

Findings in REDD related research programs in terms of the link between remote sensing and ground measurement

International Seminar on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD), 10-12 March, 2010, Tokyo, Japan

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With the link
between remote
sensing and ground
measurement

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 1. Secondary forest in slash-and-burn fallow land (Laos)
 2. Nationwide forest (Cambodia)
 3. Peat swamp forest under drainage influence (Indonesia)

Research programs
supported by MoE,
Japan

Requirements for monitoring methods for REDD

- Accuracy
 - Less errors in each element
 - Covering all important elements
- Large-scale
- Semi-real time
- Choices
 - Cause of DD, data availability, cost, etc.

Importance assessment of GHG subcategories in total potential of CO₂-e emission from forest degradation in the test-sites

GHG	Subcategory
CO ₂	AG and BG biomasses
	Deadwood, Litter
	Soil organic matter (SOM)
N ₂ O	Fire
	SOM mineralization
CH ₄	Fire

from more or less project data	Estimates from the default values in GPG (IPCC 2003)
356)	
36) >	
0%	

Important assessment using GPG-LULUCF

GHG subcategories in forestland (IPCC 2003)

Peat swamp forest in the test-site in Indonesia		
CO ₂	Biomass (aboveground and belowground)	242 (197-347)
	Deadwood, litter	<54 (43-63) >
	SOM (0-30 cm depth)	<315>
N ₂ O	Fire	3 (2-4)
	SOM mineralization	<39> (0-117)
CH ₄	Fire	28 (22-35)
		681 (580-881)

GHG	Subcategory
CO ₂	AG and BG biomasses
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N ₂ O	Fire
	SOM mineralization
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GHG subcategories with high priority for monitoring



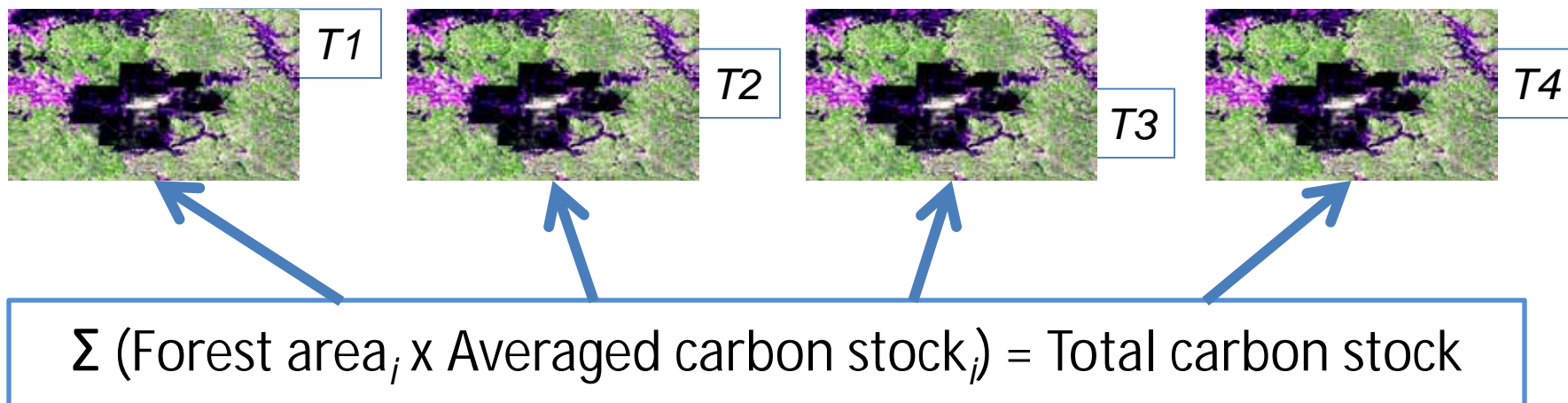
Requirements for monitoring methods for REDD

- Accuracy
 - Less errors in each element
 - Covering all important elements
- Large-scale → Use of remote sensing data is indispensable
- Semi-real time → Use of SAR data may be useful
- Choices
 - Cause of DD, data availability, cost, etc.

Radar overcomes haze and cloud cover

A proposed simplified method for estimating CO₂-e emissions from deforestation and forest degradation

- The method is the calculation of carbon stock change by monitoring forest land and periodically summing up the forest area and its averaged carbon stock for important forest types.



