Jurisdictional Approaches to Green Development

Jurisdictional-scale carbon accounting: evaluating options

Aboveground carbon loss in Democratic Republic of the Congo

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National-scale estimation of gross forest aboveground carbon loss: a case study of the Democratic Republic of the Congo

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Background

Approaches to mapping and monitoring carbon stocks (Goetz & Dubayah, 2011):

■ "Stratify and Multiply" ■ "Combine and Assign" ■ "Direct Remote Sensing"

Basic IPCC equation to calculate carbon emissions (IPCC, 2006, vol.1, ch.1.2):

Emissions = AD * EF

AD – activity data,
the extent of human activity

EF – emissions factor,
quantifies emissions of removals per unit activity

Emissions deforestation:

Area Change * Carbon stock of land cover

Area change (Deforestation) = Satellite

Carbon stocks = field and new techniques

Carbon stocks field measurements

- Areas of low accessibility -> direct field validation is expensive or not feasible
- Need to extrapolate from point to areas

Accurate carbon emission data form satellite

Emissions = Activity * Carbon stock of land cover

- Develop Activity data
- Develop carbon stock –
- Develop accuracy of Activity
- Develop accuracy assessments of both datastreams

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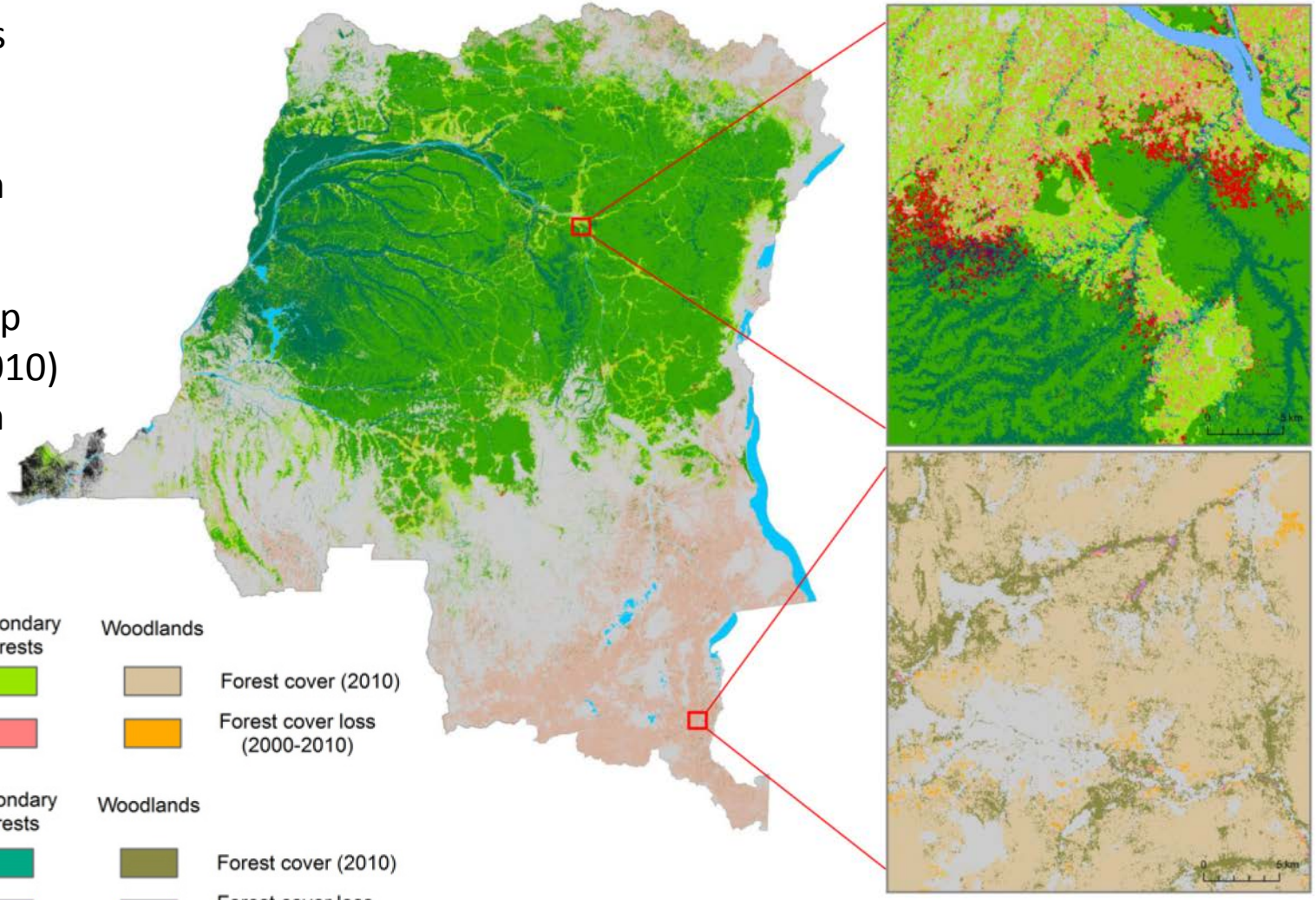
DRC Activity data: forest cover and loss

