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Potential and challenges of carbon markets for the tropical forestry sector: market developments related to avoided tropical deforestation

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Forest Services-mitigation of carbon emissions

- Sequester carbon via afforestation & reforestation--CDM
- Restore degraded lands--CDM
- Reduce emissions of carbon by changing forest management practices (e.g. conversion to RIL, extend rotation)
- Reduce emissions by reducing deforestation

Emerging voluntary markets

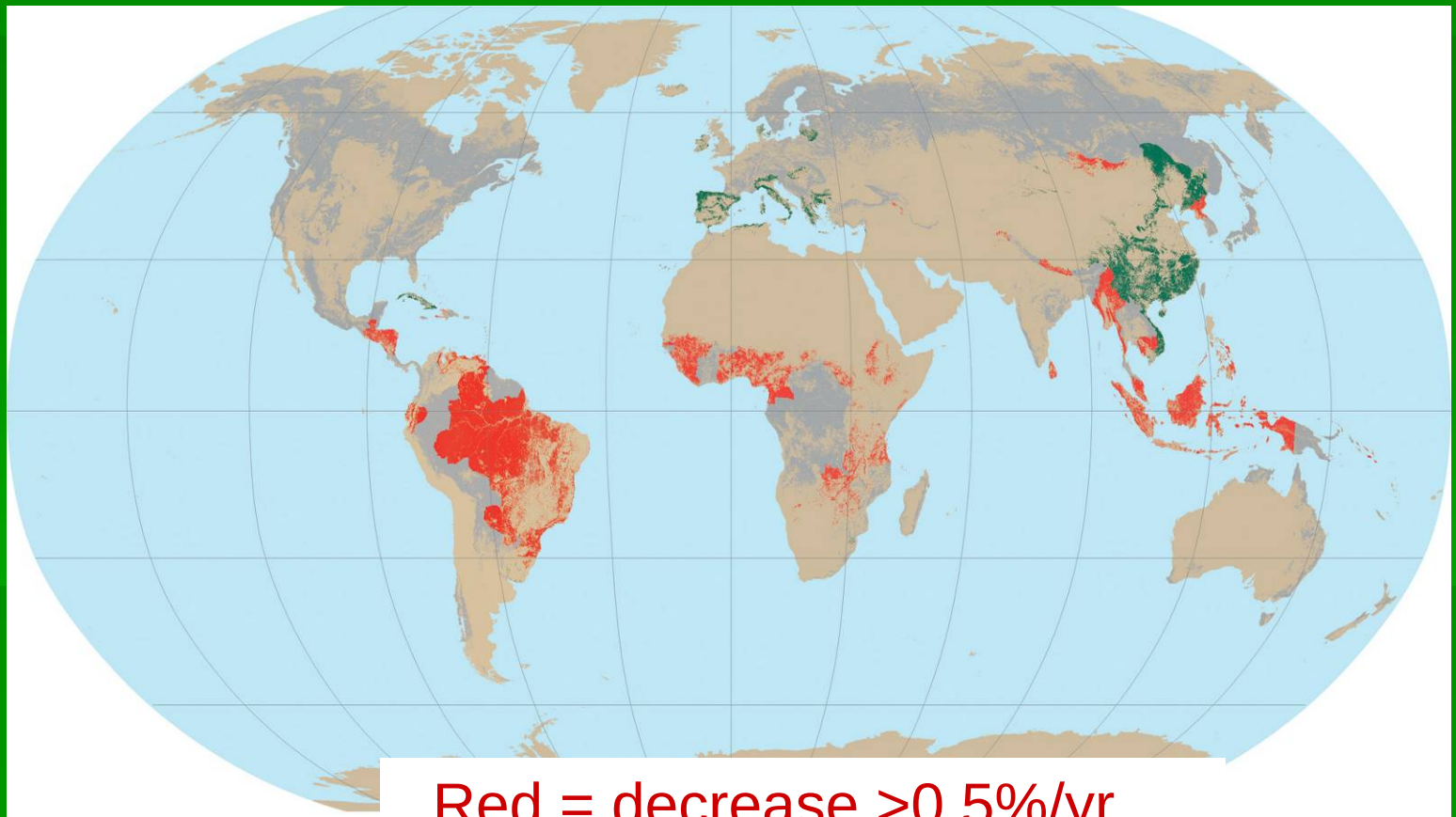
Status of Voluntary Market

- Chicago Climate Exchange
  - Prices vary $1 to $4.50 per ton CO_2
- Retail Market
  - Prices observed on the retail market range from $1 to $78 per ton CO_2 !
- Voluntary markets have potentially more scope to provide sustainable development benefits through avoiding the bureaucratic process and high transaction costs of mandatory market

Voluntary Market Buyers

- Corporate
  - Corporate social responsibility
  - Marketing
  - US Companies anticipating of future regulation
- Non-profits
- Events
- Individuals

