

# NATIONAL FOREST MONITORING SYSTEMS FOR REDD+ National Forest Inventories



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Assessing Emission Factors

# INTERNATIONAL REQUIREMENTS



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# Copenhagen REDD+ Decision (4/CP.15)

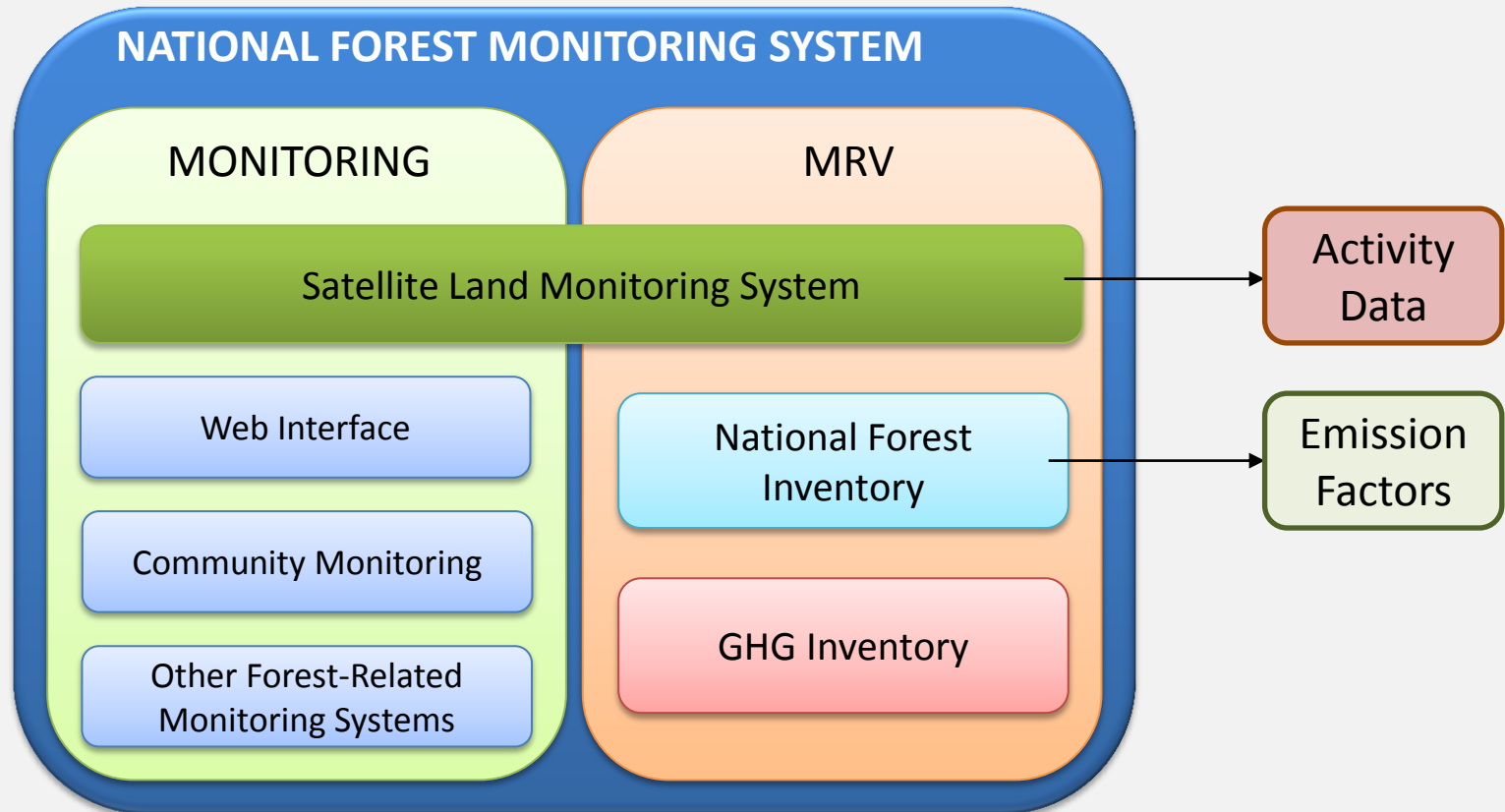
No global agreement, but...



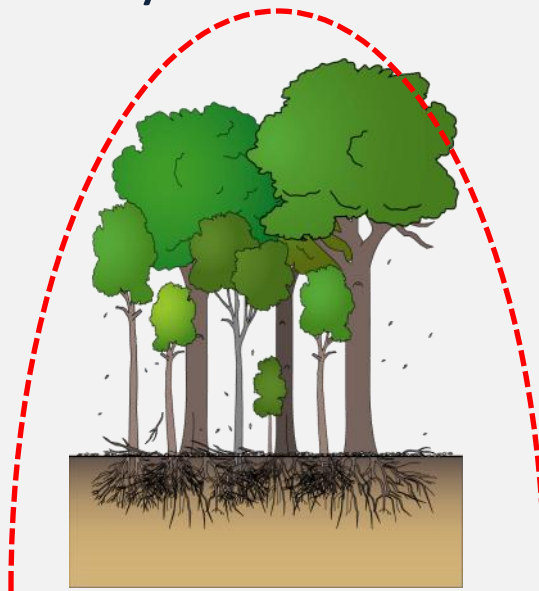
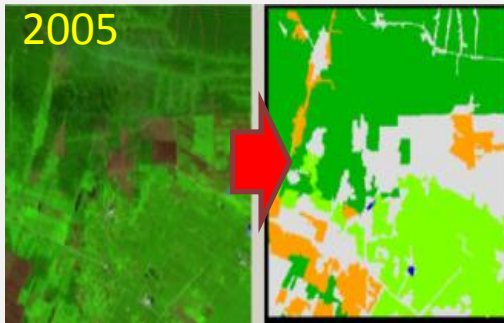
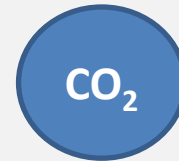
- Methodological guidance on REDD+
- Requests developing country Parties on issues relating to measurement and reporting:
  - (c) To use the most recent **IPCC guidance and guidelines** ... as a basis for estimating anthropogenic **forest-related greenhouse gas emissions** by sources and removals by sinks, forest **carbon stocks** and forest **area changes**
- To establish ... national forest monitoring systems ... that:
  - Use a **combination of remote sensing and ground-based forest carbon inventory** approaches for estimating, as appropriate, anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes



