Construction of the cost curve step 1
Tuesday 26 April 2011 9:00 - 10:30
Bangkok

Land Use Dynamics and Drivers of Change: Analysis of patterns and opportunities for REDD+

ASB Partnership for the Tropical Forest Margins

Meine van Noordwijk, World Agroforestry Centre TRANSFORMING LIVES AND LANDSCAPES

Acknowledging: Sonya Dewi, Andree Ekadinata, Atiek Widayati, Valentina Robiglio, Doug White & Glen Hyman

How to describe land use & land cover in the context of REDD+

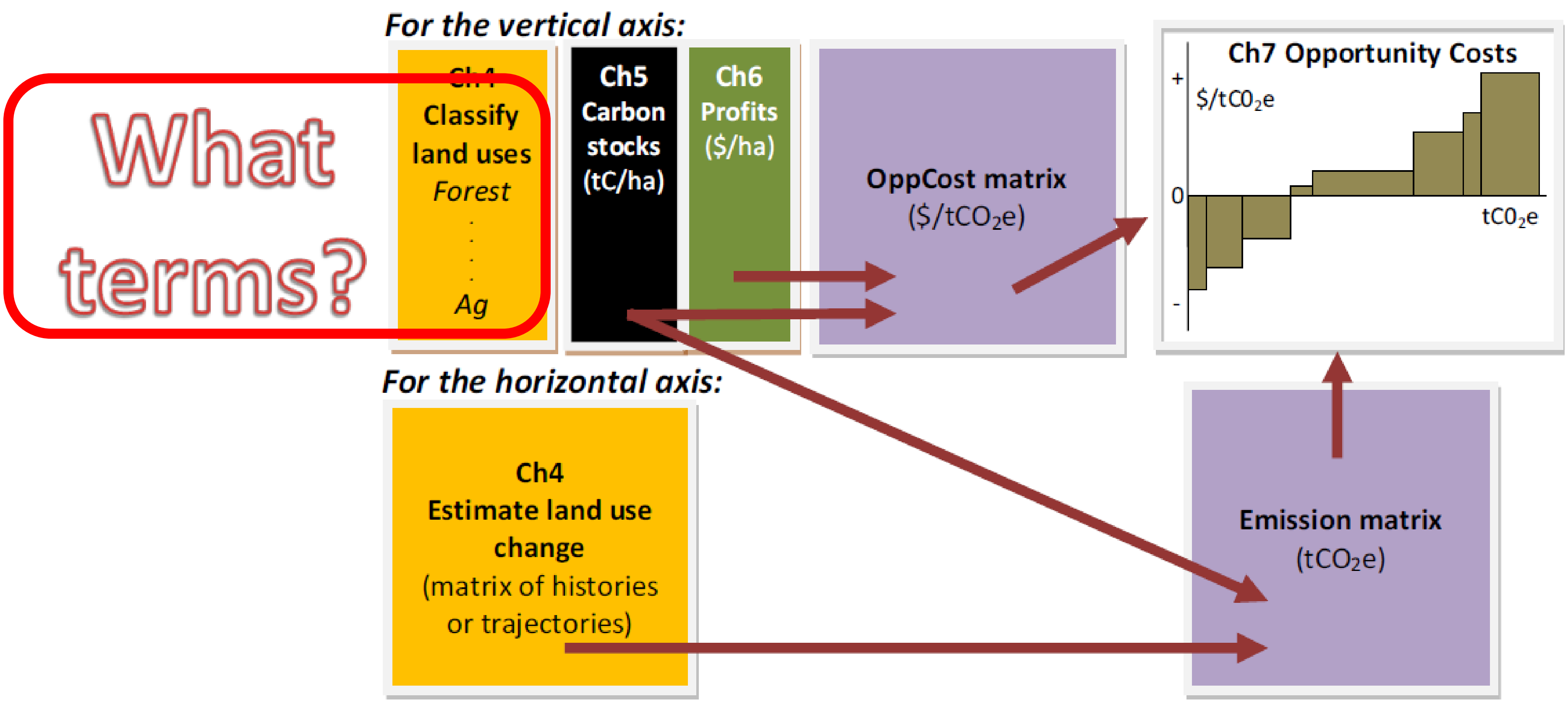

Figure 2.1. Analytical steps for developing an opportunity cost curve

Land Use Dynamics and Drivers of Change: Analysis of patterns and opportunities for REDD+

Outline

1. Forest definition, land use change and REDD+ eligibility
2. Land use ~ series of land cover types as basis for OpCost analysis: ***legend***
3. Land cover observation → land use interpretation
4. Accuracy in relation to scale and use
5. Land use change matrix and its use

Brief 01

ALLREDDI

Accountability and Local Level Initiative to Reduce Emission from Deforestation and Degradation in Indonesia

http://www.worldagroforestry.org/sea/Publications/files/policybrief/PB0018-11.pdf
Indonesia's land-use and land-cover changes and their trajectories (1990, 2000 and 2005)

http://www.worldagroforestry.org/sea/Publications/files/policybrief/PB0019-11.pdf
Forest carbon-stock estimates based on National Forest Inventory data

http://www.worldagroforestry.org/sea/Publications/files/policybrief/PB0020-11.pdf
Estimating losses in aboveground carbon stock from land-use and land-cover changes in Indonesia (1990, 2000, 2005)

http://www.worldagroforestry.org/sea/Publications/files/policybrief/PB0021-11.pdf
Institutionalising emissions reduction as part of sustainable development planning at national and sub-national levels in Indonesia

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REDD+

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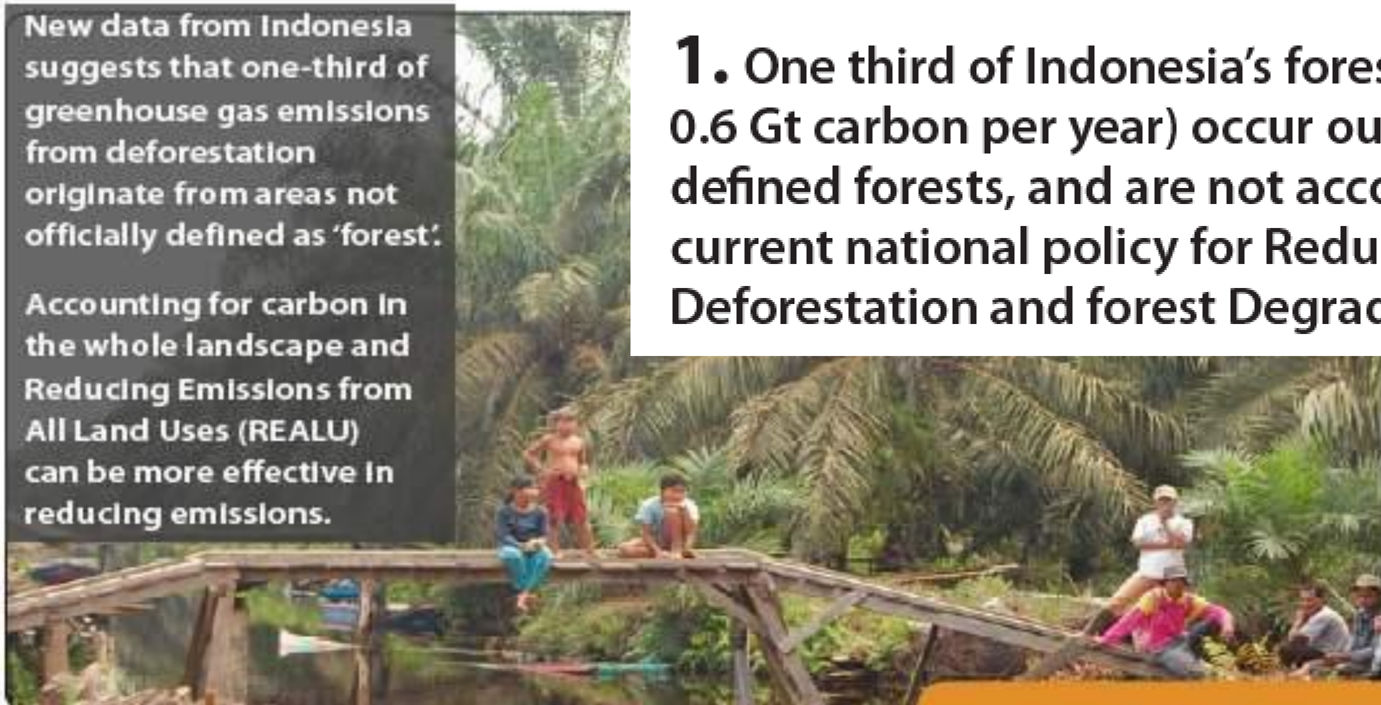
Policy*briefs* 16

Reducing emissions from deforestation, inside and outside the 'forest'



New data from Indonesia suggests that one-third of greenhouse gas emissions from deforestation originate from areas not officially defined as 'forest'.

Accounting for carbon in the whole landscape and Reducing Emissions from All Land Uses (REALU) can be more effective in reducing emissions.

1. One third of Indonesia's forest emissions (total of 0.6 Gt carbon per year) occur outside institutionally defined forests, and are not accounted for under the current national policy for Reducing Emissions from Deforestation and forest Degradation (REDD+).

http://www.asb.cgiar.org/

Main findings

1. One third of Indonesia's forest emissions (total of 0.6 Gt carbon per year) occur outside institutionally defined forests, and are not accounted for under the current national policy for Reducing Emissions from Deforestation and forest Degradation (REDD+).

Implications

- Current REDD+ approaches in Indonesia may not reduce net CO_2 emissions
- An approach for Reducing Emissions from All Land Uses

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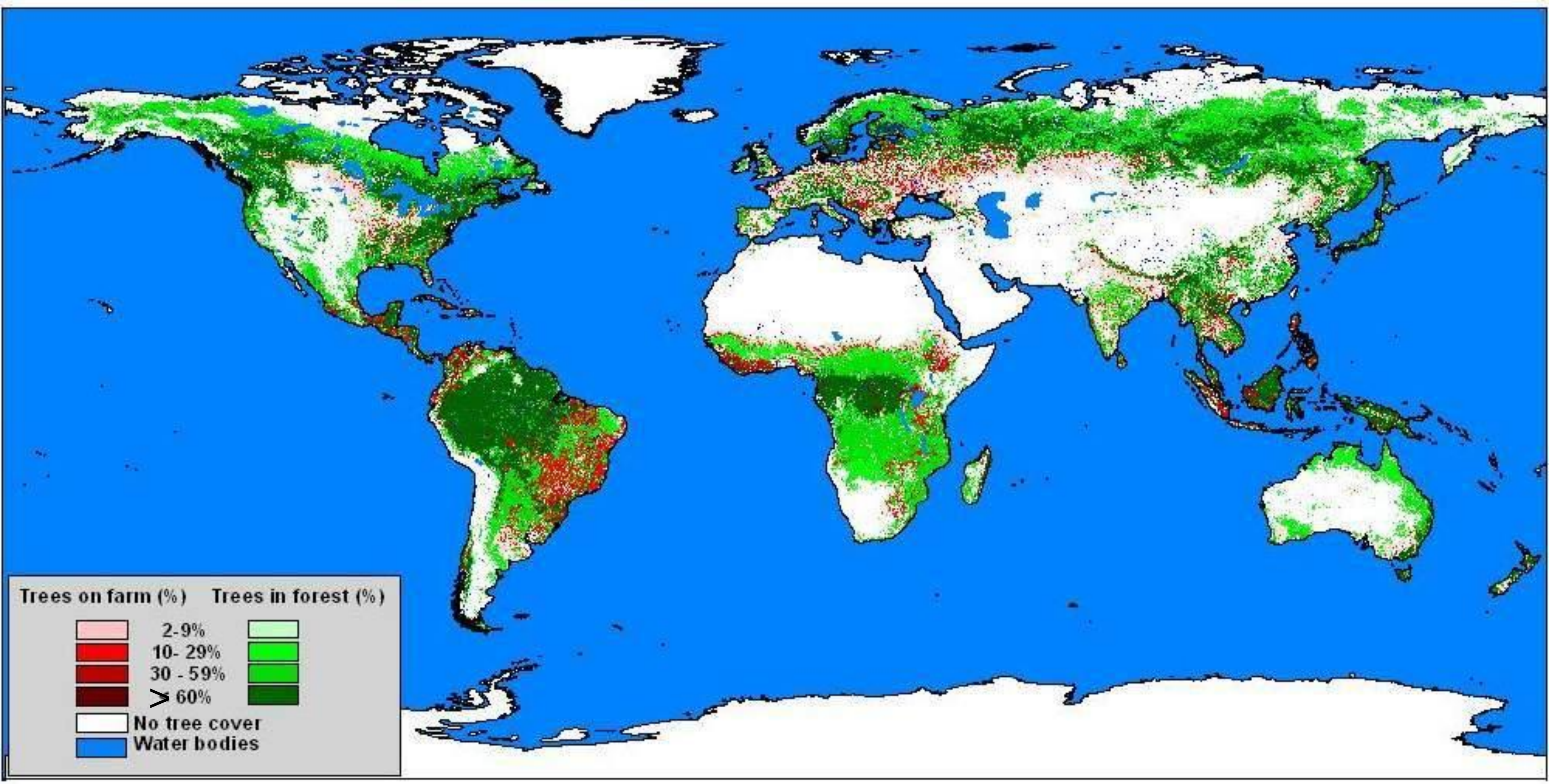
English	Thai	Khmer	Lao	Vietnam	Bahasa Indonesia
Forest					
Woodland					
Agroforest					
Secondary forest					
Old growth forest					
Plantation					
Tree					
Palm					
Rubber					

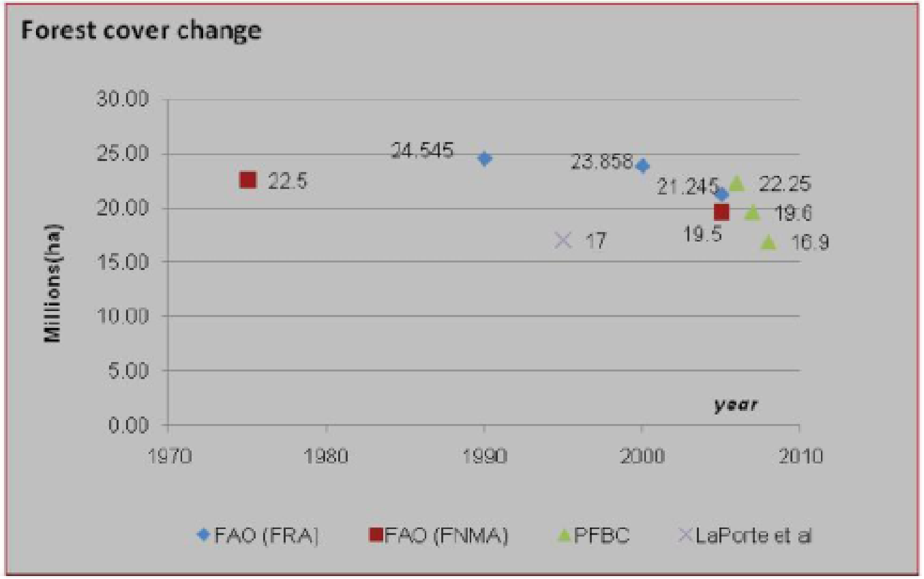


The holistic forest+tree view of the world

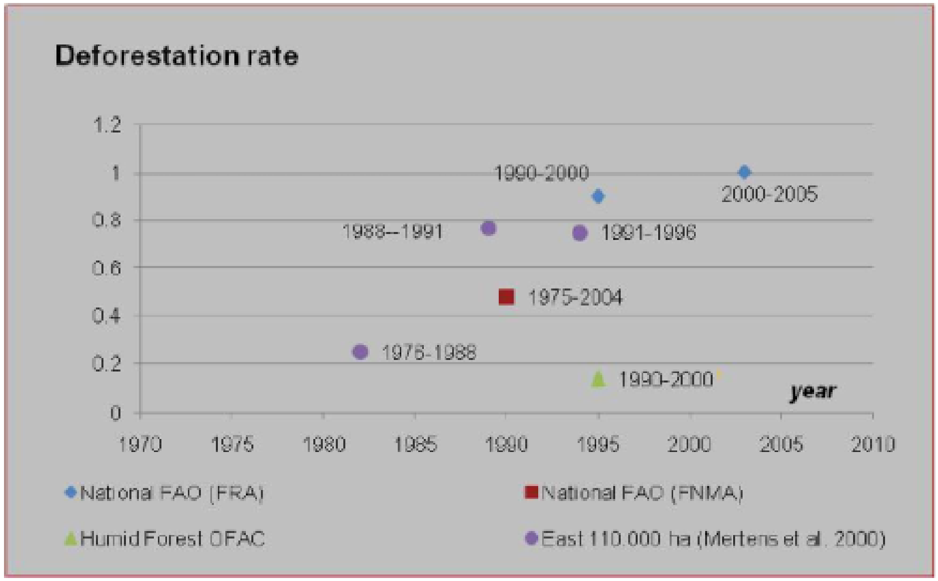
Source: Global tree cover inside and outside forest, according to the Global Land Cover 2000 dataset, the FAO spatial data on farms versus forest, and the analysis by Zomer et al. (2009)

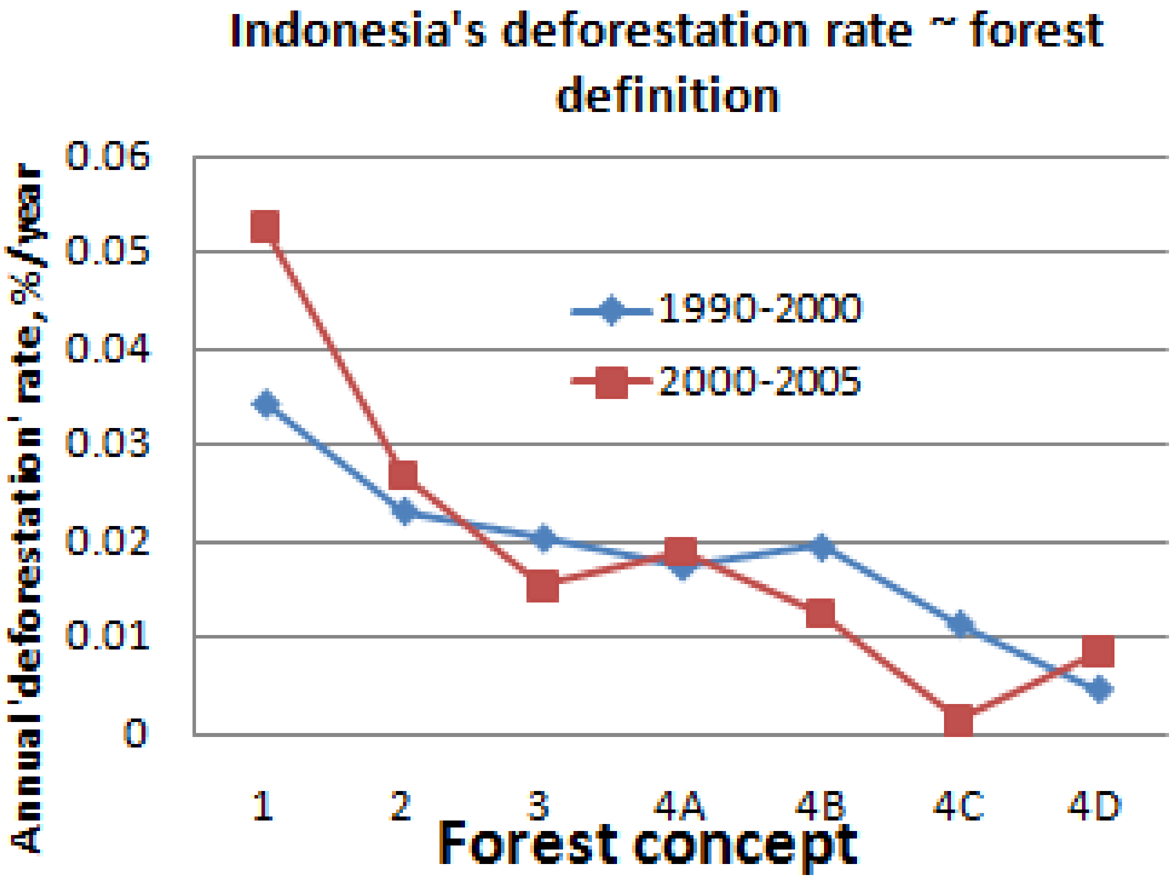
Published forest cover data and deforestation data have little consistency; reasons are: differences in remote sensing approach (source & procesing) and differences in forest definition

Forest cover data



Deforestation rates





Stakeholder:

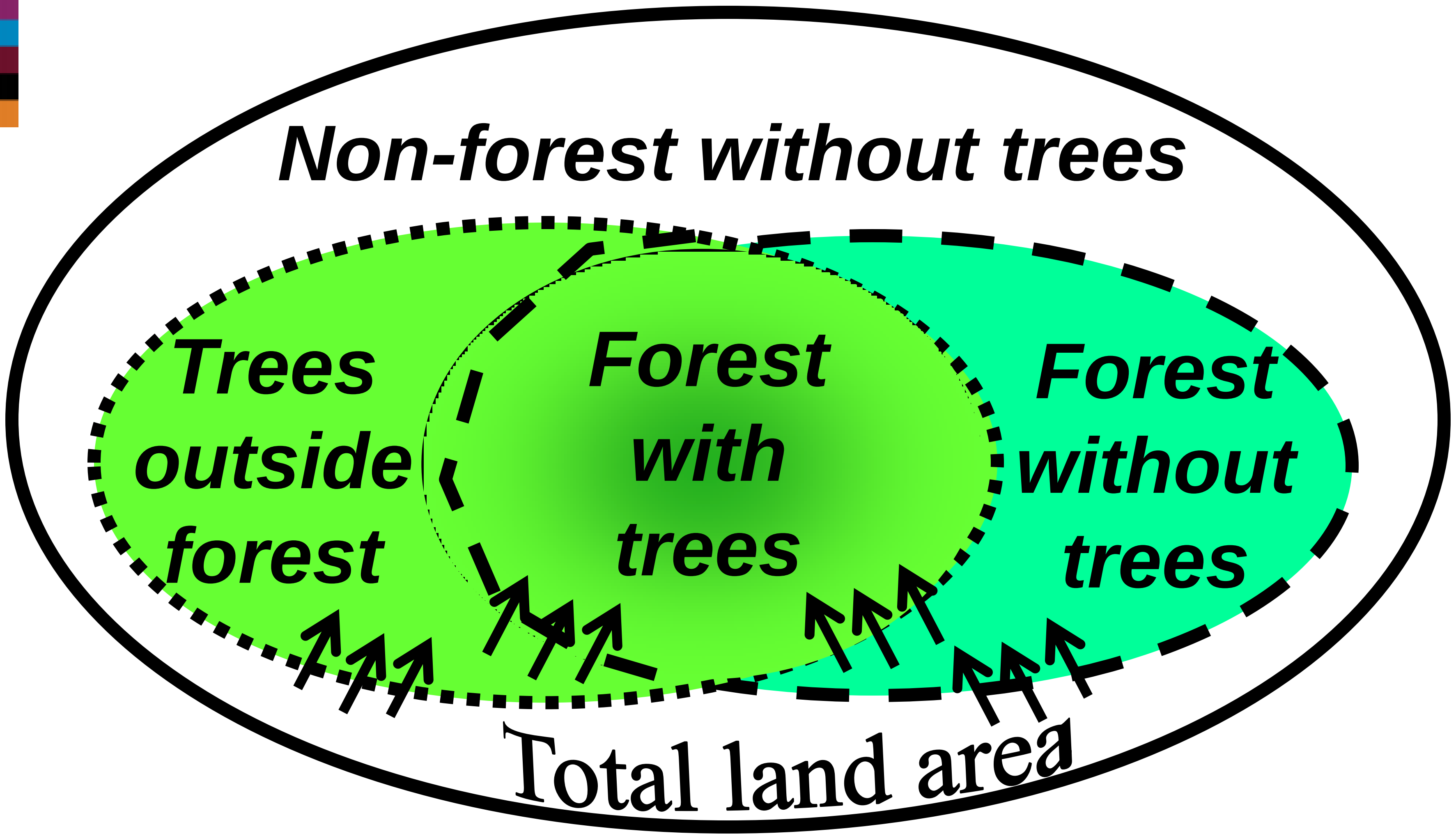
1. Undisturbed natural forest ← *Rainforest foundation*
2. Undisturbed + sust. logged natural forest ← *Conservation agency*
3. Closed canopy undisturbed + logged forest

