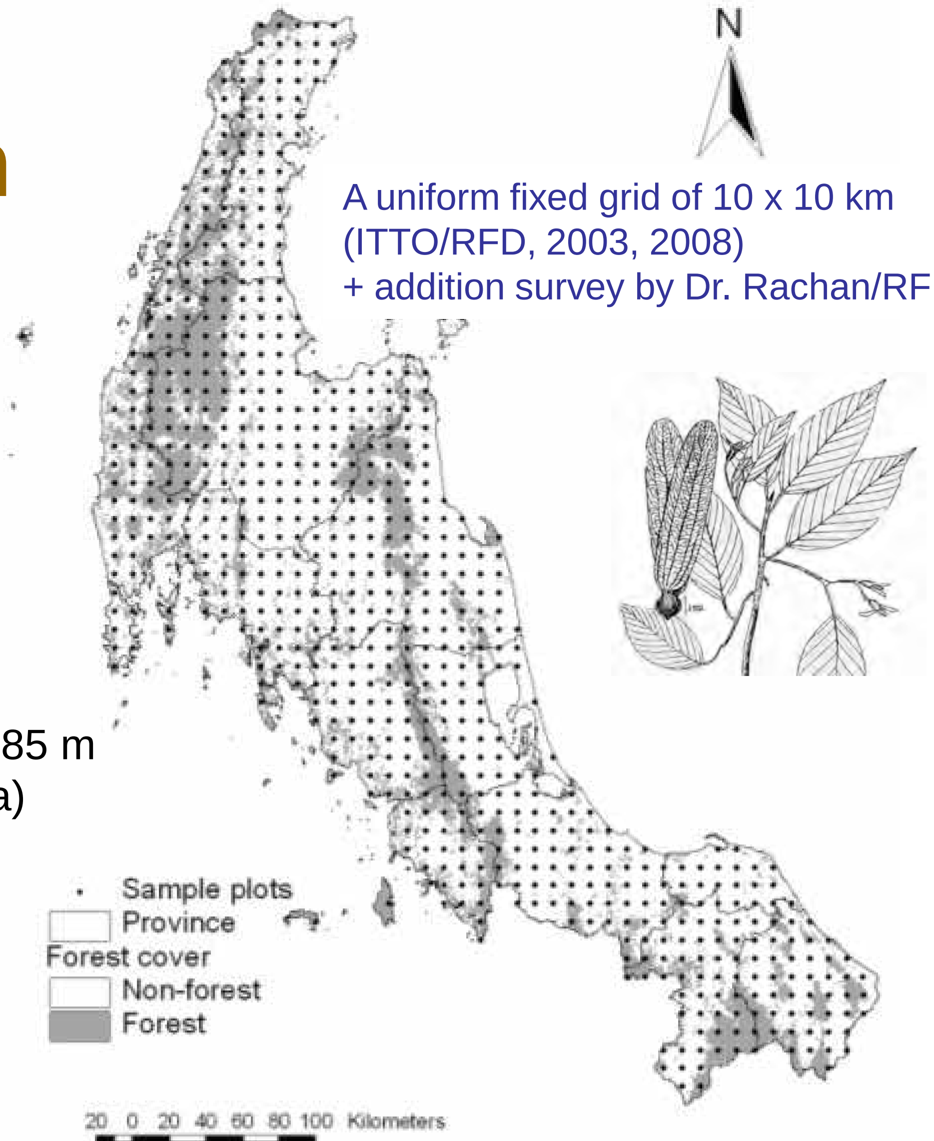
Species Selection

Criteria for selection

- Forest trees DBH>4.5 cm
- Presence > 15 records
- Representatives of genus
- Conservation important



A uniform fixed grid of 10 x 10 km
(ITTO/RFD, 2003, 2008)
+ addition survey by Dr. Rachan/RFD



160/260 plts

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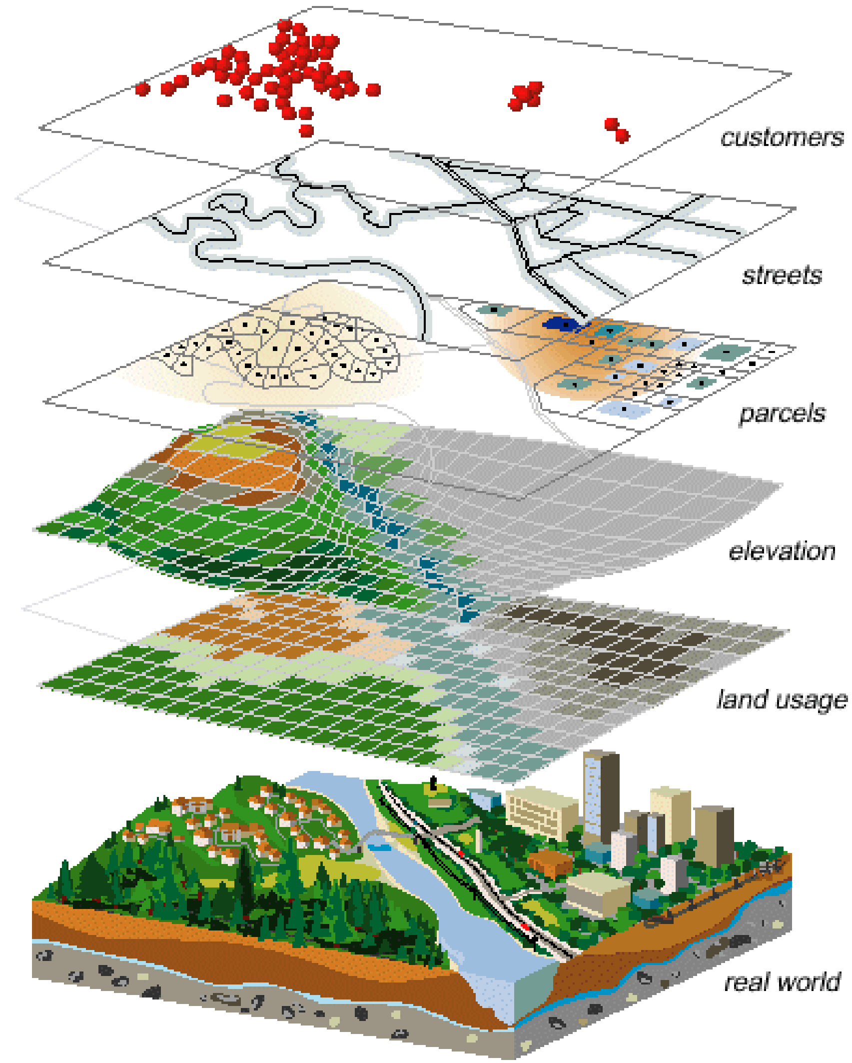
Bio-physical Factors

- Bioclimate – 19 var.
- Soil properties
  - Dept
  - Texture
  - Fertility
- Altitude (DEM)
- Slope
- Aspect
- Forest cover (mask)
- etc.