Tropical deforestation and global carbon cycle



Red = decrease >0.5%/yr
Green= increase >0.5%/yr
Grey= change below 0.5%/yr

From FAO 2006

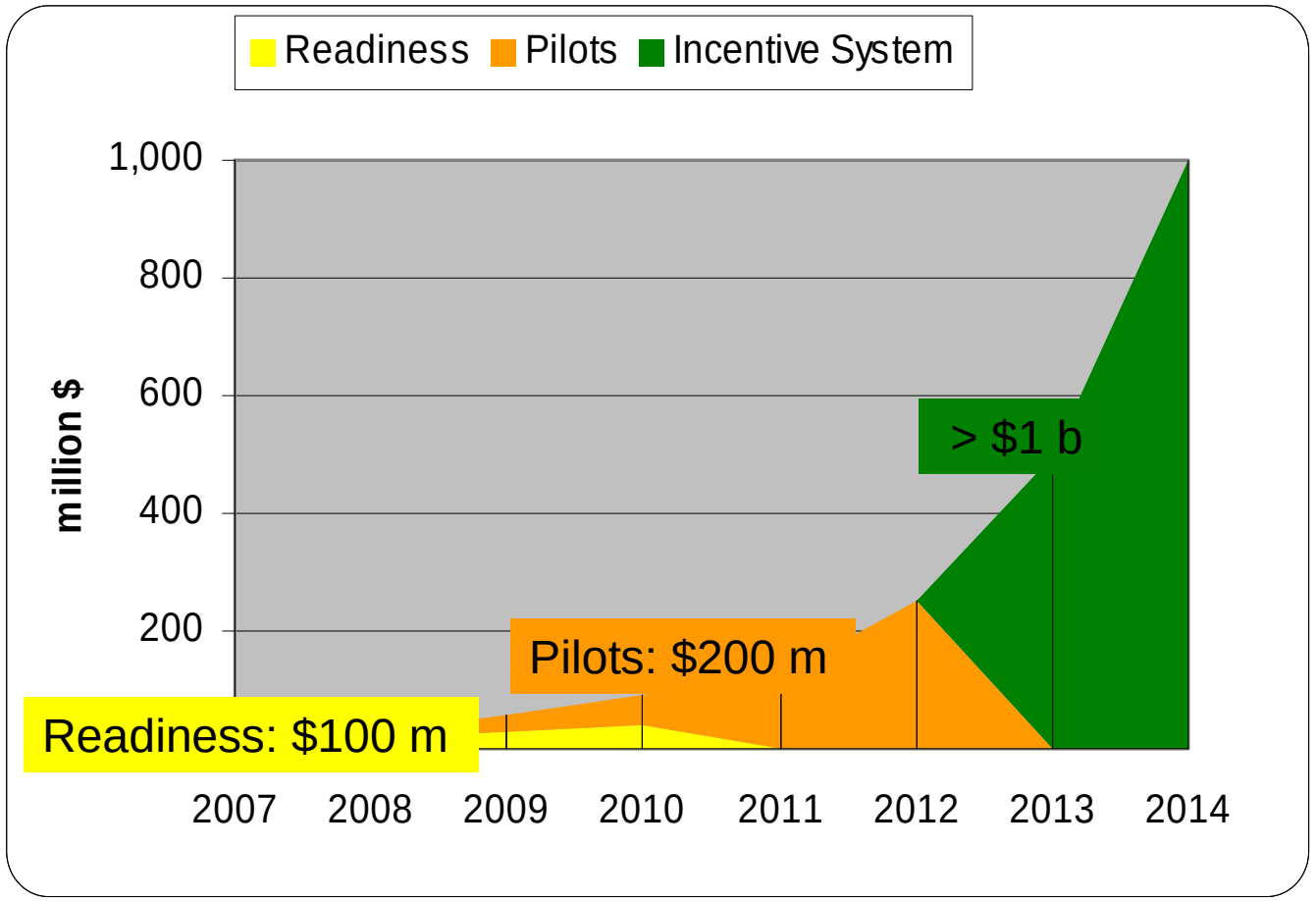
Deforestation and Degradation in Developing Countries

- Responsible for approximately 20% of global emissions
  - In Brazil deforestation and degradation accounts for 70% of total emissions, in Indonesia 80%
- Currently inclusion of REDD activities under consideration by UNFCCC
  - Focus on national level emissions reductions
  - Voluntary target?
- World Bank Forest Carbon Partnership Facility

Proposed Response

Prepare for a system of positive incentives post-2012 that includes REDD through

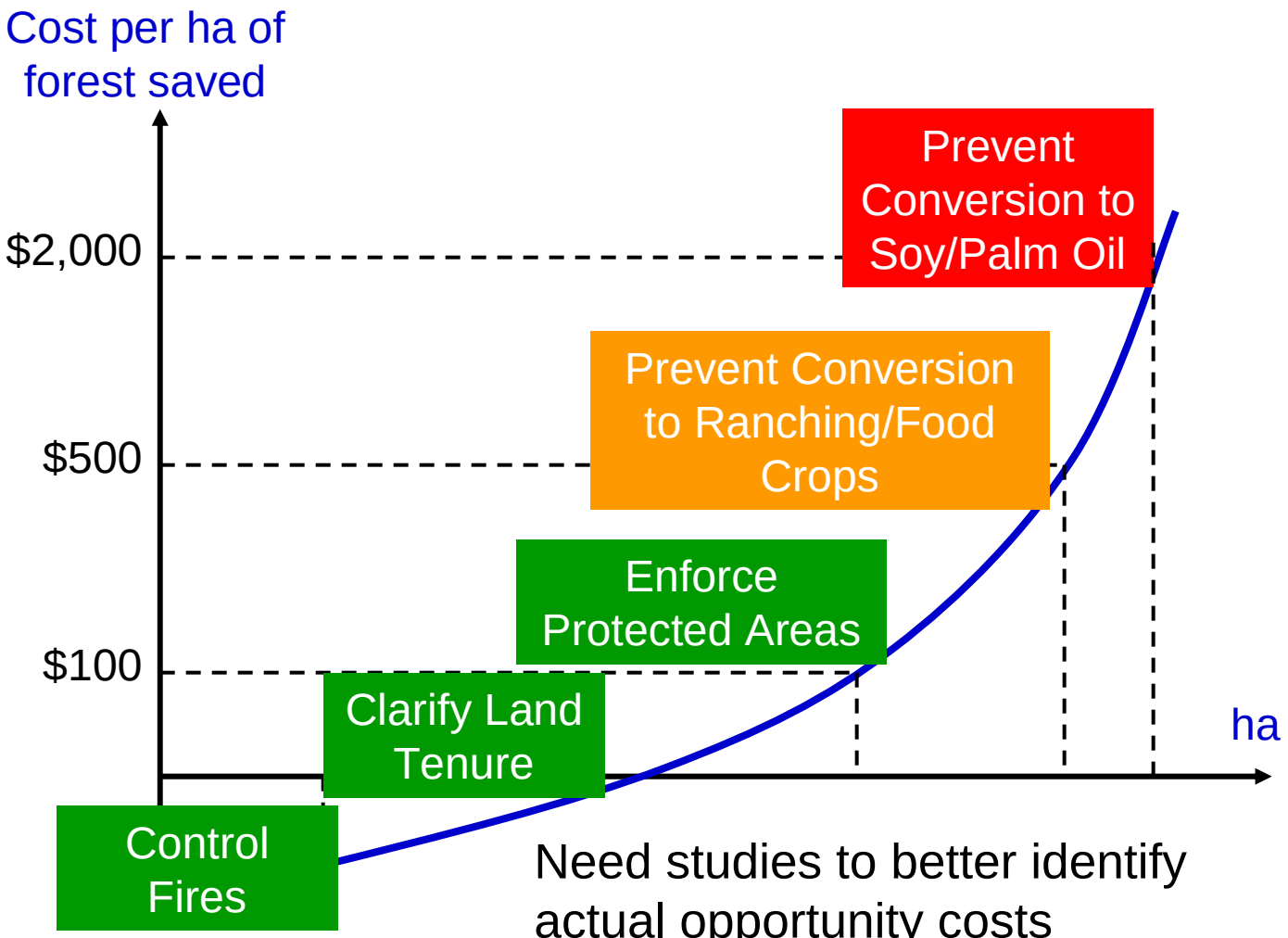
- Capacity building: readiness for a future system
- Pilot performance-based payments