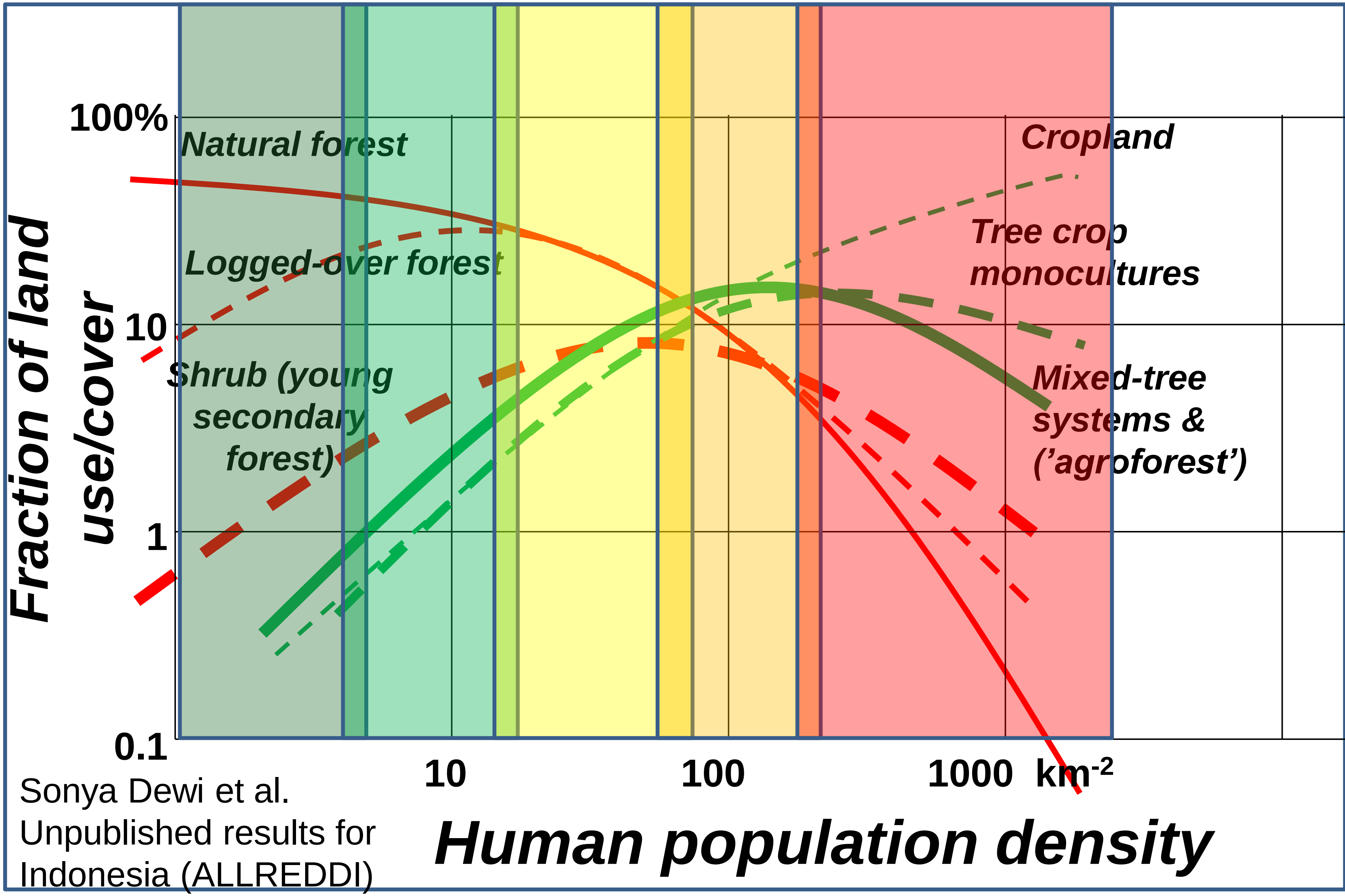
4A. as 3 + agroforest ← *Forest ecologist*

4B. as 3 + timber plantations ← *Ministry of Forestry*

4C. as 3 + agroforest + timber plant's + estate crops ← *UNFCCC definition*

4D as 4C + shrub ← *Modis data*


Non-forest without trees
Trees outside forest
Forest with trees
Forest without trees
Total land area



Fraction of land use/cover
100%
10
1
0.1
Natural forest
Logged-over forest
Shrub (young secondary forest)
Cropland
Tree crop monocultures
Mixed-tree systems & ('agroforest')
10
100
1000
km-2
Human population density
Sonya Dewi et al.
Unpublished results for
Indonesia (ALLREDDI)

SPACE ≈ TIME ??

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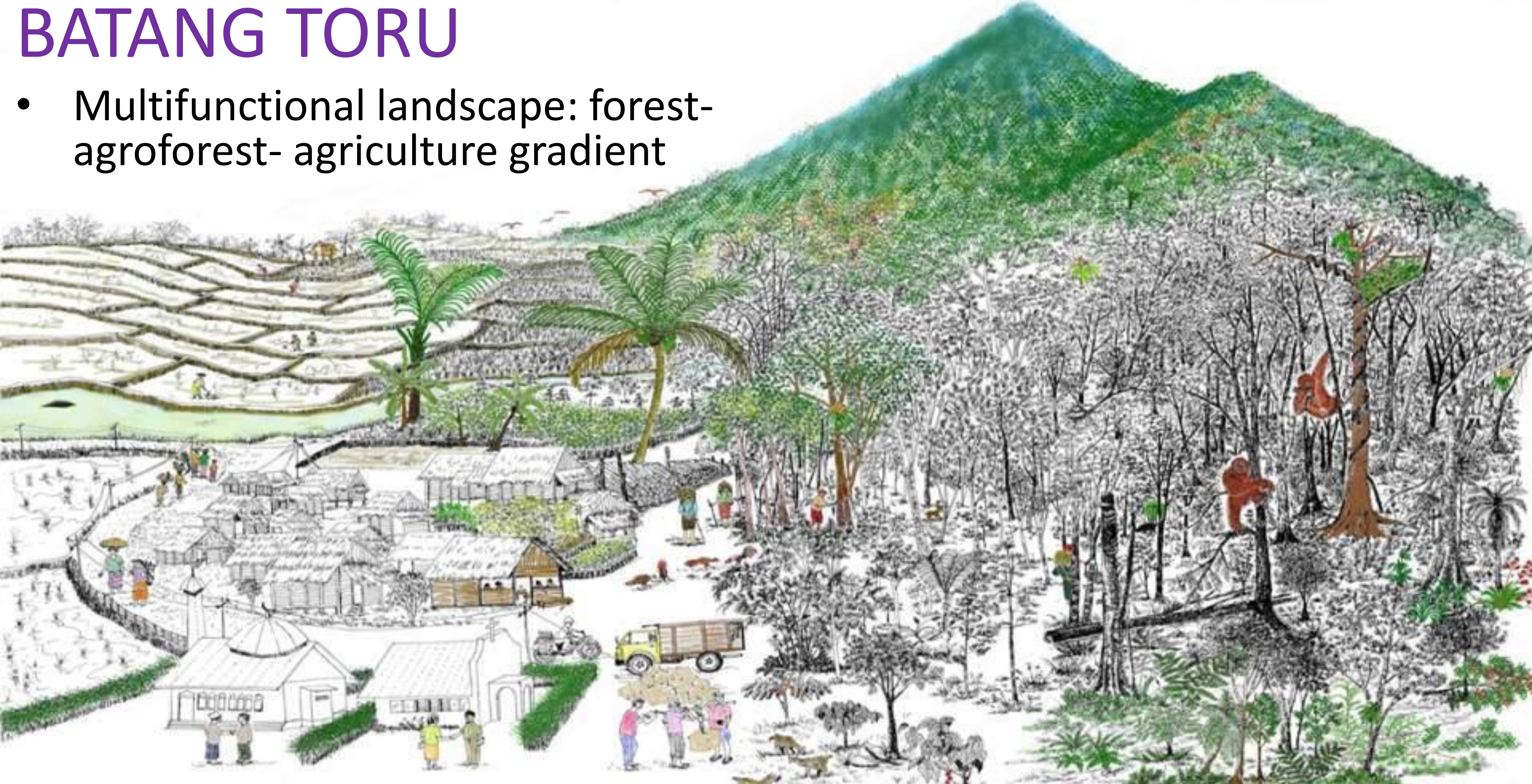
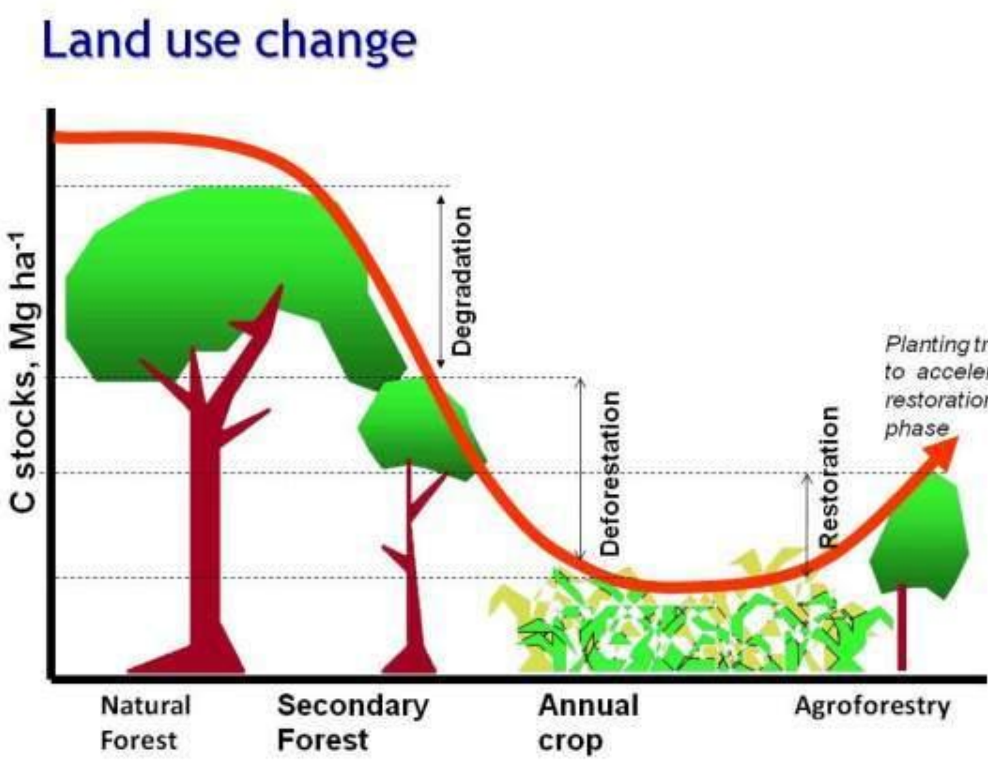
BATANG TORU

- Multifunctional landscape: forest-agroforest- agriculture gradient



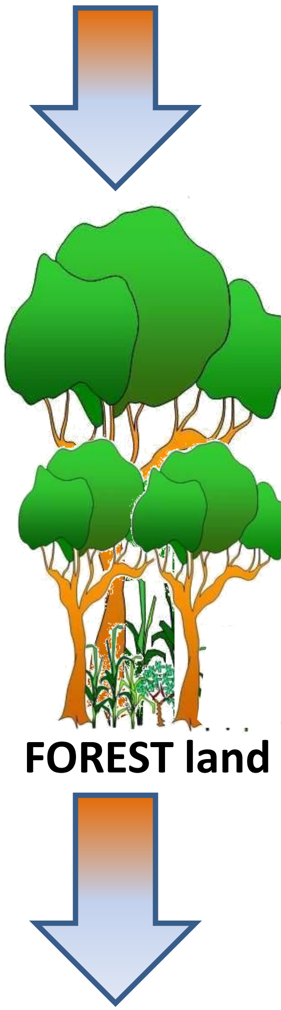
A. Stock - Difference

The difference between C-stocks gives C emissions



B. Gain-Loss

C-emissions are calculated from gain minus loss



C-gain

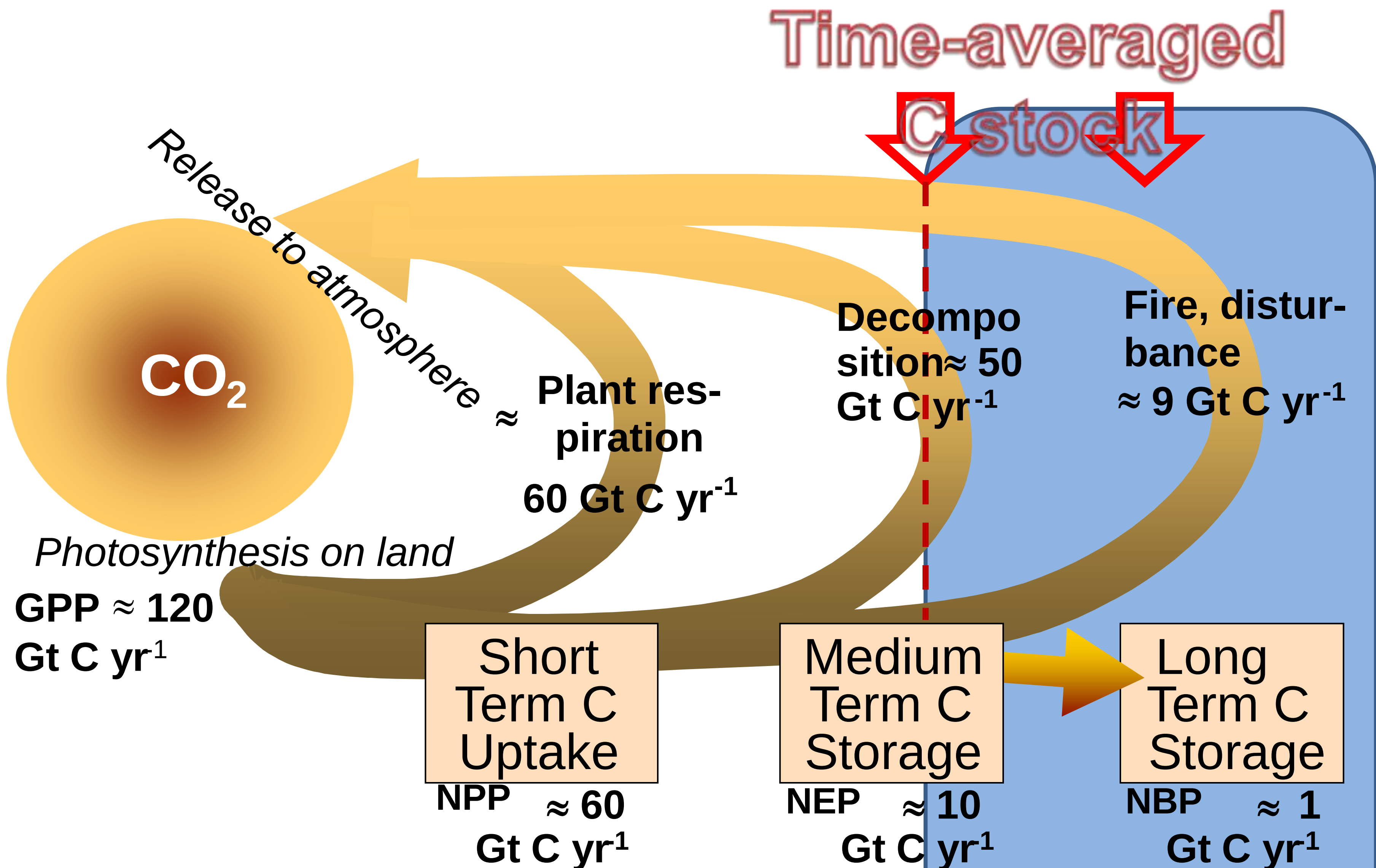
- Growth
- Enrichment

C-loss

- Timber harvests
- Fuelwood removals
- Charcoal production
- Fires
- Grazing

ΔC Landscape = Activity data × Emission factor

ΔC Landscape	Activity data	Emission factor
Annual changes in C-stocks in the landscape (ton C yr^{-1})	ACTIVITY DATA Area of changes between each pairwise of land cover types (ha y^{-1})	Changes in time-averaged C-stock between each pairwise of land cover types



GPP = Gross Primary Productivity
NPP = Net Primary Productivity
NEP = Net Ecosystem Productivity
NBP = Net Biome Productivity

Land cover ≠ Land use

The distinction between land use and land cover is at the basis of the development of a LU legend that is

1) Carbon relevant;
2) Profitability relevant ;
3) Compatible with existing standards;
4) Compatible with ongoing national REDD efforts.

Land Unit

Land Unit :

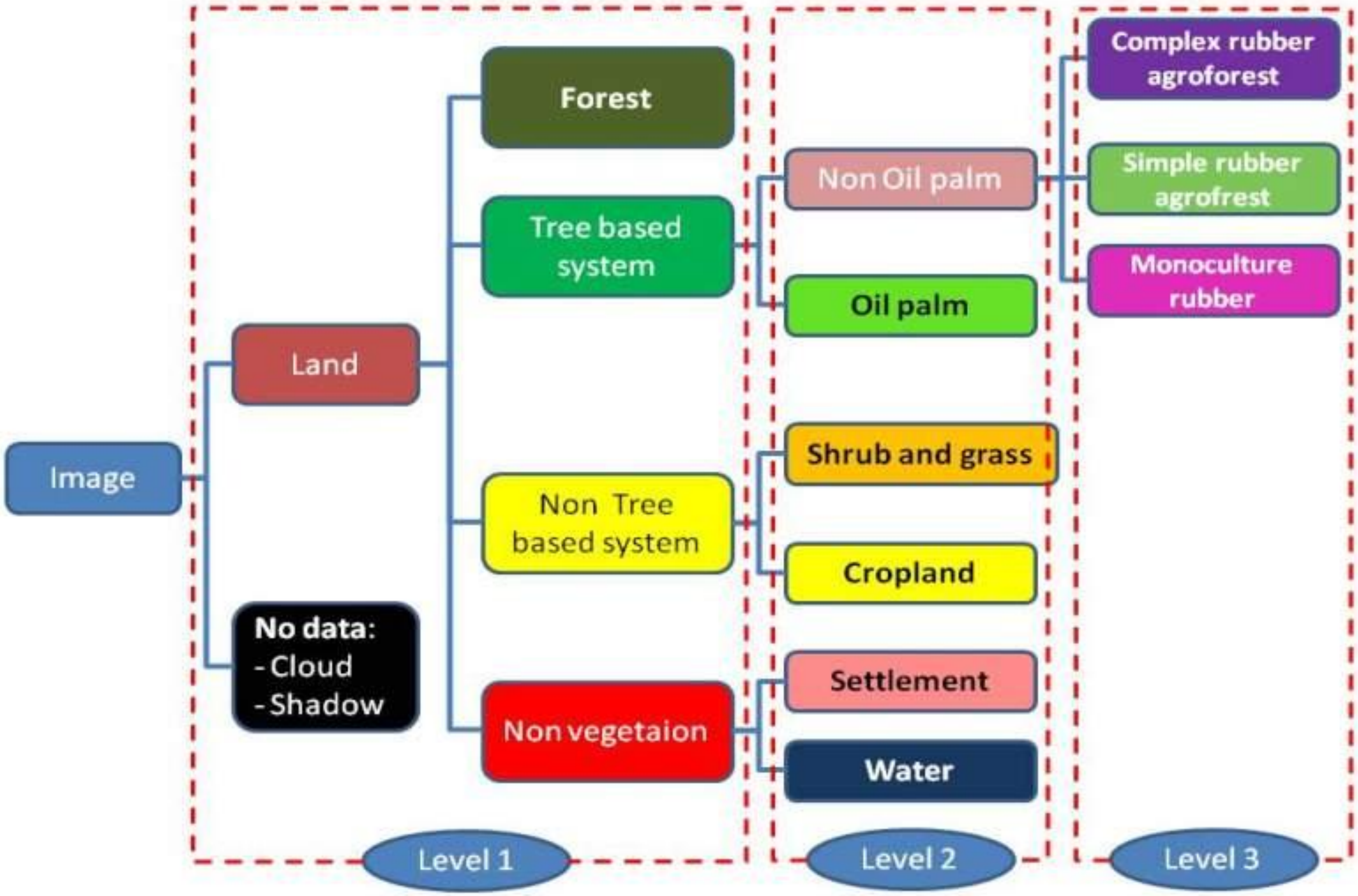
Ecologically homogeneous tract of land at the scale of issue

Land Unit attributes

- Vegetation/land cover
- Land Use
- Carbon
- Soil
- Geology….

