Monitoring forest degradation for REDD+

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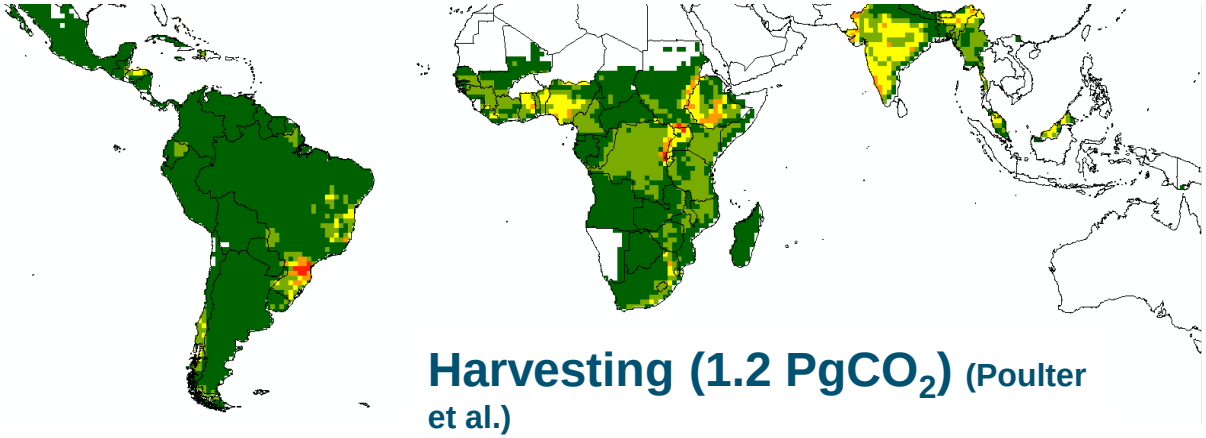
Includes:

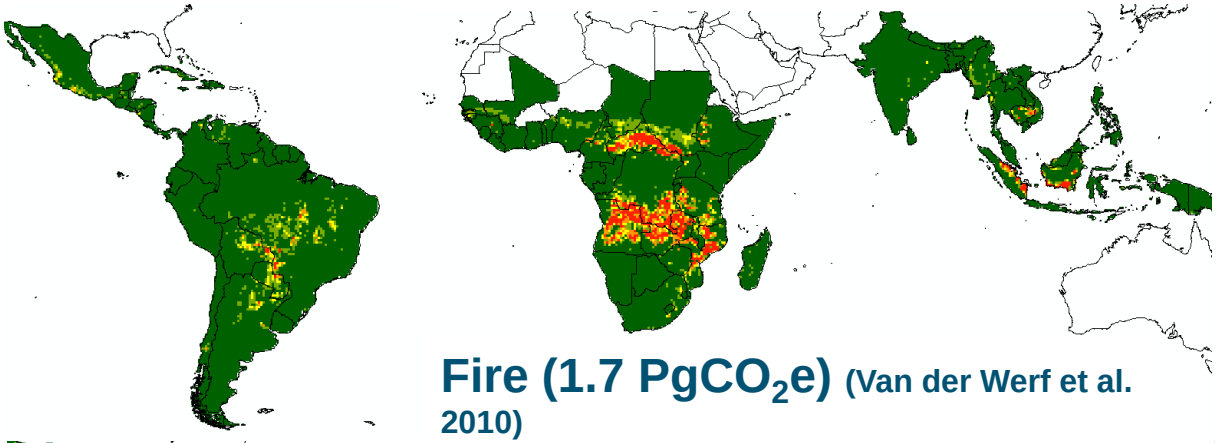
Summary of a GOFC-GOLD/GFOI expert workshop
http://www.gfoi.org/rd/second-rd-workshop/

Parts are taking from GOFC-GOLD Sourcebook module 2.2:
http://www.gofcgold.wur.nl/redd/Training_materials.php