Choices of monitoring methods for REDD

Objective variables	Approaches	Requirements	Costs	Spatial scale up	Technical difficulties	Applicability of the approach in estimating anthropogenic GHG emissions by each activity				Improvement in accuracy expected by local people participating in the monitoring	
						Conversion to crop land	Reducing fallow period of slash-and-burn agriculture	Logging	Fuel wood collection		
Forest area	Land cover classification	Remote sensor with medium or higher resolution	Medium	Easy	•Not applicable when clouded	Possible	Possible	Partially possible	Partially possible	Low	
		SAR with microwaves longer than L-band	Medium	Easy	•Not applicable to areas with steep slopes	Possible	Possible	?	?	Low	
Averaged carbon stock per unit land area	Gain-loss method	Growth rate, removal rate	Measurement on ground	3 examples of choice		?	?	?	?	High	
	Stock difference method	PSP data	Measurement on the ground	High	Difficult	•Limitation in representativeness and secretness of plot	Possible	Possible	Possible	Possible	High
		Community age	Remote sensor with medium or higher resolution	Medium	Easy	•Applicable to land use with periodical naked land stages e.g. slash-and-burn farming	Impossible	Possible	Impossible	Impossible	Low
		Crown diameter	Remote sensor with high resolution	High	Medium	•Not applicable when clouded •Crowns are hardly recognized in some forests	Partly possible	Impossible	Partly possible	Impossible	Low
			Aerial photograph	High	Medium	•Not applicable when clouded •Crowns are hardly recognized in some forests	Partly possible	Impossible	Partly possible	Impossible	Low
			Multi-polarization SAR	Low	Medium	•Methods are not tested •Applicable to small parts of globe	?	?	?	Impossible	Low
		Overstory height	Airborne LIDAR	High	Difficult	•Nothing in particular	Possible	Possible	Possible	Impossible	Low
Stereo mapping remote sensor (DSM)	Medium		Easy	•Not applicable when clouded •Methods are not tested	?	?	?	Impossible	Low		
Measurement on the ground	?		Difficult	•Methods are not tested	Possible	Possible	Possible	Impossible	High		
Backscattering-coefficients	SAR with microwaves longer than L-band	Low	Medium	•Not applicable to areas with steep slopes •Not applicable to high biomass forest	Partly possible	Partly possible	Impossible	Impossible	Low		



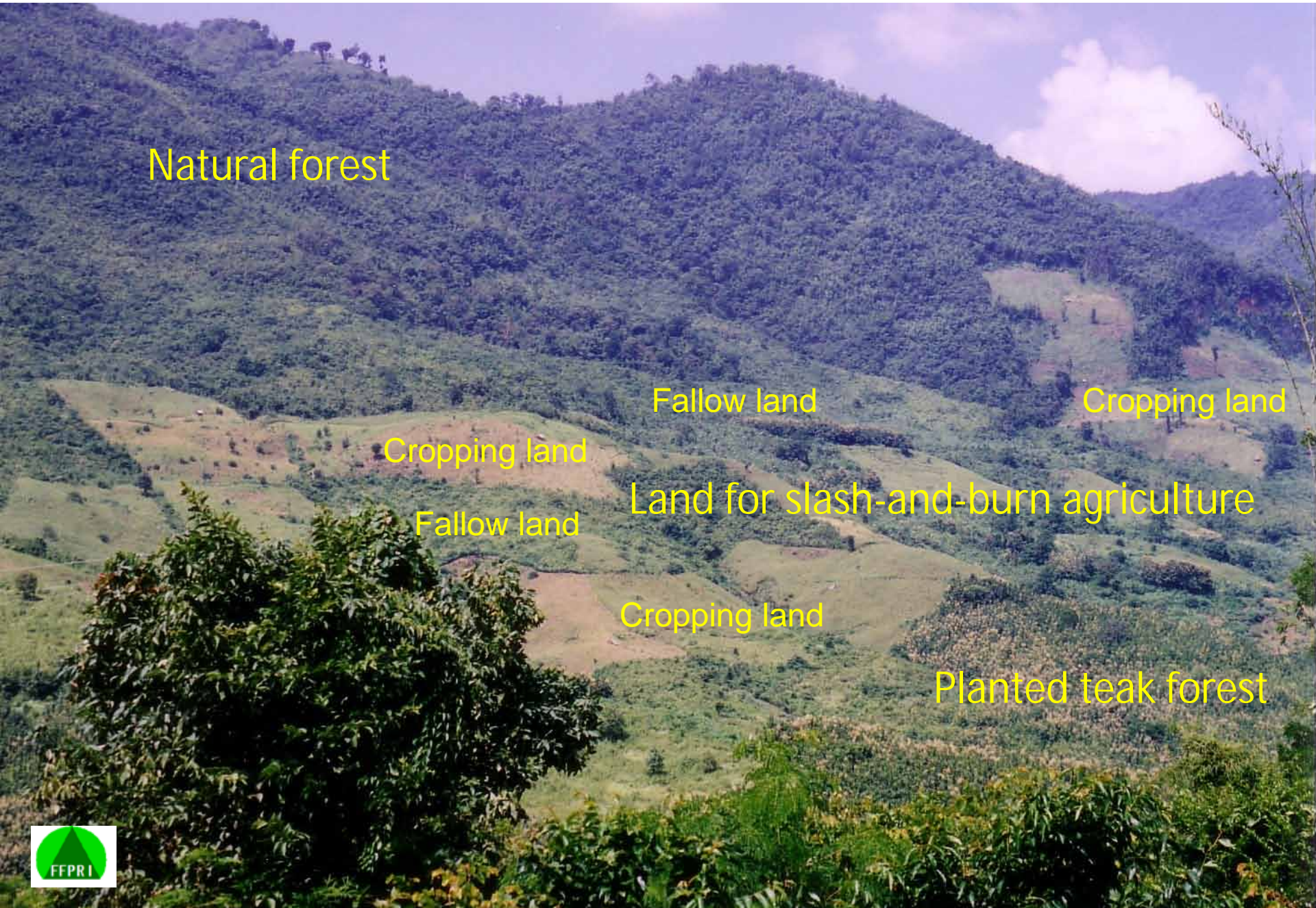
This table is applicable to dry land forest.

