Threats to tropical forests
and what we can do about it

Ryszard Laskowski
Institute of Environmental Sciences
Jagiellonian University
www.eko.uj.edu.pl/laskowski

Human activities: dangers and hopes for the future

- Timber production (mostly for export and fuel)
- Slash-and-burn practices:
  - for agriculture and cattle ranches
    - main crops: coffee, cocoa, banana trees, mango trees, papaya, avocado, sugar cane *(250 different fruits originate from tropical rainforests; only 20 from the temperate zone)*
- Tourism – the hope for tropical rainforests?
  - already high and still increasing economic value

Deforestation: the most important problem for tropical rainforests

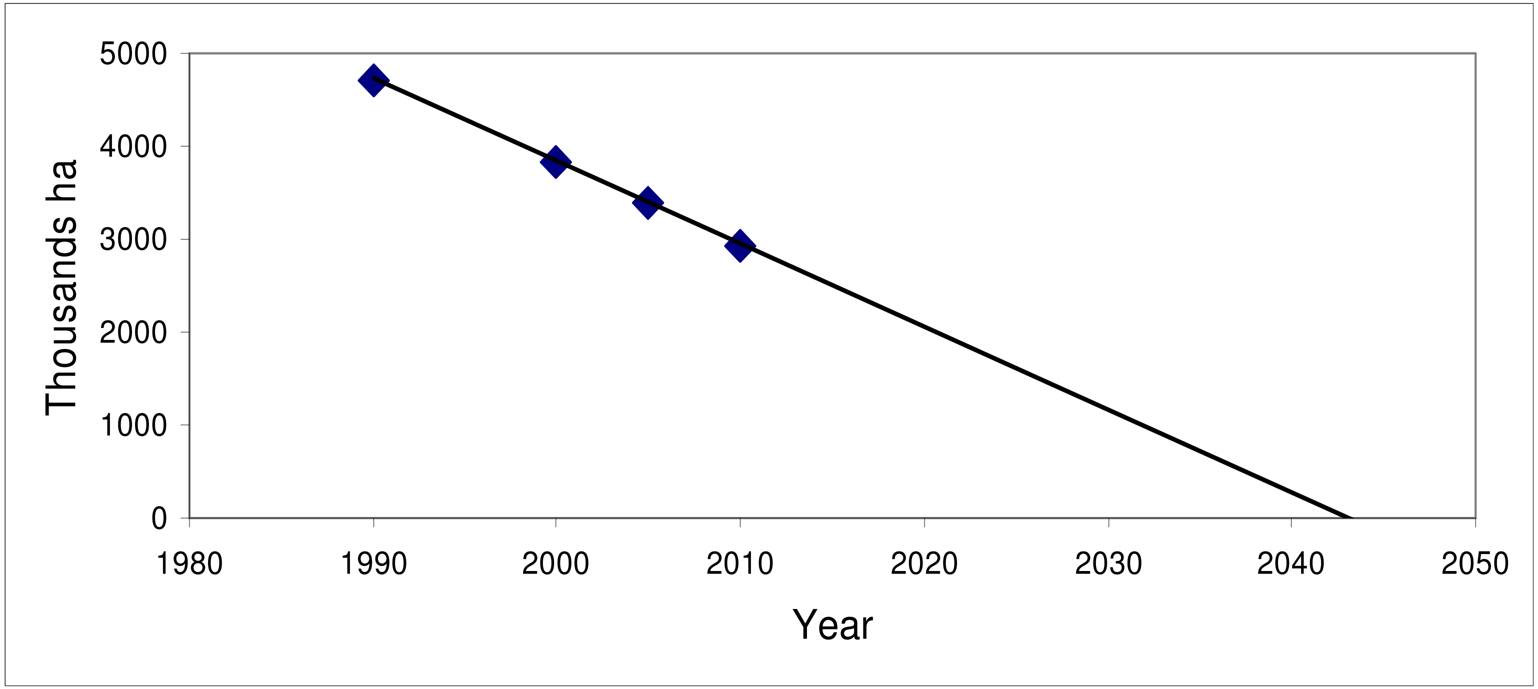
- Originally: 14% of the Earth surface
  → now only 6%!
- Currentr annual deforestation rate:
  ca. 50 000 – 100 000 km^2 (*Poland = 312 000 km^2*)
- At this deforestation rate:
  → tropical rainforests will vanish by 2050!
- Extremely high extinction rate:
  → up to 50 000 species per year!

Deforestation: eastern Amazon (eye altitude ca. 50 km)

Deforestation: western Amazon (eye altitude ca. 500 km)

Deforestation in Uganda

- **Total forest cover 2010: 2,937,000 ha**
- **Losses in 1990 – 2010:**
  - **1,763,000 ha (37.1% of forest cover)**
  - **average of 88,150 ha (1.86% per year)**