Pearson's correlation (> 0.7)



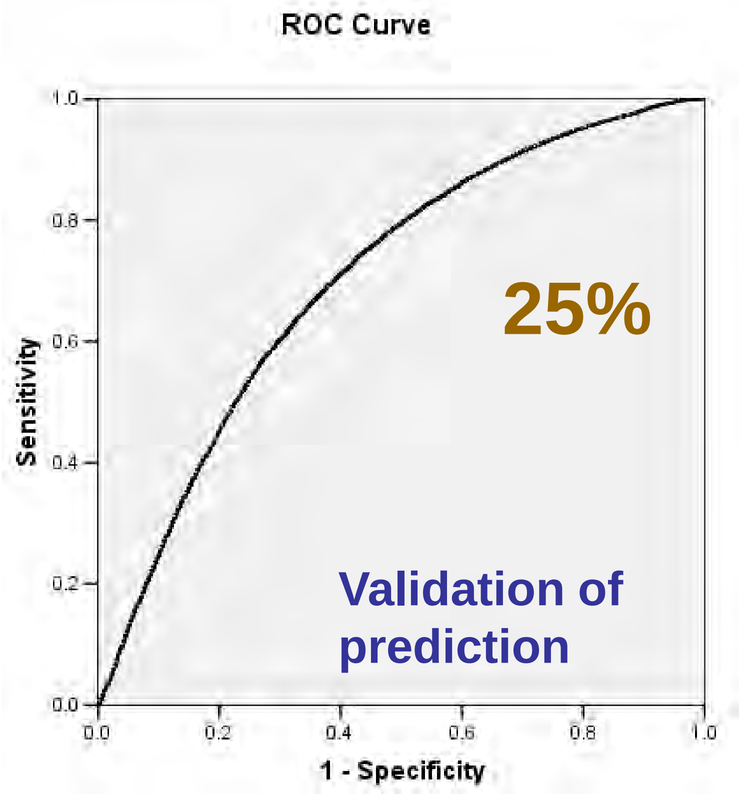
Maximum Entropy or Maxent Model:

75%

$$P = \frac{q(x)\, e^{entropy}}{1 + q(x)\, e^{entropy}}$$

P = probability of occurrence

Phillips et al (2006)



Why Maxent?

- require present-data only
- provide better accuracy
- work well with small sample size

Elith et al (2006)

Logistic threshold : Maximum training sensitivity plus specificity (Liu et al., 2005)

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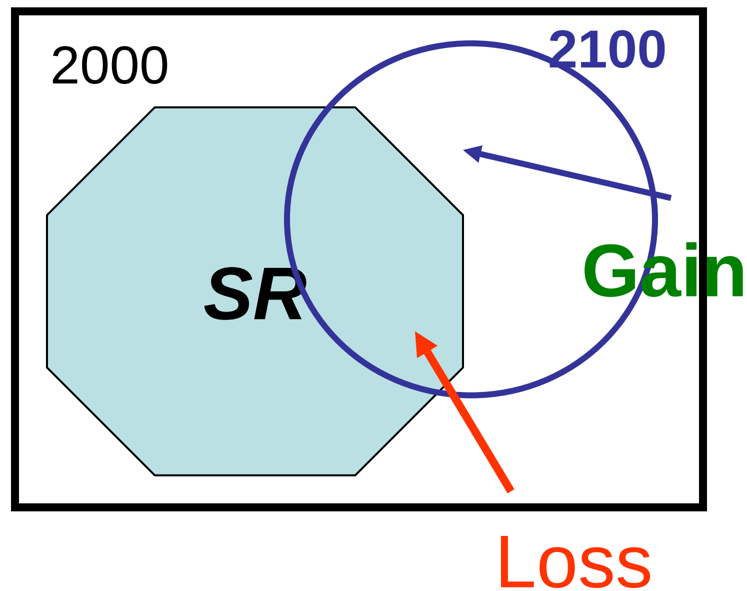
Impacts Assessment

Individual species

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

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



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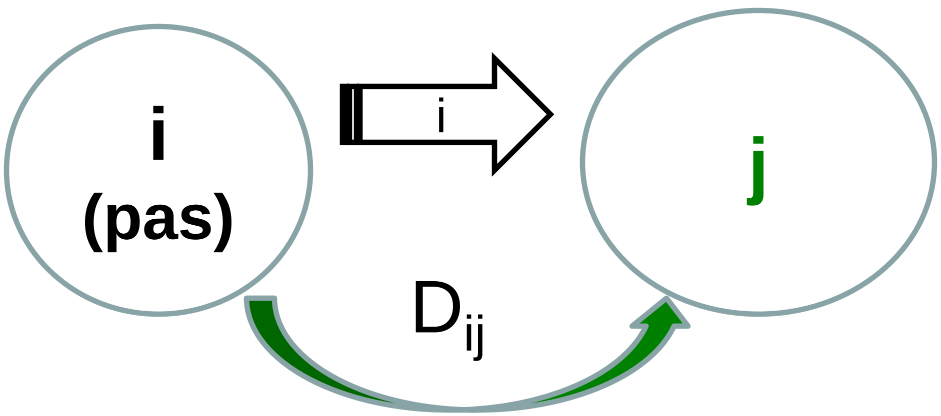
Conservation Adaptation to CC