# National Forest Monitoring Systems for REDD+



# Measuring & Reporting Carbon Emissions and Removals related to Forestry



	FL Wet evergreen	FL Moist evergreen	FL Moist semi-deciduous	FL South-west subtype	FL North-west subtype	FL Dry semi-deciduous	FL Dry evergreen	Agricultural land	Shrub/Treeless	Savannas	Settlements	Wetlands	Other land	Unclassified	Final Area
FL Wet evergreen	51														51
FL Moist evergreen	42														42
FL Moist semi-deciduous		60													60
FL South-west subtype			52												52
FL North-west subtype				12											12
FL Dry semi-deciduous					2										2
FL Dry evergreen						25									25
Agricultural land							2								2
Shrub/Treeless								20							20
Savannas									12						12
Settlements										10		25			35
Wetlands											0		2		2
Other land														25	25
Unclassified														10	10
Initial Area	56	44	61	52	13	8	29	25	22	12	25	17	25	10	0
Net change (Δ=TD-TI)	-8	-2	-1	0	-1	-4	-2	-12	3	1	11	-15	1	1	0

Area change data from satellite remote sensing

Forest carbon stock change data from a national forest inventory

Inventory of greenhouse gas emissions from the forest sector

ACTIVITY DATA



EMISSION FACTOR



EMISSIONS ESTIMATE





Empowered lives.  
Resilient nations.



<http://www.treshugger.com>



Min of Agriculture, Peru



<http://florc.edu.blogspot.com>

tC/ha ?



<http://www4.ncsu.edu>



Google Earth

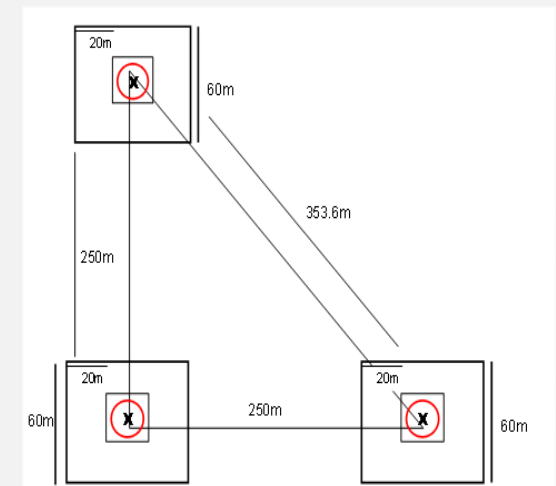
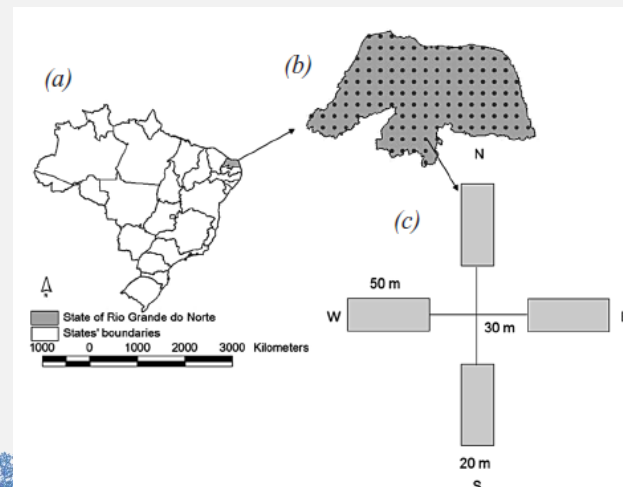
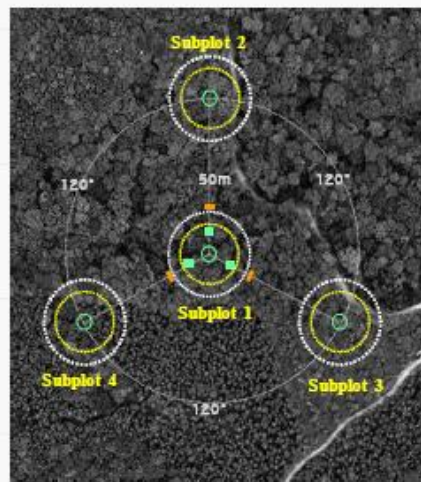
Assessing Emission Factors

# NATIONAL FOREST INVENTORIES



# National Forest Inventories (NFIs)

- The goal of a NFI is to generate information for:
  - **Decision making** (national / sub-national)
  - **Monitoring** in forestry + related sectors
- **41 out of 42** Annex 1 countries **use NFIs** as a data source to compile their national GHG inventory
  - Fulfills IPCC requirement of '**completeness**'
- Diverse approaches around the world