DRC FACET atlas
(SDSU, 2010)
2000-2010,
60-m resolution

&

DRC wetland map
(Bwangoy et al., 2010)
60-m resolution



terra firma (dryland)
wetland

primary,
secondary forests,
woodlands

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DRC Data: Carbon data

GLAS-predicted aboveground carbon densities (Baccini et al., 2012):

Regression model (**explains 83%** of variance in field measurements):

*AGB = - 31.631 + 15.952 * HOME * + 7.832 * H10 – 18.805 * H60 – – 38.428 * CANOPY_ENE + 8.285 * H25*

H10, H25, H60	height in the waveform, where the given energy percentile is reached
HOME	the height of median energy
CANOPY_ENE	the integral of the function between signal beginning and the top of ground peak

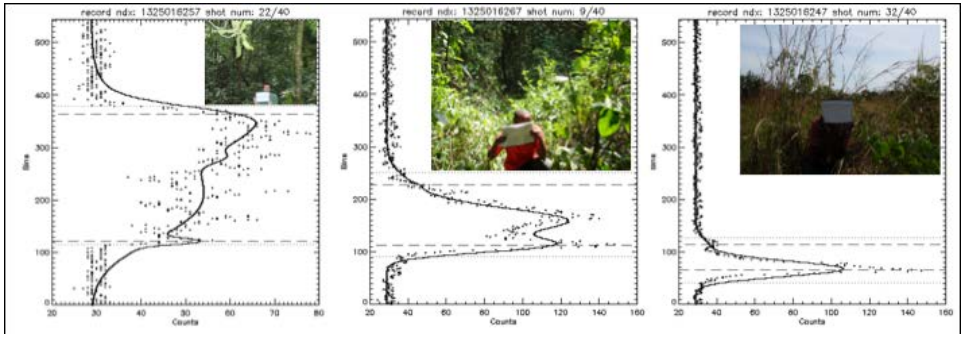
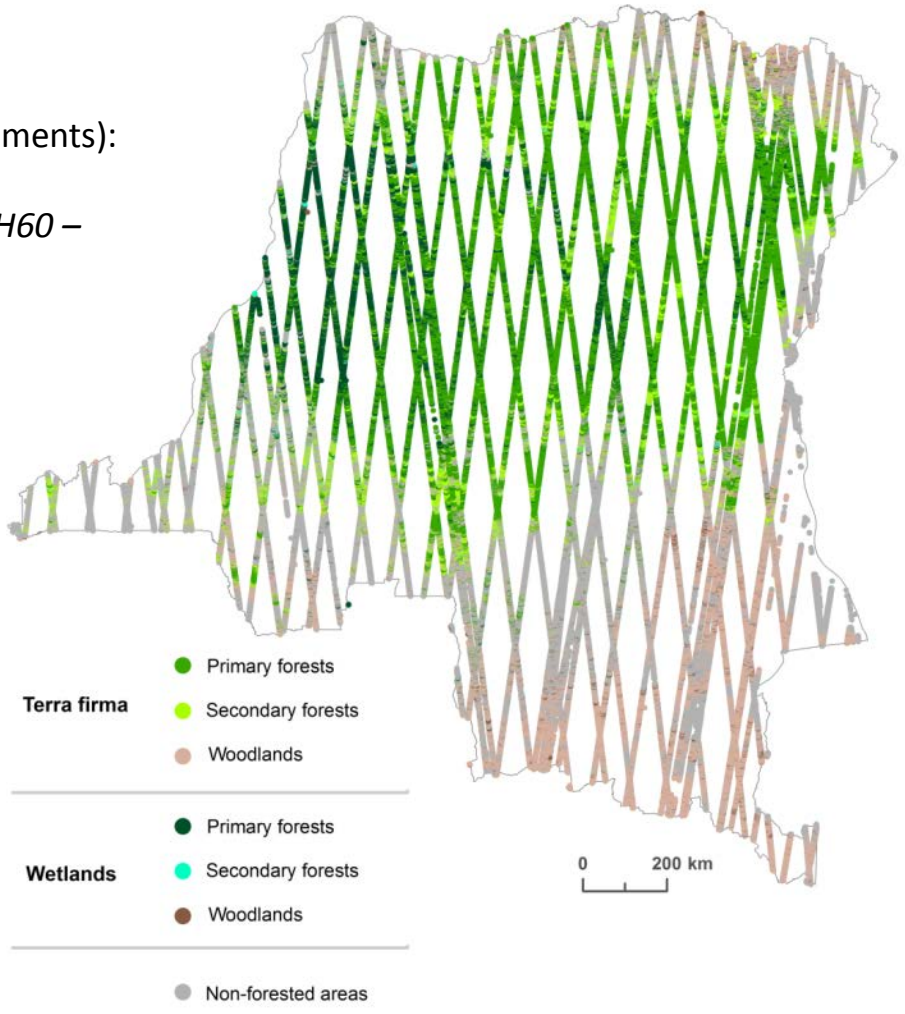