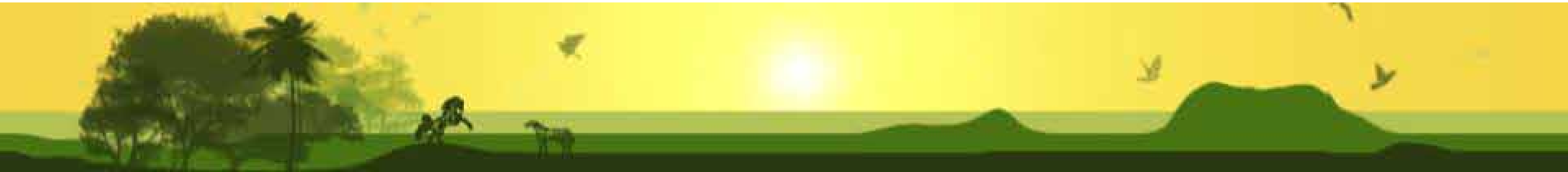
Gravity Model (Haynes and Fotheringham, 1984)

$$I_{ij} = \frac{(R_i \, x \, A_j)}{(D_{ij} \, x \, C_{ij})}$$



I_{ij}	= interaction volume from i to j or priority area
R_i	= assemblages of species at risk (2000)
A_i	= attractive factors going to j (naturalness and assemblages in 2100)
D_{ij}	= distance between existing protected areas and new area
C_{ij}	= connectivity between i and j (veg. & road buffer)

Results



Modeled species

All: 1,110 records of 57 Dip. spp.
from 8 genera (THA - 65 spp.)
Selection: 31 Dip. spp.

Genera:
- Anisoptera
- Dipterocarpus
- Hopea
- Neobalanocarpus
- Parashorea
- Shorea
- Vatica.

Top five species with high records:
- *Parashorea stellata - 110*
- *Dipterocarpus kerrii - 85*
- *Dipterocarpus baudii – 69*
- *Shorea gratissima - 67*
- *Hopea odorata - 55*

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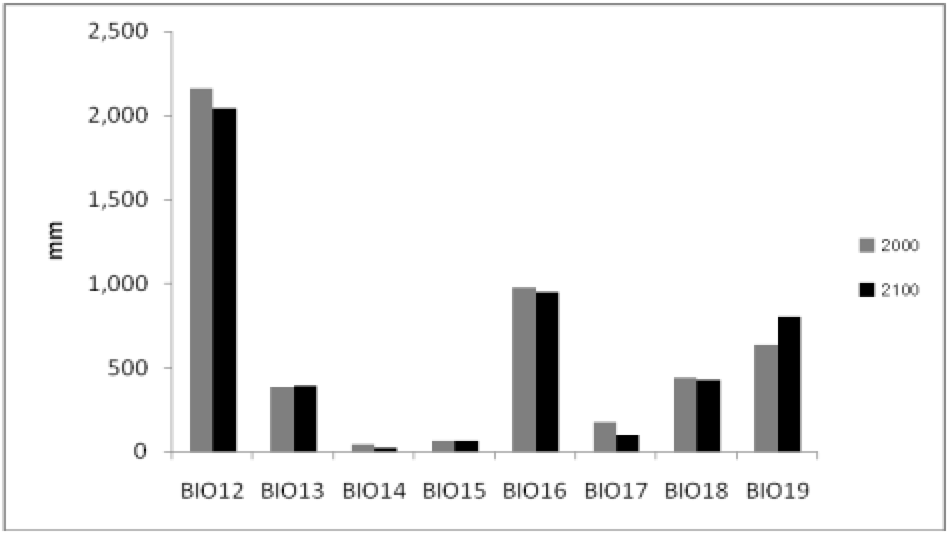
Current & predicted climate

- Latitude and longitude were not significant factors.
- Altitude was significant for all calibrated equations.
- Seasonal patterns are significant factors to distribution.

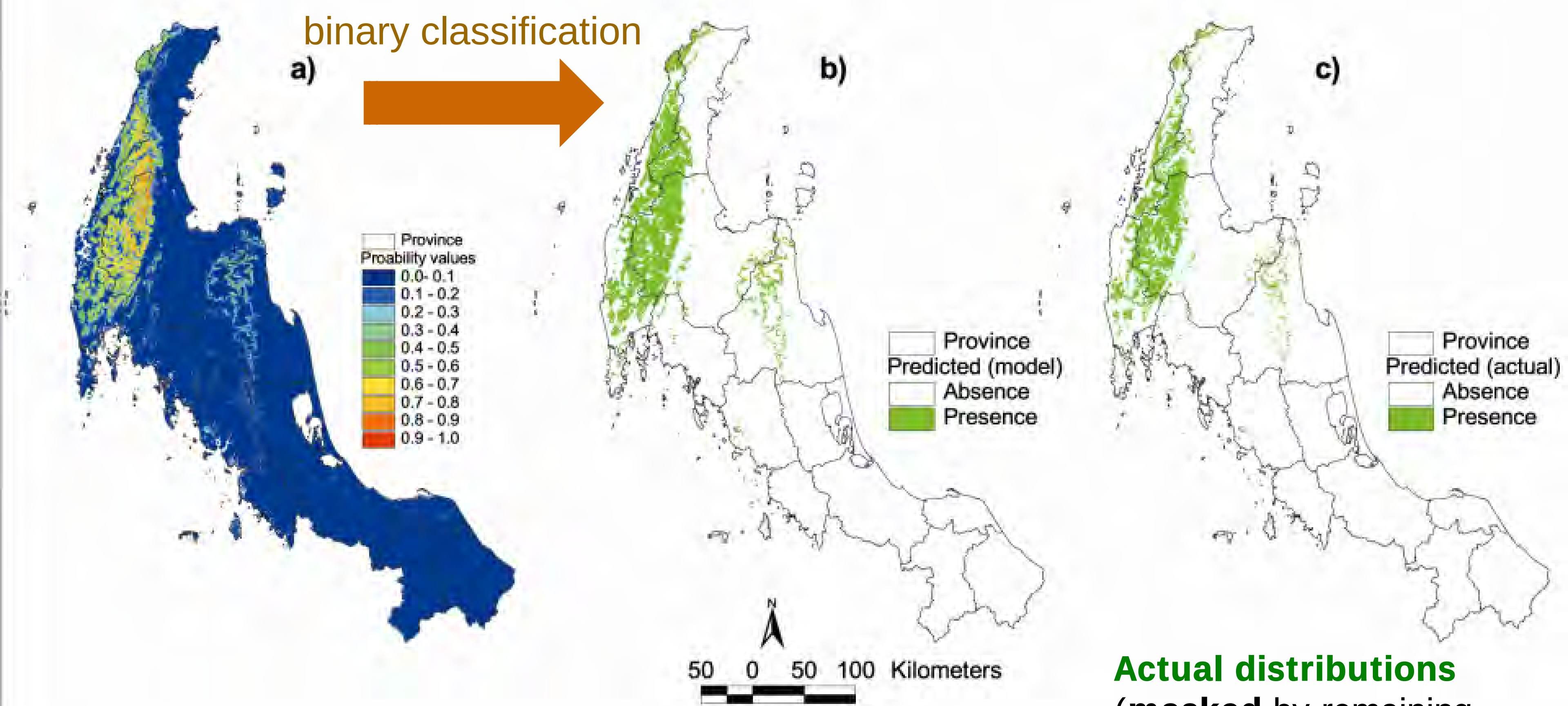


- mean T (Bio1) will increase from 26.6 °C ('00) to 28.7 °C (2100

- max. T (Bio5), min. T (Bio), mean T of driest Q (bio), and mean T of warmest Q (bio10) will increase relatively.