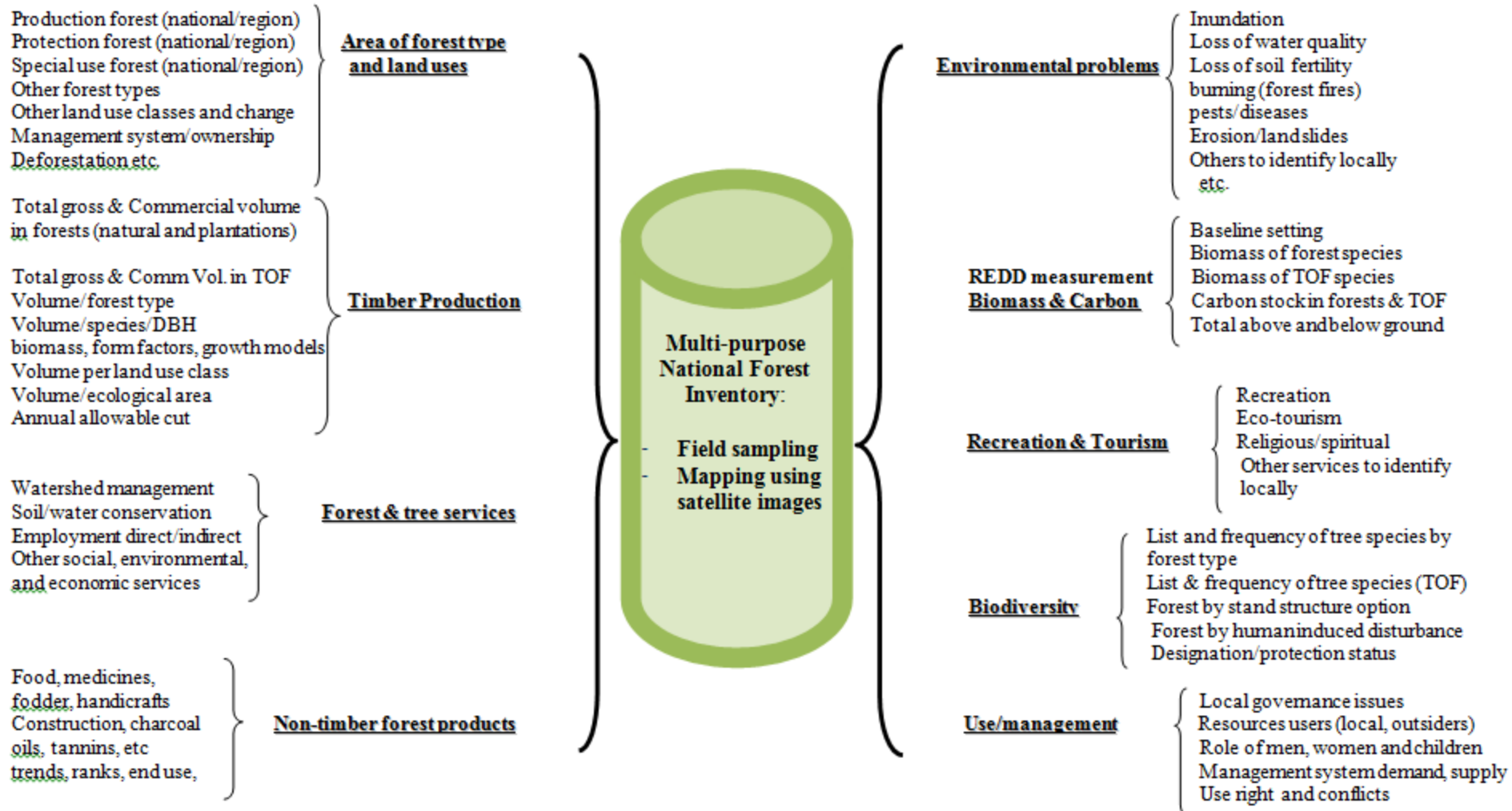
# Multipurpose NFIs



## Multi-purpose National Forest Inventory:

- Field sampling
- Mapping using satellite images

# Multipurpose NFIs



## REDD+ Reporting

# Carbon Inventories in the Land Use Sector

- Estimation must be made:
  - For carbon stock **CHANGES!** (= EFs)
  - For diverse **ecological conditions**
  - Under diverse **management regimes**
  - Emissions and removals due to **human activity**
  - For changes in all carbon pools
- IPCC requirements for NFIs
  - Estimations of Emission Factors made to Tier 2 or Tier 3 level – this requires:
    - **Country-specific** estimates of emission factors
    - **Multi-temporal** inventory data
    - **Uncertainty analysis** and Quality Assurance / Quality Control (**QA/QC**)

Multi-Data Change without uncertainty	EF Tier 1
Multi-temporal Change with uncertainty	EF Tier 2
Multi-temporal Trend with uncertainty	EF Tier 3