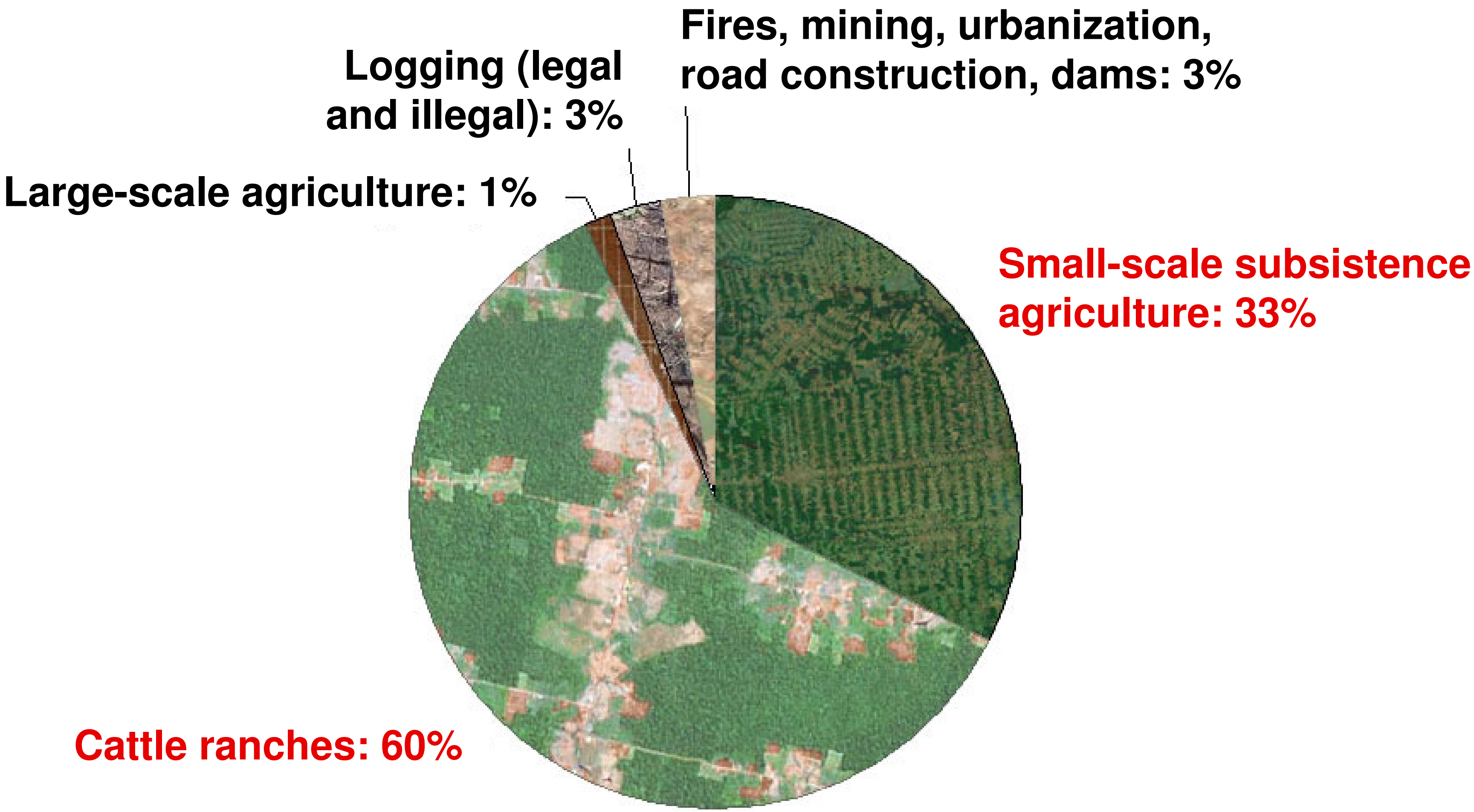
http://rainforests.mongabay.com

Deforestation: slush-and-burn

Slush-and-burn in Southern Mexico

Deforestation – plantations replacing rainforest in Venezuela

Main causes of deforestation: Brazil, 2000-2005



What we can do about it?

REDD:

Reducing carbon Emissions from Deforestation and Degradation

Two useful definitions

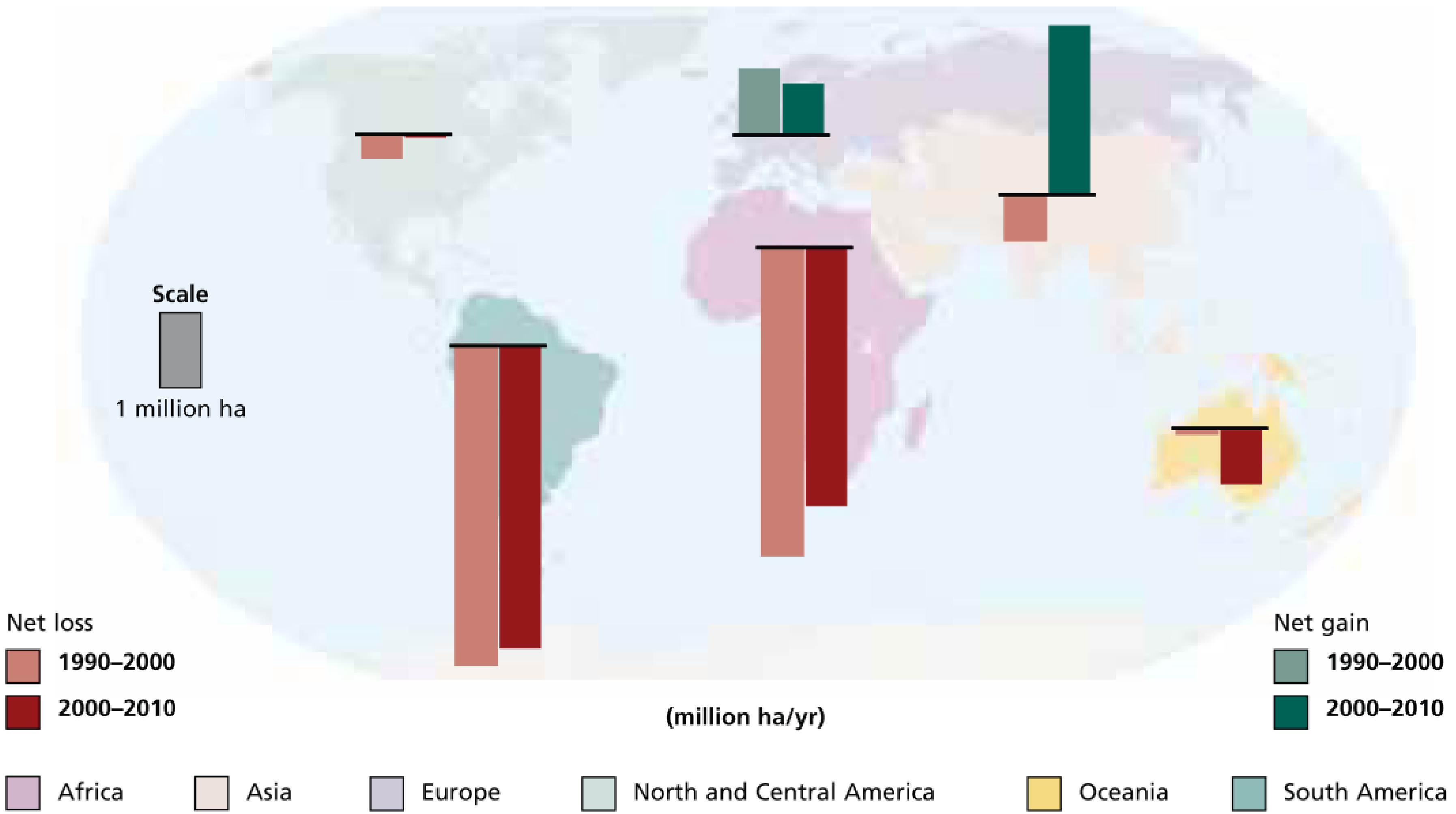
- **Deforestation**: "permanent removal of forest cover and withdrawal of land from forest use, whether deliberately or circumstantially" (IPCC) = entire loss of patches of forest via clearing

- **Forest degradation**: "changes in the forest negatively affecting its production capacity"
  – may eventually result in deforestation

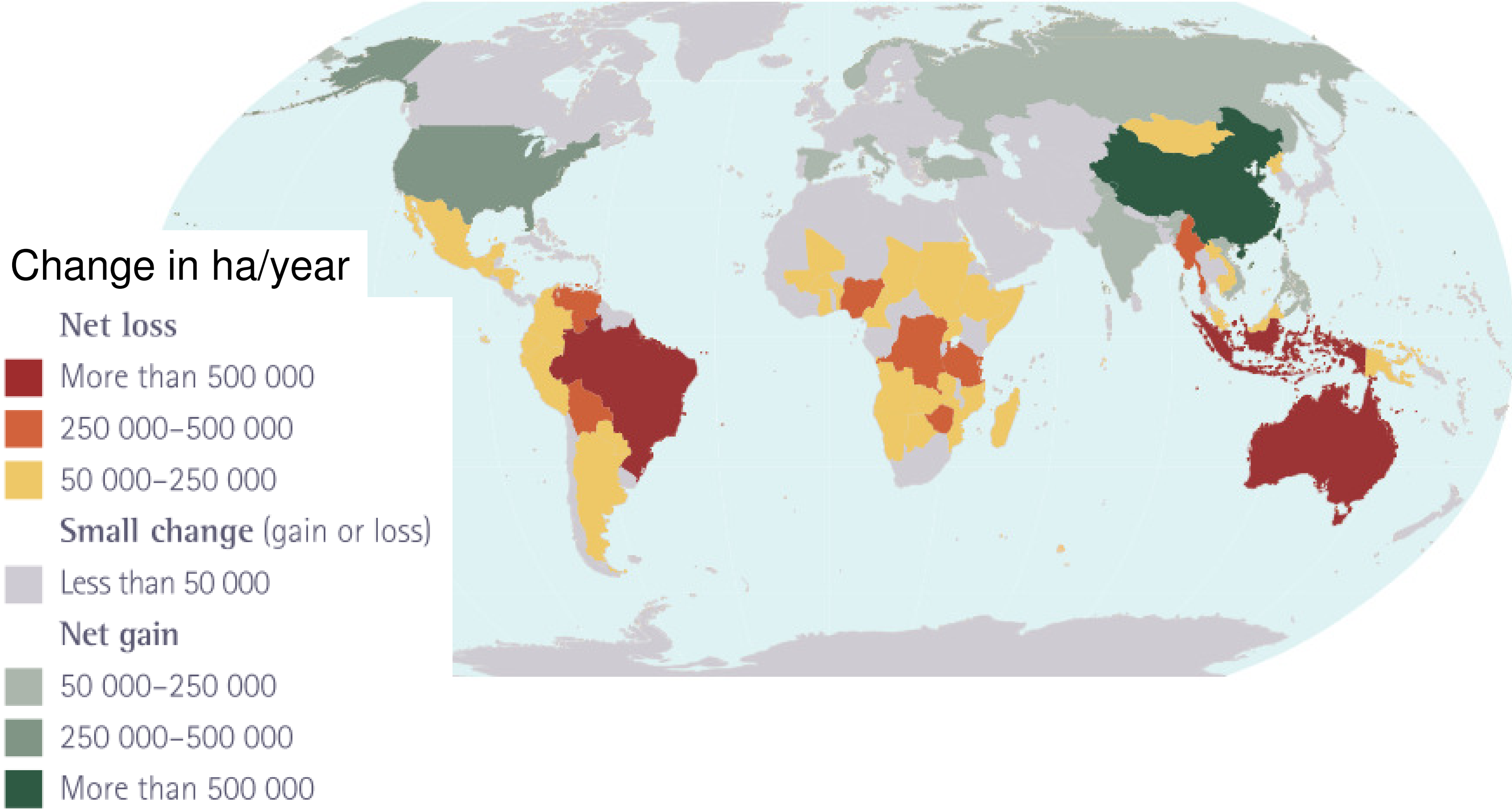
What is **REDD** and why do we need it?