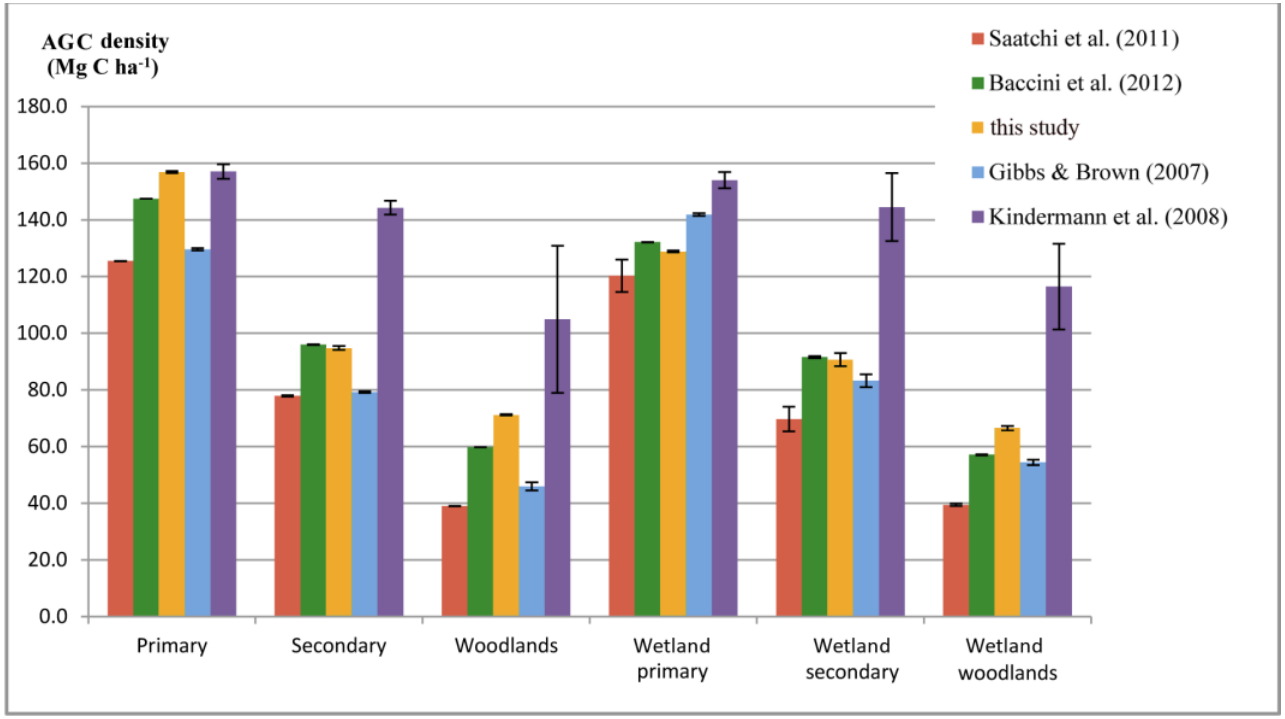
figure from *Baccini et al., 2012*



DRC

Data: Carbon data

Forest type	Mean AGC density (Mg C ha^{-1})	Number of GLAS samples	STD
Primary forest	156.8 ± 0.4	115,566	67.03
Secondary forest	94.8 ± 0.7	31,443	67.45
Woodlands	71.2 ± 0.2	121,671	44.24
Wetland primary forest	128.9 ± 0.4	85,923	55.29
Wetland secondary forest	90.7 ± 2.3	3,148	65.83
Wetland woodlands	66.5 ± 0.8	13,707	45.81



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DRC Methods: forest cover loss validation