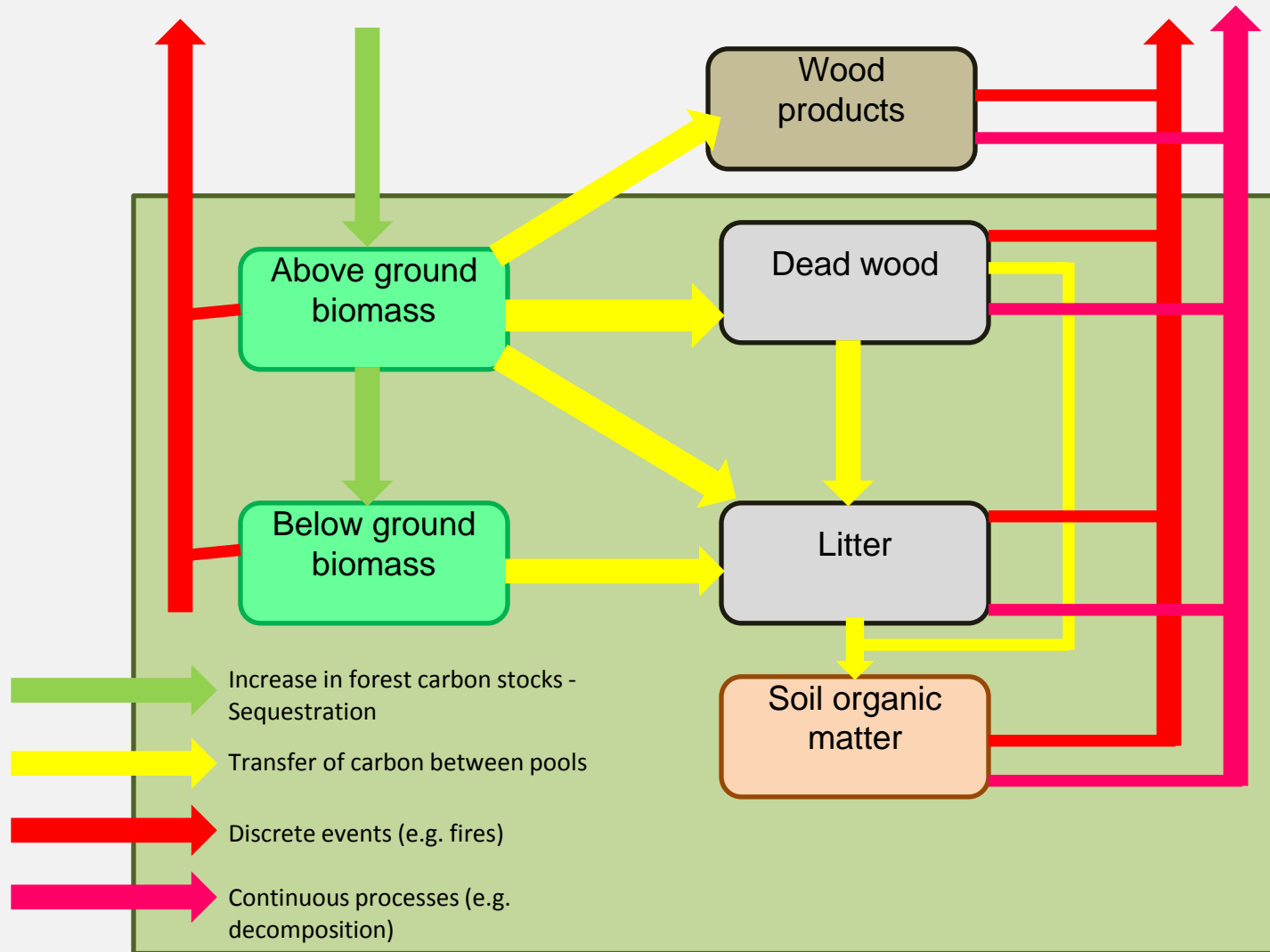
# Need to Report on Changes in the Five Forest Carbon Pools

- Above-ground biomass
  - Below-ground biomass
- } biomass
- Deadwood
  - Litter
- } dead organic matter
- Soil
- { - mineral  
- organic

$$\underline{\Delta C} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{LI} + \Delta C_{SO}$$



# Changes in Forest Carbon Pools



# How NFIs are used to generate EFs

- Tier 2 or Tier 3 (Tier 1: Default values: no NFI)
  - **Tier 2:** IPCC default assumptions + default methodology + country specific data
  - **Tier 3:** Country specific assumptions + methodology + data (to be internationally reviewed)
- NFI strategies/methodological approaches for assessing C pool changes:
  - 1. Direct measurement of changes:** Gain-Loss ('default') or Stock-Difference methods applied in permanent sample plots (Tier 2 or Tier 3)
  - 2. Empirical modelling of changes:** NFI data used for reconstruction of e.g. a forest age class distribution or of an activity chronosequence (Tier 2 or Tier 3)
  - 3. Carbon budget modelling:** NFI data inserted into a model with other data, e.g. climatological, biogeographical (e.g. Canada's Carbon Budget Model, CBM-CFS3) (Tier 3)