- **REDD** = financial incentives to help developing countries reduce deforestation rates to meet C emission 'baseline'
  - countries can sell 'carbon credits' on the international carbon market
  - over 70 countries eligible
- Tropical deforestation = 1 – 2 bln tonnes C per year = 15-20% global C emission
- In Africa – ca. 70% of total C emission

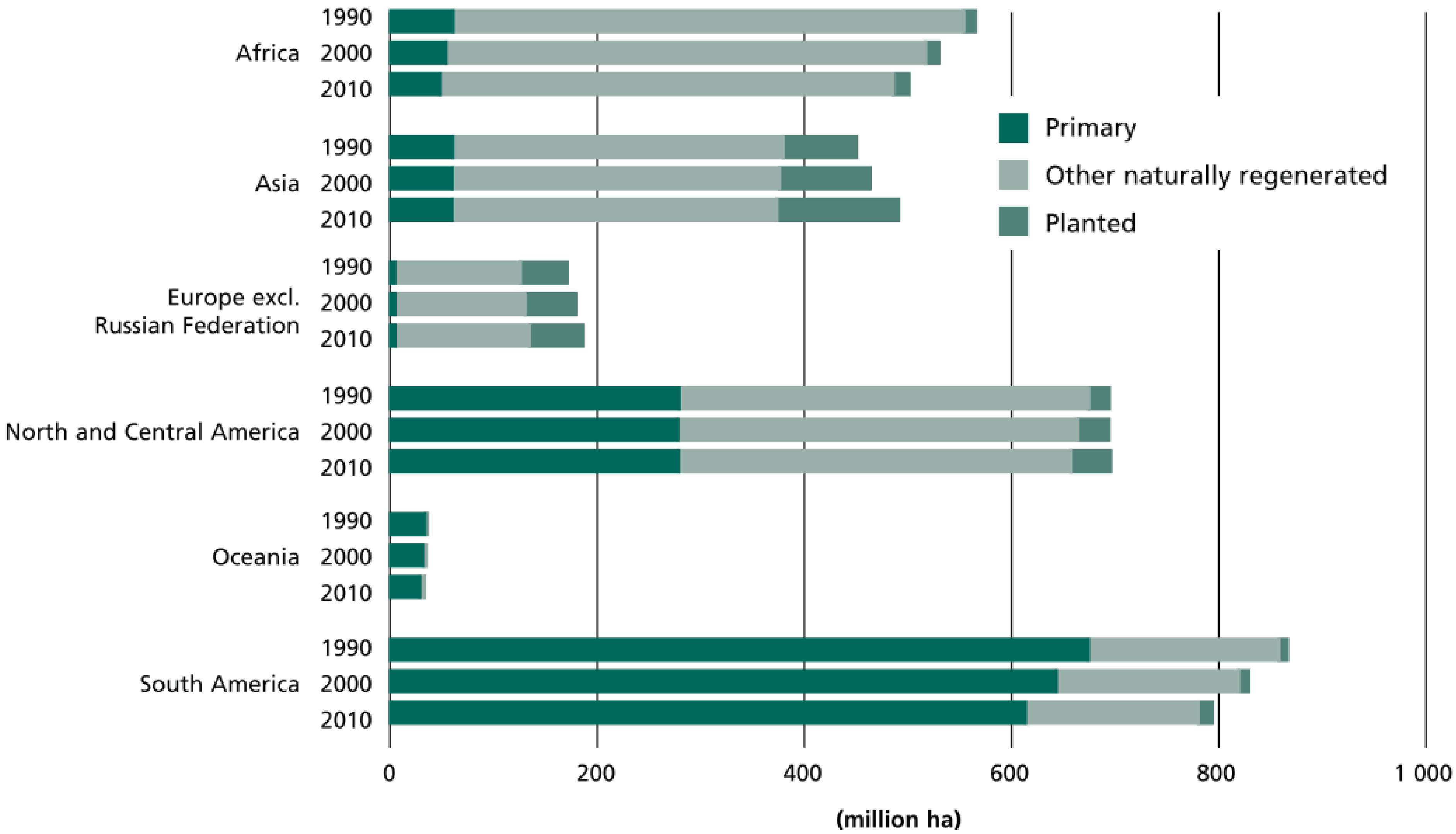
Annual change in forest area by region
1990–2010