LCCS: http://www.glcn.org

Hierarchical classification approach



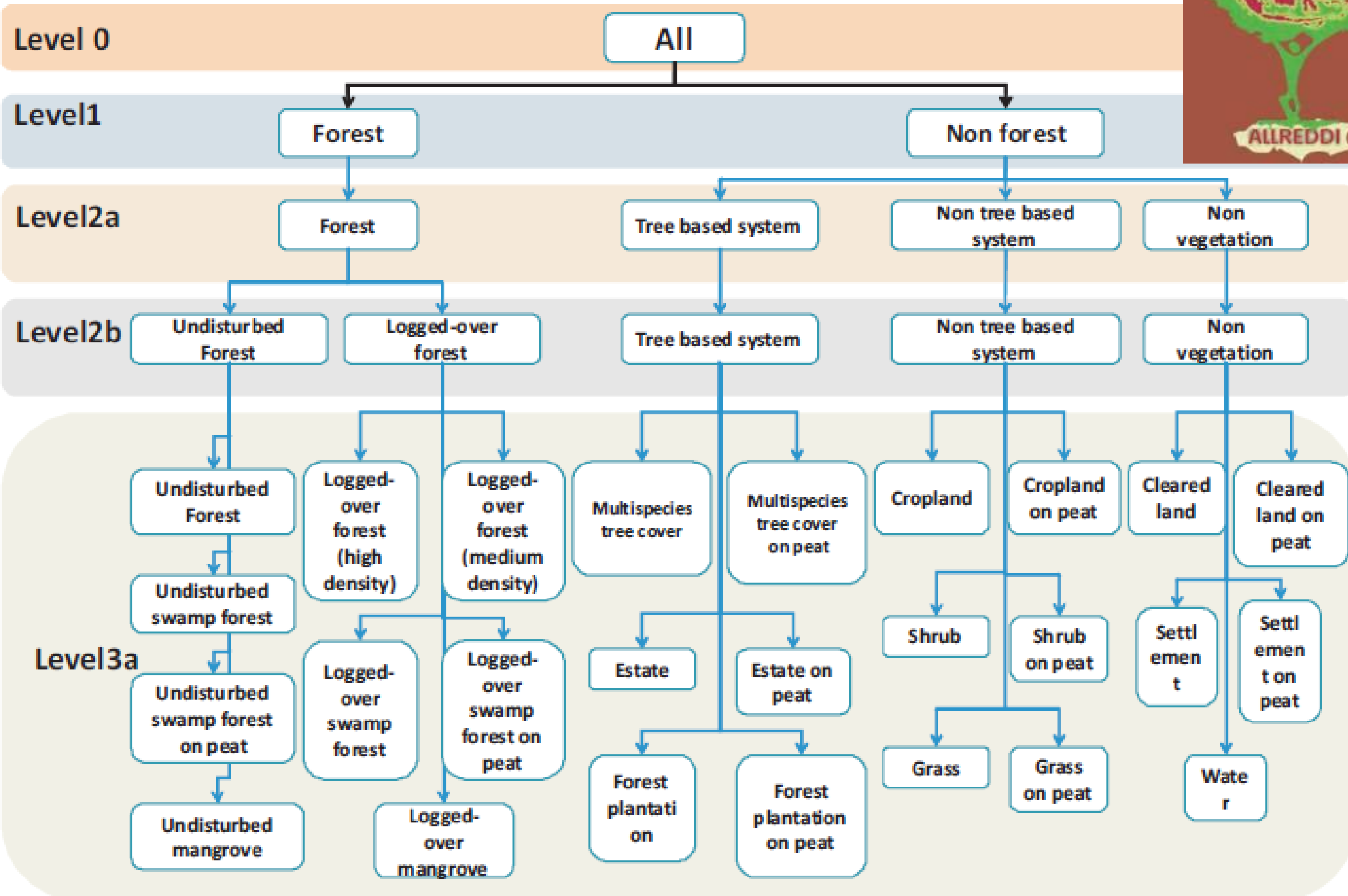


Figure 2. Hierarchical classification scheme.

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Table 4.2. Characteristics of satellite images

Satellite	Sensor	Resolution (Spatial)	Orbit cycle	Image cost
TERRA	MODIS	250 m 500 m 1000m	2 days	Low
LANDSAT 7	ETM+	15 m (185 km) 30 m (185 km)	16 days	Medium
DMC II		32 m (80x80 km)	1 day	Medium
SPOT 1-3	XS PAN	20 m (60x60 km) 10 m (60x60 km)	26 days	Medium
SPOT 4	XS PAN VGT	20 m (60x60 km) 10 m (60x60 km) 1 (2000 km)	26 days	Medium
SPOT 5	HRS HRG	10 m (60x60 km) 5 m (60x60 km)	26 days	Medium
TERRA	ASTER	15 m 30 m		Medium
IRS-C	Pan LISS-III	5.8 m (70 km) 23 m (142 km)	24 days	Medium
IKONOS	PAN MS	1 m (min10 x 10 km) 4 m (min10 x 10 km)	3 days	High
QUICKBIRD		2.5 m (22x22 km) 61 cm (22x22 km)	3 days	High
ALOS	PRISM AVNIR2 PALSAR	2.5 m (70 km) 10 m (70 km) 10 m (70km)	46 days	High

There are many types of satellite imagery.

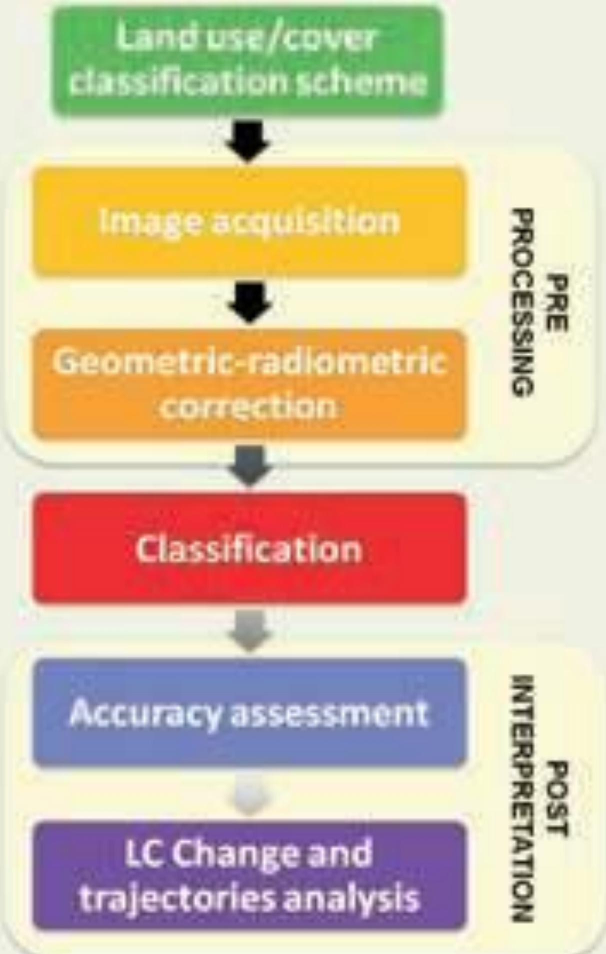
How to choose?

websites for acquiring data:

- the United States Geological Survey's GLOVIS site (http://glovis.usgs.gov/)
- Global Land Cover Facility at the University of Maryland (http://glcf.umiacs.umd.edu/index.shtml).

Technical Sourcebook:

- GOFC-GOLD on REDD (for Monitoring and Reporting) (http://www.gofc-gold.uni-jena.de/redd/index.php)



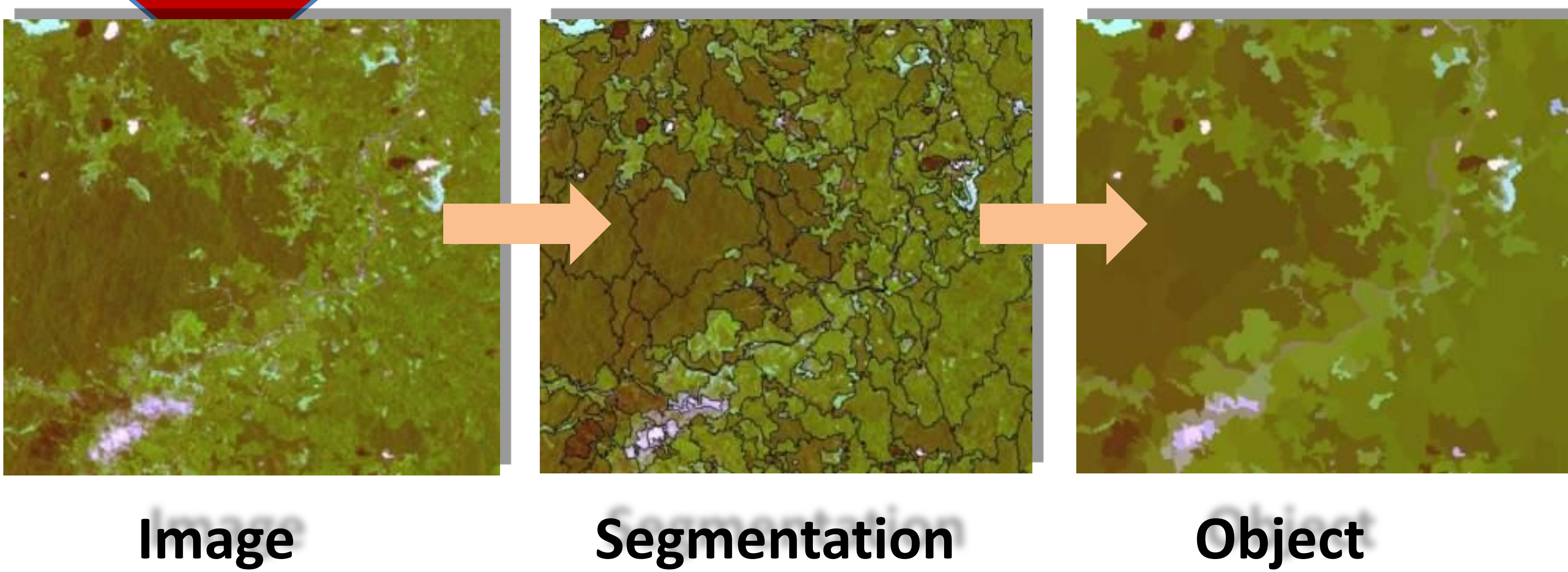
Four stages of ALUCT:

1. **Clarification of the questions**, leading to the level of detail needed in the legend of land cover types and the resolution of images needed to do so
2. ***Image acquisition* and *pre-processing***: Selecting the resolution, spectral properties and source of the images, selecting an image date relevant to the study and of sufficient quality (low cloud cover)
3. ***Image classification*** based on ground-truth sample points and/or pre-established spatial patterns,
4. ***Post interpretation analysis*** focussed on the research questions of interest, usually linking 'land use' and system life cycles to the land cover types that can be recognized

Image processing
- Acquisition
- Geometric and atmospheric correction

Classifi-cation
- Segmentation and classification
- Draft map production

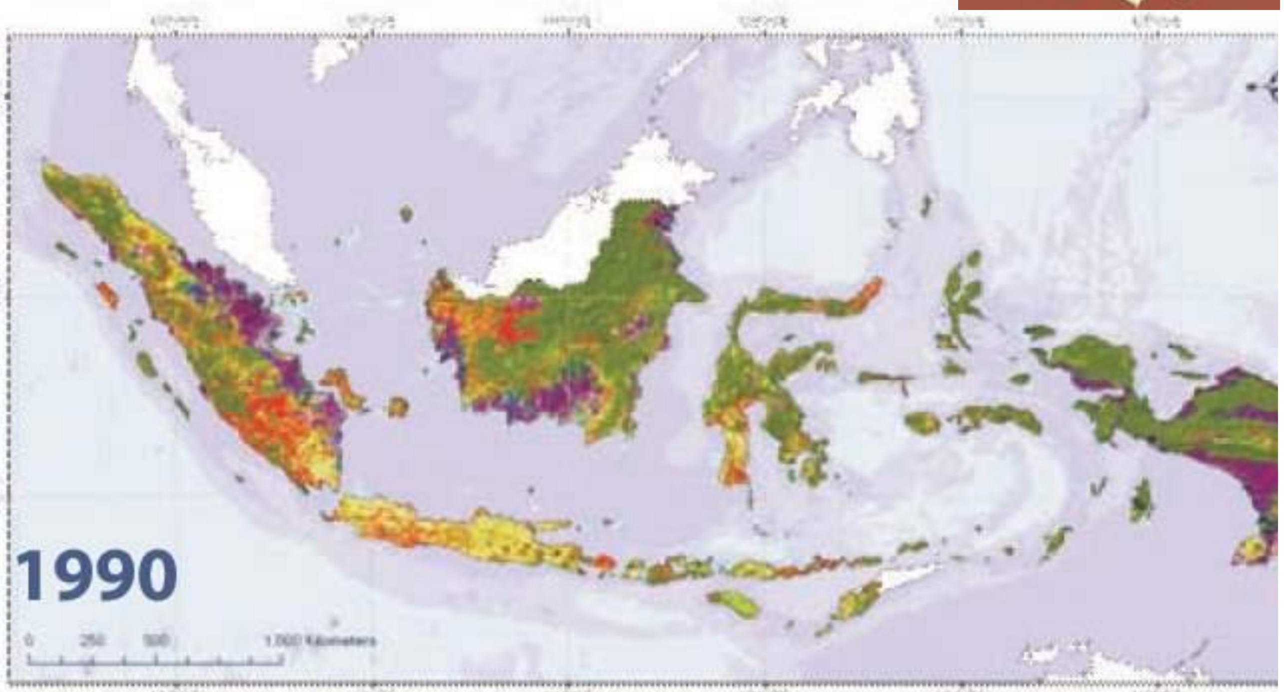
Post inter-pretation
- Accuracy analysis
- Final map & change analysis



ALLREDDI

Legend

- Agroforest
- Agroforest on peat
- Cleared Land
- Cleared Land on peat
- Cloud and shadow
- Cropland
- Cropland on peat
- Estate
- Estate on peat
- Grass
- Grasss on peat
- Logged over forest-high density
- Logged over forest-low density
- Logged over mangrove
- Logged over swamp forest
- Logged over swamp forest on peat
- Settlement
- Settlement on peat
- Shrub
- Shrub on peat
- Timber plantation
- Timber plantation on peat
- Undisturbed forest
- Undisturbed mangrove
- Undisturbed swamp forest



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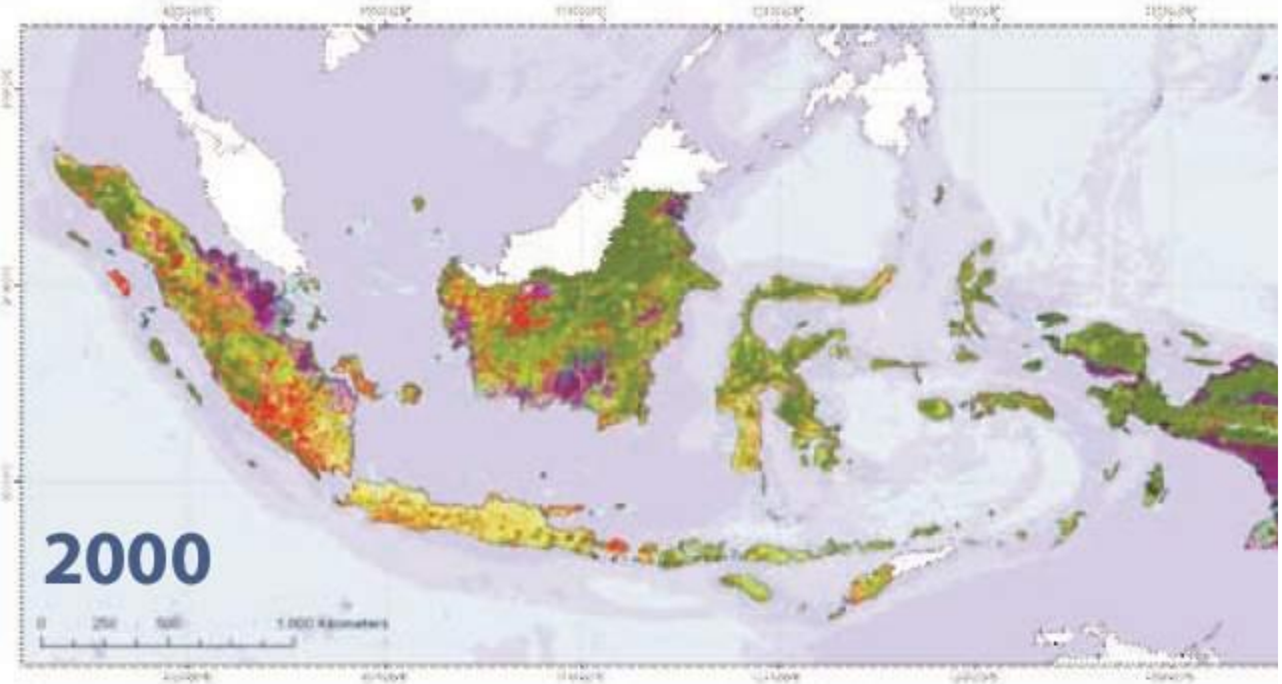
ALLREDDI



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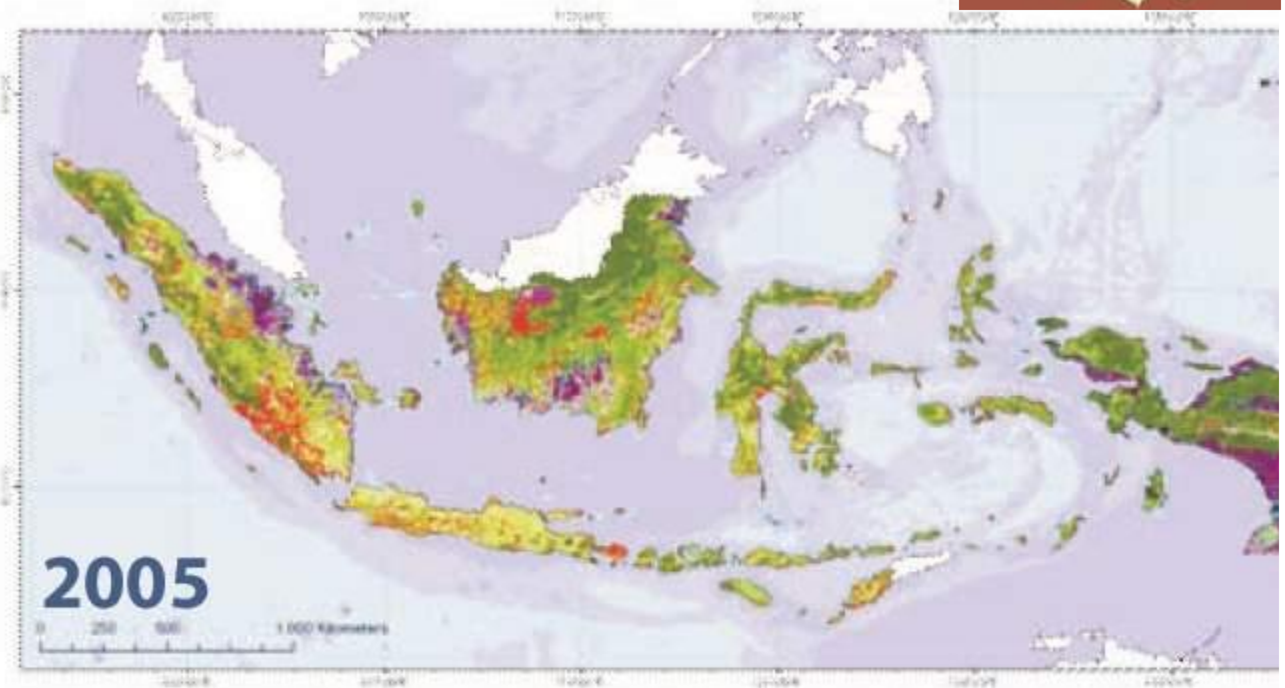

Legend

- Agrofore
- Agrofore
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- Cleared l
- Cloud an
- Croplanc
- Cropland on peat
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ALLREDDI

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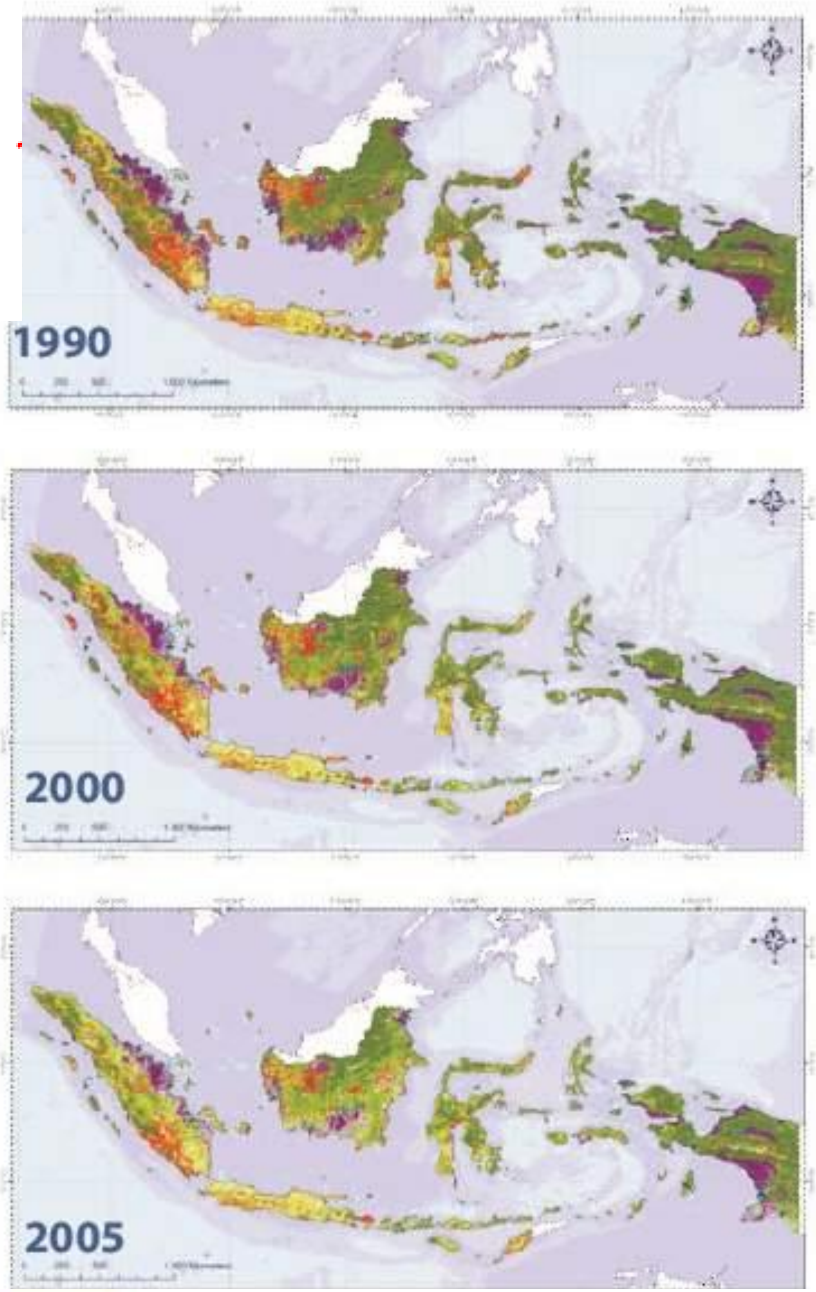