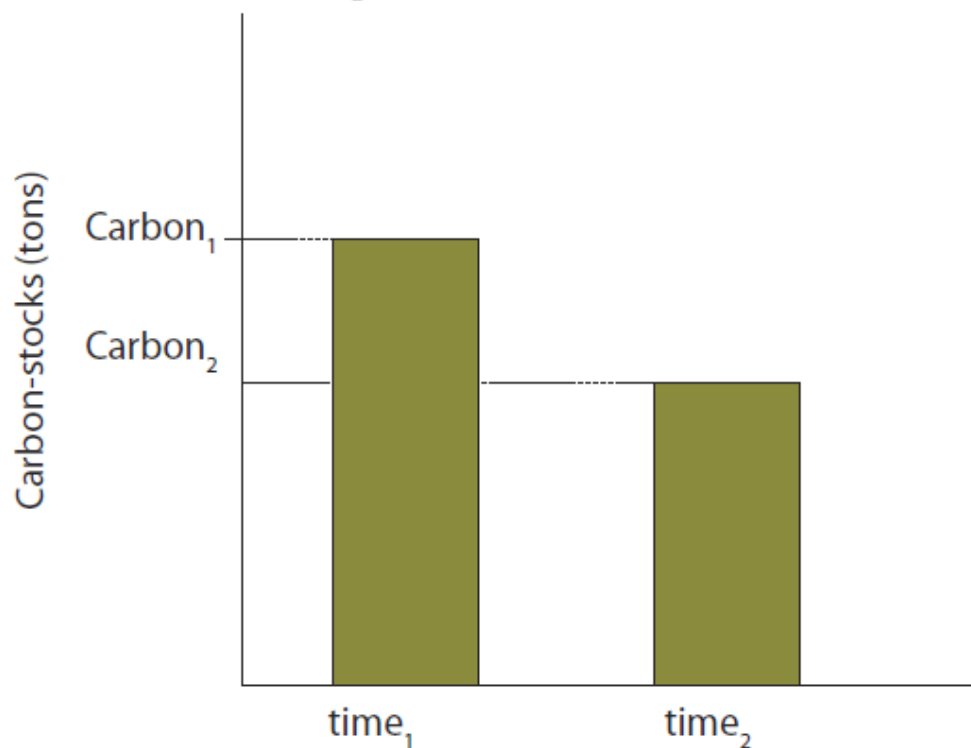
## Direct Measurement of Changes

# Stock-Difference and Gain-Loss

### METHOD 1

#### Stock-difference

The difference between carbon stocks gives carbon emissions



Carbon<sub>1</sub> : Carbon stocks time<sub>1</sub>

Carbon<sub>2</sub> : Carbon stocks time<sub>2</sub>

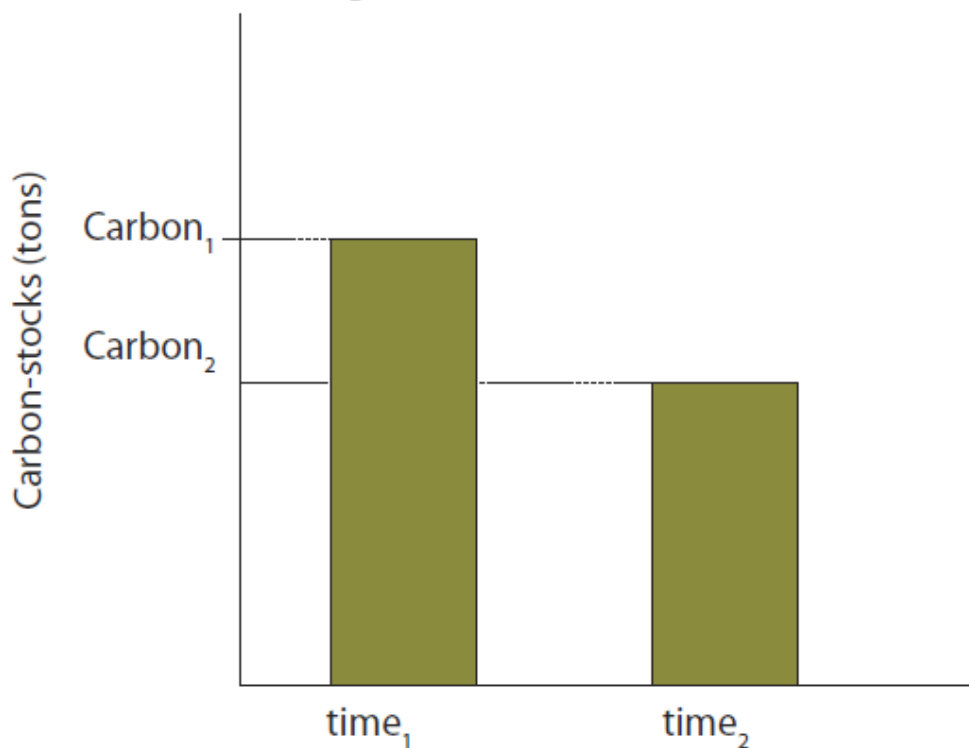
# Direct Measurement of Changes

## Stock-Difference and Gain-Loss

### METHOD 1

#### Stock-difference

The difference between carbon stocks gives carbon emissions



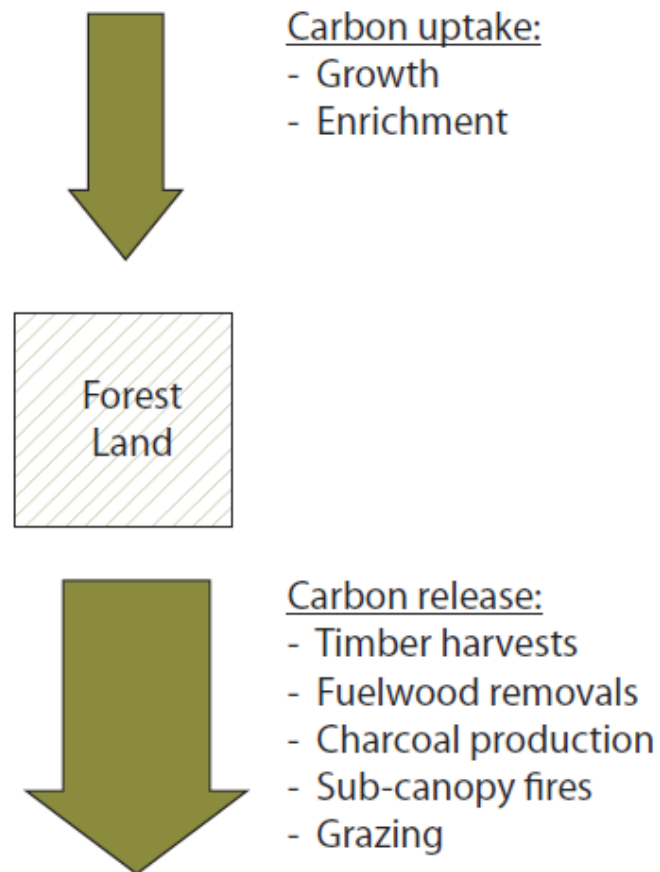
Carbon<sub>1</sub> : Carbon stocks time<sub>1</sub>

Carbon<sub>2</sub> : Carbon stocks time<sub>2</sub>

### METHOD 2

#### Gain-loss

Carbon emissions are calculated from gain minus loss





# Emission Factors in the GHG Inventory

TABLE 5(KP-1)A.2. SUPPLEMENTARY BACKGROUND DATA ON CARBON STOCK CHANGES AND NET CO<sub>2</sub> EMISSIONS AND REMOVALS FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL  
Article 3.3 activities: Deforestation<sup>1(a)</sup>