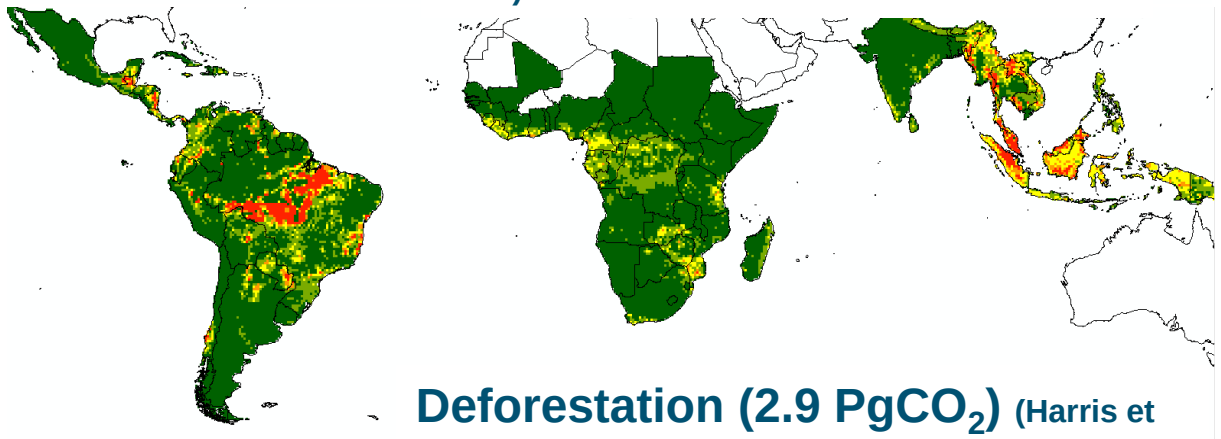
Sept. 2015



Harvesting (1.2 $PgCO_2$) (Poulter et al.)



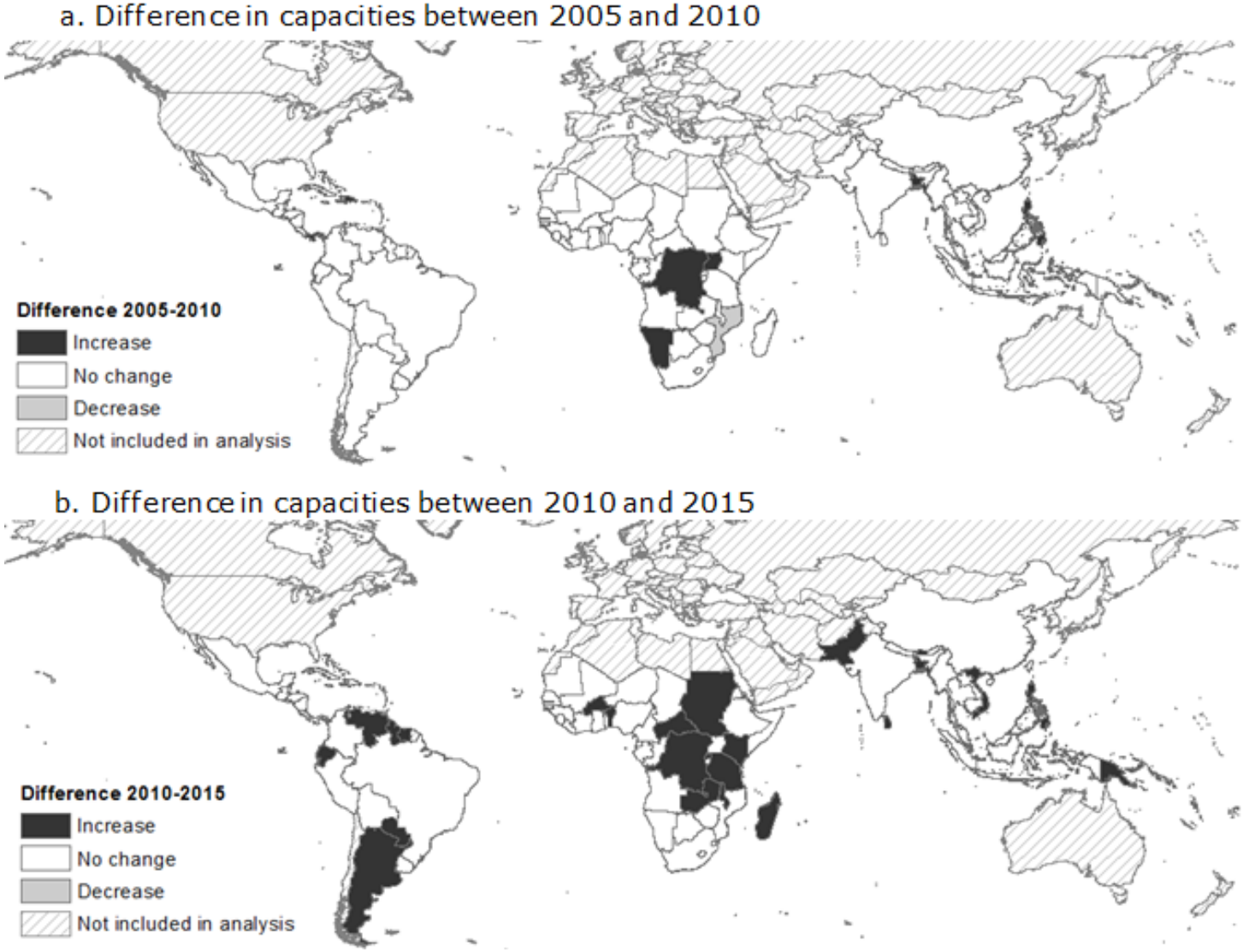
Fire (1.7 $PgCO_2e$) (Van der Werf et al. 2010)