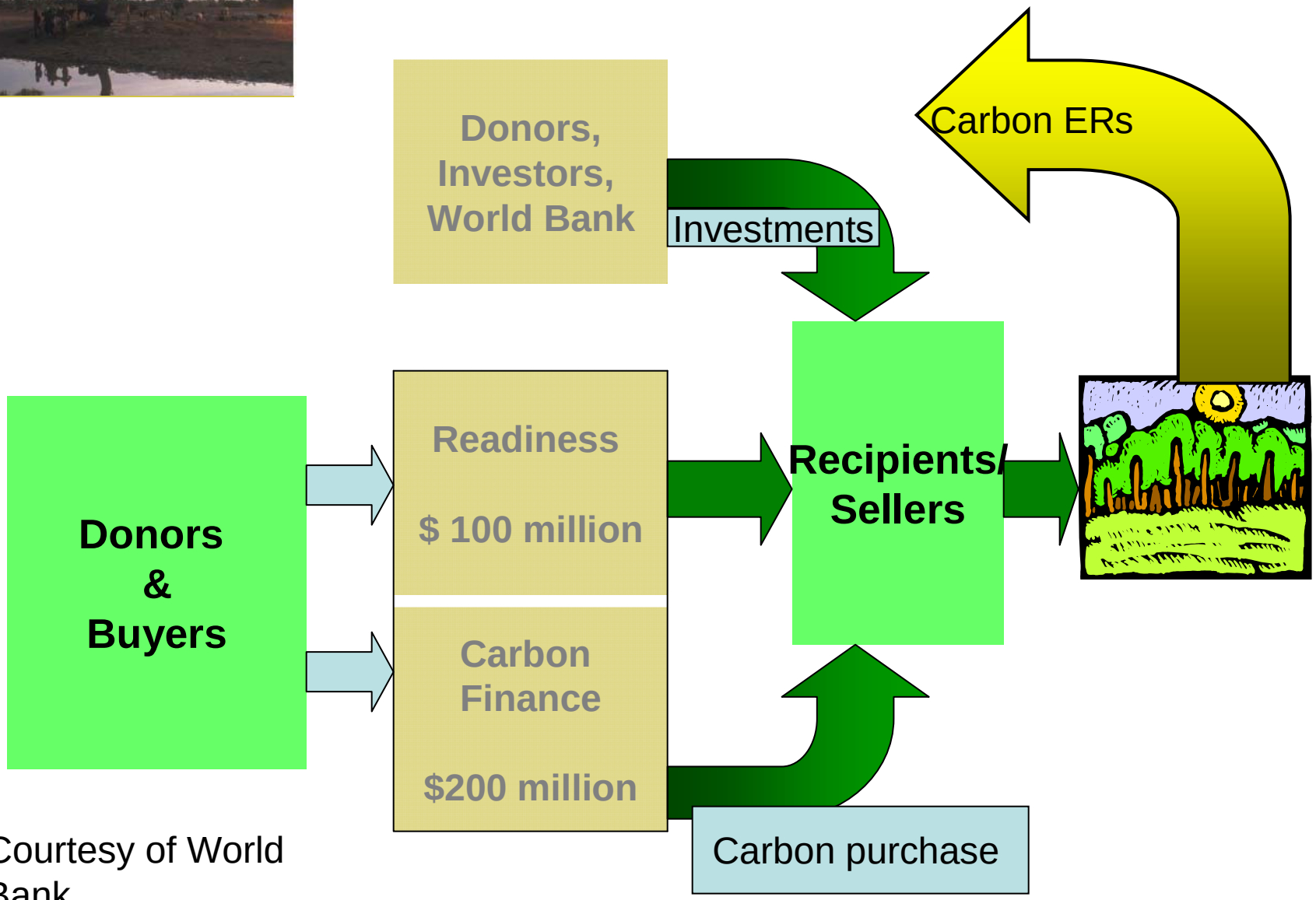
Courtesy of World Bank

Carbon Finance Mechanism

- **Price Carbon ≥ Opportunity Cost of land**
- **Low-hanging fruit seen as opportunity**



Courtesy of World Bank



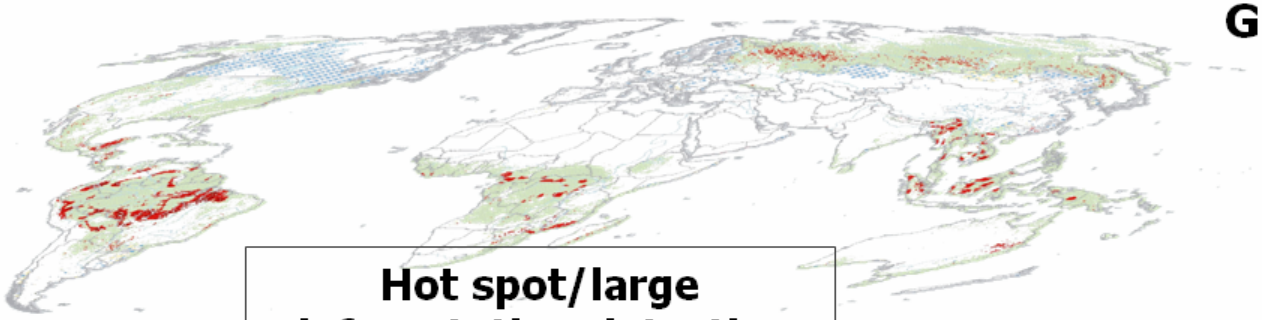
Courtesy of World Bank

What is needed to facilitate markets in REDD?