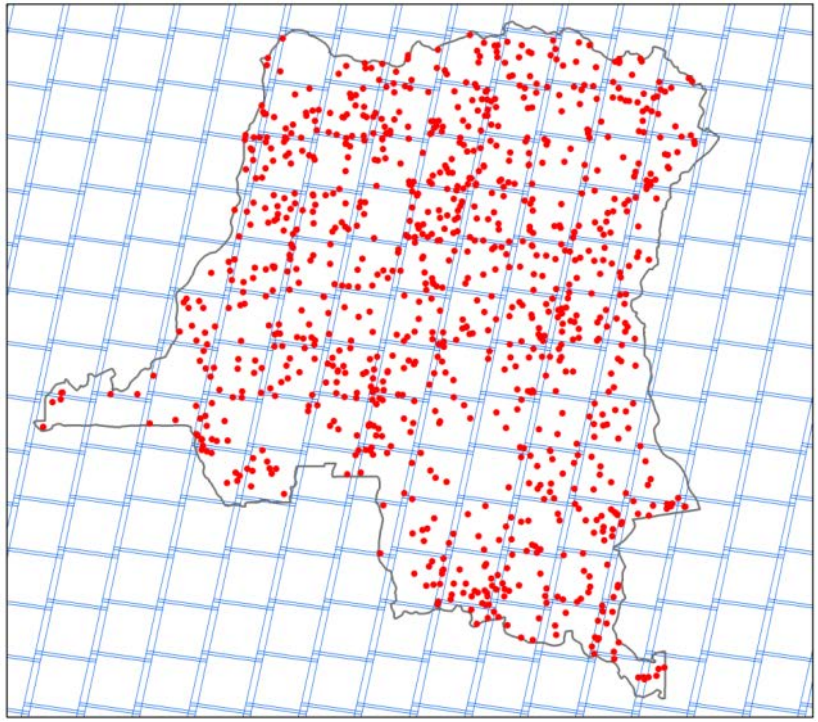
Primary objective – estimate error-adjusted area of forest cover loss within each forest type (Olofsson et al., 2013)

Sampling design:

- Stratified random sampling
- Allocation of samples among strata -> arbitrary, between equal and proportional, to account for both committed and omitted loss area
- National-scale land cover product is conservative, tends to omit loss -> -> additional “no loss – probable loss” stratum to better estimate omitted loss area