Legend

- Agroforest
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ALLREDDI

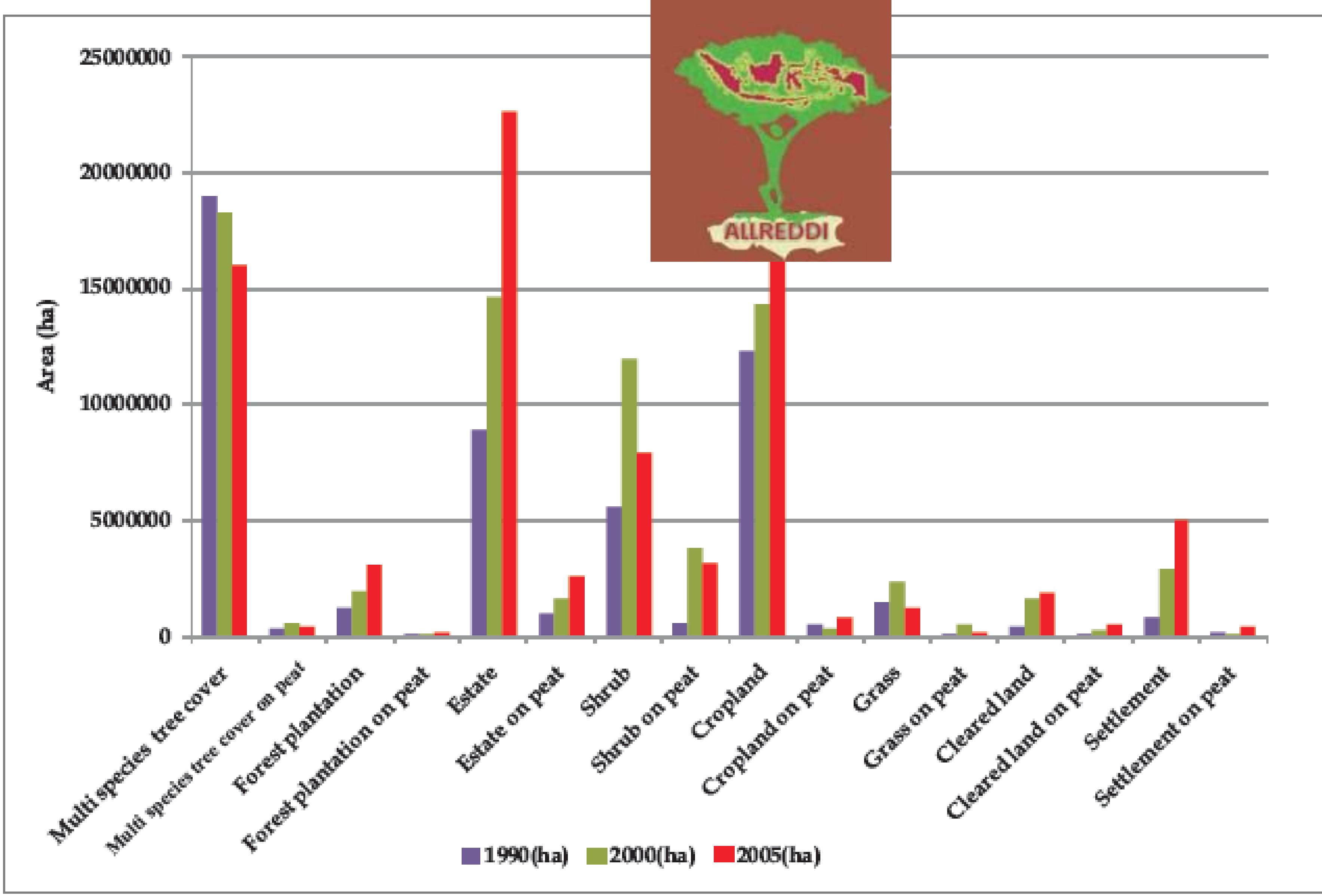
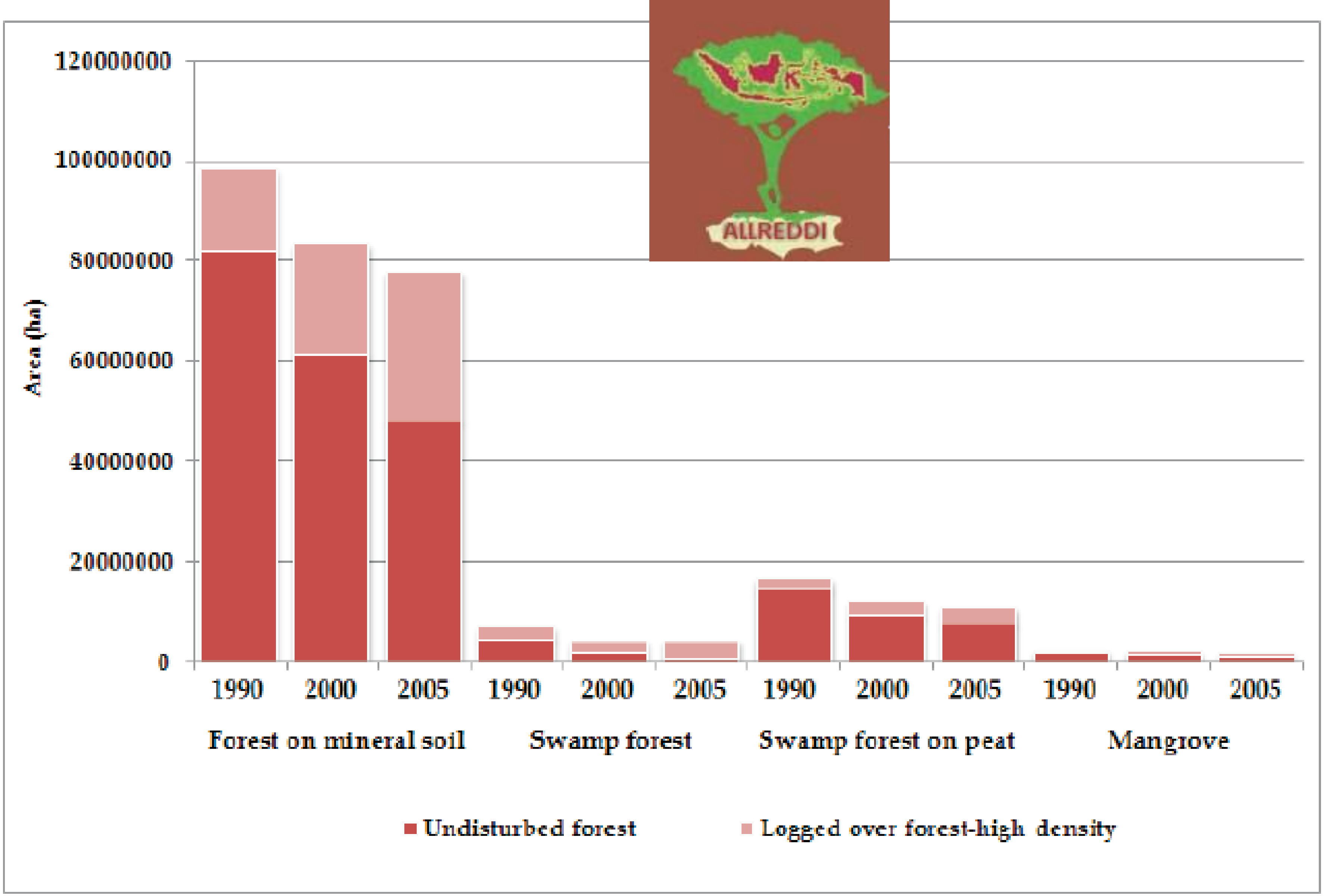


Figure 3. Overall land-cover change in Indonesia for the years 1990, 2000 and 2005



ALLREDDI
120000000
100000000
80000000
60000000
40000000
20000000
0
Area (ha)
1990
2000
2005
1990
2000
2005
1990
2000
2005
1990
2000
2005
Forest on mineral soil
Swamp forest
Swamp forest on peat
Mangrove
Undisturbed forest
Logged over forest-high density

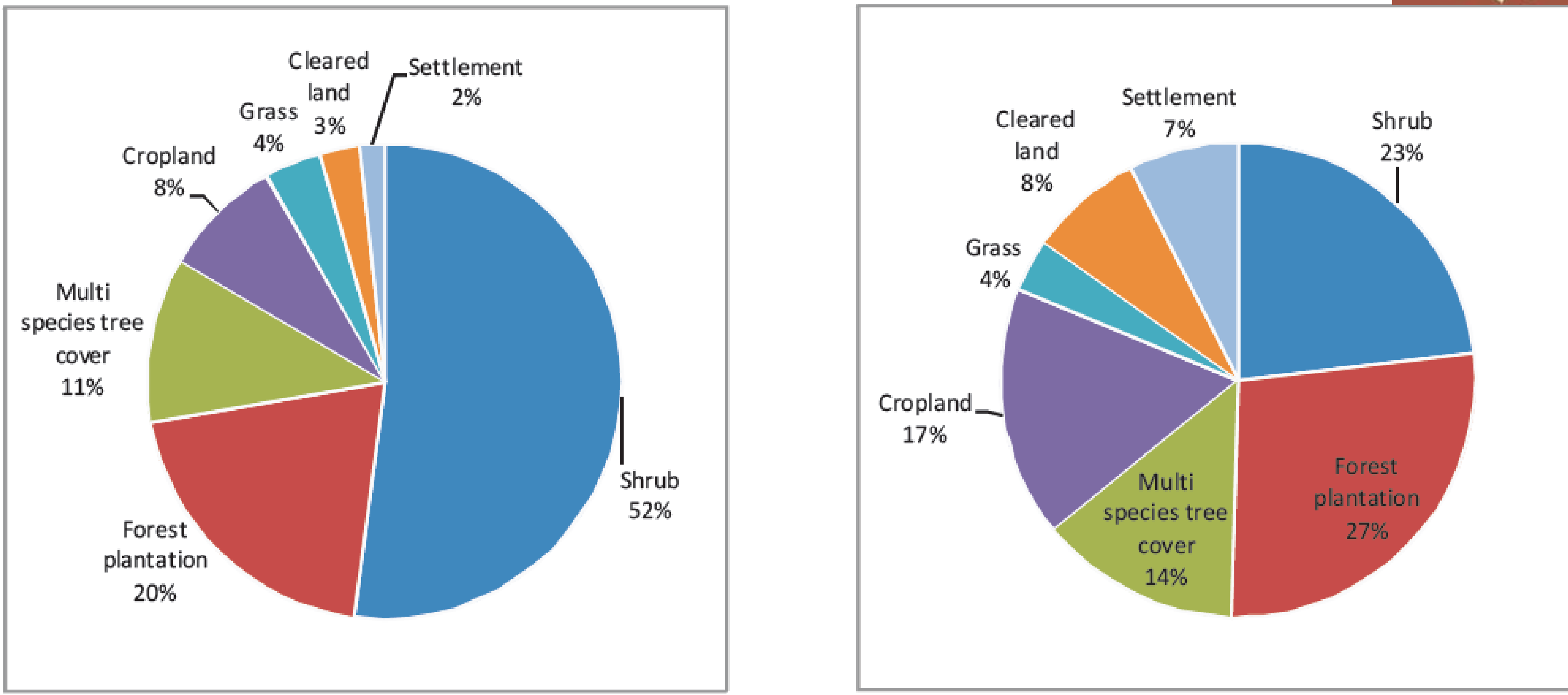
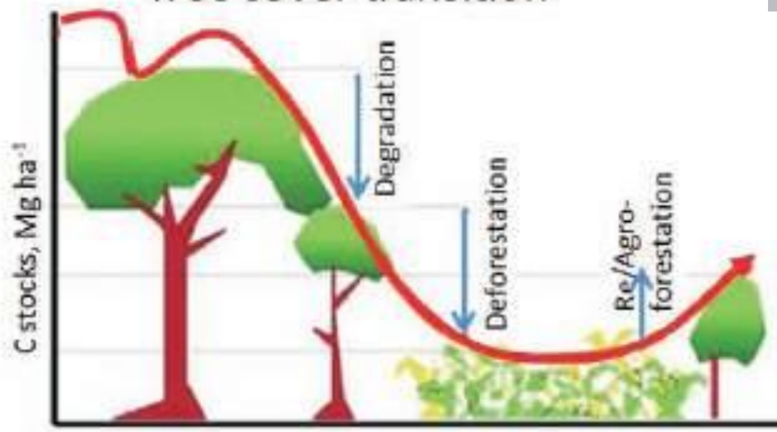
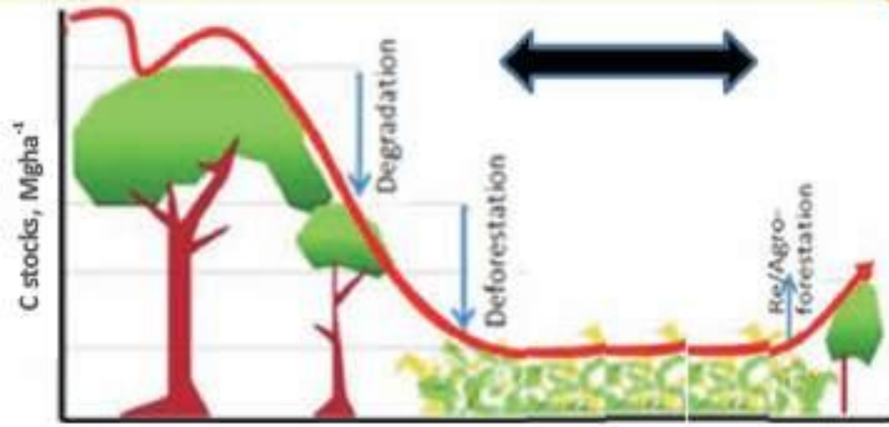


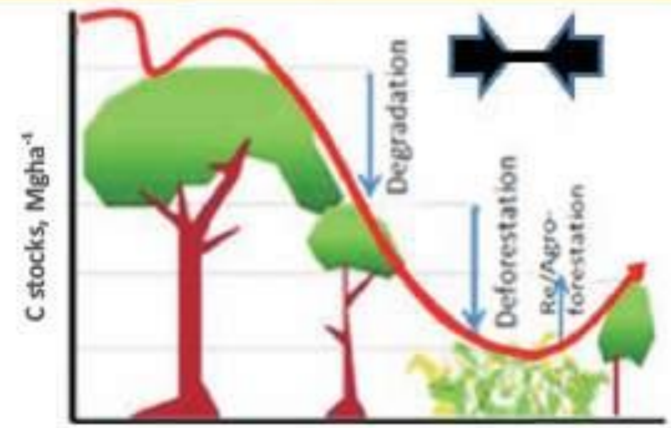
Figure 4. Types of land cover that replaced forest in 1990–2000 (left panel) and 2000–2005 (right panel)

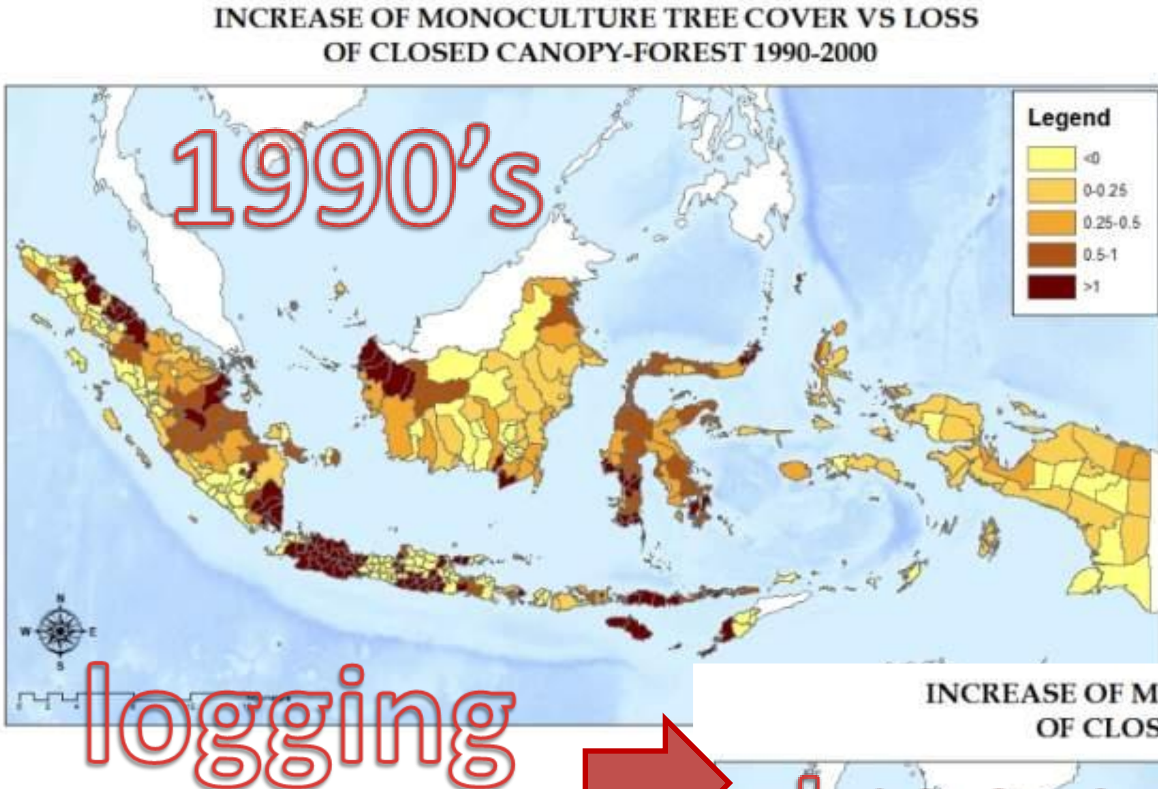
Tree cover transition



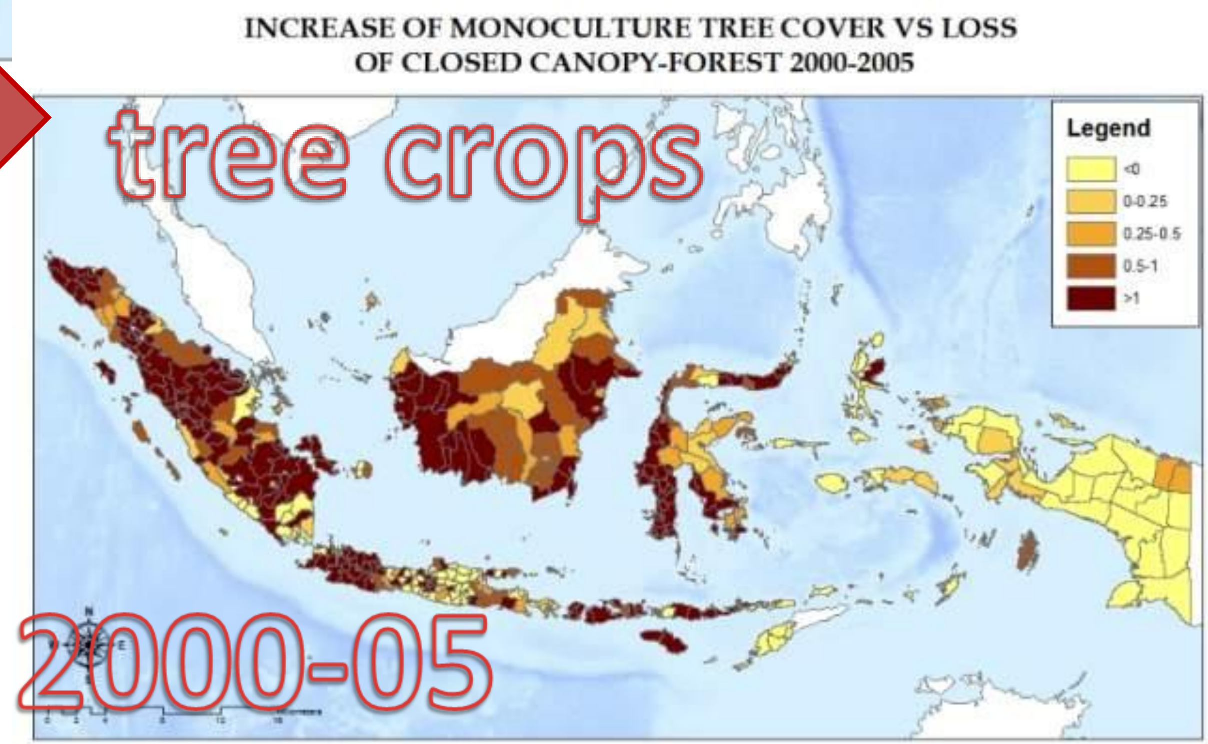
Widening: area planted < area cleared | **Contracting: area planted > cleared**