Deforestation (2.9 $PgCO_2$) (Harris et al. 2012)

83
240
515 **$GgCO_2e$**
941
>941

Source: Rosa Roman et al.



Increase in forest area change monitoring capacities for FAO FRA 2015

(Source: Romijn et al. 2015, Forest Ecology & Management)

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Degradation: Introduction

- Forest degradation (changes in forests remaining forests) leads to a decline in carbon stock
- Emission levels per unit area are lower than for deforestation; cumulative and secondary effects can result in significant carbon emissions
- Monitoring forest degradation is important also to avoid displacement of emissions from reduced deforestation
- More severe degradation (area/intensity) usually results in more distinct indicators for efficient national monitoring

Definition in terms of REDD+

- Over 50 definitions have been identified in the scientific literature (Simula 2009)
- General guidance from SBSTA expert meeting (UNFCCC 2008): "Degradation leads to a loss of carbon stock within forests that remain forests"
- Definition of forests directly affects definition of forest degradation (... within remaining forest)
- From a monitoring perspective it is important to consider:
    - Importance of purpose and available data – i.e. assessing the impact of REDD+ interventions
    - Different types of degradation may require different methods and data for monitoring
    - Existing country data and capacities

GFOI/GOFC-GOLD R&D/expert workshop

- Oct 2014 in Wageningen/Netherlands
- All presentations and workshop report online:
  - http://www.gfoi.org/rd/second-rd-workshop/
- Developing country: Donors drive the need to assess degradation (FCPF: 10% rule)
- First order estimate (proxies) on what is important tends to be acceptable now (in preparation)
- Define monitoring and capacity building priorities
- Current submitted FREL often include degradation in appendix, although starting to change (i.e Guyana, Indonesia)

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Some guidance on monitoring

- Monitoring degradation vs. impact of reducing degradation (change in change)
- Long-term monitoring and consistency is key: dynamics in carbon stock changes, inherent cycle issues (logging, fire, shifting cultivation)
- Approach national monitoring following several key questions:
    - Ask for importance of key degradation processes
        - Timber extraction, fuel wood use, fire affecting forests, shifting cultivation, grazing
    - Derive at risk areas (i.e., using roads, concessions, infrastructure) , or even areas affected (can be coarse)
    - Guide to use available national (or other) data and methods choices

Develop a national framework for monitoring degradation

- Two basic choices!
- **Aggregated** – a method that monitors all relevant degradation within forests combined:
    - Ground-based monitoring lead:
        - Most relevant for countries that have good ground-based monitoring program and capacities
        - Can lead to use stock/change method, but gain/loss is starting point (requires activity data)
    - Remote-sensing monitoring lead:
        - Recommended for countries with limited data and capacities
        - Combination of moderate resolution time-series and higher resolution data
        - Focus on activity data and initially use standard/regional/global emission factors

Develop a national framework for monitoring degradation

- Two basic choices!
- **Disaggregated** – use of methods that tracks specific degradation processes:
    - Need to clearly define and disaggregate different processes, in particular the degree of removals varies, areas affected and how it can be observed
    - This method is most useful if focus is on few, specific degradation types and some data and capacities are already available for these
    - Tuned approaches can be efficient