GEOGRAPHICAL LOCATION <sup>1(a)</sup>	ACTIVITY DATA		IMPLIED CARBON STOCK CHANGE FACTORS <sup>1(a)</sup>											Implied emission / removal factor per area <sup>1(a)</sup>	CHANGE IN CARBON STOCK <sup>1(a)</sup>							Net CO <sub>2</sub> emissions/ removals <sup>1(a)</sup>			
			Carbon stock change in above-ground biomass per			Carbon stock change in below-ground biomass per			Net carbon stock change in litter per	Net carbon stock change in dead wood	Net carbon stock change in soils per		Carbon stock change in above-ground biomass <sup>1(a)</sup>			Carbon stock change in below-ground biomass <sup>1(a)</sup>			Net carbon stock change in litter <sup>1(a)</sup>	Net carbon stock change in dead wood <sup>1(a)</sup>	Net carbon stock change in soils <sup>1(a)</sup>				
			Gains	Losses	Net change	Gains	Losses	Net change			Mineral soils	Organic soils	Gains		Losses	Net change	Gains	Losses			Net change		Mineral soils	Organic soils	
Identification code	Subdivision <sup>1</sup>	Area subject to the activity (kha)	Area of organic soils <sup>1</sup> (kha)	(Mg C/ha)											(Mg CO <sub>2</sub> /ha)	(Gg C)							(Gg CO <sub>2</sub> )		
Total for activity A.2.		6,501.52	NO	0.00	-0.39	-0.39	0.00	-0.17	-0.17	-0.15	-0.34	-0.47	NO	5.57	0.50	-2,561.09	-2,560.59	0.23	-1,135.73	-1,135.50	-958.47	-2,185.90	-3,044.52	NO	36,244.92
AUS <sup>1</sup>		1,203.73	NO	0.00	-0.80	-0.80	0.00	-0.34	-0.34	-0.33	-0.41	-0.55	NO	8.87	0.27	-812.57	-812.30	0.12	-350.44	-350.32	-331.81	-416.51	-556.98	NO	9,049.08
	Acacia Forest and Woodland	61.17	NO	IE	-0.18	-0.18	IE	-0.08	-0.08	-0.14	-0.18	0.01	NO	2.08	IE	-10.92	-10.92	IE	-4.95	-4.95	-8.59	-10.92	0.69	NO	127.18
	Acacia Open Woodland	0.44	NO	IE	-0.52	-0.52	IE	-0.50	-0.50	-0.22	-0.33	0.04	NO	5.61	IE	-0.23	-0.23	IE	-0.22	-0.22	-0.10	-0.15	0.02	NO	2.49
	Acacia Shrubland	93.21	NO	IE	-0.12	-0.12	IE	-0.12	-0.12	-0.15	-0.06	-0.01	NO	1.71	IE	-11.28	-11.28	IE	-10.86	-10.86	-14.21	-5.86	-1.38	NO	159.82
	Casuarina Forest and Woodland	48.32	NO	IE	-0.46	-0.46	IE	-0.21	-0.21	-0.29	-0.15	-0.19	NO	4.76	IE	-22.01	-22.01	IE	-10.10	-10.10	-14.15	-7.09	-9.17	NO	229.99
	Casuarina Forest and Woodland	51.32	NO	IE	-0.39	-0.39	IE	-0.18	-0.18	-0.23	-0.45	-0.05	NO	4.74	IE	-20.05	-20.05	IE	-9.03	-9.03	-11.68	-23.06	-2.53	NO	243.29
	Eucalyptus Low Open Forest	1.38	NO	IE	0.19	0.19	IE	0.09	0.09	-0.20	-0.50	-0.23	NO	2.40	IE	0.27	0.27	IE	0.12	0.12	-0.28	-0.69	-0.22	NO	3.31
	Eucalyptus Open Forest	1,000.00	NO	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	0.00	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	4,386.28
	Eucalyptus Open Forest	1,000.00	NO	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	0.00	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	896.73
	Eucalyptus Open Forest	1,000.00	NO	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	0.00	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	522.03
	Eucalyptus Open Forest	1,000.00	NO	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	0.00	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	2,103.99
	Eucalyptus Open Forest	1,000.00	NO	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	0.00	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	32.09
	Heath	1,000.00	NO	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	0.00	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	7.70
	Low Open Forest	1,000.00	NO	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	0.00	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	181.40
	Low Open Forest	1,000.00	NO	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	0.00	IE	0.00	0.00	IE	0.00	0.00	0.00	0.00	0.00	NO	13.15

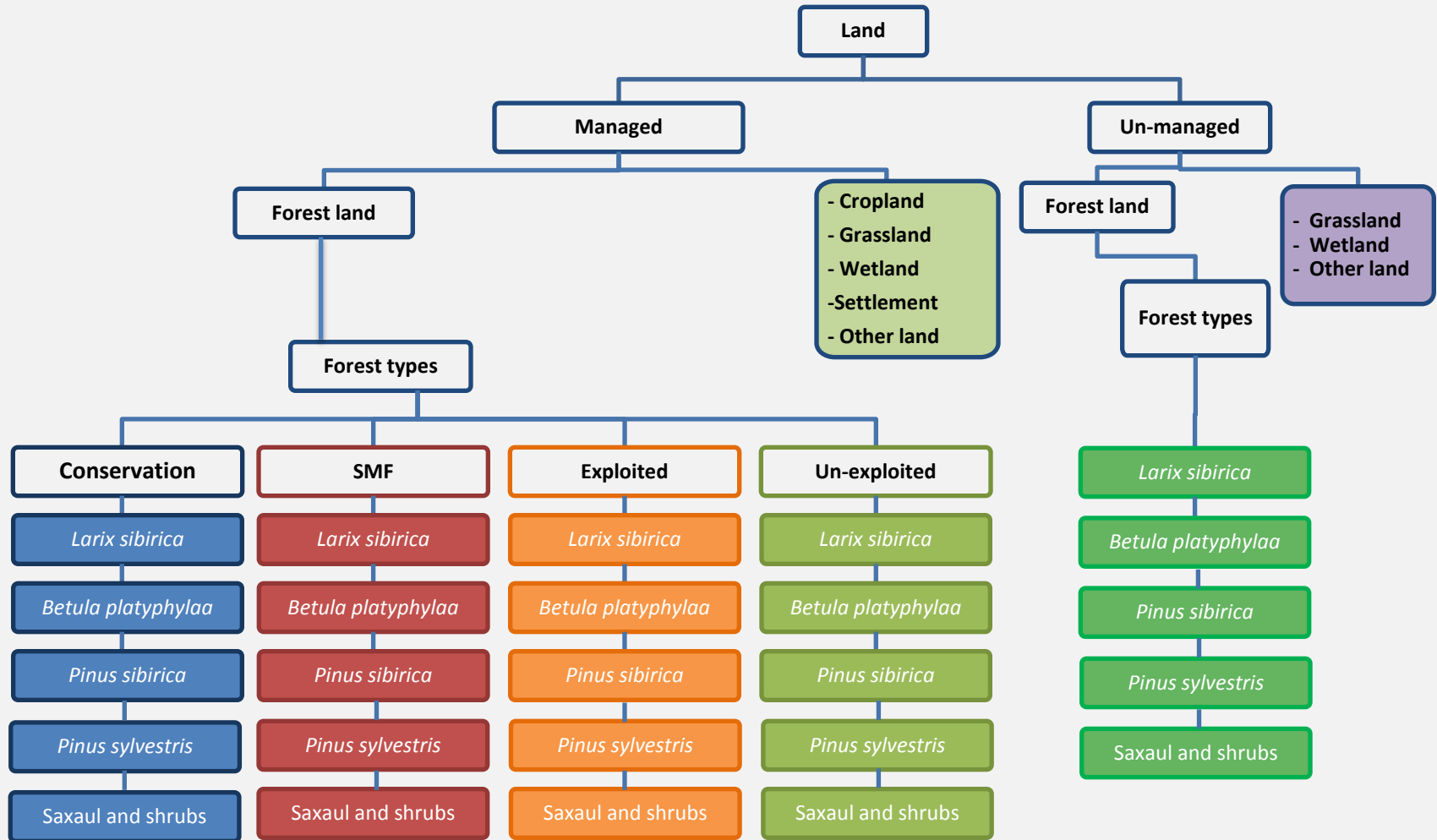
IMPLIED CARBON STOCK CHANGE FACTORS <sup>1(a)</sup>											Implied emission / removal factor per area <sup>1(a)</sup>
Carbon stock change in above-ground biomass per			Carbon stock change in below-ground biomass per			Net carbon stock change in litter per	Net carbon stock change in dead wood	Net carbon stock change in soils per			
Gains	Losses	Net change	Gains	Losses	Net change			Mineral soils	Organic soils		
(Mg C/ha)											Mg CO <sub>2</sub> /ha