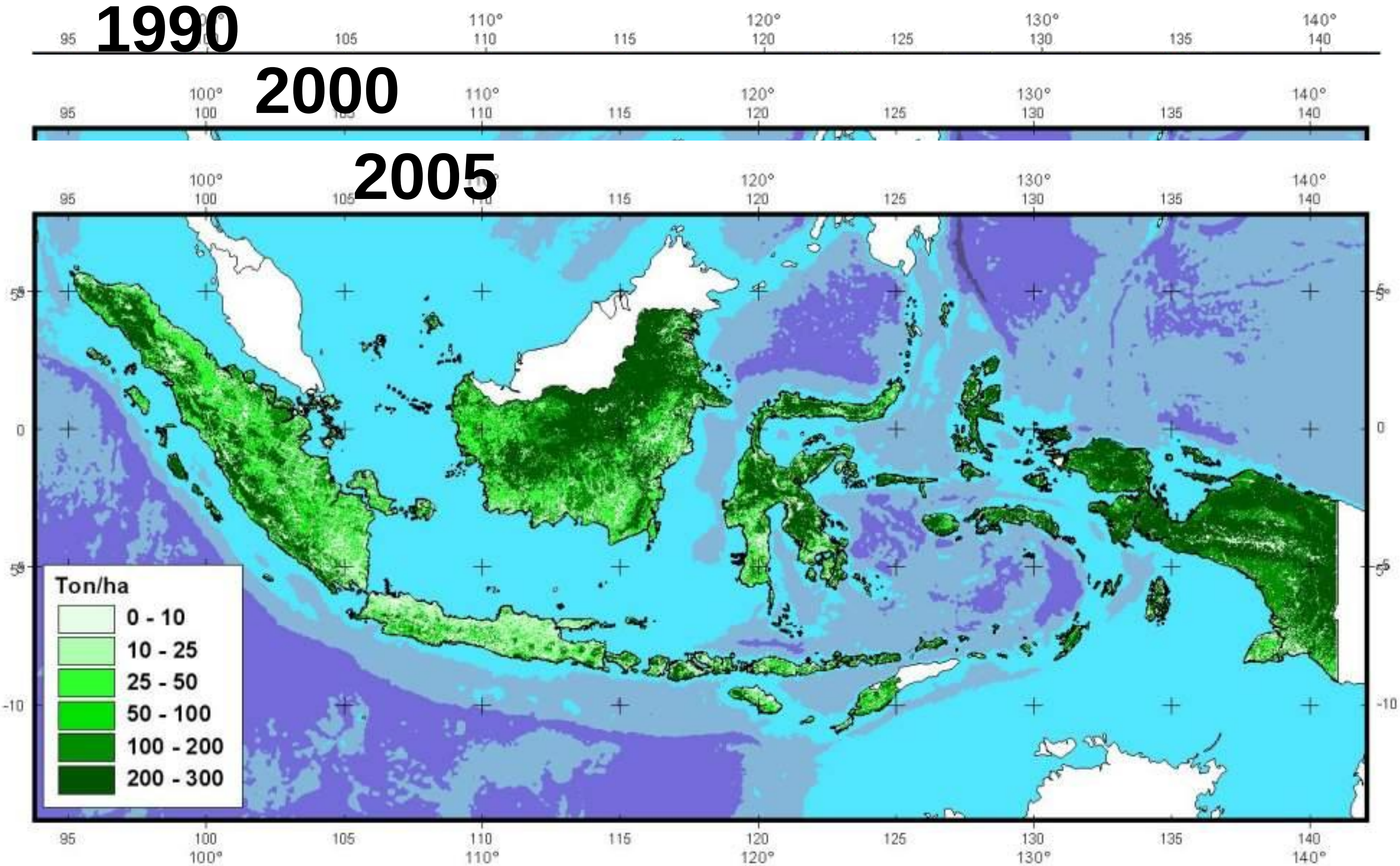




In the 1990's loss of natural cover increased the amount of 'low C-stock' & low economic value land; tree (crop) planting was 28% of the loss of natural forest area



After 2000 planting of tree (crop)s equals 90% of concurrent loss of natural forest; the amount of low C-stock & low economic value land decreases



Results of ALLREDDI analysis

Net Emissions: 0.6 Gt year^{-1}

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Validation process

Error Matrix:

	1	2	3	4	5	6	7	8	9	Google	Users
1	40					3				43	93.0
2		31				2				33	93.9
3			29		1	3				33	87.9
4				28		4	1		1	34	82.4
5					24	2				26	92.3
6	1	4	1	4	1	36	3	3	3	56	64.3
7				3			30			41	73.2
8	1						4	26		31	83.9
9			1	2			3		21	27	77.8
Landsat	42	35	31	37	26	50	41	37	25	324	
Producers	95.2	88.6	93.5	75.7	92.3	72.0	73.2	70.3	84.0		

LCC Notes: 1-Forest, 95% canopy; 2-Forest, 80% canopy; 3-Forest, 65% canopy; 4-Forest, 50% canopy; 5-oil palm; 6-shifting cultivation; 7-short rotation fallow; 8-large cattle ranches; 9- without vegetation.

Source: White and Hyman, 2009.

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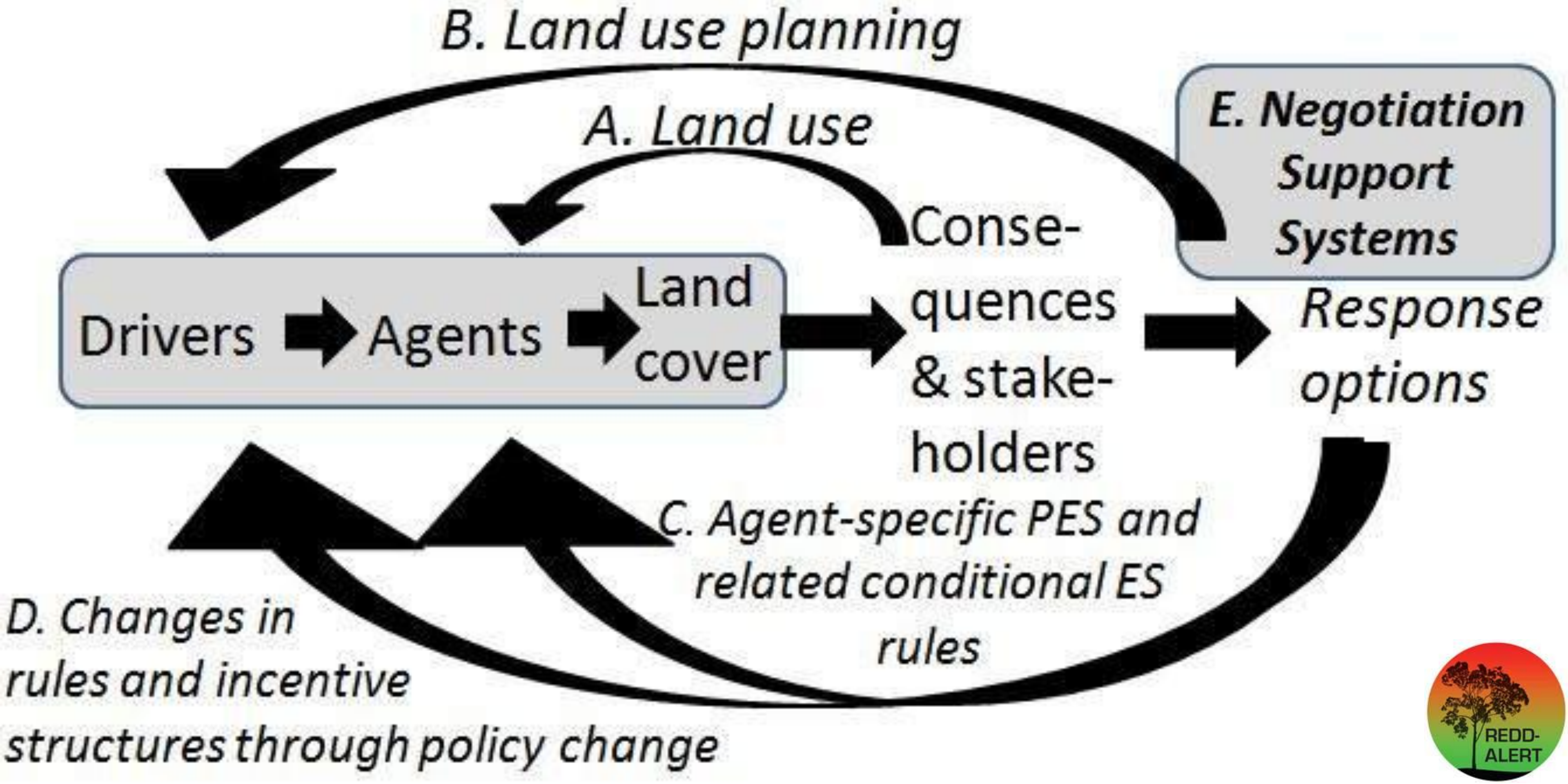
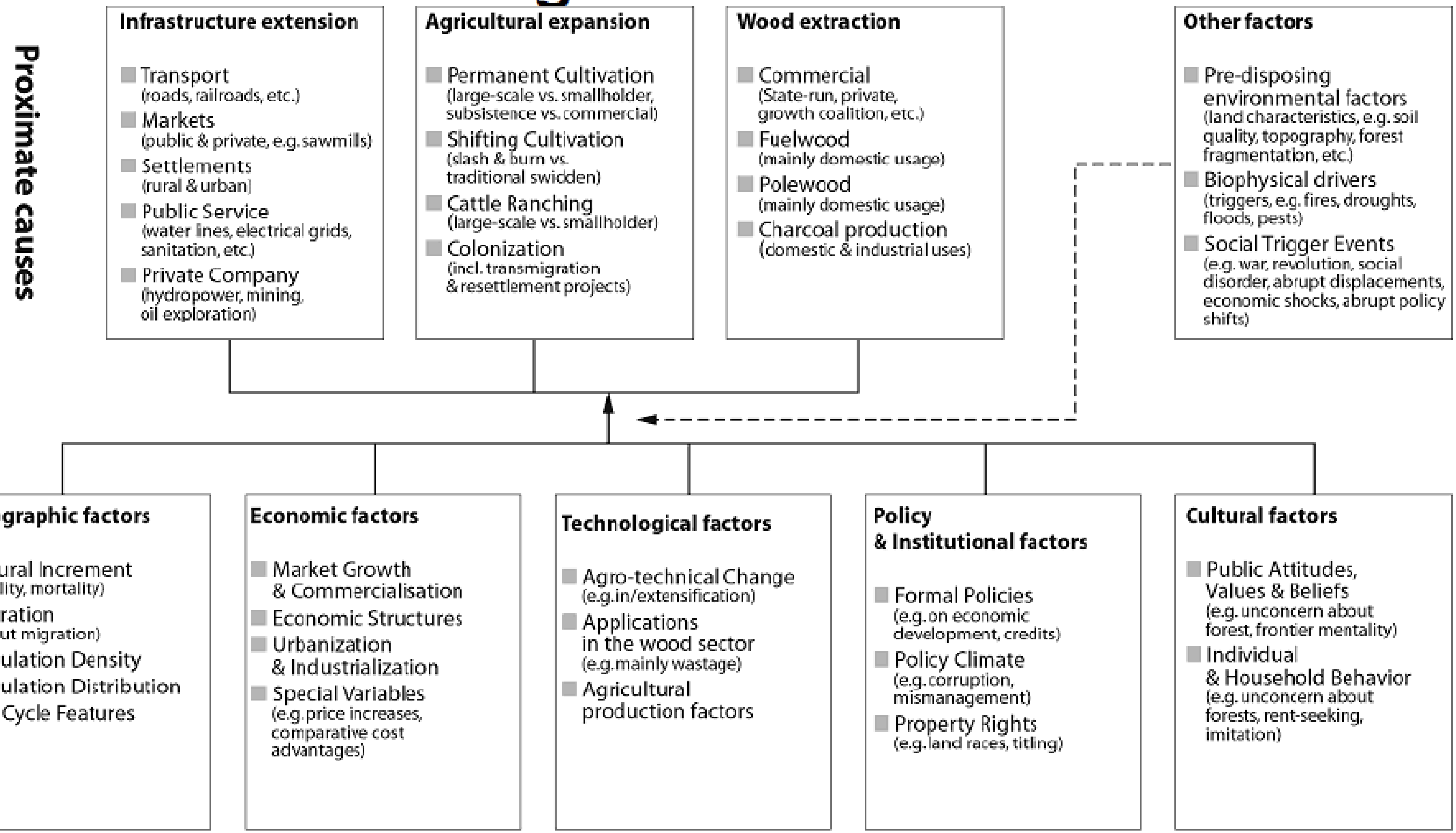
http://www.ecologyandsociety.org/vol16/iss1/resp1/



Feedback Loops Added to Four Conceptual Models Linking Land Change with Driving Forces and Actors

Drivers of change as analyzed by Eric Lambin c.s.



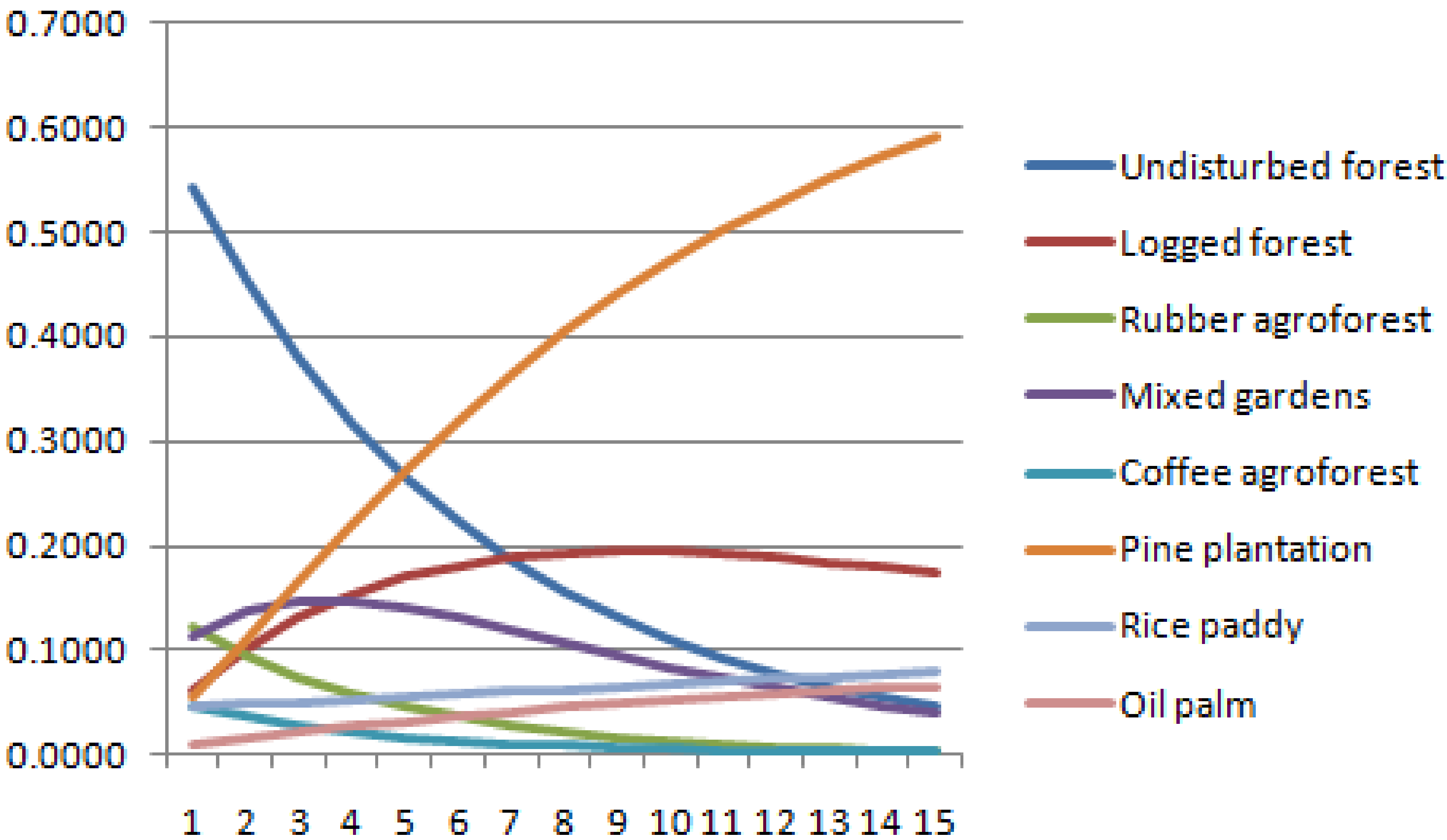
Batang Toru 1994-2009 L U Change probabilities

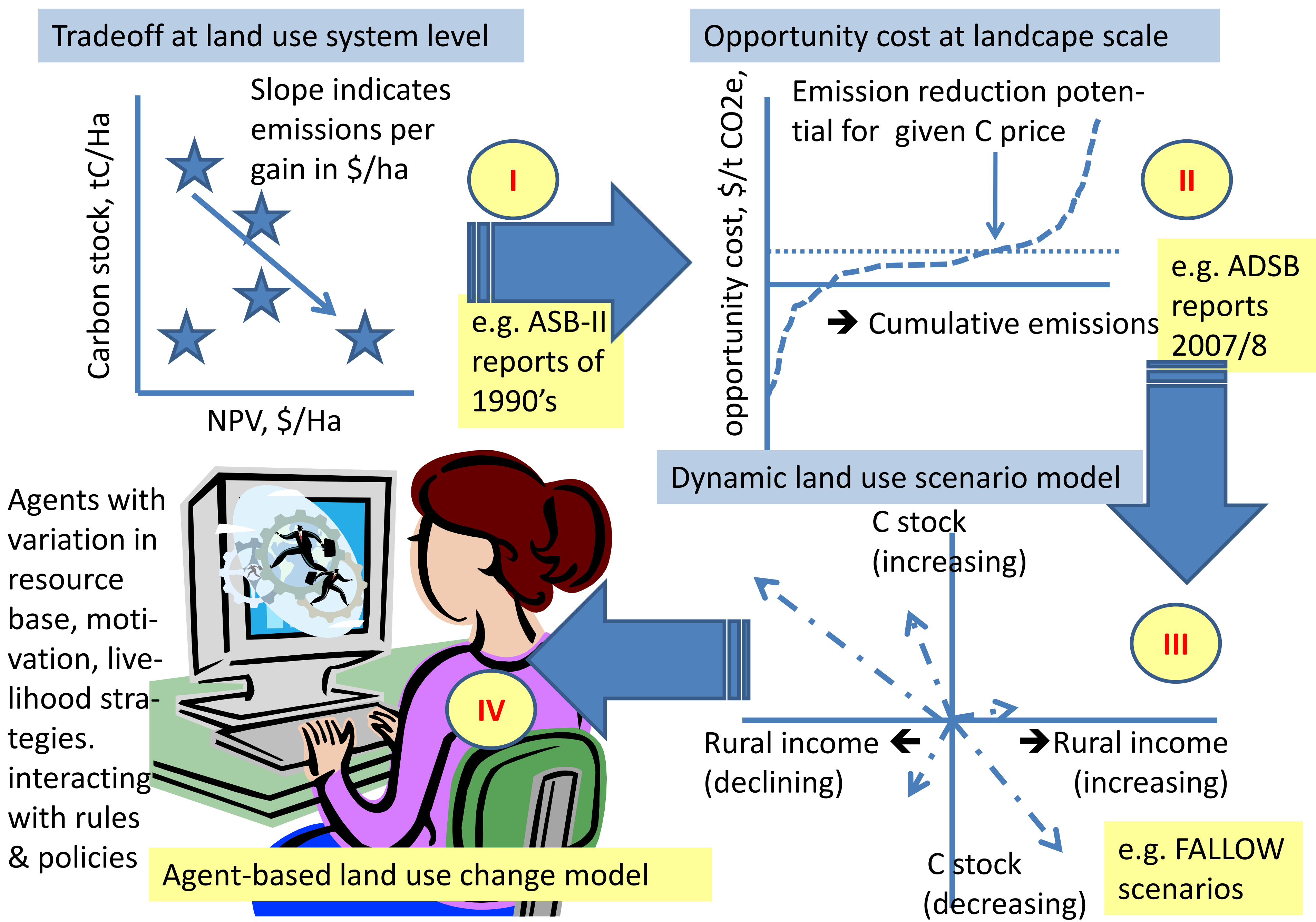
	Fraction	Undisturbed forest	Logged forest	Rubber agroforest	Mixed gardens	Coffee agroforest	Pine plantation	Rice	Oil palm	Total
Undisturbed forest	0.6476	0.8375	0.0777	0.0001	0.0392	0.0086	0.0287	0.0000	0.0083	1
Logged forest	0.0134	0	0.9450	0	0.0036	0	0.0344	0.0097	0.0072	1
Rubber agroforest	0.1570	0	0	0.7812	0.1108	0.0148	0.0912	0.0000	0.0020	1
Mixed gardens	0.0626	0	0	0	0.7731	0	0.2129	0.0056	0.0084	1
Coffee agroforest	0.0630	0	0	0	0.3446	0.6213	0.0326	0.0015	0	1
Pine plantation	0.0059	0	0	0	0	0	1	0	0	1
Rice paddy	0.0469	0	0	0	0	0	0	1	0	1
Oil palm	0.0035	0	0	0	0	0	0	0	1	1
Total	1.0000									

vector T matrix T → T+1

$$
\begin{pmatrix} f_{LU1} \\ f_{LU2} \\ f_{LU3} \\ f_{LU4} \\ .. \\ .. \\ .. \\ f_{LUn-1} \\ f_{LUn} \end{pmatrix}
\begin{pmatrix}
P_{1,1} & P_{1,2} & P_{1,3} & \ldots\ldots P_{1,n-1} & P_{1,n} \\
P_{2,1} & P_{2,2} & P_{2,3} & \ldots\ldots P_{2,n-1} & P_{2,n} \\
P_{3,1} & P_{3,2} & P_{3,3} & \ldots\ldots P_{3,n-1} & P_{3,n} \\
P_{4,1} & P_{4,2} & P_{4,3} & \ldots\ldots P_{4,n-1} & P_{4,n} \\
.. & & & & \\
.. & & & & \\
.. & & & & \\
P_{n-1,1} & P_{n-1,2} & & \ldots P_{n-1,n-1} & P_{n-1,n} \\
P_{n,1} & P_{n,2} & P_{n,3} & \ldots\ldots P_{n,n-1} & P_{n,n}
\end{pmatrix}
$$