- annual rainfall will slightly decrease from 2,253 mm to 2,075 mm
- rainfall of wettest month (bio13) and wettest Q (bio16) – increase
- rainfall in the driest mnt. (bio14), Q (bio17) and warmest Q (bio18) - decrease.

Dipterocarp baudii



Probability values

Potential distributions

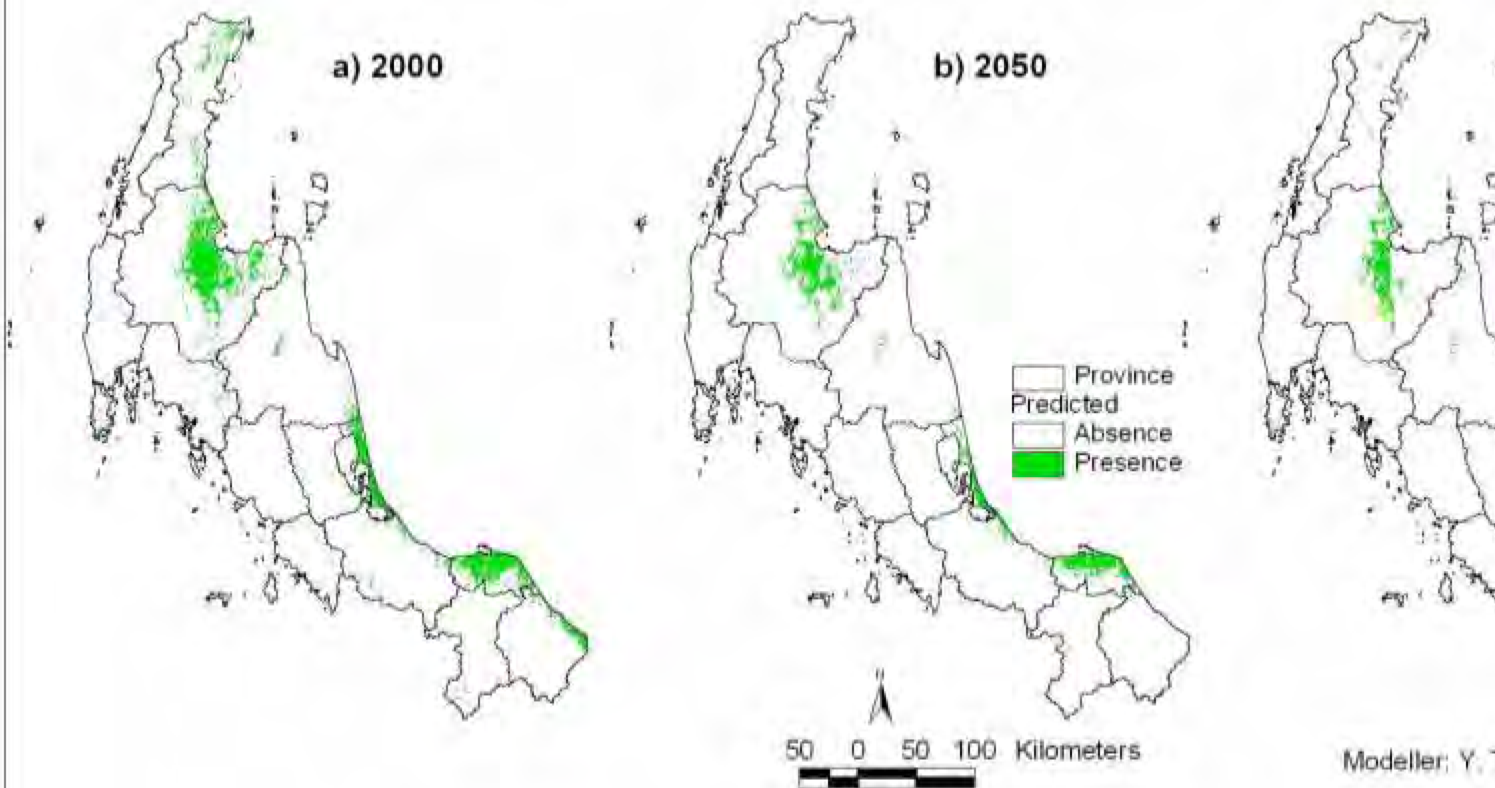
Actual distributions (**masked** by remaining forest cover)