- Need to have a robust and transparent monitoring system to quantify reference case and to monitor future emissions
- Need data with low uncertainty for
  - Area change
  - Carbon stocks of forests undergoing change

C monitoring system for deforestation

Global observations

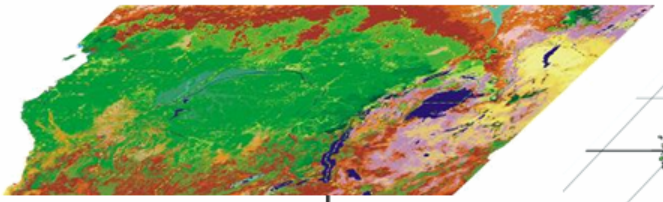


MODIS/MERIS-type sensors
Deforestation (<10-20 ha)
(intra-) annual
Hot spots of forest change
Top-down standards

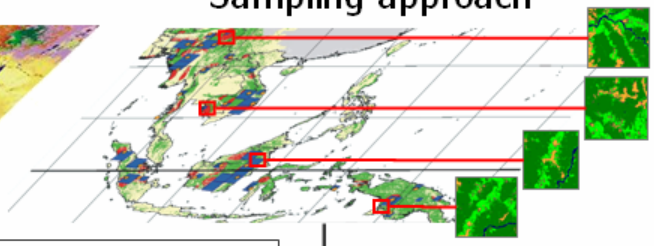
Hot spot/large deforestation detection

Regional/national observations

Wall-to-wall mapping



Sampling approach



Landsat/Spot-type / SAR
Deforestation (<0.5-1 ha)
(inter-)annual
Regionally-tuned forest degradation mapping
Bottom-up flexibility

Change in forest area and density

Fine-scale/in-situ observations

Estimation of carbon emissions

- Forest inventories
- In-situ plot data
- Targeted remote surveys—e.g. Lidar and aerial imagery
- FAO statistics
- IPCC-GPG / AFOLU

DeFries et al. 2006.

Winro

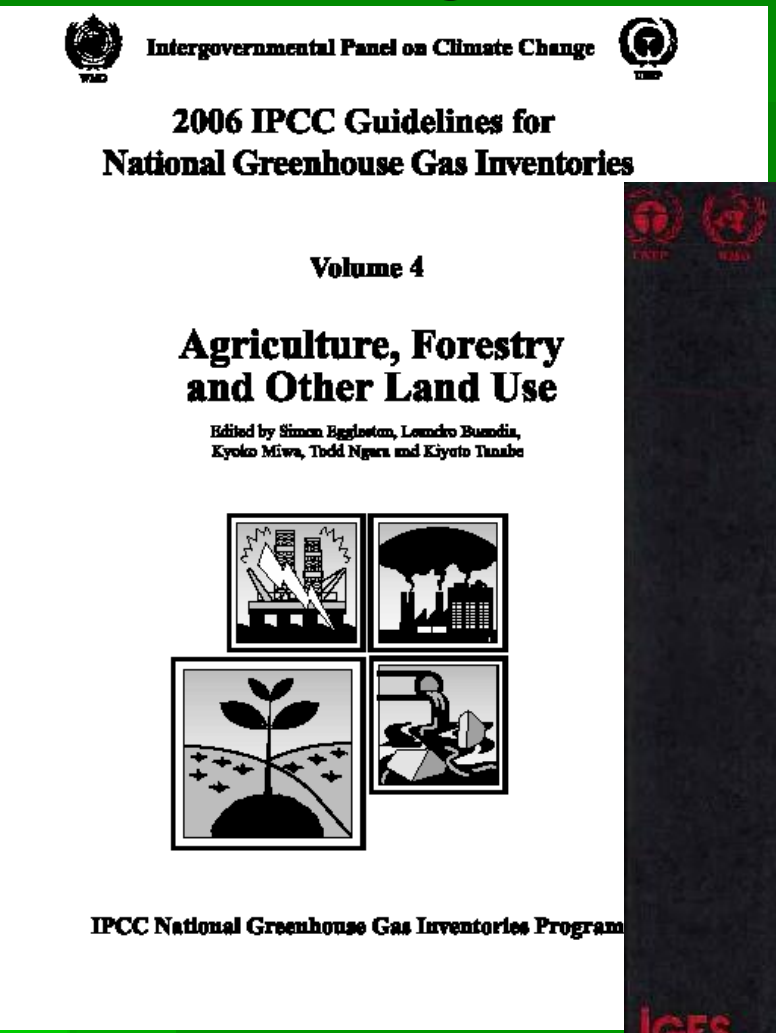
Reference scenarios

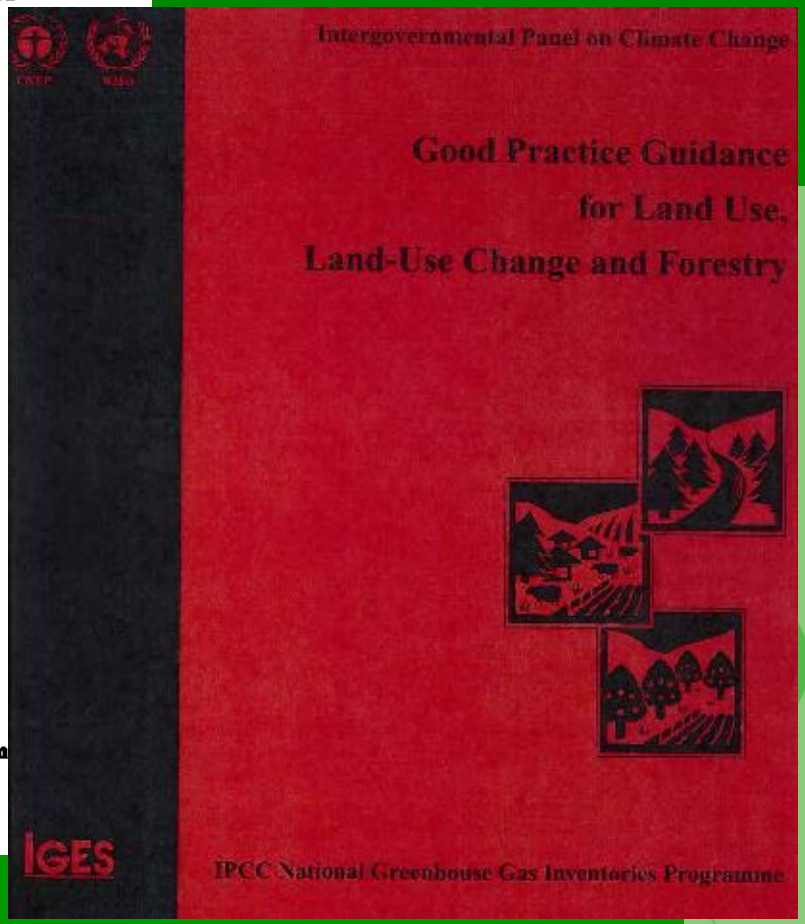
- Methods exist in IPCC reports to estimate emissions for deforestation
  - Emissions = gross deforestation rate x ΔC stock
  - Includes steps to account for fate of cleared biomass
- Methods exist in IPCC reports to estimate emissions for some forms of forest degradation- *"forests remaining as forests"*
- Methods generally based on historical data of deforestation/degradation and C stocks—that vary by national circumstance
- Remote sensing data are available for most countries to estimate gross deforestation since the early 1990s
- Data for carbon stock estimates are often old or completely lacking