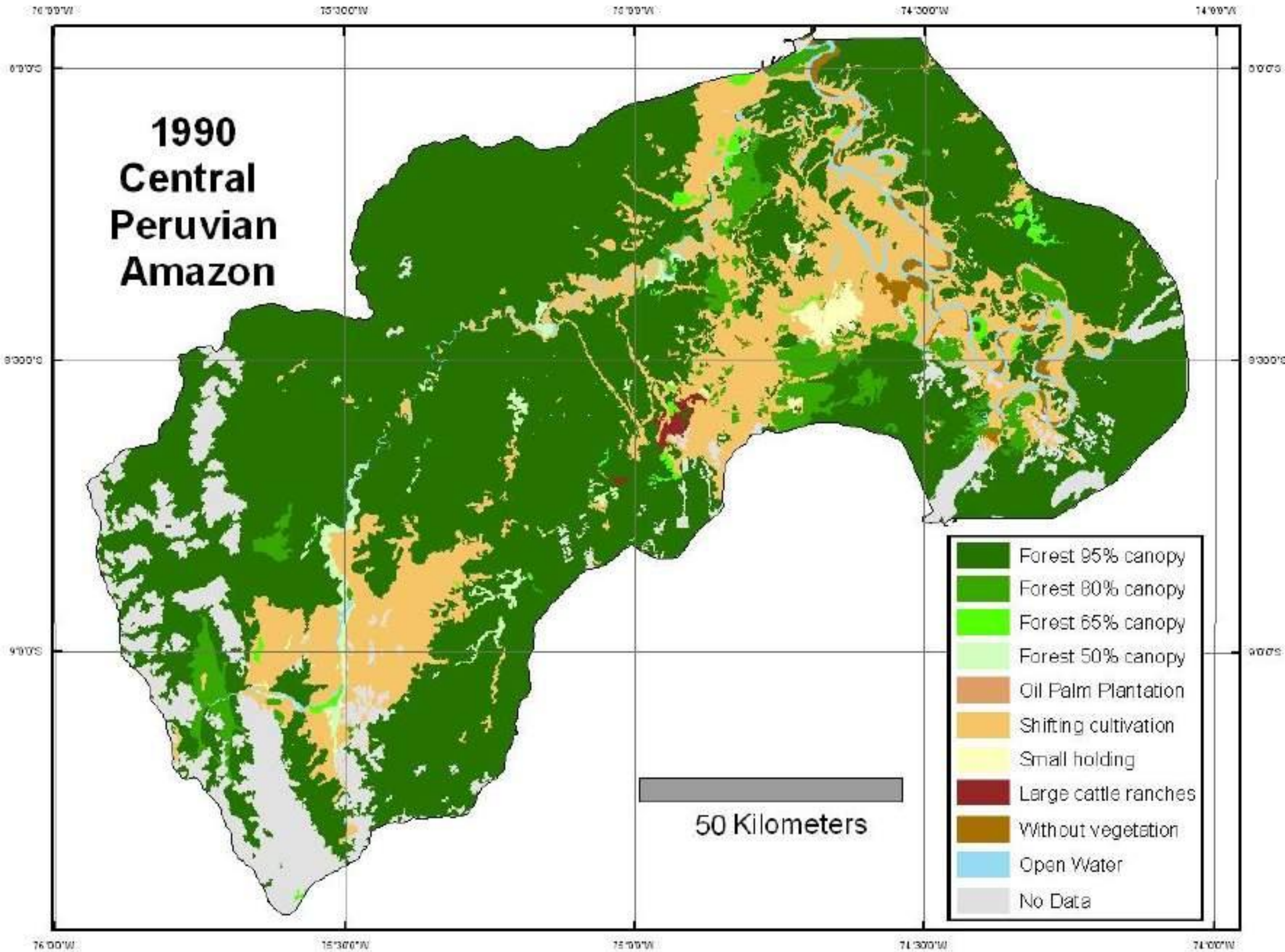
Direct extrapolation of the Batang Toru (1994-2009) Land Use Change Matrix – ***is this realistic?***

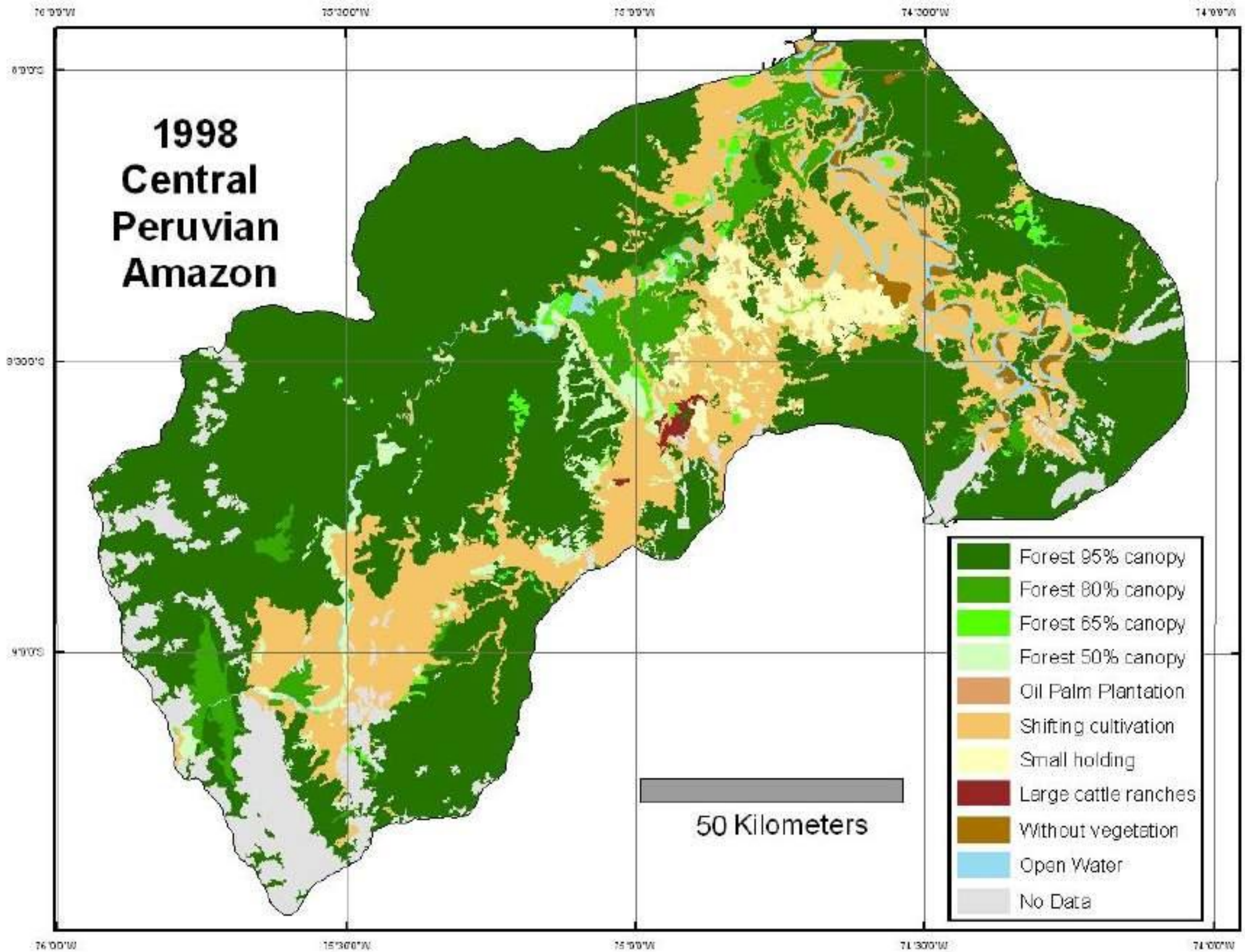


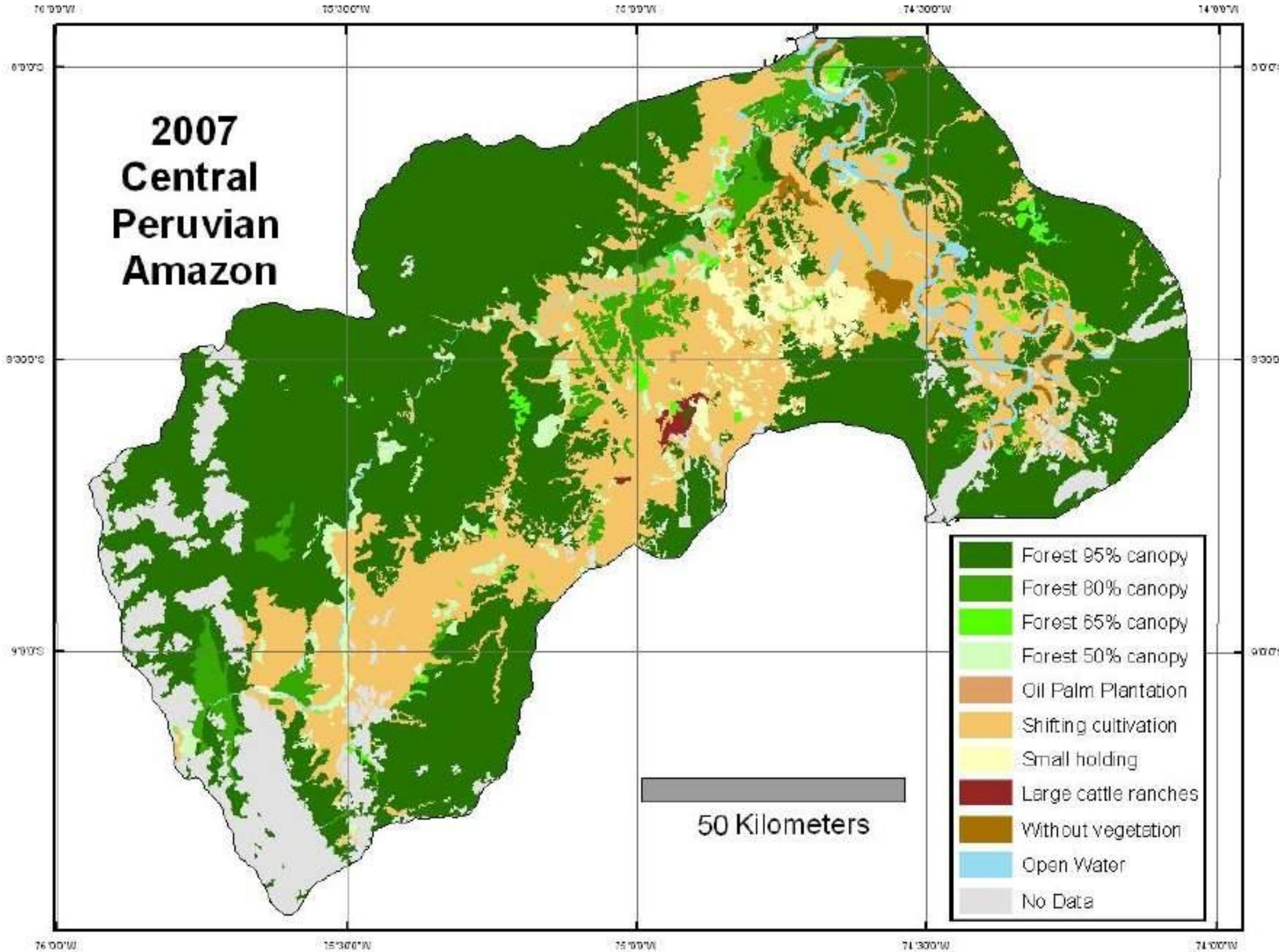


Tradeoff at land use system level
Slope indicates emissions per gain in $/ha
Carbon stock, tC/Ha
NPV, $/Ha
I
e.g. ASB-II reports of 1990's
Opportunity cost at landcape scale
opportunity cost, $/t CO2e,
Emission reduction potential for given C price
➔ Cumulative emissions
II
e.g. ADSB reports 2007/8
Dynamic land use scenario model
C stock (increasing)
Rural income (declining)
➔Rural income (increasing)
C stock (decreasing)
III
e.g. FALLOW scenarios
Agents with variation in resource base, motivation, livelihood strategies. interacting with rules & policies
IV
Agent-based land use change model

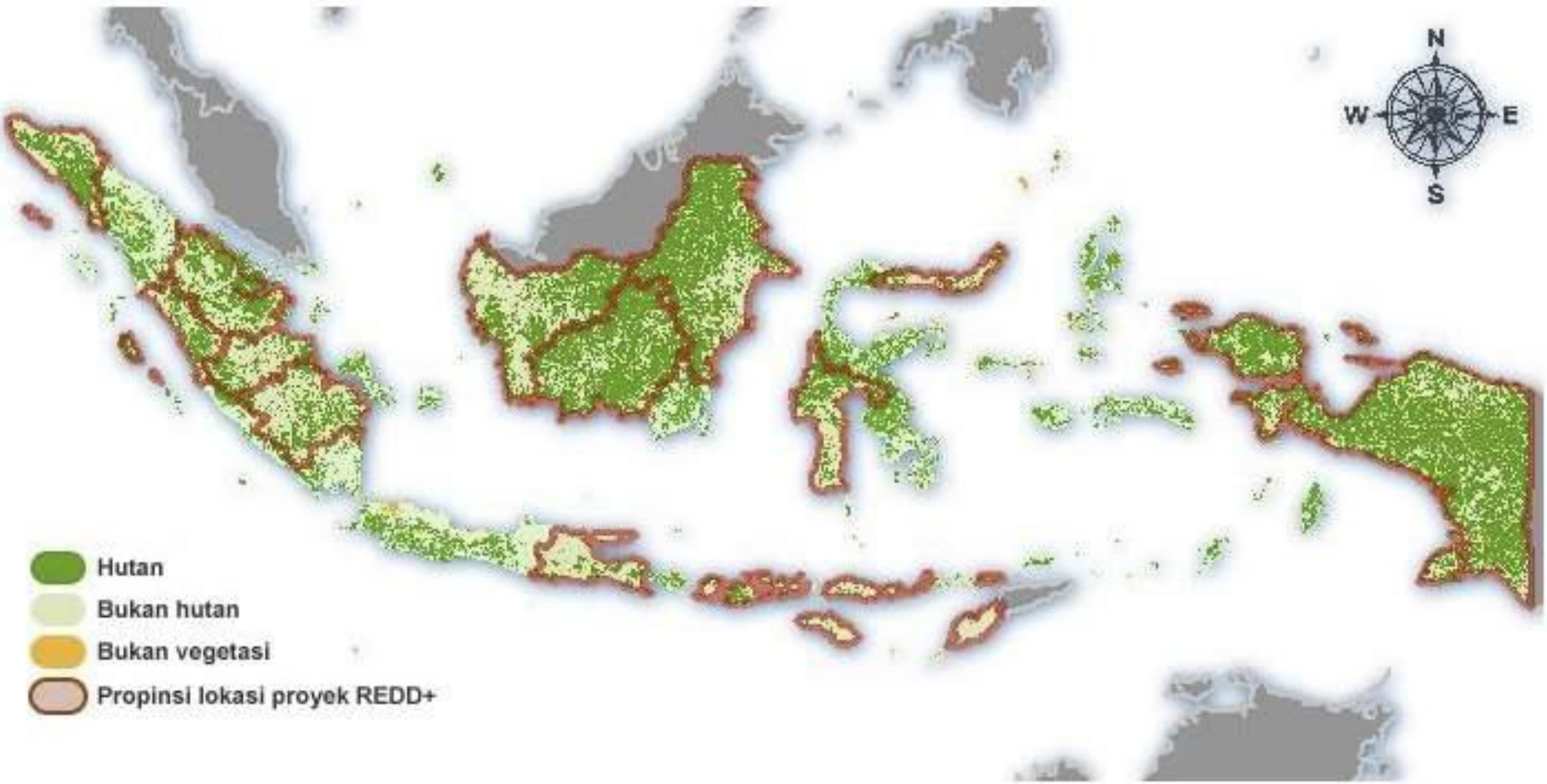
Slides not used in main talk…


1990
Central
Peruvian
Amazon
50 Kilometers
Forest 95% canopy
Forest 80% canopy
Forest 65% canopy
Forest 50% canopy
Oil Palm Plantation
Shifting cultivation
Small holding
Large cattle ranches
Without vegetation
Open Water
No Data

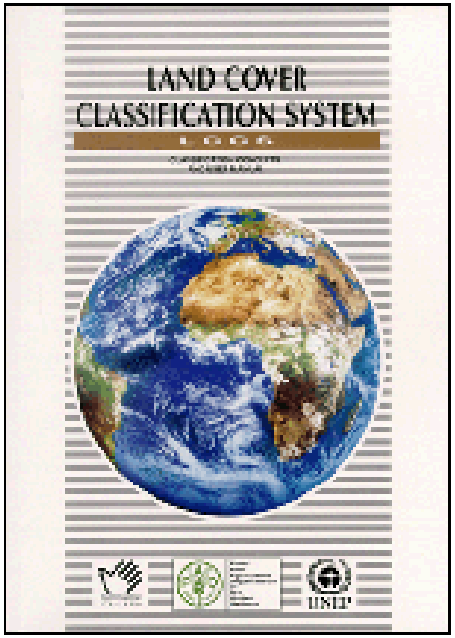

1998
Central
Peruvian
Amazon
Forest 95% canopy
Forest 80% canopy
Forest 65% canopy
Forest 50% canopy
Oil Palm Plantation
Shifting cultivation
Small holding
Large cattle ranches
Without vegetation
Open Water
No Data
50 Kilometers


2007
Central
Peruvian
Amazon
50 Kilometers
Forest 95% canopy
Forest 80% canopy
Forest 65% canopy
Forest 50% canopy
Oil Palm Plantation
Shifting cultivation
Small holding
Large cattle ranches
Without vegetation
Open Water
No Data

REDD pilot projects as exist per April 2011



http://redd-i.org/index.php?option=com_content&view=article&id=205&Itemid=57

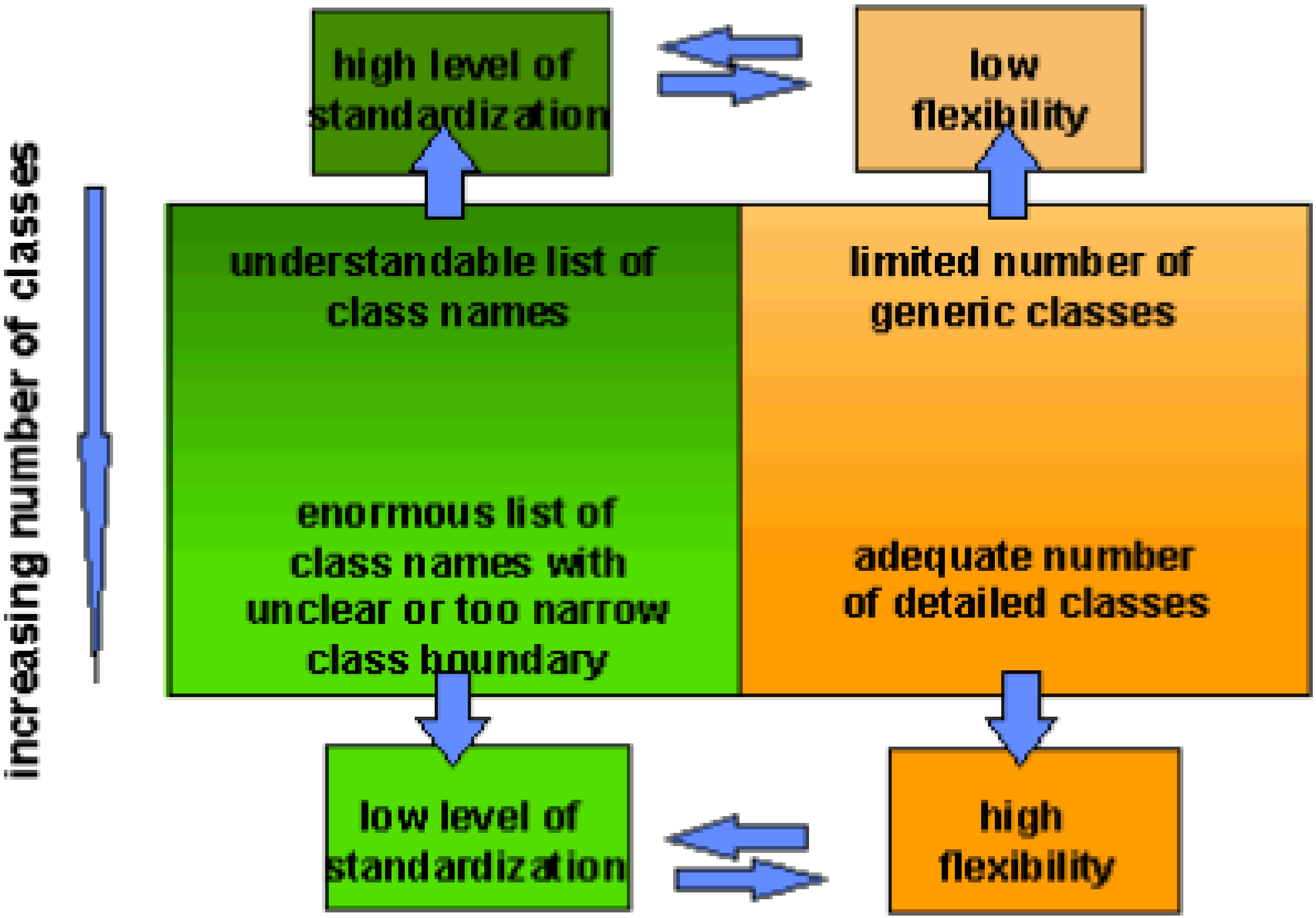


LAND COVER CLASSIFICATION SYSTEM (LCCS):

CLASSIFICATION CONCEPTS AND USER MANUAL

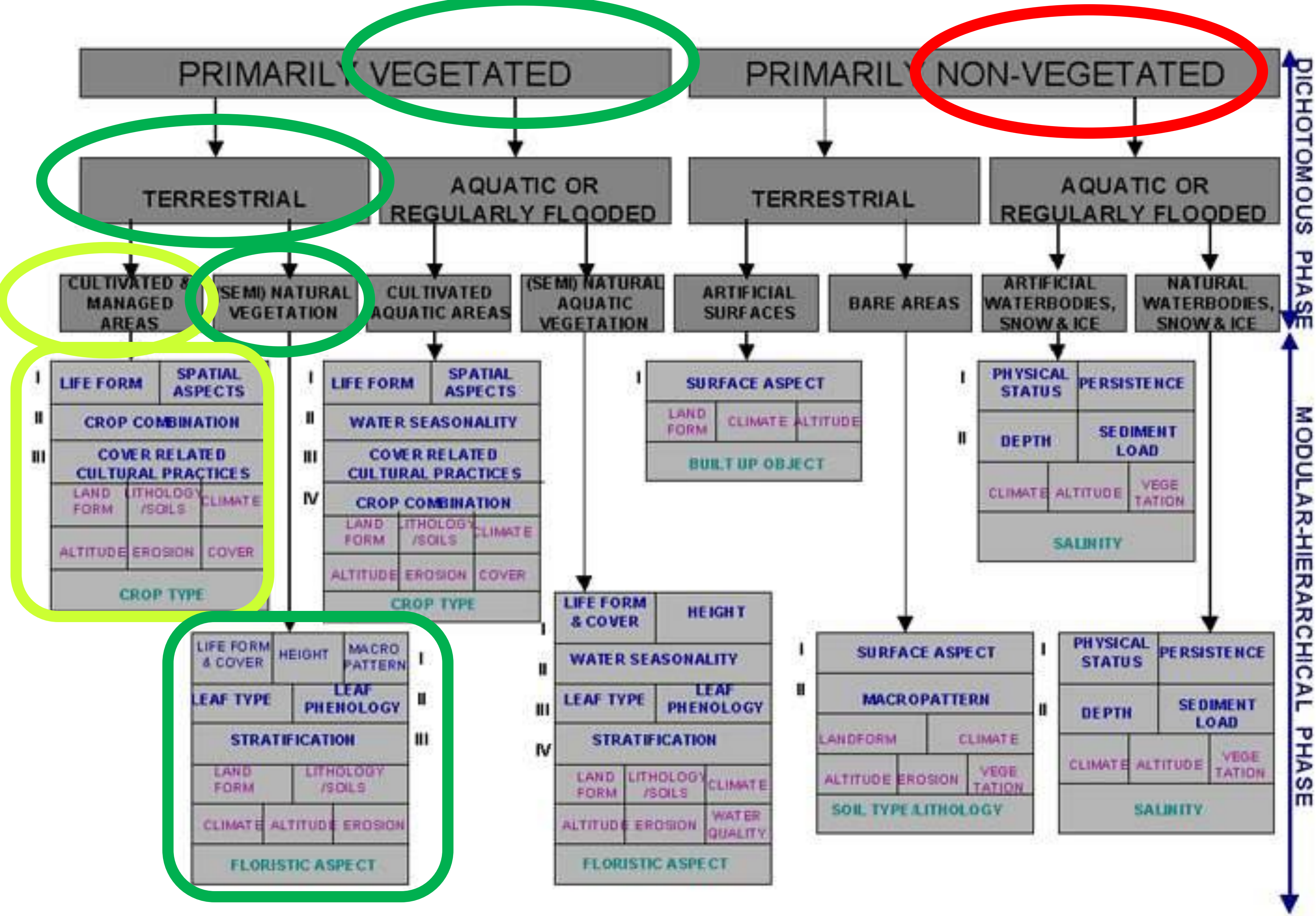
FOR SOFTWARE
VERSION 1.0

by
Antonio Di Gregorio
Environment and Natural Resources Service
Africover - East Africa Project
Nairobi, Kenia
and
Louisa J.M. Jansen
FAO Land and Water Development Division


high level of standardization
low flexibility
increasing number of classes
understandable list of class names
limited number of generic classes
enormous list of class names with unclear or too narrow class boundary
adequate number of detailed classes
low level of standardization
high flexibility

General criteria for a reference classi-fication. It should be:

- ***comprehensive, scientifically sound*** **and** ***practically oriented***;
- *meet the* ***needs of a variety of users*** (neither single-project oriented nor taking a sectoral approach); users can use just a sub-set of the classification and develop from there according to their own specific needs;
- potentially ***applicable as a common reference system***, and facilitate comparisons between classes derived from different classifications;
- be a ***flexible*** system, which can be used at different scales and at different levels of detail allowing cross-reference of local and regional with continental and global maps without loss of information;
- *able to describe the* ***complete range of land cover features*** (e.g., forest and cultivated areas as well as ice and bare land, etc.), with clear class boundary definition that are unambiguous and unique;
- adapted to fully describe the whole variety of land cover types with the ***minimal set of classifiers*** necessary (the less classifiers used in the definition, the less the error expected and the less time and resources necessary for field validation); and
- based on a ***clear and systematic description of the class***, where the diagnostic criteria used to define a class must be clearly defined, with pure land cover criteria distinct from environmental criteria (e.g., climate, floristic and altitude), as the latter influence land cover but are not inherent features.