Develop a national framework for monitoring degradation

- Pros and cons of aggregated for disaggregated approach
  - Policy guidance – requires separation of different processes and drivers (in terms of setting priorities and results); is largely national requirement
  - Country circumstances – make use of available data and capacities may lead to specific method choice
  - Aggregated approach methodologically simpler and potentially more precise for international IPCC reporting

- Once decided, methodological choices exist

Table 1. Forest degradation mapping methods				
Degradation type	**EO data type**	**Sensor**	**Method**	**R&D needs**
Tree removal Selective logging with infrastructure	VHR Optical	Quickbird	Visual interpretation (VTT)	Sample VHR Opt and w2w Opt/SAR (& ground data/LiDAR) to estimate AGB (VTT)
		RapidEye	Time-series analysis & spectral unmixing (RSS)	
		RapidEye	Calibrated NDVI differences Spectral Mixture Analysis (SIRS)	Transferability to Sentinel-2
	Moderate Optical	Landsat	Structural metrics & change detection (VTT)	
		CBERS-2 Landsat	Soil/Veg fraction ratioing, DEGRAD system (INPE)	Forest disturbance classes Baseline generation
	Moderate – Coarse Optical	Landsat MODIS VCF	Landsat change detection % reduction in canopy cover MODIS VCC (FAO)	Consistent detection of degradation signal Identify appropriate data Thresholds of parameters Certainty of reporting
	L-SAR	ALOS	HV ratio, buffer roads (VTT)	
	C-SAR	RADARSAT-2	Multi-temporal aggregation (VTT)	
	X-SAR	TerraSAR-X	HH ratio, road extraction (VTT)	
		TerraSAR-X (SM VV)	Change detection (WUR)	Automation of methods Tuning of algorithms Precipitation effects Software development
Tree removal Selective logging without infrastructure	VHR Optical	RapidEye	Time-series analysis & spectral unmixing (RSS)	
Tree removal Clearcut	VHR Optical	RapidEye	Time-series analysis & spectral unmixing (RSS)	
	L-SAR	JERS-1 ALOS PALSAR	Time-series analysis (UNSW)	Monitoring methods using ALOS-2
	X-SAR	TerraSAR-X (SM VV)	Change detection (WUR)	Automation of methods Tuning of algorithms Precipitation effects Software development
Shifting cultivation	Moderate Optical	Landsat	Time-series vegetation indices (UNSW)	Seasonality and veg indices
	L-SAR	ALOS PALSAR (FBD)	Time-series (WUR)	
Fire	NFI & Moderate Optical	Landsat	Time-series disturbance & recovery trajectories (ECOSUR)	Relating ground and RS data (ECOSUR)
	VHR Optical	RapidEye	Time-series analysis & spectral unmixing (RSS)	

Agroforestry	VHR Optical	Aerial survey Quickbird	Coarse digitizing of defoliation & colour change (CSIRO)	Integration of independent datasets
	Moderate-Coarse Optical	Hyperion Landsat MODIS		
Grazing	NFI & Moderate Optical	Landsat	Time-series disturbance & recovery trajectories (ECOSUR)	Relating ground and RS data
Forest regrowth	Moderate Optical	Landsat	Time-series reflectance trajectories (UNSW)	
	Moderate – Coarse Optical	Landsat MODIS	Temporal reflectance trajectories 'VegMachine' VMAT, BFAST algorithm (CSIRO)	Calibration to absolute change?
	SAR/Opt synergy	ALOS PALSAR Landsat	Threshold intensity and FPC (UNSW)	Transferability to other savannah woodlands
Direct AGB estimates - Quantitative	Forest inventory & Optical	Landsat	Time-series disturbance & recovery trajectories (ECOSUR)	Relating ground and RS data
	LiDAR & forest inventory (+Opt/SAR)	LiDAR RapidEye Landsat	Carbon stock mapping using forest inventory, LiDAR and Opt LU map (RSS)	Forest inventory design Allometrics Correlating Field & RS data Uncertainty analysis Usefulness of SAR data
		LiDAR	Gain/loss method (USDA-FS)	Precision/bias
		LiDAR Landsat ALOS PALSAR TerraSAR-X	Carbon densities by LU type – adjusted Baccini AGB & Opt/SAR LU (CIFOR)	Transferability to SPOT Methods for discriminating peat lands
		Terrestrial LiDAR	Echidna, VEGNET – plant area index (CSIRO)	
	L-SAR	ALOS PALSAR & AVNIR	Regression analysis with field/LiDAR data (VTT)	Statistical sampling framework Practical affordable methods
		ALOS PALSAR	Regression analysis, validated by VHR Opt & forest inventory (SIRS)	
	X-SAR	TanDEM-X SRTM	InSAR height difference & AGB, validated using forest inventory & LiDAR (NFLI)	DEM correction C- to X-band Modelling & field AGB Seasonality, leaf on/off