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1. Secondary forest in slash-and-burn fallow land (Laos)



Natural forest

Fallow land

Cropping land

Cropping land

Land for slash-and-burn agriculture

Fallow land

Cropping land

Planted teak forest

A flow for estimating chronosequential changes in carbon stock in slash-and-burn fallow land

Chronosequential analysis of satellite images of Landsat/ETM+, ASTER, etc.



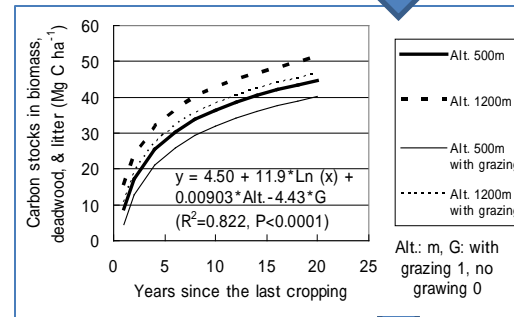
Time and spatial distribution of cropping land

Oral history

Changes in land area for slash-and-burn agriculture

Changes in mean fallow period

Plot setting and ground measurement

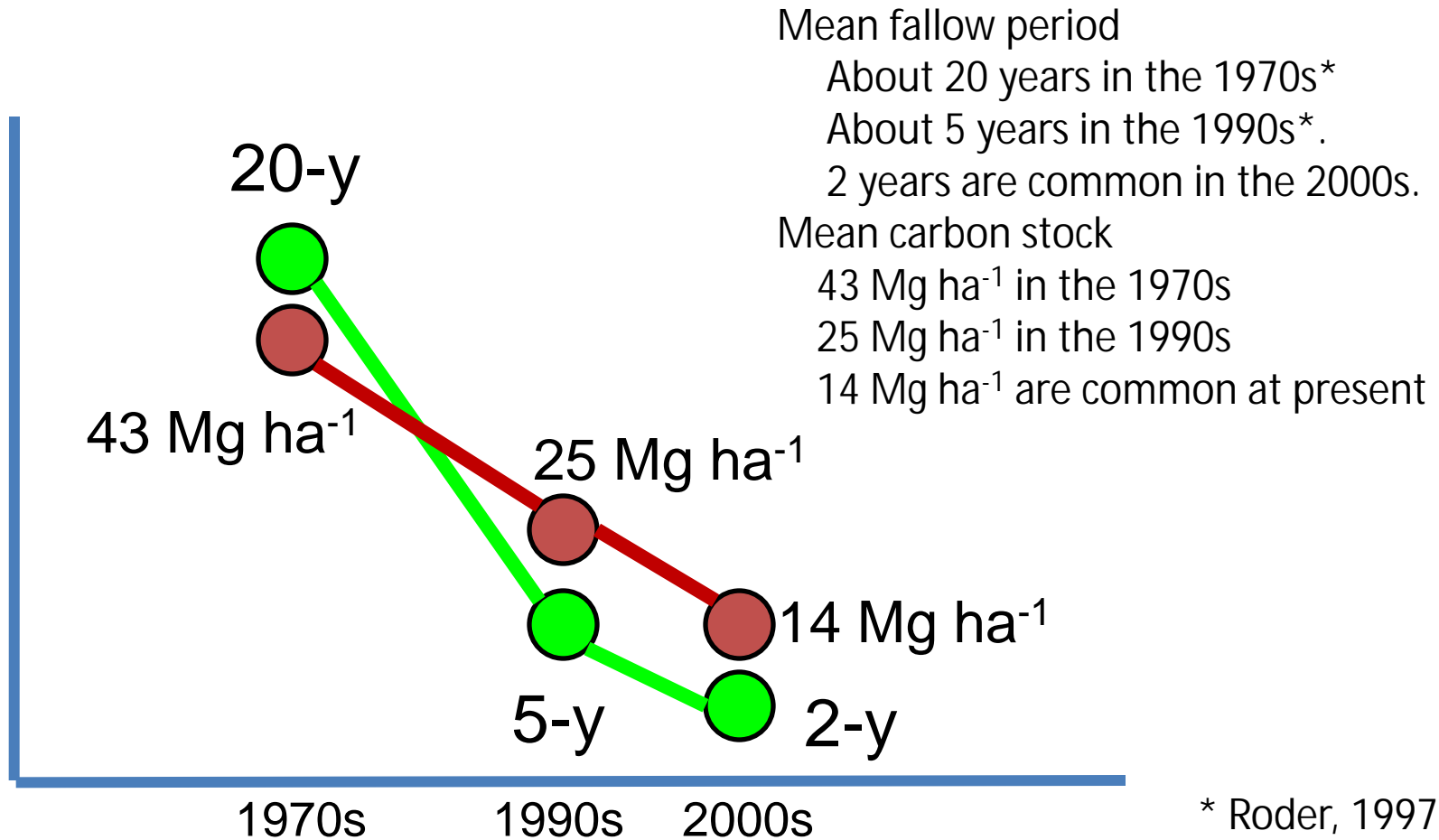


Relationship between Community age and carbon stock

Fallow-period-average carbon stock

Chronosequential changes in carbon stock

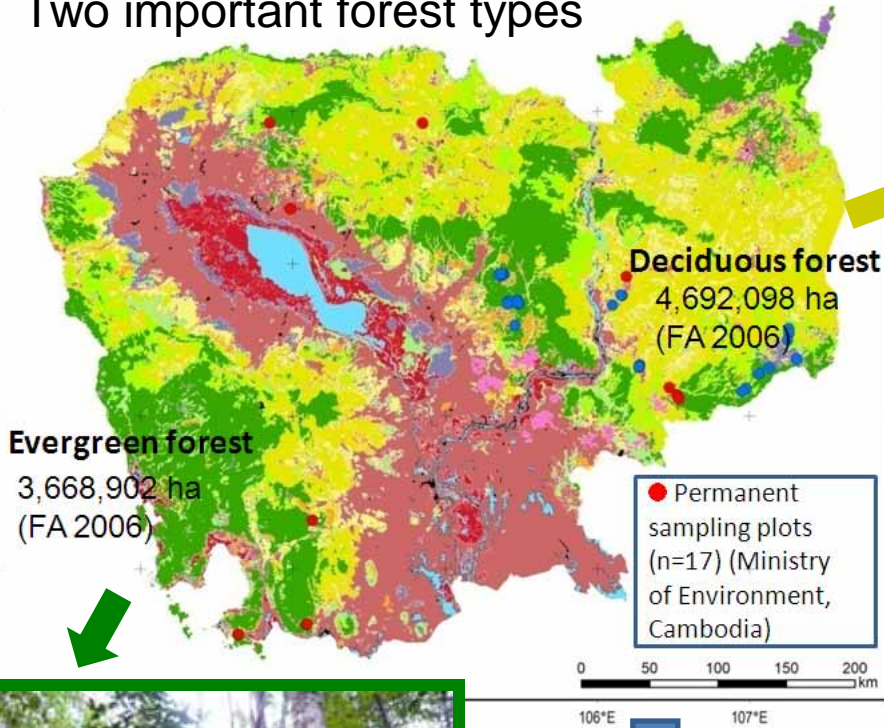
- Fallow period and carbon stock have been drastically reduced in northern Laos



* Roder, 1997.