PRIMARILY VEGETATED
PRIMARILY NON-VEGETATED
TERRESTRIAL
AQUATIC OR REGULARLY FLOODED
TERRESTRIAL
AQUATIC OR REGULARLY FLOODED
CULTIVATED & MANAGED AREAS
(SEMI) NATURAL VEGETATION
CULTIVATED AQUATIC AREAS
(SEMI) NATURAL AQUATIC VEGETATION
ARTIFICIAL SURFACES
BARE AREAS
ARTIFICIAL WATERBODIES, SNOW & ICE
NATURAL WATERBODIES, SNOW & ICE
LIFE FORM
SPATIAL ASPECTS
CROP COMBINATION
COVER RELATED CULTURAL PRACTICES
LAND FORM
LITHOLOGY /SOILS
CLIMATE
ALTITUDE
EROSION
COVER
CROP TYPE
WATER SEASONALITY
SURFACE ASPECT
BUILT UP OBJECT
PHYSICAL STATUS
PERSISTENCE
DEPTH
SEDIMENT LOAD
VEGE TATION
SALINITY
HEIGHT
LIFE FORM & COVER
MACRO PATTERN
LEAF TYPE
LEAF PHENOLOGY
STRATIFICATION
FLORISTIC ASPECT
WATER QUALITY
MACROPATTERN
LANDFORM
SOIL TYPE/LITHOLOGY
DICHOTOMOUS PHASE
MODULAR-HIERARCHICAL PHASE

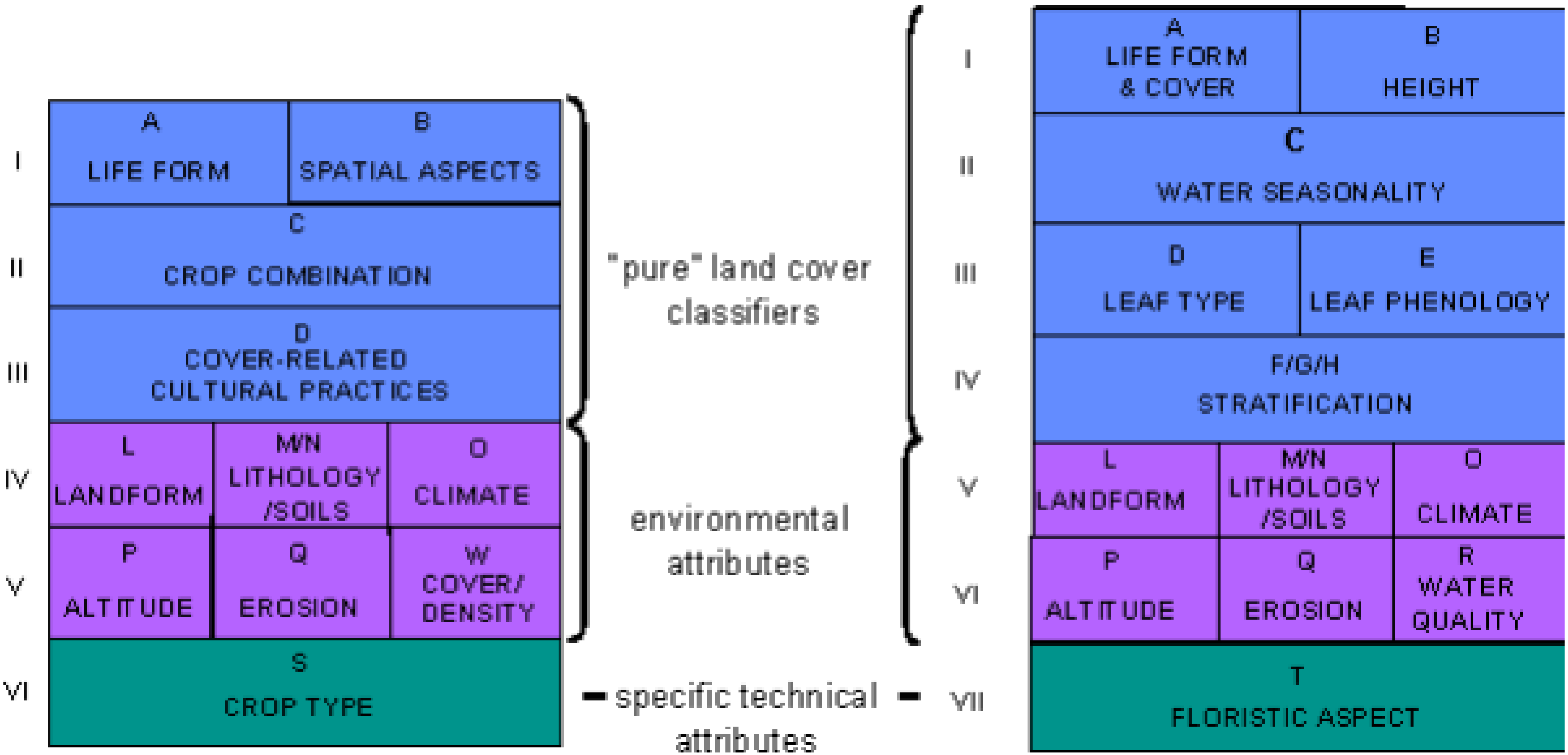

I
II
III
IV
V
VI
A
LIFE FORM
B
SPATIAL ASPECTS
C
CROP COMBINATION
D
COVER-RELATED
CULTURAL PRACTICES
L
LANDFORM
M/N
LITHOLOGY
/SOILS
O
CLIMATE
P
ALTITUDE
Q
EROSION
W
COVER/
DENSITY
S
CROP TYPE
"pure" land cover
classifiers
environmental
attributes
specific technical
attributes
I
II
III
IV
V
VI
VII
A
LIFE FORM
& COVER
B
HEIGHT
C
WATER SEASONALITY
D
LEAF TYPE
E
LEAF PHENOLOGY
F/G/H
STRATIFICATION
L
LANDFORM
M/N
LITHOLOGY
/SOILS
O
CLIMATE
P
ALTITUDE
Q
EROSION
R
WATER
QUALITY
T
FLORISTIC ASPECT

TABLE 3.
Example of the formation of land cover classes.

Example "Natural and Semi-Natural Terrestrial Vegetation (A12)":

Classifiers Used:	Boolean Formula:	Standard Class Name:	Code:
Life Form & Cover	A3A10	Closed Forest	20005
Height	A3A10B2	High Closed Forest	20006
Spatial Distribution	A3A10B2C1	Continuous Closed Forest	20007
Leaf Type	A3A10B2C1D1	Broadleaved Closed Forest	20095
Leaf Phenology	A3A10B2C1D1E2	Broadleaved Deciduous Forest	20097
2nd Layer: LF, C, H	A3A10B2C1D1E2F2F5F7G2	Multi-Layered Broadleaved Deciduous Forest	20628
3rd Layer: LF, C, H	A3A10B2C1D1E2F2F5F7G2 F2F5F10G2	Multi-Layered Broadleaved Deciduous Forest With Emergents	20630

Object-based classification

- Segmentation→ spectral properties (band properties, band combination), spatial properties (smoothness, shape)
- Multi layer → utilising auxiliary layers (DEM, accessibility maps)

→ Hence "hierarchical object-based classification" approach

Land cover changes and trajectories of changes

- Time series analyses of areas of changes → area calculation | time-step

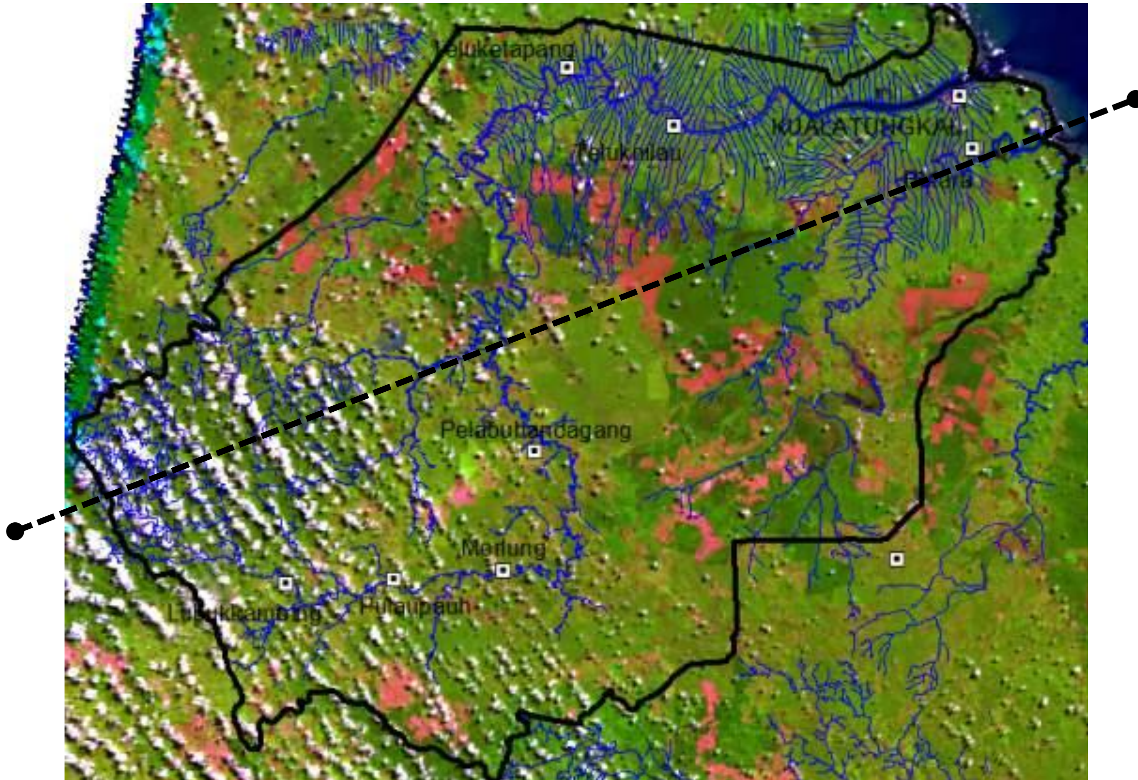
LUT	T1 (ha)	T2 (ha)
Forest		
Agroforest		
Crops		

- Trajectories analysis for each change-step → matrix of changes | change-step

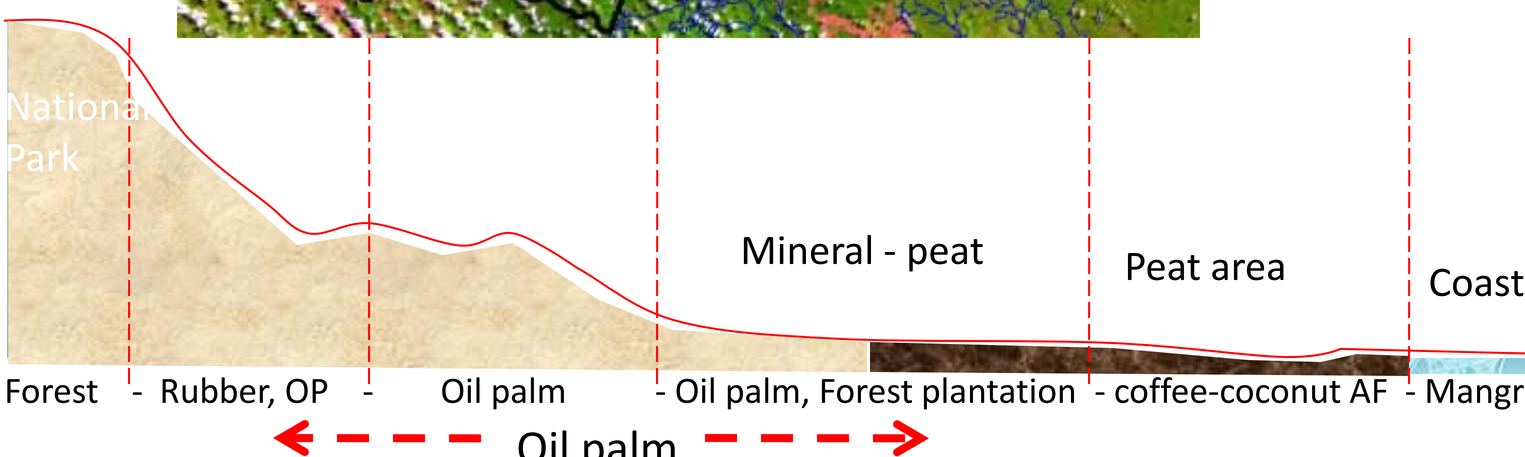
1990→ 2000	Forest	Agroforest	Crops
Forest			
Agroforest			
Crops			

Applying ALUCT – LC mapping and LCC analyses @national level

Applying ALUCT @site



REALU Site of Tanjung Jabung Barat, Jambi, Indonesia



Methods RESFA** modified

Scenario building for LEDs

Enabling conditions for REDD+/REALU

Tradeoff Analyses- incl. additionality and leakage

If it is worthwhile, what directions can best be pursued in project design?

Yes, Yes-if, No-unless, No

Assessments of Emissions from LUC (AsEmLU)

Drivers of land use changes (DriLUC)

Abatement cost of land use changes

Livelihood options

C- stock appraisal (RACSA)

Land use change & Trajectory analyses (ALUCT)

Land use profitability analyses

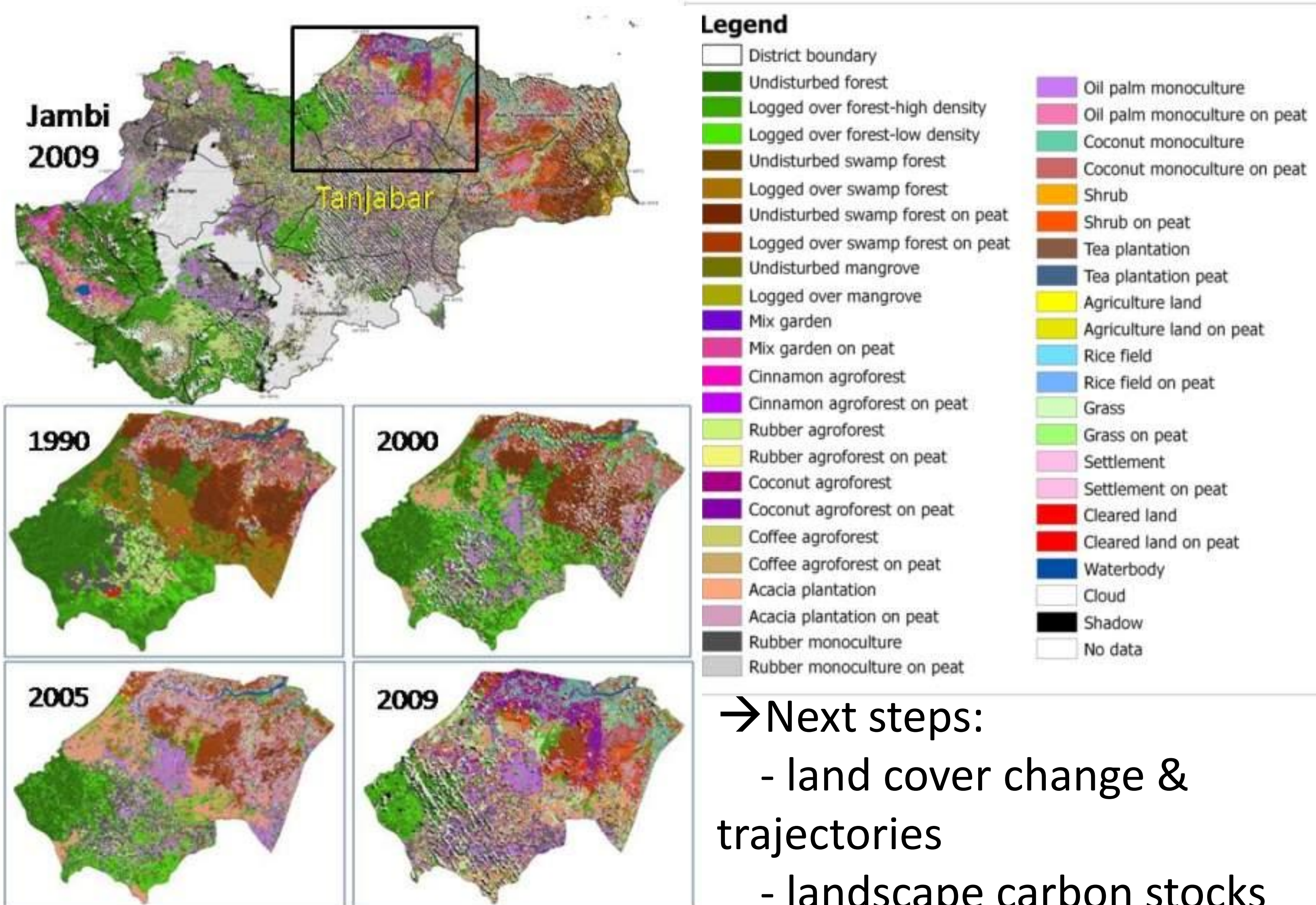
Land tenure assessments (RATA)

Institutional Assessments (RISNA)

Key question: Is it worthwhile to pursue a project to reduce net emissions from land use (incl. forest) for this area, or will it be too complex, too costly or low in co-benefit returns?