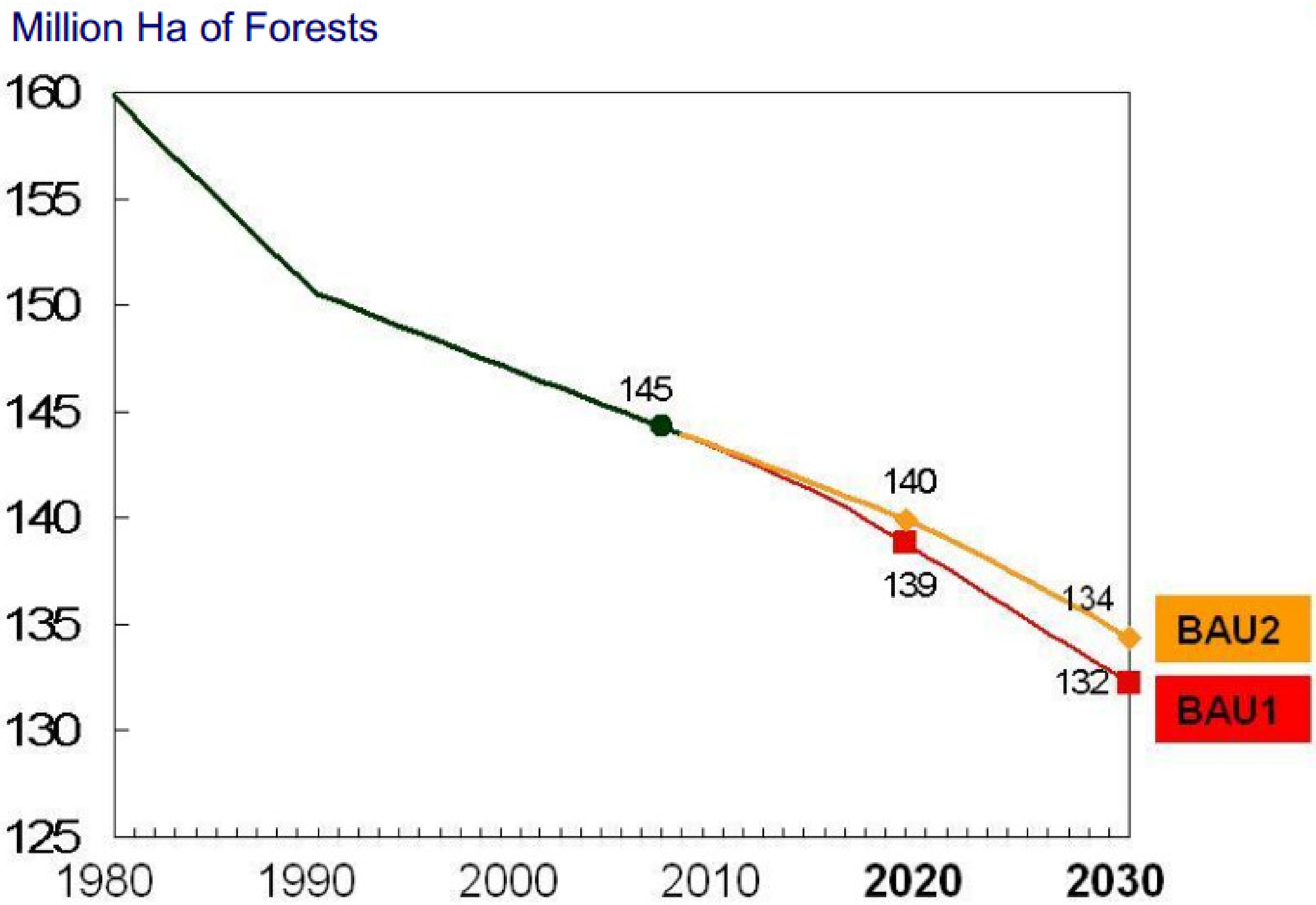
Net change in forest area by country
2005-2010



Trends in forest characteristics by region and subregion, 1990–2010



Historical and future deforestation scenarios in Democratic Republic of Congo



"The REDD+ challenge in DRC" (http://unfccc.int)