2. Nationwide forest (Cambodia)

Two important forest types



Logging



Rubber plantations

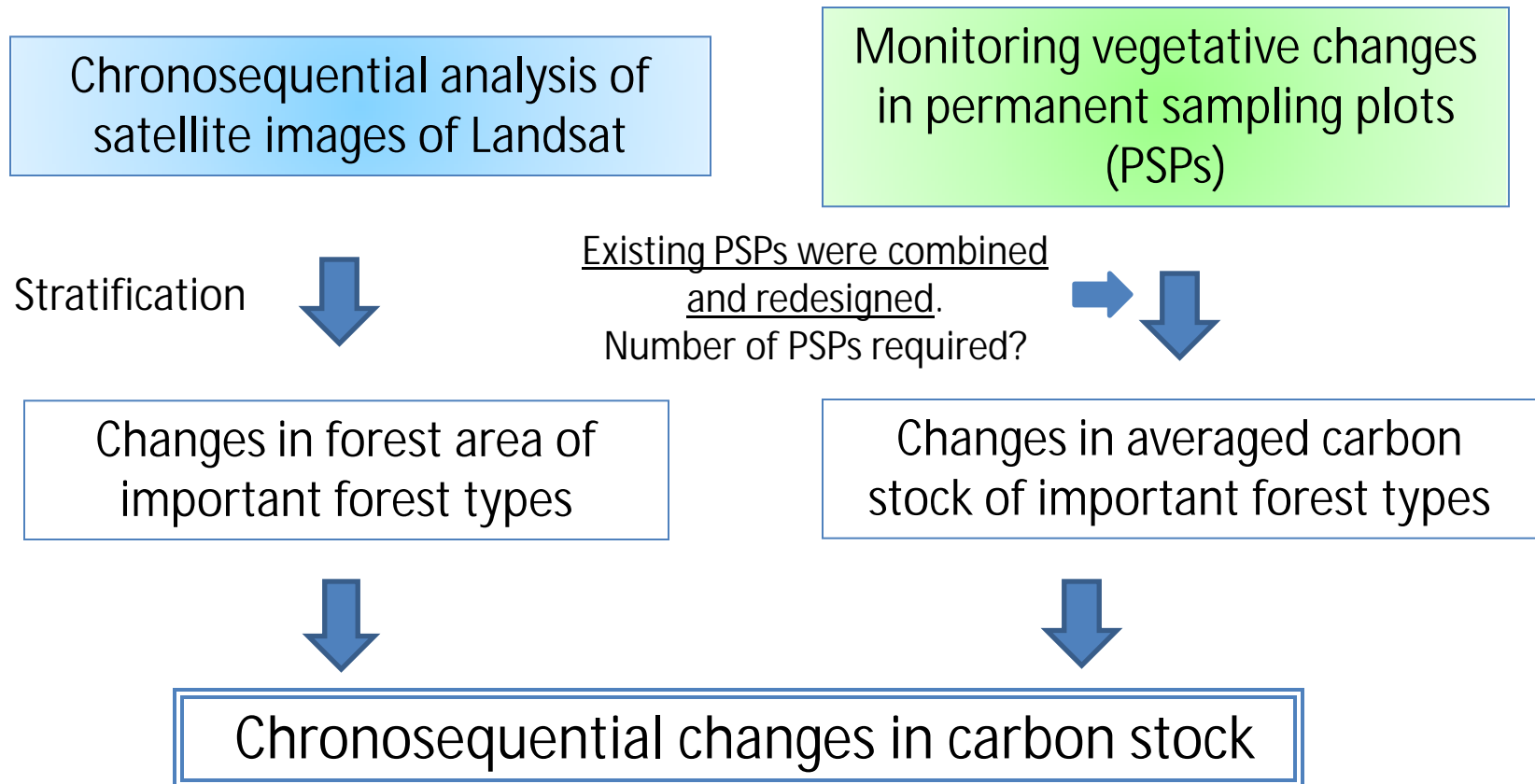


Crop land

By Eriko Ito

A flow for estimating nationwide forest carbon stock

$$\Sigma (\text{Forest area}_i \times \text{Averaged carbon stock}_i) = \text{Total carbon stock}$$



Data for averaged carbon stock

- 155 permanent sampling plots (PSPs)
 - 17 by Ministry of Environment , Cambodia
 - 138 by Forestry Administration, Cambodia
- Plot area: 2,000–2,500 m²
- DBH of trees 5 cm in DBH, species
- Equations and parameters for estimating biomass carbon