Table 3. Operational Readiness of EO sensors for monitoring forest degradation

Data source	Technical capabilities/ sensitivity	Global data coverage	Length of Time series	Methods developed and tested	Large area demon-strations	Country operational examples	Capacity implications
Optical moderate (Landsat/S2)	Severe degradation	Yes	(1972) 1984+				
L-band moderate (ALOS 1/2)	Severe degradation	Global 2obs/yr Trop 4obs/yr	1995 & 2007-2010 & 2014+	No	No	No	Systematic observations already in operations
C-band moderate (S1, ASAR, ERS, RADARSAT-2…)	1. Detection of logging activities 2. Large scale degradation 3. Improved LCC 4. Fire	Regional data required. Need for recommendation for ESA	Time series exist over selected FCT ND sites. (bi-monthly required)	Mature R&D example in Central Kalimantan	Central Kalimantan	No	Need to provide recommendation to ESA
Optical Fine (SPOT, Rapideye, …)	Possibility to simulate S-2	Requests required					
VHR (RapidEye)	1. Detection of logging activities 2. Hot-spot monitoring 3. Improved LCC 4. Fire	Yes (patchy)	2002 (SPOT5)/2009+ (RapidEye)	Several examples	No	No (Guyana?)	
X-band fine (TSX, COSMO)	1. Detection of logging activities 2. Hot-spot monitoring 3. Improved LCC 4. Fire	Requests required	No	Yes	No	No	GFOI to submit requests over GFOI SS
X-band TanDEM-X	Estimation of height change	Yes (2 times)	2011+	Yes	No	No	TSX back in TDX mode March 2015
LiDAR airborne	Estimation of height and structure	No	No	Yes	Yes	Yes (for biomass stock)	High technical capacity needed, cost and logistics constraints

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Table 5. Forest degradation data sources

Technology Reference Levels: TRL1: Methods developed and tested; **TRL2:** Large area demonstration; **TRL3:** Country operational examples

Indicator / process	Sub-type	Data sources: Activity data	Data sources: Emission factors	Data sources: proxies
		*IPCC default values may be applicable throughout, especially for non-key categories. Defaults and country-specific data should not be combined without consideration of consistency issues		
Tree removal	Clearcut	Optical: 30m or better (TRL3) SAR L (TRL2) or C (TRL1) band	**Sample based:** • Repeated NFI or permanent plots (TRL3) • Field sampling: disturbed vs. undisturbed areas (TRL3) • Terrestrial LiDAR (TRL2) **RS combined with field observations (NFI or bespoke):** • Height changes: airborne LiDAR (TRL2), InSAR height differences (TRL1) • Backscatter derived AGB estimates (TRL1) • VHR Optical texture based AGB model (TRL1)	Forest concessions boundaries Land use plan Harvest estimates combined with growth estimates Settlements transport network (road, rivers)
	Selective w. infrastructure	Optical: 30m or better (TRL3) SAR L (TRL1), C (TRL1) or X (TRL1) band		
	Selective w.o. infrastructure	Optical: 5m or better (TRL2) SAR X (TRL1) band		
Forest area affected by shifting cultivation	Areal expansion	Optical: 30m or better (TRL3) SAR L (TRL2) or C (TRL1) band		Settlements transport network (road, rivers) Forest concessions boundaries
Fire	Fire scars	Optical: 30m or better (TRL3) SAR L (TRL2) or C (TRL1) band		Forest concessions boundaries? Land use plan? Settlements transport network (road, rivers)? Data from local communities and stakeholders? Fuel loads?
	Ground Fire	Optical: 5m or better (TRL2) SAR X (TRL1) band		
Forest area affected by agroforestry (crop under tree cover)		Optical: 5m or better (TRL1)	**Sample based:** • Repeated NFI or permanent plots (TRL3) • Field sampling: disturbed vs. undisturbed areas (TRL3) • Terrestrial LiDAR (TRL2)	Land use plan Settlements transport network (road, rivers)
Fuel wood and charcoal		Mostly not detectable from RS		Population consumption per capita Forest growth potential GIS model