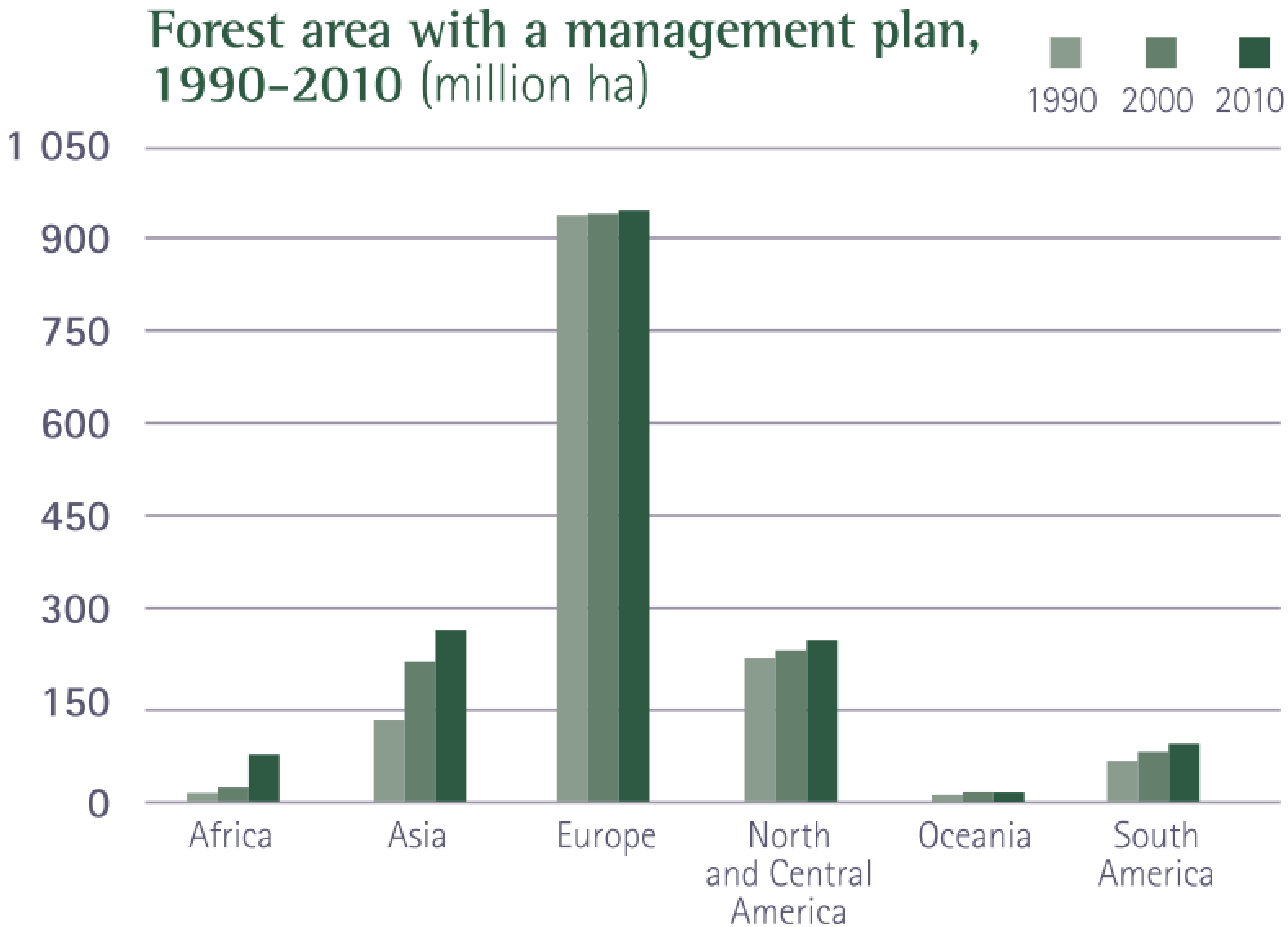
Some intriguing quotes: "Better REDD than dead", *The Economist, 2012*

- Indonesia’s peat-based plantations, a quarter of the total, contribute less than 1% to the country’s GDP but nearly 20% of the national C emissions.
- Indonesia’s National Council on Climate Change puts the opportunity cost of forgoing an oil-palm plantation at $30 a tonne C.
- Capturing and storing emissions from power stations is estimated to cost $75-115 per tonne C.
- $17 billion – 30 billion between now and 2015 could cut deforestation by a quarter. (EU ≈ $17 000 bln)

Doubts and problems

- No trusted estimates of actual deforestation rates in many countries (especially in Africa)
- Lack of trust in keeping the promise by governments in developing countries
- No good control over deforestation and afforestation activities
- "Small scale deforestation on a large scale" – non-commercial deforestation by forest folk
- **Lack of knowledge among local people**

Forest management plans urgently needed for tropical countries!