Leaf weight: $Wl = 173 \mathbf{ba}^{0.938}$ (n = 509, R² = 0.780, P < 0.001)

Branch weight: $Wb = 0.217 \mathbf{ba}^{1.26} \mathbf{D}^{1.48}$ (n = 509, R² = 0.910, P < 0.001)

Stem weight: $Ws = 2.69 \mathbf{ba}^{1.29} \mathbf{D}^{1.35}$ (n = 509, R² = 0.971, P < 0.001)

Root weight: $Wr = 0.500 \mathbf{ba}^{1.20} \mathbf{D}^{1.33}$ (n = 509, R² = 0.943, P < 0.001)

ba: basal area, m²; **D**: basic density; Carbon fraction: 0.5

Kiyono et al. JARQ 44 (1), 81 - 92 (2010) <http://www.jircas.affrc.go.jp>

Other carbon pools are negligible or not available

- Understory and litter:
Destructively sampled.
- Deadwood:
Non-destructively sampled.
- SOM:
Not considered at present
because no data available.



The averaged carbon stock (PSPs)

Evergreen forest	140.0 ± 89.5 (SD) Mg-C ha ⁻¹ (n = 117)
Deciduous forest	74.5 ± 49.9 (SD) Mg-C ha ⁻¹ (n = 38)

- UNFCCC provided a tool applicable for carbon-stock-monitoring purposes and estimates the number of permanent sample plots (PSPs) needed for monitoring changes in carbon pools at a desired precision level and the costs of establishment of the plots. http://cdm.unfccc.int/Reference/tools/ar/methAR_tool03_v01.pdf
- Numbers of PSPs required for reliable estimation were 66 for EF and 50 for DF. Additional 12 DF PSPs are needed.

The nationwide forest carbon stock (Cambodia) (tentative)

$$\Sigma (\text{Forest area}_j \times \text{Averaged carbon stock}_j) = \text{Total carbon stock}$$

Forest type	Forest area km ²	Averaged carbon stock Mg-C ha ⁻¹	Total carbon stock Tg-C
EF	36,689	140.0 ± 89.5	513.6 ± 328.3
DF	46,921	74.5 ± 49.9	349.4 ± 234.3
Total	83,610		863.0 ± 403.3