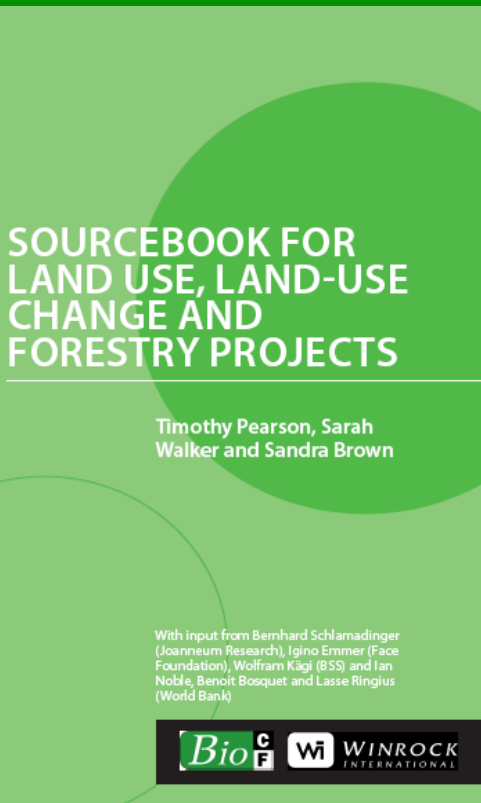
Monitoring change in forest cover

- Remote sensing data available for many land cover changes and many developing countries since 1990s and deforestation can be measured from space with confidence
  - Not all areas covered; cloud cover issues for some key tropical countries
  - Identification of degraded forests developing
  - Identification of selectively logged forest developing
- Development of new technology (e.g. Radar) and new analytical methods in RS progressing for addressing these challenges and likely to be available for future monitoring

Many sources available on methods for obtaining data on forest carbon stocks







IPCC guidance on estimating carbon stocks of forests undergoing conversion

- Uses a Tier approach for "emission factors" or carbon stocks
  - Tier 1—use of default factors provided at continental scale, stratified by general biome class; reports 6 types based on wet to dry climate and lowland to montane—HIGH UNCERTAINTY
  - Tier 2—some country specific data from a variety of sources and assessment of fate of carbon (burned, left to decompose, etc.)—HIGH TO LOW UNCERTAINTY
  - Tier 3—advanced methods and detailed country specific data, including national inventories, measurements systems repeated through time, etc.—LOW UNCERTAINTY

Deforestation tends to focus on estimating area change with high accuracy, but knowing carbon stocks well is equally important to knowing area well to minimize total uncertainty

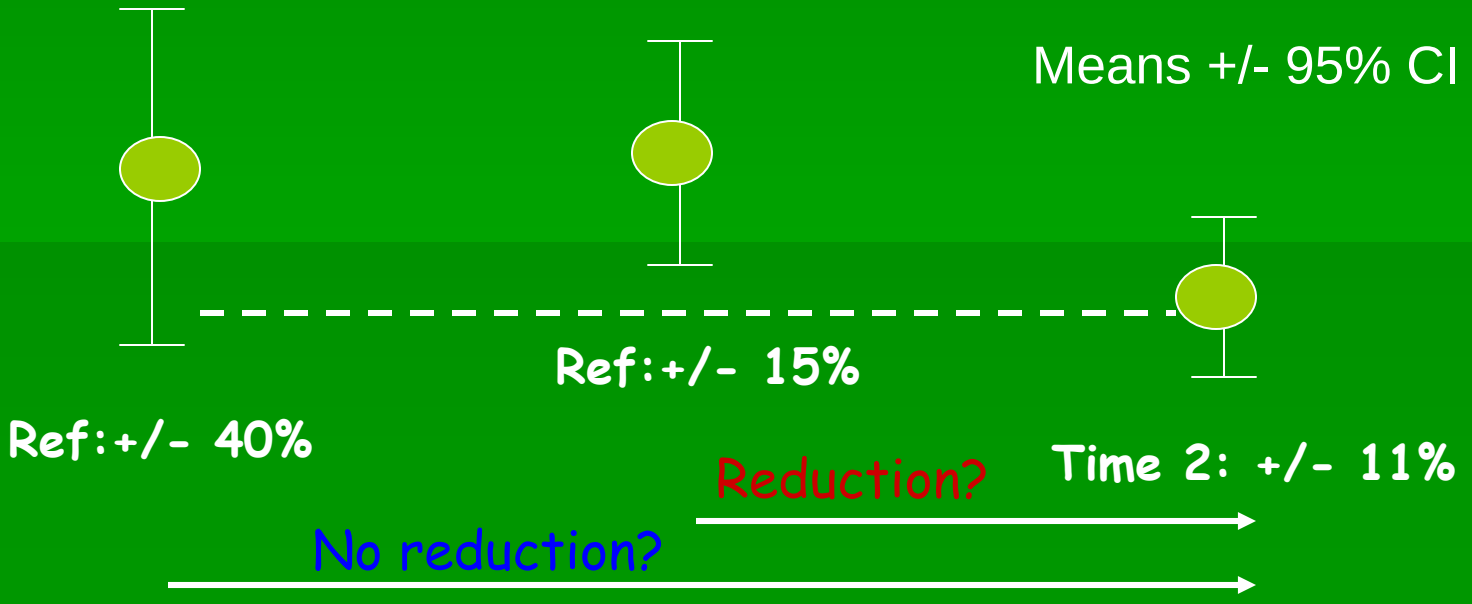
Lack of uncertainty in carbon stocks reduces total uncertainty

- Focus is on accurate accounting of area change but this needs to be matched by low uncertainty in carbon stocks estimates
- Increasing area analyzed has no effect on total precision

Remote Sensing Uncertainty	Carbon Stock Uncertainty	Total Uncertainty
5 %	50 %	21 %
5 %	30 %	17 %
5 %	15 %	11 %

What level of certainty should reference scenarios target?