Allocation of validation samples (1000 60-m FACET pixels):

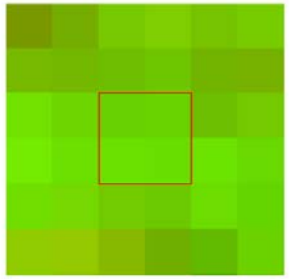
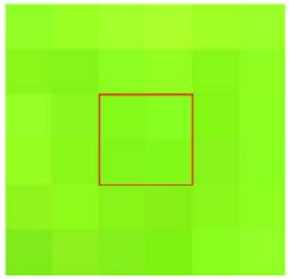
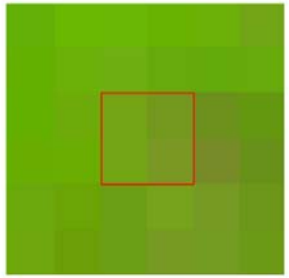
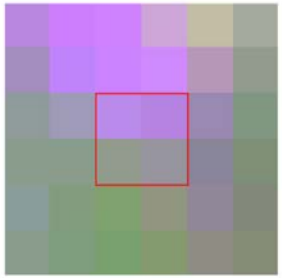
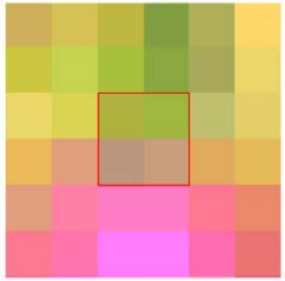
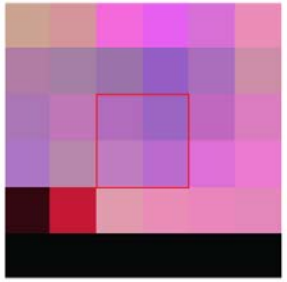
	No loss	Probable loss	Loss	Total
Primary forest	200	70	63	333
Secondary forest	30	87	50	167
Woodlands	100	90	60	250
Swamp primary forest	80	30	57	167
Swamp secondary forest	15	15	12	42
Swamp woodlands	15	15	12	42



Validation data:

- original 30-m Landsat images (2000 and 2010),
- high resolution imagery from Google Earth and CARPE archives (available for 484 samples)

DRC Methods: forest cover loss validation

2000 Landsat	2010 Landsat	2009-2011 VHR imagery	Reference loss
			0 (no loss)
			0.5
			1 (loss)

DRC Results: forest cover loss validation

Forest type	Error-adjusted area of 2000-2010 forest cover loss (ha) 30 m data	FACET map area of 2000-2010 forest cover loss (ha) 60 m data
Primary forest	1,129,210 ± 443,156	949,803
Secondary forest	2,994,876 ± 664,625	2,022,852
Woodlands	722,979 ± 396,475	494,668
Swamp primary forest	98,925 ± 11,218	117,473
Swamp secondary forest	87,440 ± 78,014	91,979
Swamp woodlands	29,153 ± 7,704	34,983

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DRC Methods: combining uncertainties

IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006, vol.1, ch.3):

- ***multiplication approach*** ← *AGC loss = ΔAD * CD*

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \cdots + U_n^2}$$

U_{total} - the percentage uncertainty in the product of the quantities (half the 95% confidence interval divided by the total and expressed as percentage);
U_i - the percentage uncertainties associated with each of the quantities.

Forest type	U_{AD} (%)	U_{CD}(%)	U_{total} (%)
Primary forest	20.02	0.13	20.02
Secondary forest	11.32	0.40	11.33
Woodlands	27.98	0.18	27.98

Forest type	U_{AD} (%)	U_{CD}(%)	U_{total} (%)
Swamp primary forest	5.79	0.15	5.79
Swamp secondary forest	45.52	1.29	45.54
Swamp woodlands	13.48	0.59	13.50

- ***addition and subtraction approach*** ← *Total DRC AGC loss = Σ*

$$U_{total} = \frac{\sqrt{(U_1 * x_1)^2 + (U_2 * x_2)^2 + \cdots + (U_n * x_n)^2}}{|x_1 + x_2 + \cdots + x_n|}$$

x_i **and** U_i - the uncertain quantities and percentage uncertainties associated with them.