Predicted extent of occurrence

Dipterocarp grandiflorus

5.1%

2.4%



Gain ~ 0%
Loss = 53%
Turn = 53%

IUCN B1 criterion: Low abundance >> **very low** abundance

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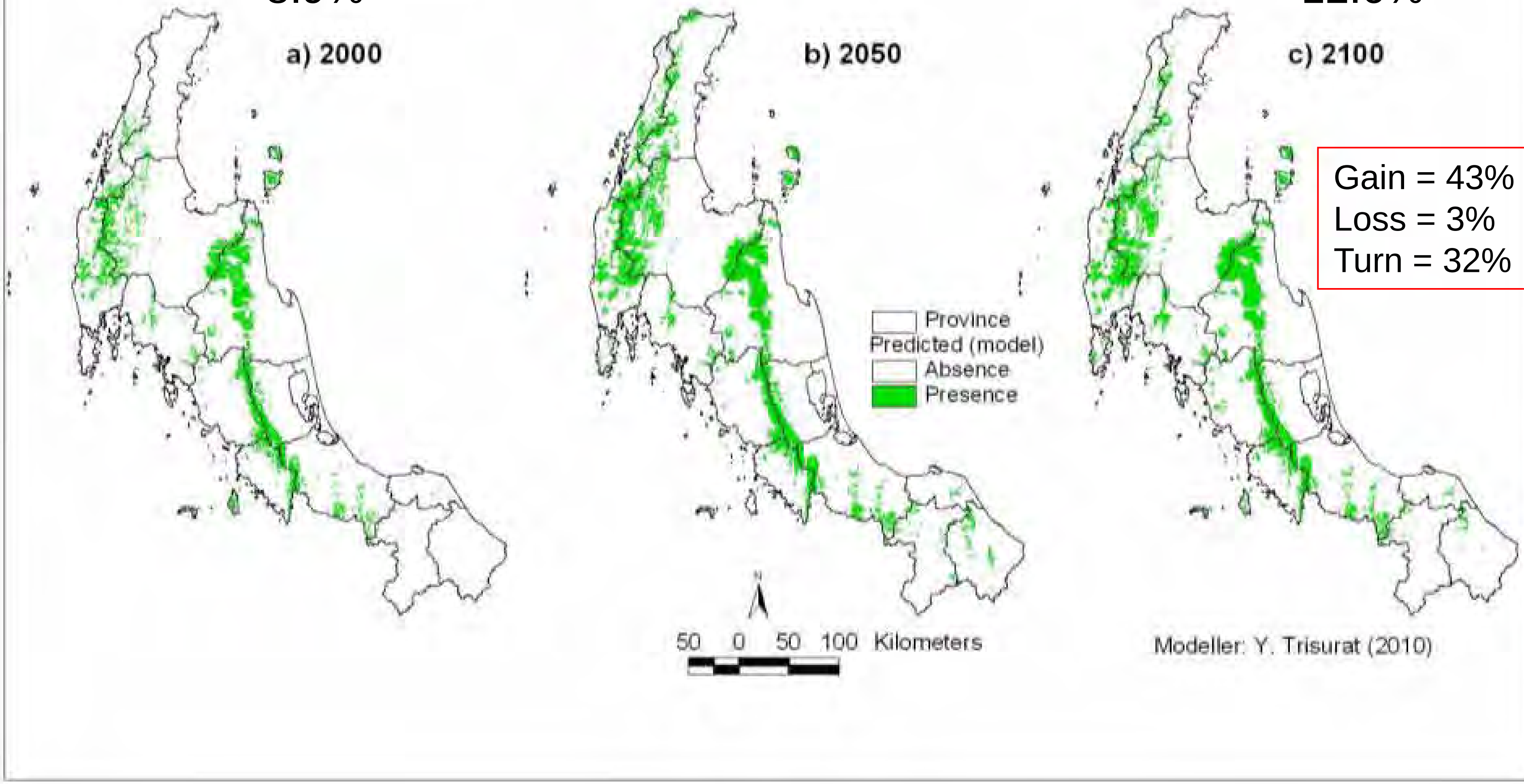
Ficus spp.

8.9% | 12.6%



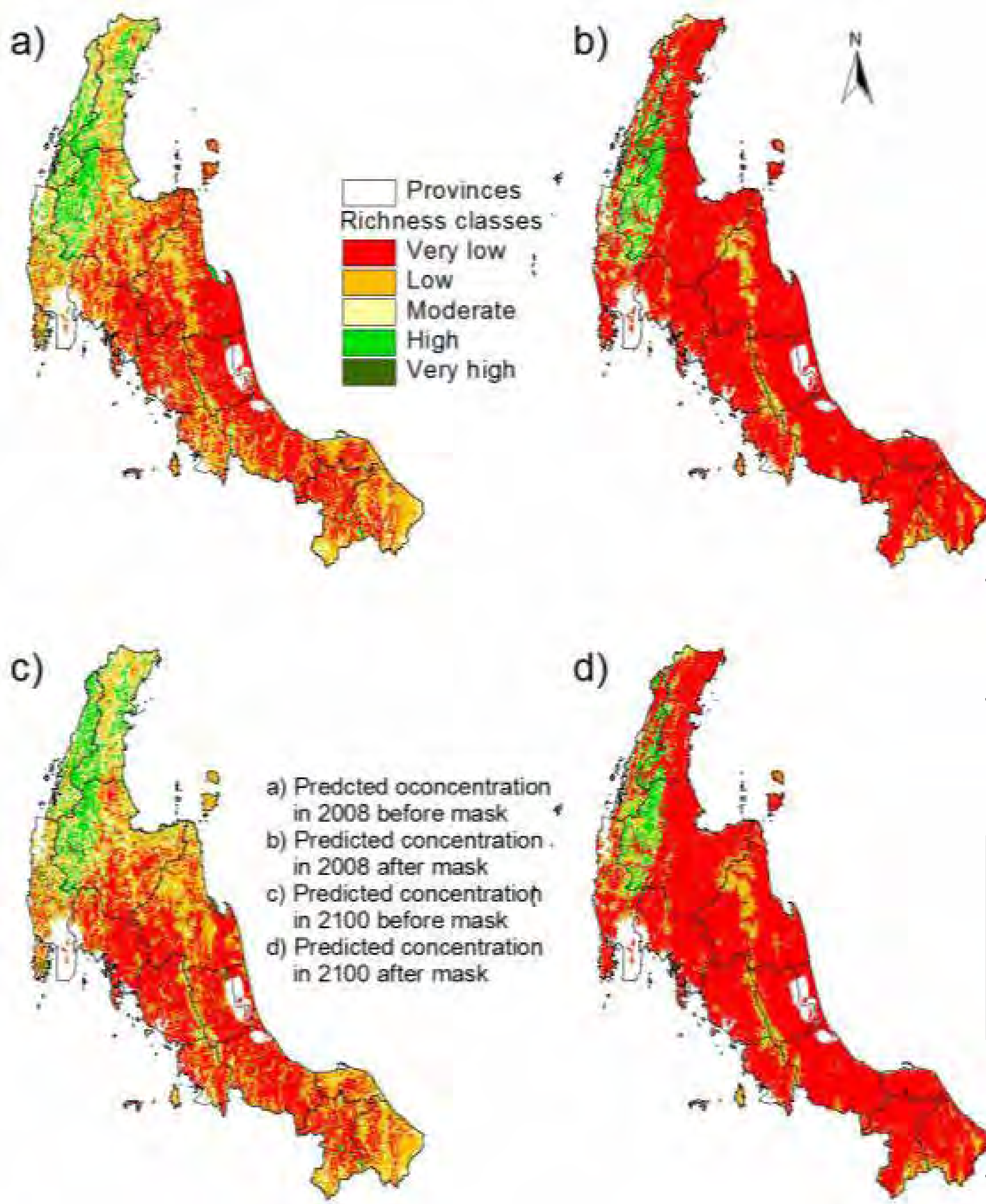
Gain = 43%
Loss = 3%
Turn = 32%

Common >> More common

14 species : suit. niches < 5% ; 7 species : suit. niches 5-10%
10 species: suit. niches > 10%