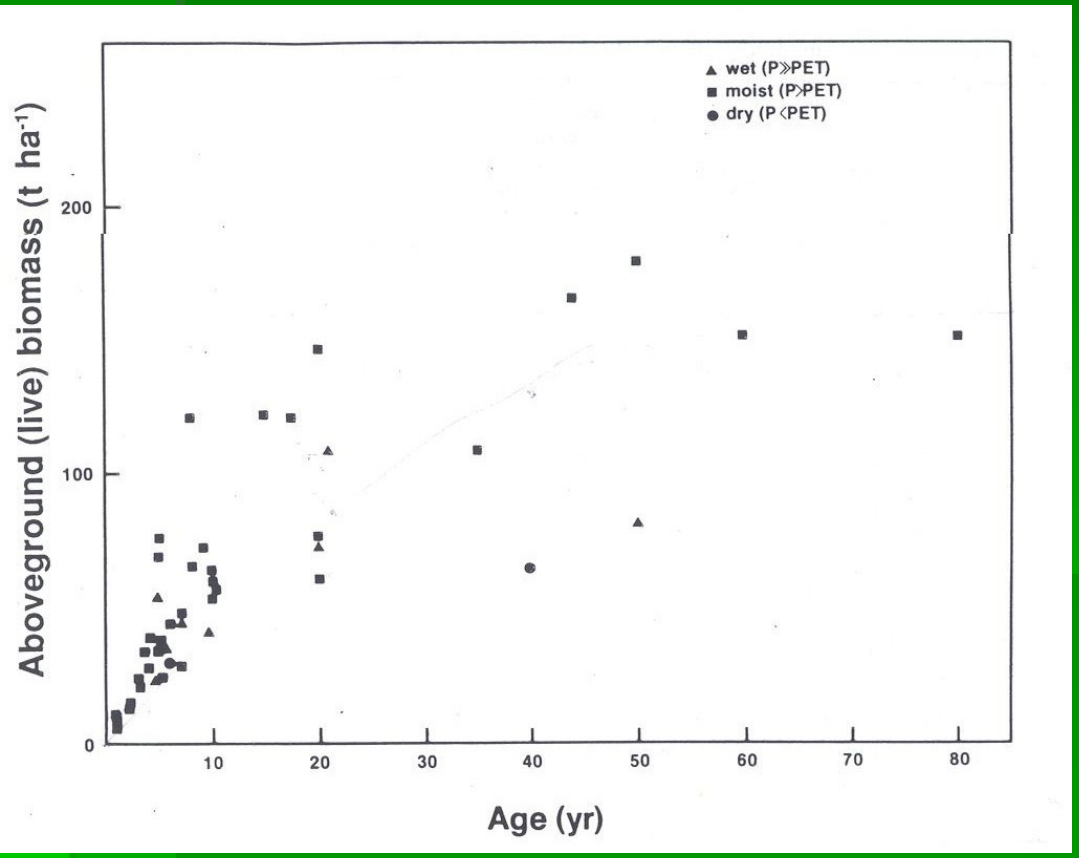
- Depending of tier used to estimate reference scenario and using principle of conservatism:



Challenges for developing reference scenarios:

- Certain areas of tropical world have poor remote sensing coverage because of persistent cloud cover—adds more challenge for interpretation and determining rate
- How to match deforestation with carbon stock of forests undergoing change?
  - Forests undergo many anthropogenic changes that affect C stocks but cannot be detected in remote sensing imagery
- Spatial modeling in a GIS could provide indicators of disturbance to select areas for measuring/estimating C stocks—stratify by disturbance factors

Current satellite sensors cannot be used to estimate carbon stocks



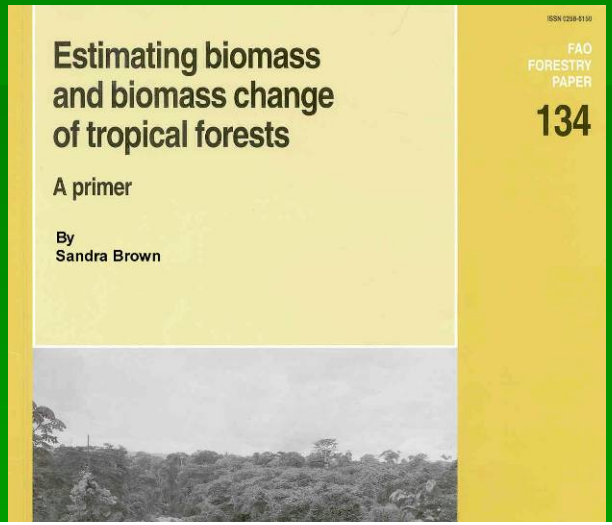
- Optical satellites can differentiate forest from non forest
- But, difficult to distinguish secondary from mature forests, yet biomass can differ greatly because of variations in:
  - Age
  - Land use history
  - Ecological zone