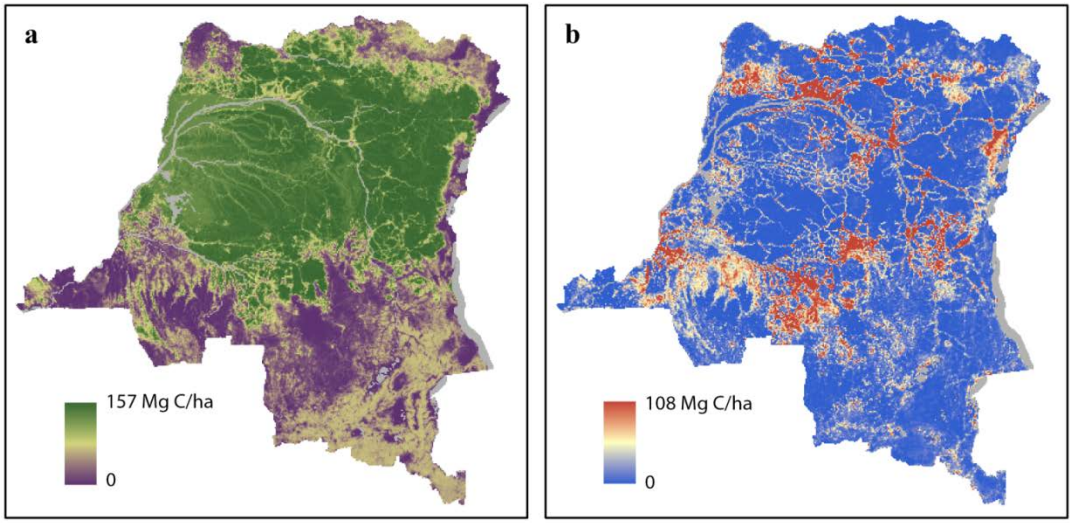
$$\boldsymbol{Total\ DRC\ AGC\ loss:\ U_{total} = 9.4\%}$$

Results

DRC Results and Discussion

Source	Extent	2000-2005	2005-2010
		Annual gross forest cover loss (% of the forest area)	
current study	forests + woodlands	0.32% ± 0.03%	
	forests	0.35% ± 0.03%	
FACET map Potapov et al. (2012) – 60 m	forests + woodlands	**0.22%**	0.25%
Hansen et al. (2013) – 30 m	forests + woodlands	0.34%	
Ernst et al. (2013)	forests	0.32% ± 0.05%	–
Hansen et al. (2010)	forests + woodlands	**0.12% ± 0.23%**	–
		Annual gross AGC loss (Tg C year^{-1})	
current study	forests + woodlands	53.3 ± 9.8	
		Annual gross carbon loss (Tg C year^{-1})	
Harris et al. (2012)	forests + woodlands	23	–

DRC Results and Discussion



Forest type and strata averages, aggregated to a 5-km grid:
a) year 2000 AGC;
b) estimate of 2000-2010 gross AGC loss.

- **Error-adjustment from validation can significantly increase loss estimates for landscapes dominated by small-scale land dynamics, as exist in Central Africa**
- **Biomass data can be aggregated by forest type,**
- **Sample-based estimations using high spatial resolution data may be required if Landsat data are found insufficient**

This presentation - Message

- Recent advances in remote sensing enable the mapping and monitoring of carbon stocks without relying on extensive field measurements ….. Better data , more accurate results

- Good GHG emissions information relies on good input data. …..It is clear that
  - spatial scale of forest change;
  - good forest type characterization;
  - sample representativeness.

- Terra firma secondary forest cover loss accounted for 40% more carbon loss significant more then primary forest loss ….. Secondary forest is important in GHG accounting

THANKS - TERIMA KASIH

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Thank you for attention!