Family	Scientific name	2000	2100	2000-2100 (%) +/-	2000-2100 (%) **Turnover**
DIPTEROCARPACEAE	*Anisoptera costata*	10.34	9.70	-9.51	**66.92**
DIPTEROCARPACEAE	*Dipterocarpus alatus*	0.18	0.13	-18.75	**55.70**
DIPTEROCARPACEAE	*D. chartaceus*	0.49	0.19	-61.2	**62.93**
DIPTEROCARPACEAE	*D. costatus*	6.37	6.10	-2.69	**41.94**
DIPTEROCARPACEAE	*D. dyeri*	4.40	4.32	-0.23	**40.05**
DIPTEROCARPACEAE	*D. grandiflorus*	5.07	2.41	-51.70	**52.89**
EUPHORBIACEAE	*Croton sp.*	12.66	10.40	-14.54	**31.77**
FABACEAE	*Parkia timoriana*	3.14	4.24	38.56	**34.41**
GUTTIFERAE	*Calophyllum calaba*	4.70	4.90	3.35	**38.91**
MORACEAE	*Ficus racemosa*	4.87	5.54	12.83	**33.32**
MORACEAE	*Ficus sp.*	8.97	12.60	6.87	**32.50**
MYRTACEAE	*Syzygium sp.*	6.83	6.54	-6.86	**30.54**

15 spp. gain, 16 spp., lose suit. niches
12 species **Turnover rate >30%**



Diptercarpus spp. richness (31 spp.)

Very low = <4
Low = 4-7
Moderate = 7-10
High = 10-14
Very high = > 14

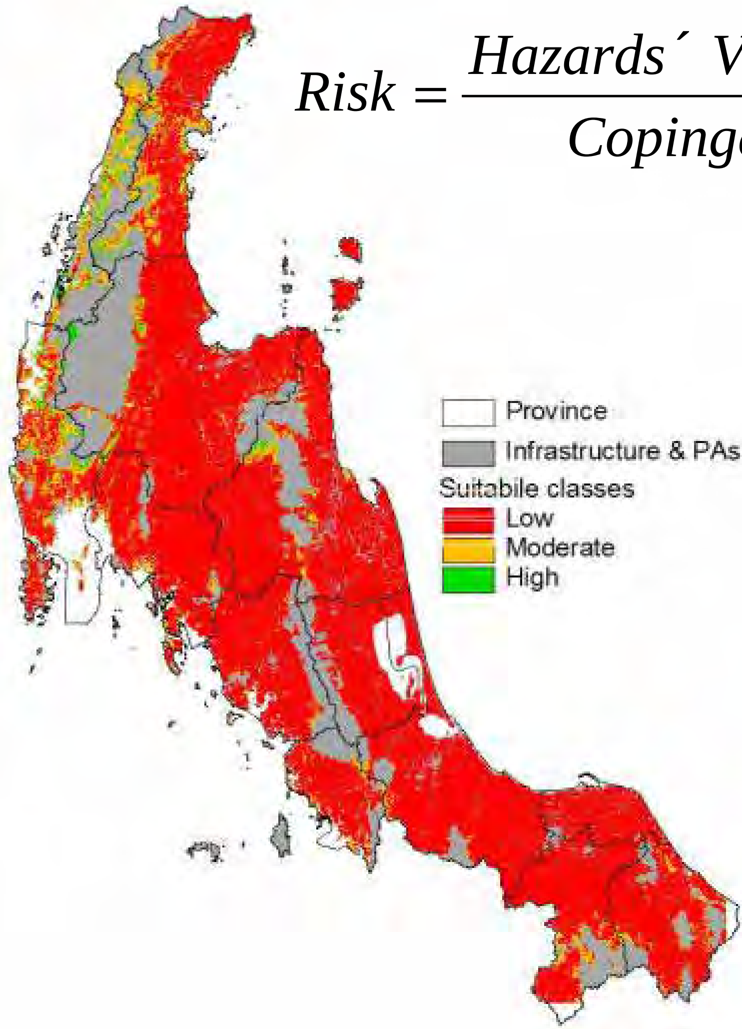
Classes	2000 (%)		2100 (%)	
	Pot.	Act.	Pot.	Act.
Very low	40	77	39	78
Low	35	11	35	13
Moderate	16	7	16	4
High	8	5	8	5
Very high	1	0	2	0
Concent.	**25**	**12**	**26**	**9**
PAs	**38**	**72**	**38**	**75**