3. Peat swamp forest under drainage influence (Indonesia)

Primary forest



The Mega Rice Project Site

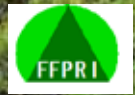
Land use change with drainage



Degraded forest



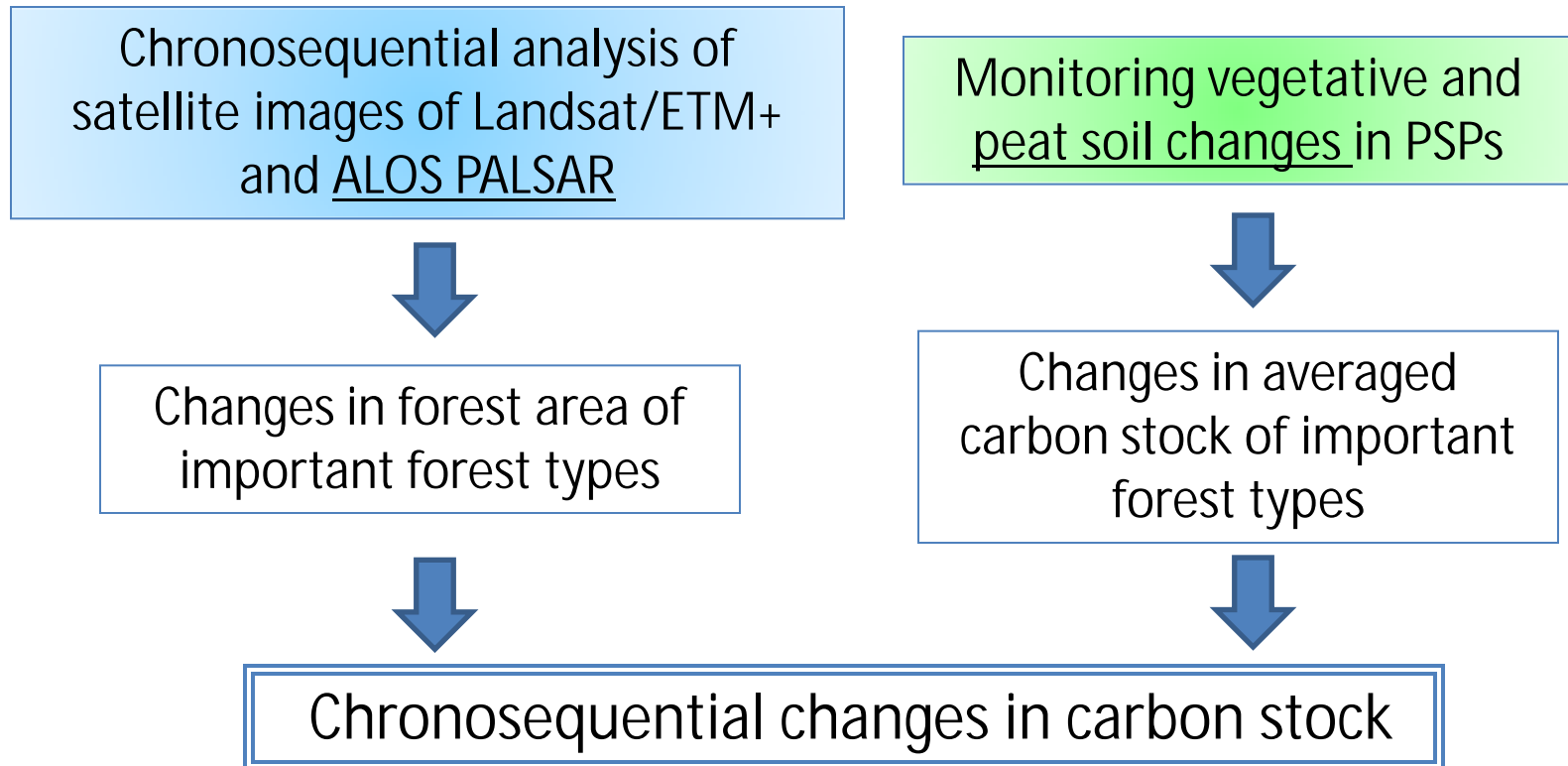
Fire



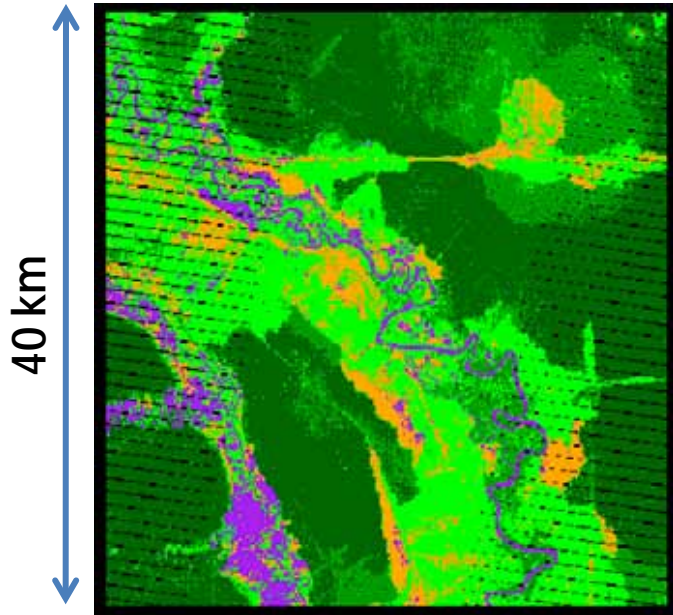
By T. Inoue

A flow for estimating carbon stock of peat swamp forest under drainage influence

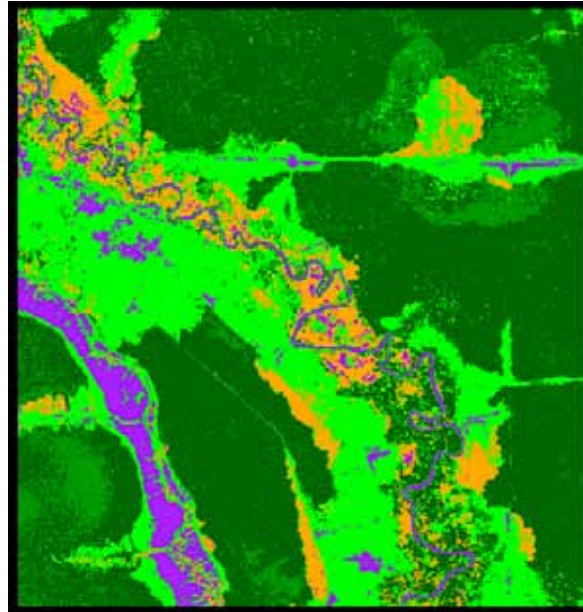
$$\Sigma (\text{Forest area}_i \times \text{Averaged carbon stock}_i) = \text{Total carbon stock}$$