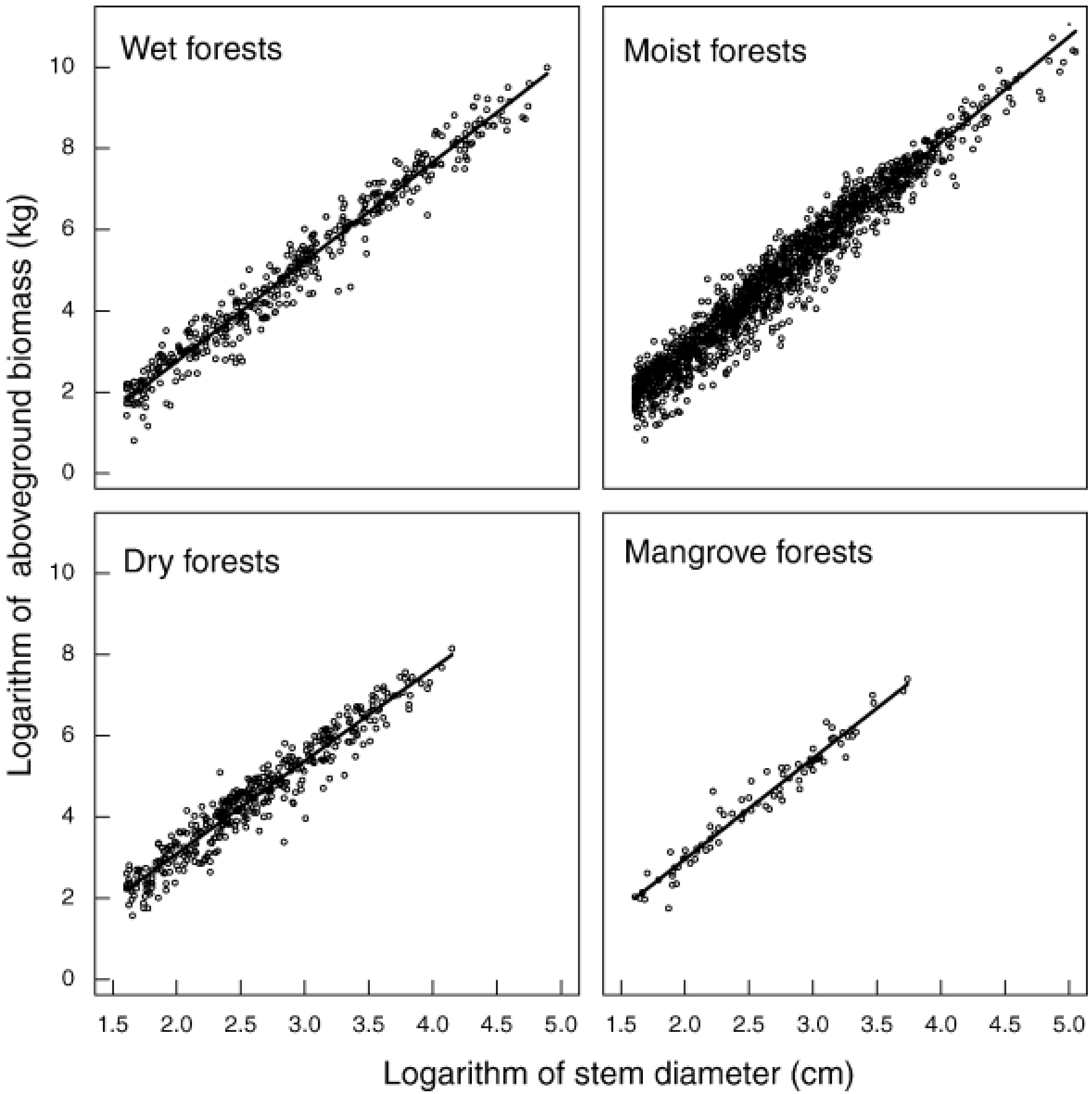
FAO Global Forest Resources Assessment 2010

Estimating forest C pools

Forest carbon pools: priorities and costs
1 = lowest priority/cost; 4 = highest

Carbon pool	Method	Priority	Cost
Tree biomass	DBH (H) + allometric equations	4	2
Understory	Destructive sampling	2	4
Dead trees	No-destructive measurements	2	2
Litter	Destructive sampling	2	3
Soil carbon	Destructive (density and C content)	3	4

Allometric relationships: *AGB = f(DBH)*



Chave et al. (2005) Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145: 87-89

AGB = f(DBH): empirical regressions

Dry forest stands:

$$AGB = \rho \times \exp(-0.667 + 1.784\ln(D) + 0.207(\ln(D))^2 - 0.0281(\ln(D))^3)$$

Moist forest stands:

$$AGB = \rho \times \exp(-1.499 + 2.148\ln(D) + 0.207(\ln(D))^2 - 0.0281(\ln(D))^3)$$

Moist mangrove forest stands:

$$AGB = \rho \times \exp(-1.349 + 1.980\ln(D) + 0.207(\ln(D))^2 - 0.0281(\ln(D))^3)$$

Wet forest stands:

$$AGB = \rho \times \exp(-1.239 + 1.980\ln(D) + 0.207(\ln(D))^2 - 0.0281(\ln(D))^3)$$

Chave et al. (2005) Oecologia 145: 87-89

Symbols and units

- ***ABG*** = above-ground biomass; kg dry weight
- ***D*** = tree diameter at breast height (1.3 m);

  = tree *girth*/π ≈ tree *girth*/3.14; cm
- $\boldsymbol{\rho}$ = wood specific gravity = oven-dry wood over green volume; g/cm^3
  - *Reyes et al. 1992. Wood densities of tropical tree species. USDA Forest Service.*
  - *OR: use **0.5 g/cm^3** – the mean for Africa*
- On average, **C = 50%** dry wood mass

Carbon stock in tree roots

Shoot:root ratios

- humid tropical forests on normal soils: **4:1**
- tropical forests on permanently wet soils: **10:1**
- tropical forests in areas with long dry season and soils of very low fertility: **1:1**

How many plots should be sampled?