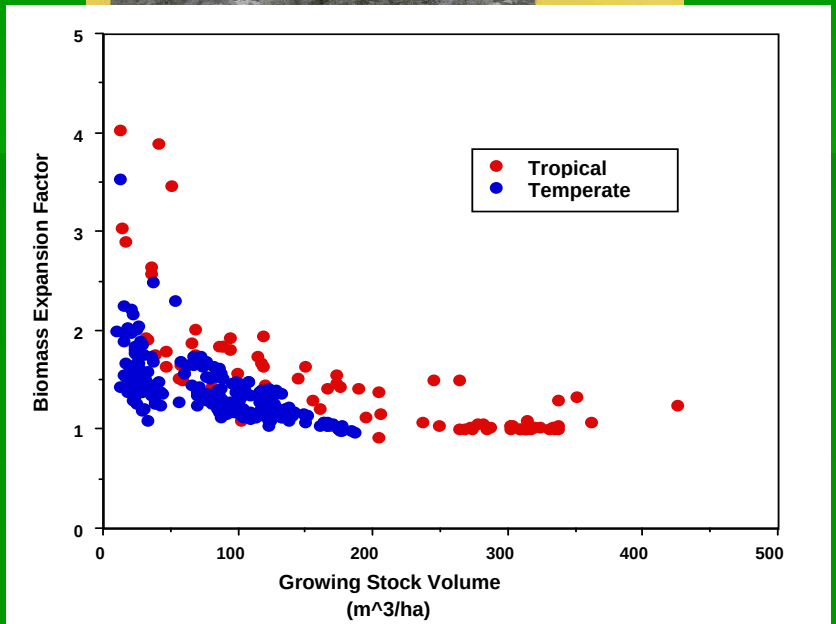
Focus on key carbon pools

- ✓ Aboveground biomass in trees (including palms, etc.) account for largest pool
- Robust models exist for belowground biomass based on aboveground biomass
- Other pools can be estimated conservatively from default factors (compile literature):
  - Dead wood (standing and lying) up to about 15% of AGB
  - Understory up to about 5% of AGB
  - Fine litter
  - Can lose up to 40% of top 30 cm of soil C when converted to crops

How are forest biomass C stocks in the tropics presently estimated?

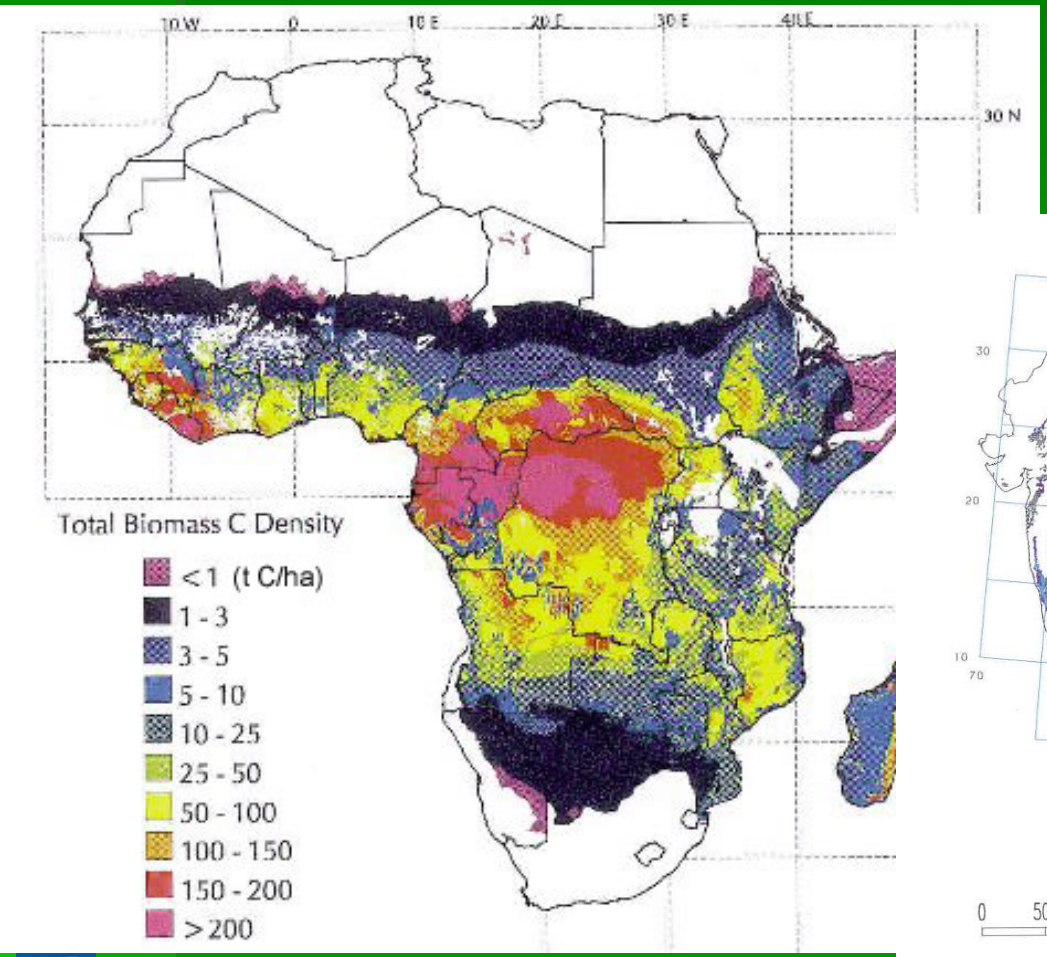
- Tools exist for converting traditional, statistically designed forest inventory data to carbon stocks in trees; defaults used for other pools (IPCC GPG Ch. 3; FAO)
- Many tropical countries have no recent national or even regional forest inventories of growing stock volume
- Research plots generally of limited use as not from population of interest and designed for other purposes