# Forest Stratification for NFI

- What?
  - Division of forest area into **homogenous populations/strata**
- Why?
  - **Facilitate UNFCCC reporting** on land uses following IPCC
    - Land use categories, sub-categories, sub-divisions
  - Where different forest types are located in different areas of the country, allows a **“random restricted” sampling approach**
  - Allows a country to sample different forest populations/strata **cost-effectively**
- How?
  - Division of sampling area into non-overlapping land uses / forest types
  - Samples taken from each strata



# Mongolia's Forest Land Stratification & GHG Reporting Sub-Divisions for REDD+



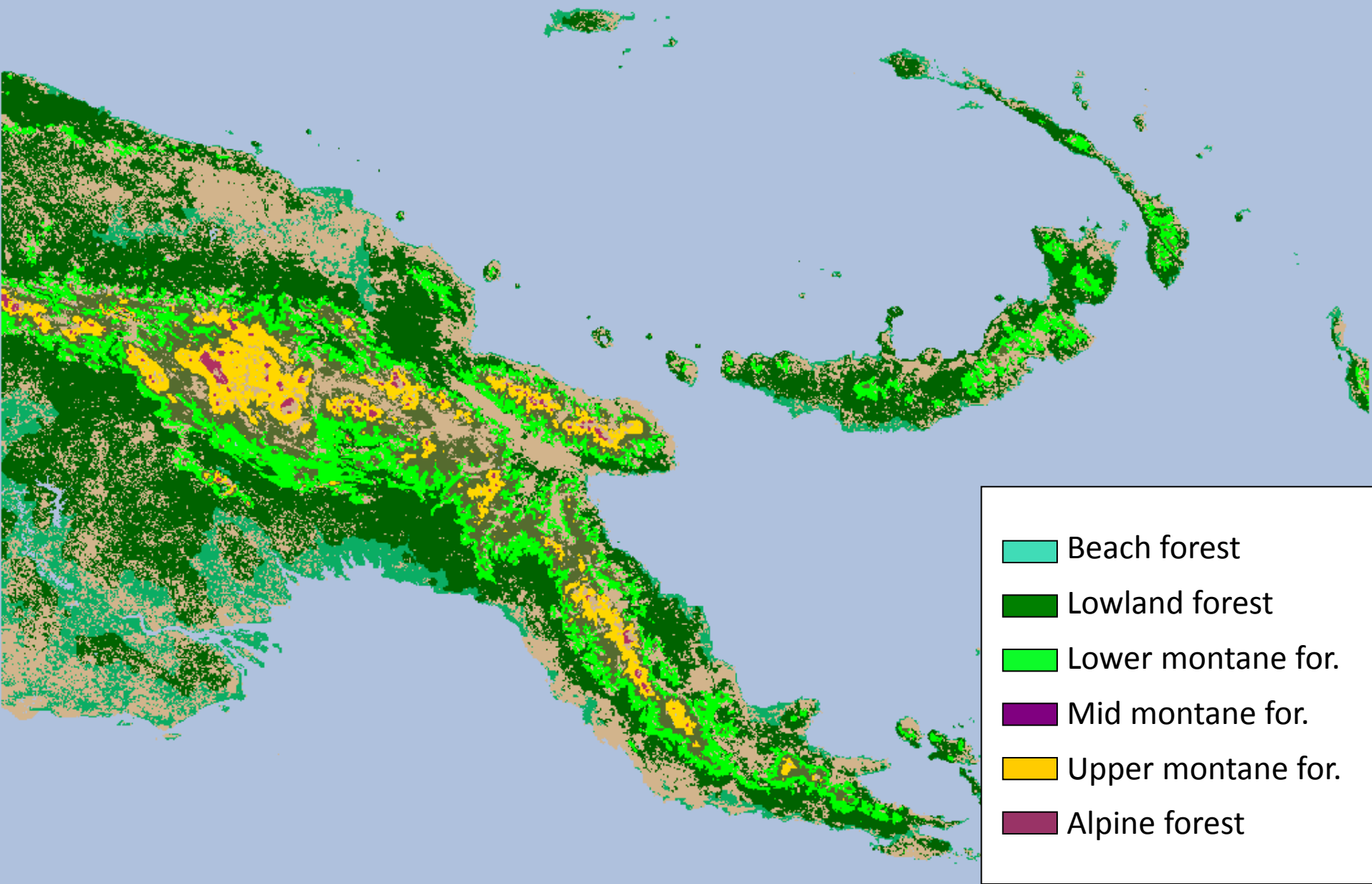
Stratification



Subdivision



# PNG's Preliminary Forest Stratification



- Beach forest
- Lowland forest
- Lower montane for.
- Mid montane for.
- Upper montane for.
- Alpine forest