- Assume the desired precision level (e.g., ±10%, ±20% of the mean)
- Select 5-10 adequate sized plots within each management type (e.g., mature forest, logged, secondary young, secondary medium age, burnt)
- Estimate C stock for each plot, calculate mean and standard deviation
- Calculate the required number of plots

Necessary preliminary calculations

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad s^2 = \frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1} \qquad s = \sqrt{s^2}$$

n – number of sampled plots

s^2 – sample variance

s – sample standard variation

Calculating the required number of plots

$$n_r = \frac{(N \times s)^2}{\dfrac{N^2 \times E^2}{t^2} + N \times s^2}$$

n_r – number of required plots

N – number of possible sampling plots

E – allowable error

t – sample statistics from the t-distribution for a chosen confidence levels (e.g., 95%); for unknown sample size t=2

Example of calculations

- Area = 10 000 ha
- Plot size = 0.1 ha
- N (number of possible sampling plots) = 100 000
- Mean C stock = 150 t C/ha
- Standard deviation = 30 t C/ha
- Desired precision = 10%
- E (allowable error) = 150 x 0.1 = 15

$$n_r = \frac{(100000 \times 30)^2}{\frac{100000^2 \times 15^2}{2^2} + 100000 \times 30^2} = 16$$

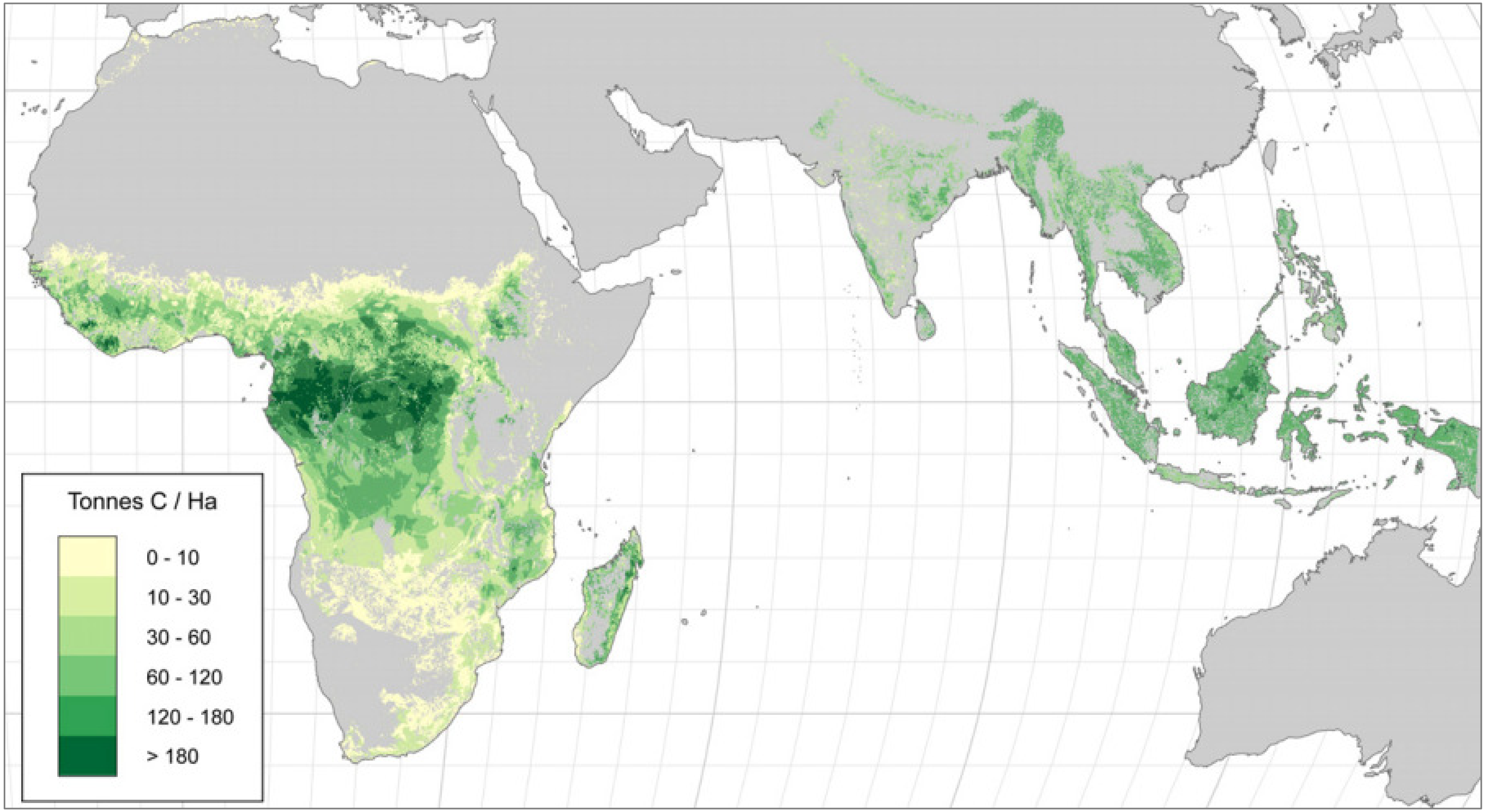
Forest biomass carbon matrix

Forest condition

Forest type

	Mature	Logged	Secondary (young)	Secondary (med. age)	Burnt
Moist					
Seasonal					
Seasonal					

Forest biomass carbon maps for Africa and Southeast Asia produced by using regression-based models to extrapolate forest inventory measurements



Gibbs et al. (2007) Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145: 87-99.

Thank you

Don't forget to prepare for the seminar!