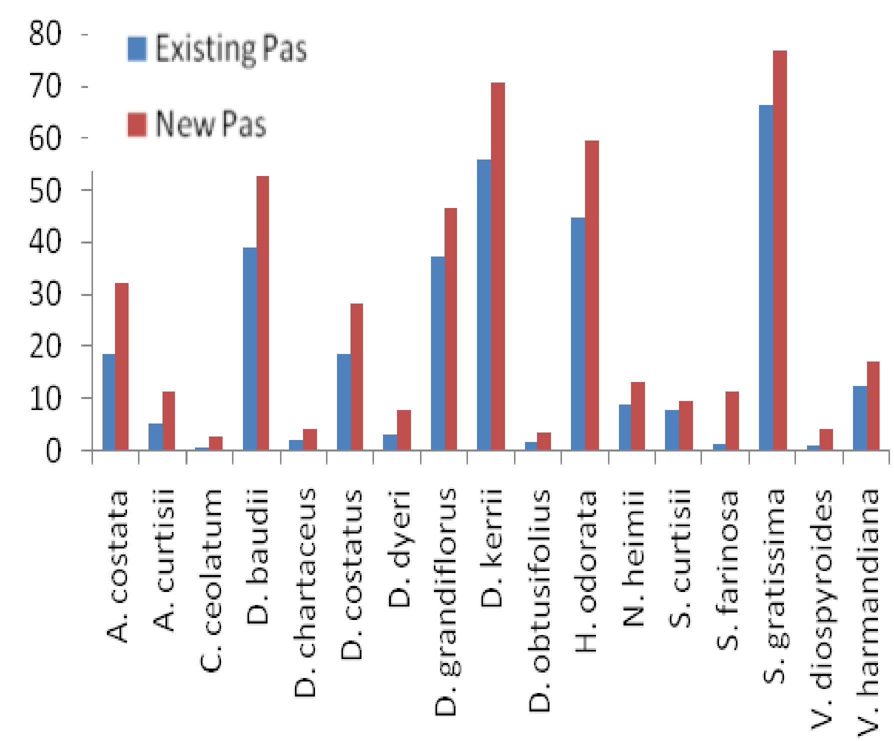
Pot. Potential; **Act**. Actual

Priority areas for additional PAs

$$Risk = \frac{Hazards \times Vulnerability}{Copingcapacity}$$

Risk Class	Current	New Pas
	14.8%	25%
Ex	5	0
H	8	9
M	5	7
L	13	15





No.	Species	Extent 2000(%)		Current	New
		Poten	Actual	status	status
1	*Anisoptera costata*	11.00	3.64	H	H
2	*A. curtisii*	9.32	1.22	Ex	H
3	*Cotylelobium lanceolatum*	18.25	1.53	Ex	H
4	*D. baudii*	11.12	5.80	H	H
5	*D. chartaceus*	15.67	1.39	Ex	H
6	*D. costatus*	9.33	2.94	H	H
7	*D. grandiflorus*	22.19	1.88	H	M
8	*D. obtusifolius*	16.41	1.72	Ex	H
9	*Neobalanocarpus heimii*	1.44	2.57	H	H
10	*S. farinosa*	25.44	2.21	Ex	H
12	*Vatica diospyroides*	13.58	1.15	H	M
13	*V. harmandiana*	5.95	1.06	H	H

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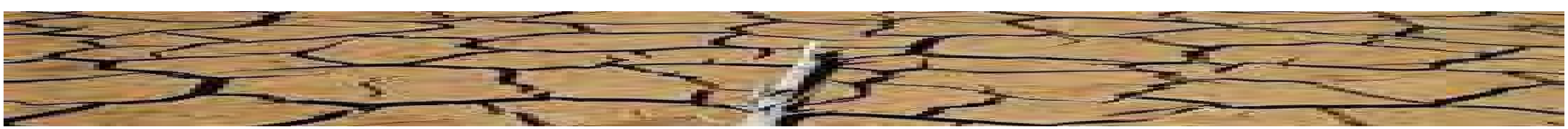
Conclusions

National studies

- A rise in mean temperature of 1.5-2.0 °C by 2100 and an increase in annual rainfall.

Southern region

- mean temperature will rise by 2.1°C from 2000 to 2100 and annual precipitation will decrease by 178 mm.
- More rainfall in wet and cold months but less in dry months

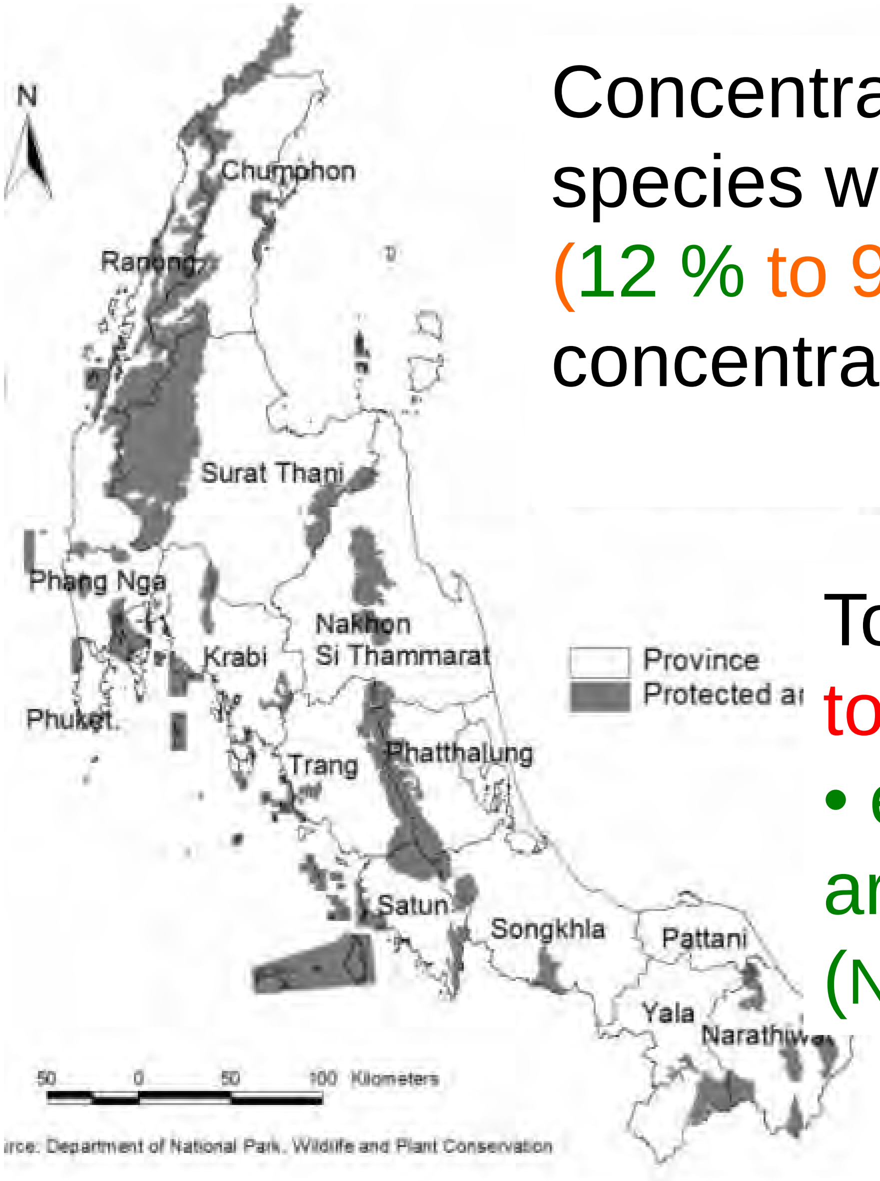


Potential impacts on species distribution

- 15 spp. will gain and 16 spp. will lose suit. niches. *(need more records – 3 approaches)*
- 12 spp. will shift current range of >30%
- 13 spp. were classified as at risk to CC

- Major changes are predicted for dipterocarpus species with a prolonged rainy season that have less drought tolerance (Baltzer et al., 2007, 2008):
- *D. baudii (IUCN CR* - lowland evergreen forests;
- *D. grandiflorus* (*CR* - primary dipt. forest-convert.)
- *Anisoptera costata (EN – humid lowland)*
- *Cotylelobium lanceolatum (VU – localizes in peninsular Malaysia)*

Concentrations of studied species will be likely to decrease (12 % to 9%) and >70% of concentration are situated in pas.