*** REDD+/REALU Site Feasibility Appraisal*

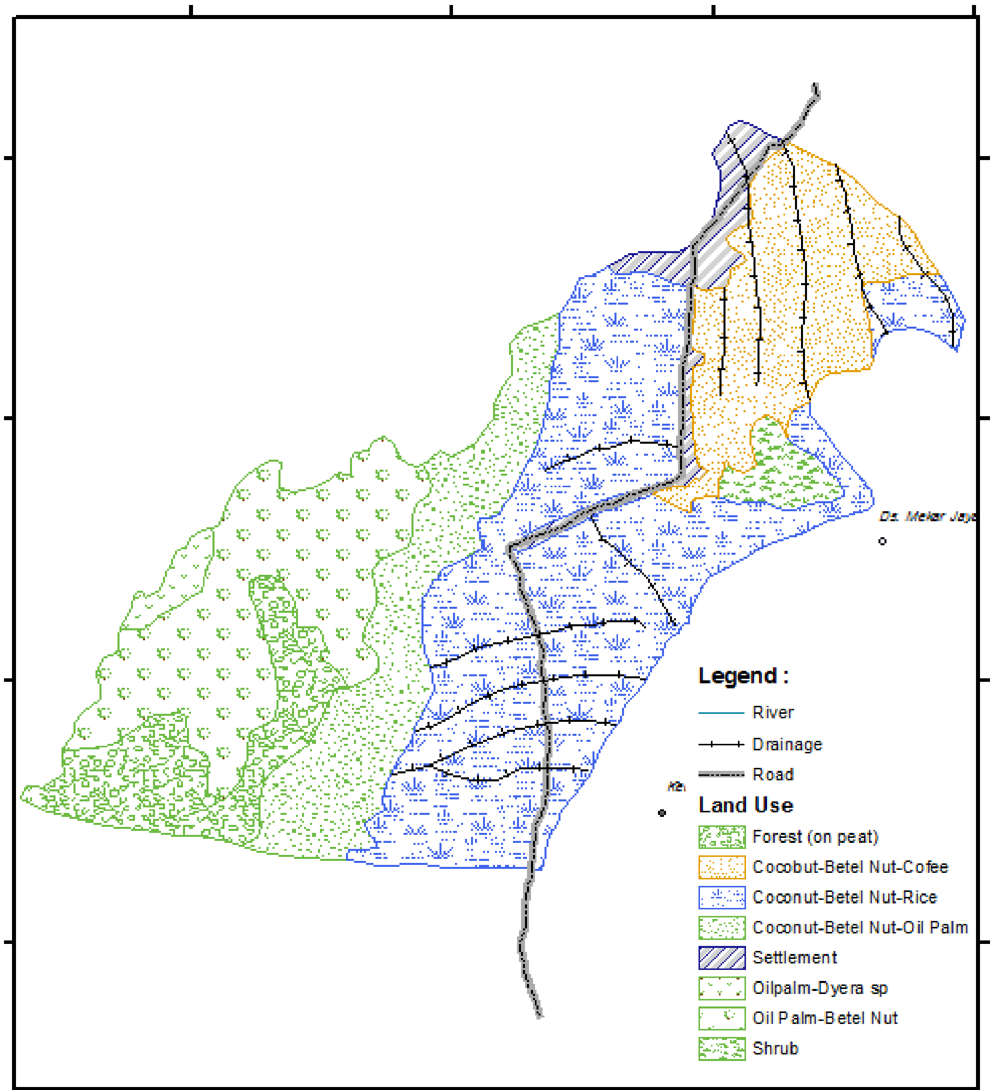
Results – LC mapping @ site



→Next steps:

- land cover change & trajectories
- landscape carbon stocks
- emissions calculation

DriLUC in the field – Example



DriLUC in the field – Example

Identification of drivers

	Downstream 'peat' area	Upstream area
1970s	- C: Forest degradation - D: Large scale logging concessions co.	- C: Forest degradation; old rubber stays from 1930s - D: Large scale logging concessions
1980s	- C: Conversion into cultivated lands, coconut –pinang farming - D: Govt. intervention for cash-crops; market price of coconut & pinang	- C: (old villages) Shifting cultivation, rubber on fallow lands– - D: Large scale OP co. - D: PIR Transmigration settlement (govt program) –OP labour
1990s	- C: Conversion of farms into OP - D: Oil palm co. into the area	- C: Expansion of OP - D: Attraction of OP profitability
2000s	- C: Growth of small-holder OP - D: Attraction of OP profitability	- C: Growth of small-holder OP –more advanced than downstream - D: Attraction of OP profitability

Geographic bias of field observations of soil carbon stocks with tropical land-use changes precludes spatial extrapolation

6318–6322 | PNAS | April 12, 2011 | vol. 108 | no. 15

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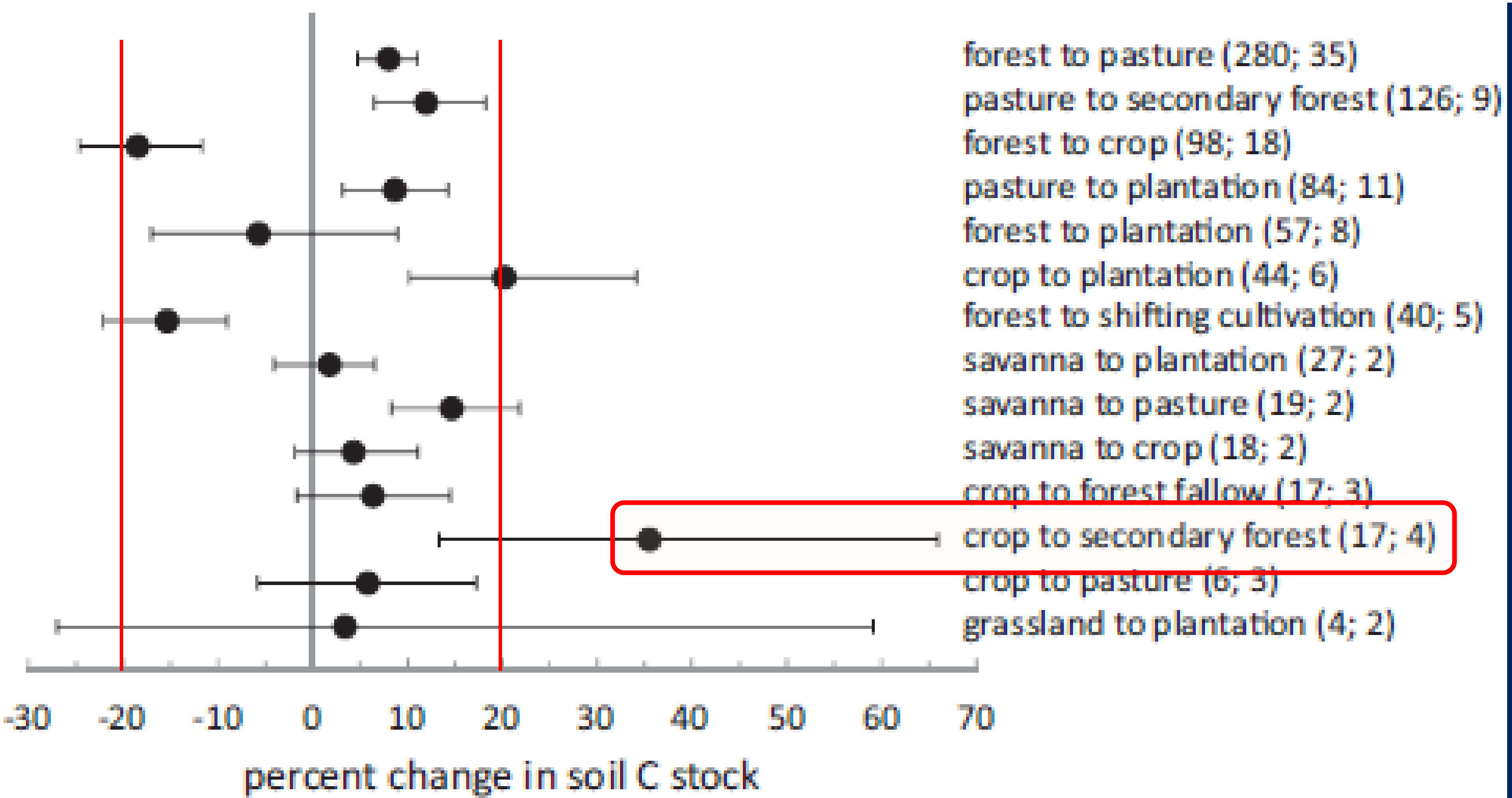
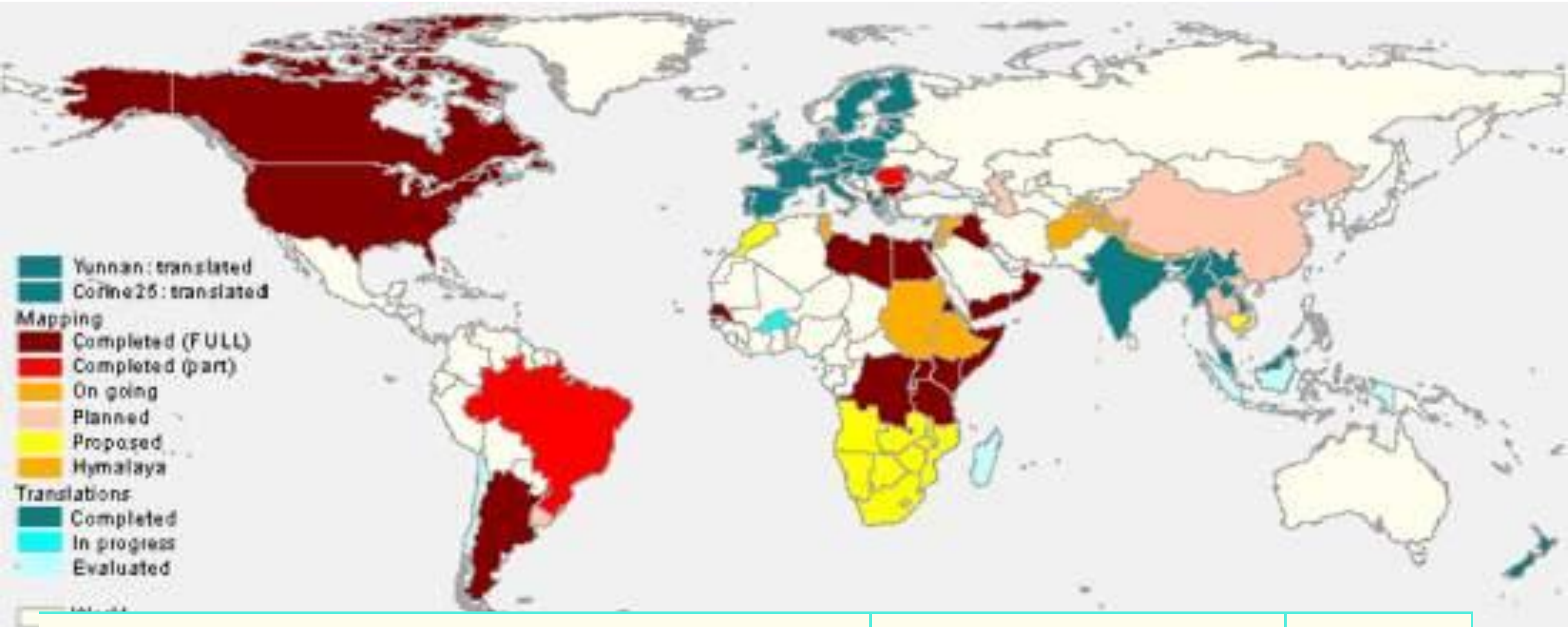
Edited* by Susan E. Trumbore, University of California, Irvine, CA, and approved March 4, 2011 (received for review November 8, 2010)

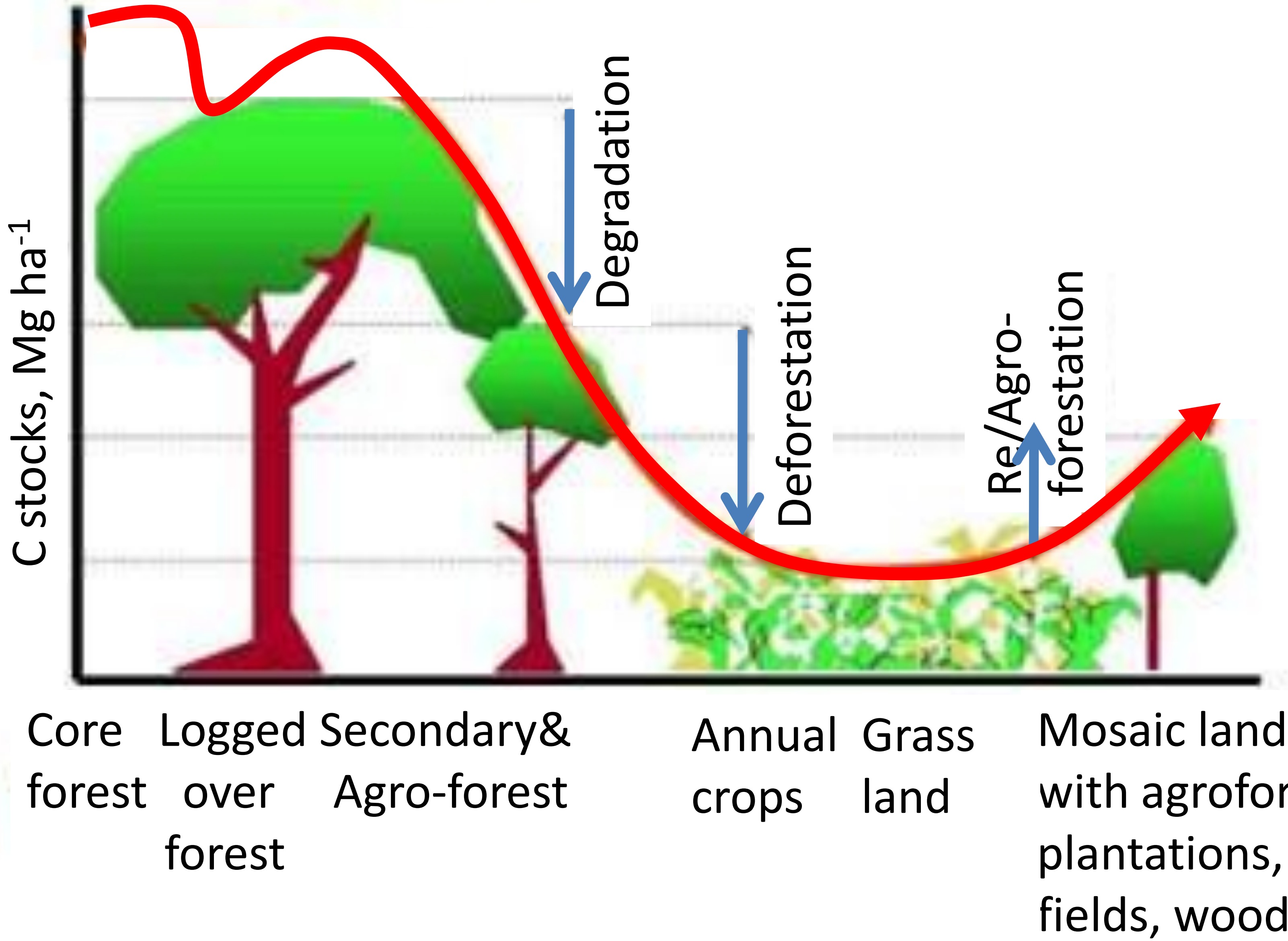


http://www.glcn.org/dat_6_en.jsp



MAPPING WITH LCCS				LEGEND TRANSLATION		
COMPLETED *national*	**COMPLETED** *partial*	**ON GOING**	**PLANNED**	**COMPLETED**	**IN PROGRESS**	**EVALUATED**
AFRICOVER	Brazil	Cuba	MEKONG basin	GLC2000	Burkina Faso	Chile
Burundi	Romania	Ethiopia	Cambodia	GLOBCOVER		Indonesia
DR of Congo	Tunisia	Jordan	Lao PDR	ASIACOVER		Madagascar
Egypt	HYMALAYA	Kenya	Thailand	Cambodia		
Eritrea	region	Lebanon	Viet Nam	Lao PDR		
Kenya	Afghanistan	Morocco	China	Malaysia		
Rwanda	Bhutan	Seychelles	Fouta Djallon	Myanmar		
Somalia	China	Sudan (N)	Highlands	Thailand		
Sudan	India	Syria	Uruguay	Viet Nam		
Tanzania	Myanmar			China		

Forest & tree cover transition






Components of C stock

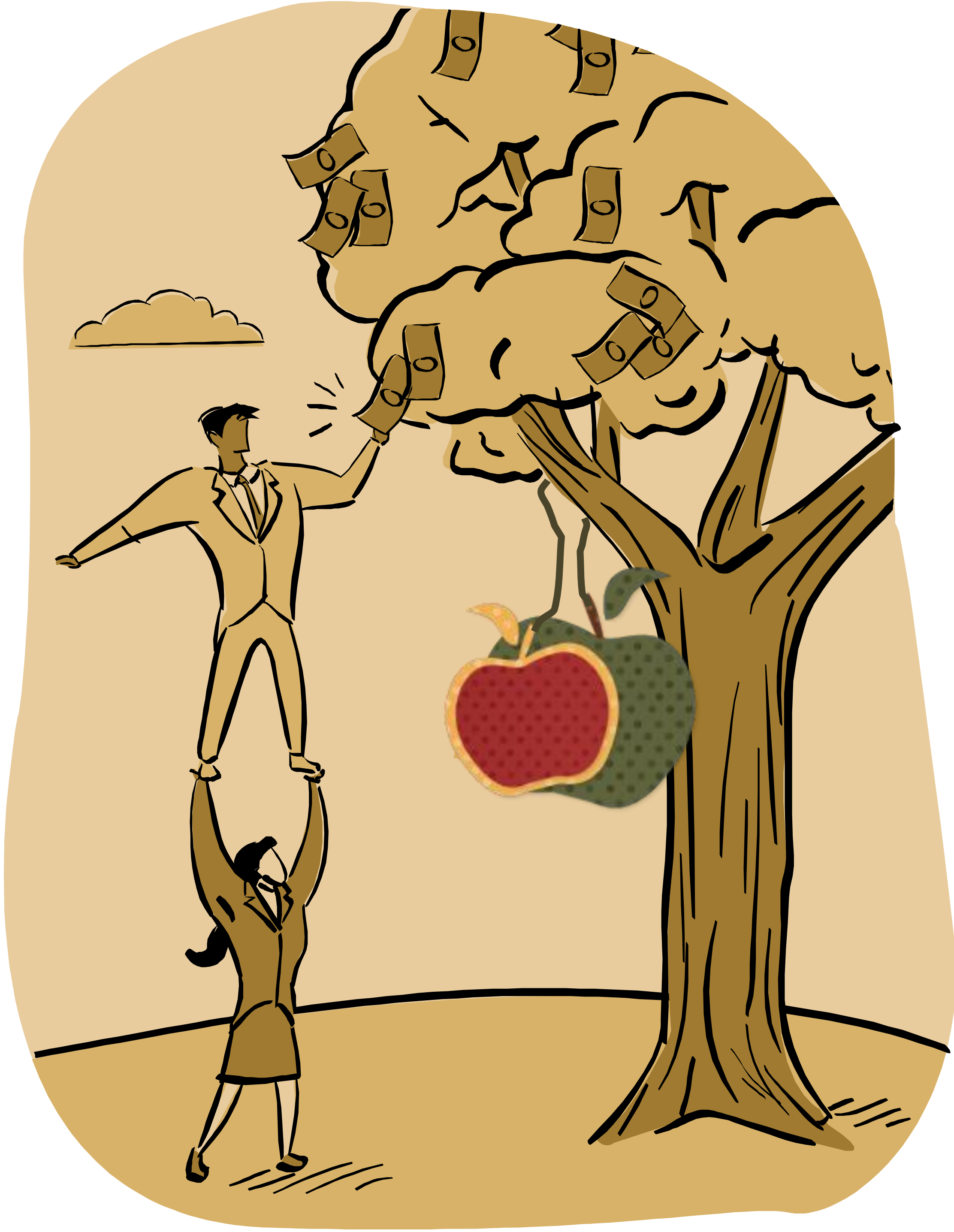
- Biomass: tree, understorey (+ seedling), roots (sh:rt = 4:1)
- Necromass: dead wood, fallen tree, trunk, surface litter
- Soil organic matter




Measuring Carbon Stocks Across Land Use Systems:

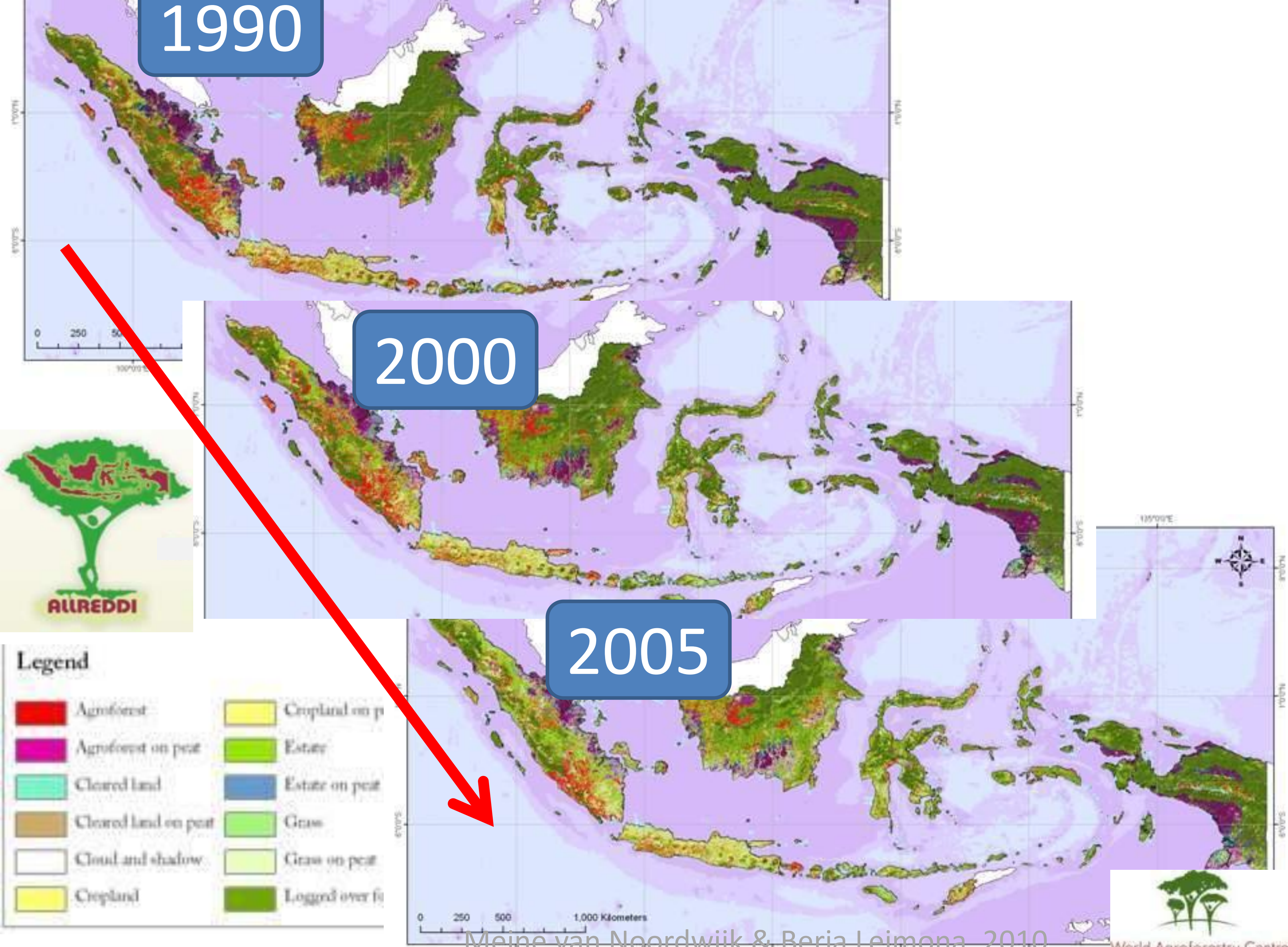
A Manual

Kurniatun Hairiah, Sonya Dewi, Fahmuddin Agus,
Meine van Noordwijk, Sandra Velarde and Subekti Rahayu



REDD-ALERT

Social capital and cooperation is needed to reach beyond the lowest hanging fruit



Meine van Noordwijk & Beria Leimona, 2010