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Some workshop conclusions

- Update of guidance documents (GOFC Sourcebook, GFOI MGD)
- Respond to the need for first order estimation for countries: look at case studies and synthesize
- Develop/test concepts for multi-stage process of step-wide improvements for estimating degradation emissions
- Gap assessment from data sources/methods tables and operational readiness >> priorities for future efforts
- R&D priorities, compare different methods, ... :
    - Several R&D initiatives ongoing
    - Coordinated satellite data acquisitions
    - Requires strong support from ground measurements
    - Opportunities to move to larger area demonstrations

Final remarks

- Close engagement of GFOI R&D and GOFC-GOLD REDD+ team:
  - Series of planned expert workshops 2015/16
  - Driven by demands from donors and countries:
    - Use of global data for national REDD+ monitoring (Nov. 2015 in Wageningen)
    - Interoperability of sensors (Canada, 2016, tbd)
    - Integration of ground/RS data, uncertainties ...
- Ongoing R&D and needs for further investments and synthesis
- GOFC-GOLD training materials:
  http://www.gofcgold.wur.nl/redd/Training_materials.php

Overview of Modules REDD+ training materials

REDD+ Background and Design

1.1 UNFCCC context and requirements and introduction to IPCC guidelines
M. Herold, E. Romijn, B. Mora
1.2 Framework for building national forest monitoring systems for REDD+
E. Romijn, M. Herold, B. Mora
1.3 Assessing and analyzing drivers of deforestation and forest degradation
E. Romijn, M. Herold

REDD+ Measuring and Monitoring

2.1 Monitoring activity data for forests using remote sensing
F. Achard, J. Miettinen, B. Mora
2.2 Monitoring activity data for forests remaining forests (incl. forest degr.)
C. Souza, S. Brown, J. Miettinen, F. Achard, M. Herold
2.3 Estimating emission factors for forest cover change (def. and degr.)
S. Brown, L. Murray, F.Casarim
2.4 Incorporating community based approaches in national REDD+ monitoring
M. Skutsch, A. Balderas Torres
2.5 Estimation of carbon emissions from deforestation and forest degradation
S. Brown, L. Murray
2.6 Estimation of GHG emissions from biomass burning
L. Boschetti
2.7 Estimation of uncertainties
G. Grassi, S. Monni, F. Achard, A. Langner, M. Herold
2.8 Overview and status of evolving technologies
B. Mora, E. Romijn

REDD+ Assessment and Reporting

3.1 National data organization and management
E. Romijn, V. De Sy
3.2 Data and guidance on developing REDD+ reference levels
M. Herold, E. Romijn, S. Brown
3.3 Guidance on reporting REDD+ performance using IPCC Guidelines and Guidance
G.Grassi, E. Romijn, M. Herold

http://www.gofcgold.wur.nl/redd/Training_materials.php

Background material

- GOFC-GOLD. 2014. *Sourcebook*. Section 2.2.
- GFOI. 2014. *Integrating Remote-sensing and Ground-based Observations for Estimation of Emissions and Removals of Greenhouse Gases in Forests: Methods and Guidance from the Global Forest Observation Initiative* (MGD). Sections 2.2.2 and 3.
- Souza. 2012. "Monitoring of Forest Degradation." In *Global Forest Monitoring from Earth Observation*.
- Morton, D., et al. 2011. "Historic Emissions from Deforestation and Forest Degradation in Mato Grosso, Brazil: 1) source data uncertainties"
- Simula. 2009. "Towards Defining Forest Degradation: Comparative Analysis Of Existing Definitions." Working Paper 154, FAO.
- Herold et al. 2011. "Options for Monitoring and Estimating Historical Carbon Emissions from Forest Degradation in the Context of REDD+." *Carbon Balance and Management.*
- Pearson, Brown, and Casarim. 2014. "Carbon Emissions from Tropical Forest Degradation Caused by Logging." *Environmental Research Letters.*