To maximize species resilience to CC

• expanding existing protected areas from 15% to 25% (Nat. Conv. Policy, forest -30%).

Linking CC with driver from LU change (more) ??

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Plant species vulnerability to climate change in Peninsular Thailand

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Full Length Research Paper

Projecting forest tree distributions and adaptation to climate change in northern Thailand

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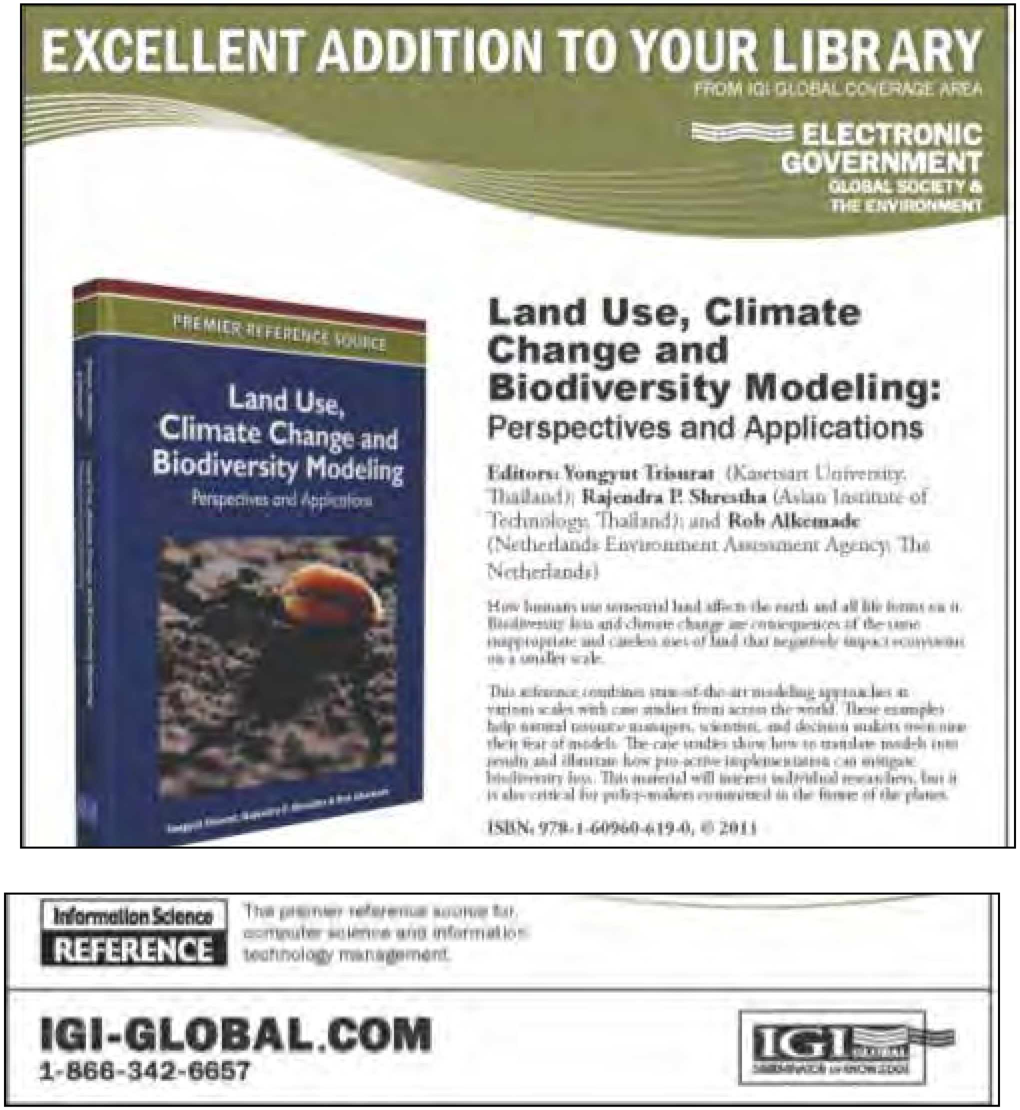

Recent publication 2011

20 Chapters

Part I: Introduction

Part II: Setting the scene

Part III: Methods: Land use and biodiversity modeling

Part IV: Case studies

Part V: Conclusion

Models

- CLUE-s
- GLOBIO3
- Maxent
- GLM
- etc.

Cases

- Asia
- Europe
- C/S America
- Africa

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- Royal Forest Department
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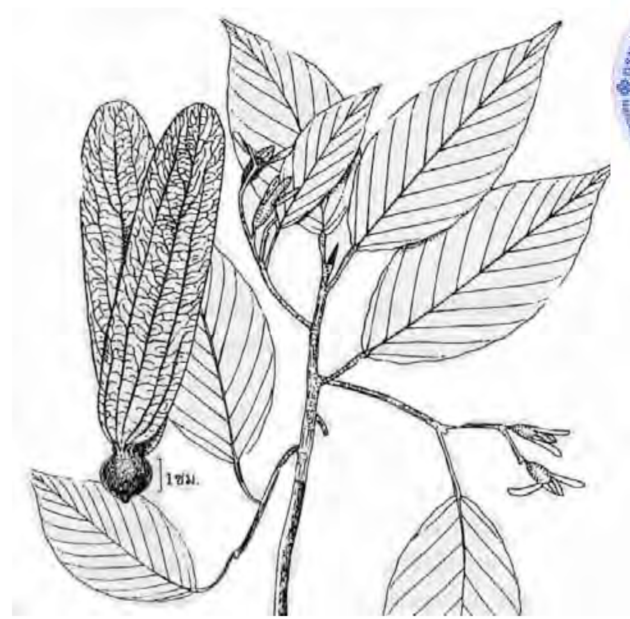

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