# Forest Stratification to support Activity Data Sub-Divisions in the GHG Inventory

TABLE 5(KP-1)A.2. SUPPLEMENTARY BACKGROUND DATA ON CARBON STOCK CHANGES AND NET CO<sub>2</sub> EMISSIONS AND REMOVALS FOR LAND USE, LAND-USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO  
Article 3.3 activities: Deforestation <sup>101</sup>

GEOGRAPHICAL LOCATION <sup>101</sup>		ACTIVITY DATA			IMPLIED CARBON STOCK CHANGE FACTORS						NET CARBON STOCK <sup>101</sup>				Net CO <sub>2</sub> emissions/removals <sup>101</sup>  (Gg CO <sub>2</sub> )	
Identification code	Subdivision <sup>101</sup>	Area subject to the activity (kha)	Area of organic soils <sup>101</sup> (kha)	Carbon stock change in above-ground biomass per			Carbon stock change in below-ground biomass per			Net carbon stock change in litter per	Net carbon stock change in litter <sup>101</sup>	Net carbon stock change in dead wood <sup>101</sup>	Net carbon stock change in soils <sup>101</sup>			
				Gains	Losses	Net change	Gains	Losses	Net change				Mineral soils	Organic soils <sup>101</sup>		
				(Mg C/ha)												
Total for activity A.2.		6,501.52	NO	0.00	-0.39	-0.39	0.00	-0.17	-0.17	-0.15	-958.47	-2,185.90	-3,044.52	NO	36,244.92	
	<i>NSW<sup>1</sup></i>	1,020.73	NO	0.00	-0.80	-0.80	0.00	-0.34	-0.34	-0.33					9,049.08	
	<i>Acacia Forest and Woodland</i>	61.17	NO	IE	-0.18	-0.18	IE	-0.08	-0.08	-0.14					127.18	
	<i>Acacia Open Woodland</i>	0.44	NO	IE	-0.52	-0.52	IE	-0.50	-0.50	-0.22					2.49	
	<i>Acacia Shrubland</i>	93.21	NO	IE	-0.12	-0.12	IE	-0.12	-0.12	-0.15					159.82	
	<i>Callitris Forest and Woodland</i>	48.32	NO	IE	-0.46	-0.46	IE	-0.21	-0.21	-0.29					229.99	
	<i>Casuarina Forest and Woodland</i>	48.32	NO	IE	-0.46	-0.46	IE	-0.21	-0.21	-0.29					229.99	
	<i>Casuarina Forest and Eucalyptus Low Open</i>	51.32	NO	IE	-0.39	-0.39	IE	-0.18	-0.18	-0.23					243.29	
	<i>Eucalyptus Low Open</i>	1.38	NO	IE	0.19	0.19	IE	0.09	0.09	-0.20					3.31	
	<i>Eucalyptus Open Forest</i>	243.31	NO	IE	-1.39	-1.39	IE	-0.63	-0.63	-0.58					4,386.28	
	<i>Eucalyptus Open</i>	82.39	NO	IE	-1.58	-1.58	IE	-0.66	-0.66	-0.30					896.73	
	<i>Eucalyptus Tall Open Forest</i>	20.71	NO	IE	-2.37	-2.37	IE	-0.31	-0.31	-0.76					522.03	
	<i>Eucalyptus Woodland</i>	338.73	NO	IE	-0.62	-0.62	IE	-0.26	-0.26	-0.26					2,103.99	
	<i>Heath</i>	1.62	NO	IE	-1.38	-1.38	IE	-1.35	-1.35	-0.59					32.09	
	<i>Low Closed Forest and Mallee</i>	1.98	NO	IE	-0.29	-0.29	IE	-0.28	-0.28	-0.14					7.70	
	<i>Woodland and Melaleuca</i>	69.97	NO	IE	-0.08	-0.08	IE	-0.08	-0.08	-0.11					181.40	
	<i>Heath</i>	1.62	NO	IE	-2.35	-2.35	IE	-1.08	-1.08	-0.19					13.15	
	<i>Low Closed Forest and Mallee</i>	1.98	NO	IE	-0.29	-0.29	IE	-0.28	-0.28	-0.14					7.70	
	<i>Woodland and Melaleuca</i>	69.97	NO	IE	-0.08	-0.08	IE	-0.08	-0.08	-0.11					181.40	
	<i>Melaleuca</i>	0.79	NO	IE	-2.35	-2.35	IE	-1.08	-1.08	-0.19					13.15	



# Key Messages

- NFIs are **national decision-making tools** so should be designed to meet a country's individual data / information needs
- NFIs are commonly used by countries (almost all Annex 1 countries) to assess Emission Factors for their national GHG inventory
- **Changes in all five forest carbon pools** should be reported on
- Two approaches set out by the IPCC for EF assessment are the **Gain-Loss** method (can be done using one NFI) and the **Stock-Difference** method (requires two NFIs)
- **Land use stratification** can be a useful first step to divide forest land into homogenous strata and ensure field sampling is statistically robust and cost-effective



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# Thank you

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<http://www.un-redd.org>