Land-cover classification by Landsat/ETM+ and ALOS PALSAR data

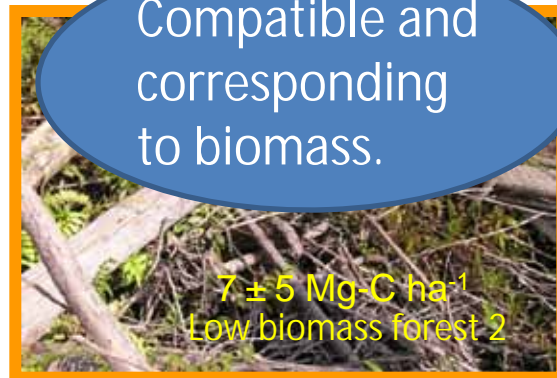
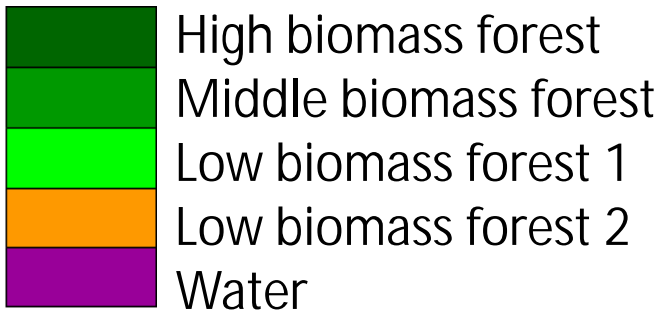
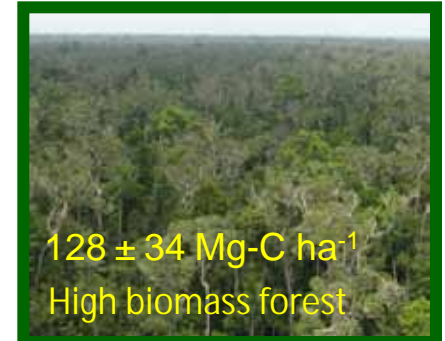


By Landsat/ETM+



By ALOS PALSAR

©JAXA, METI



Compatible and corresponding to biomass.

The forest carbon stock in the test site (Indonesia) (tentative)

	Forest type	Forest area km ²	Averaged carbon stock Mg-C ha ⁻¹	Total carbon stock Tg-C
Landsat /ETM+	High BF	677	128 ± 34	8.7 ± 2.3
	Middle BF	297	20 ± 11	0.6 ± 0.3
	Low BF1	491	4 ± 2	0.2 ± 0.1
	Low BF2	148	7 ± 5	0.1 ± 0.1
	Total	1,726		9.6 ± 2.3
ALOS PALSAR	High BF	850	ditto	10.9 ± 2.9
	Middle BF	195	ditto	0.4 ± 0.2
	Low BF1	489	ditto	0.2 ± 0.1
	Low BF2	151	ditto	0.1 ± 0.1
	Total	1,799		11.6 ± 2.9



- By moderately classifying forest types, using land-area data on each forest type, and determining averaged carbon stock of each forest type, we can expect a reasonably accurate estimation of carbon stock of the region.
- However, in reality **half** (Cambodia) and **two-thirds** (Indonesia) of the forests in the sampling plots were destroyed or heavily logged or burnt and declining carbon stock occurred within 3 years of observation.

- A sufficient number of extra plots and frequent updating of forest area and its averaged carbon stock data are vital in the region under pressure of DD.
- ALOS PALSAR data have enough potential for extracting forest area of important forest types similar to Landsat/ETM+ data and may have advantage of possibilities of semi-real time (frequent) monitoring of forest land.

Once 46-days

Conclusions

- Requirements for monitoring methods for REDD may include accuracy, large scale, semi-real time, and choices for tiers.
- A proposed simplified method is the calculation of carbon stock change by monitoring forest land and periodically summing up the forest area and its averaged carbon stock for important forest types.
- Reasonably accurate estimation of carbon stock can be expected by classifying forest types, using forest-area data on each forest type by remote-sensing, and determining averaged carbon stock of each forest type by the ground measurement.
- ALOS PALSAR may have the advantage of possibilities of semi-real time monitoring of forest land.
- Approaches using PSPs are considered to be robust. However, in the region under pressure of DD, a sufficient number of extra plots and frequent updating of data are vital.

Thank you for your kind attention.

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