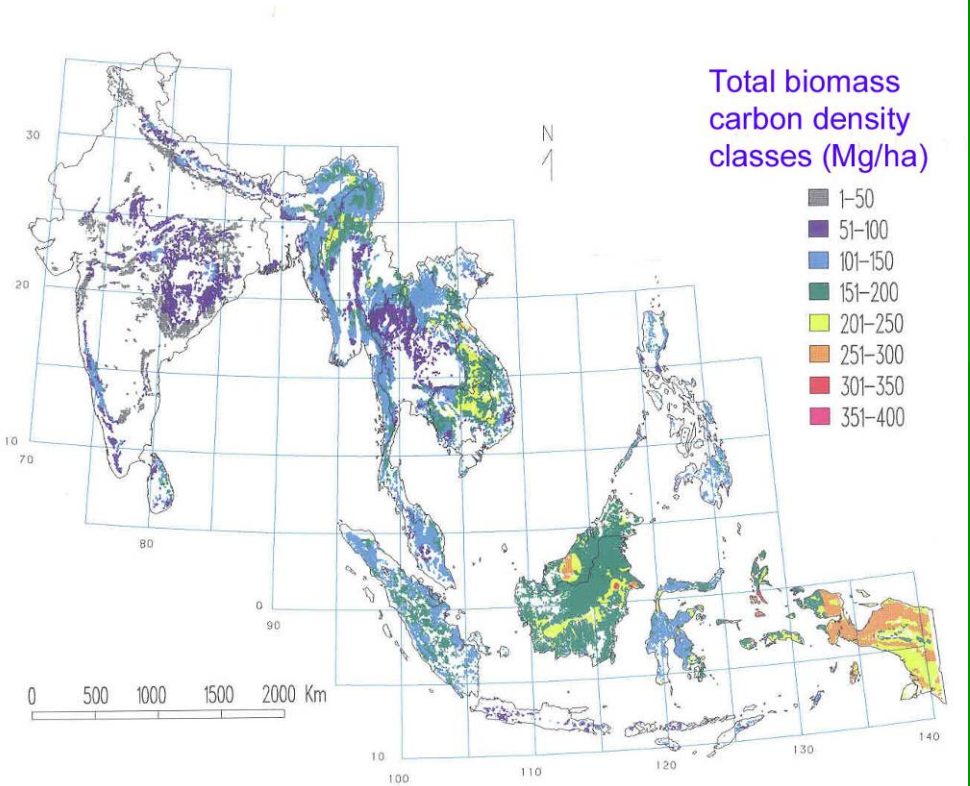




Maps of carbon stocks are available for some areas of world

- Based on a model and inventory data, and includes belowground biomass
- Can be downloaded from CDIAC





(From Gaston et al. 1999; Brown et al. 1993)

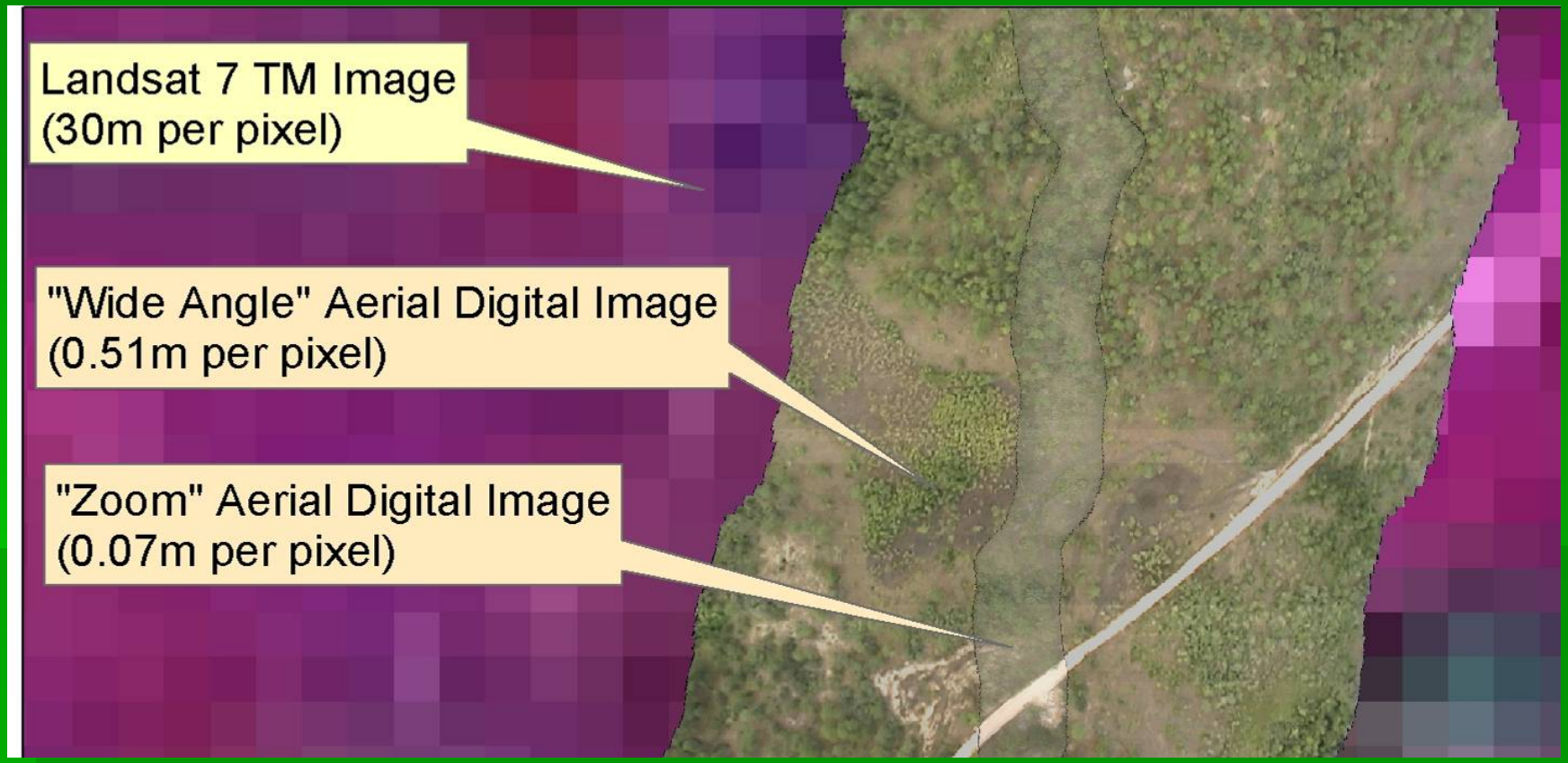
How to improve biomass carbon estimates?

- Build on existing techniques—regular "inventories" done by sampling of vulnerable areas that are identified by optical remote sensors
  - Ground-based National Inventories too expensive
  - Need remote means
- Not necessary for wall-to-wall mapping
- Use key metrics of biomass stocks to help design remote means.....

Key metrics of carbon stocks for tropical forests relevant for remotely sensing?

- LAI reaches maximum value at a young age –limits type of useable RS data (e.g Landsat/Spot of limited use)
- Height of forest saturates at a mid-age and relatively low carbon-limits LIDAR
- Presence of "big trees" (tall emergents with large crowns) are important indicator of carbon stocks
- Height and crown area combined are key indicator of biomass

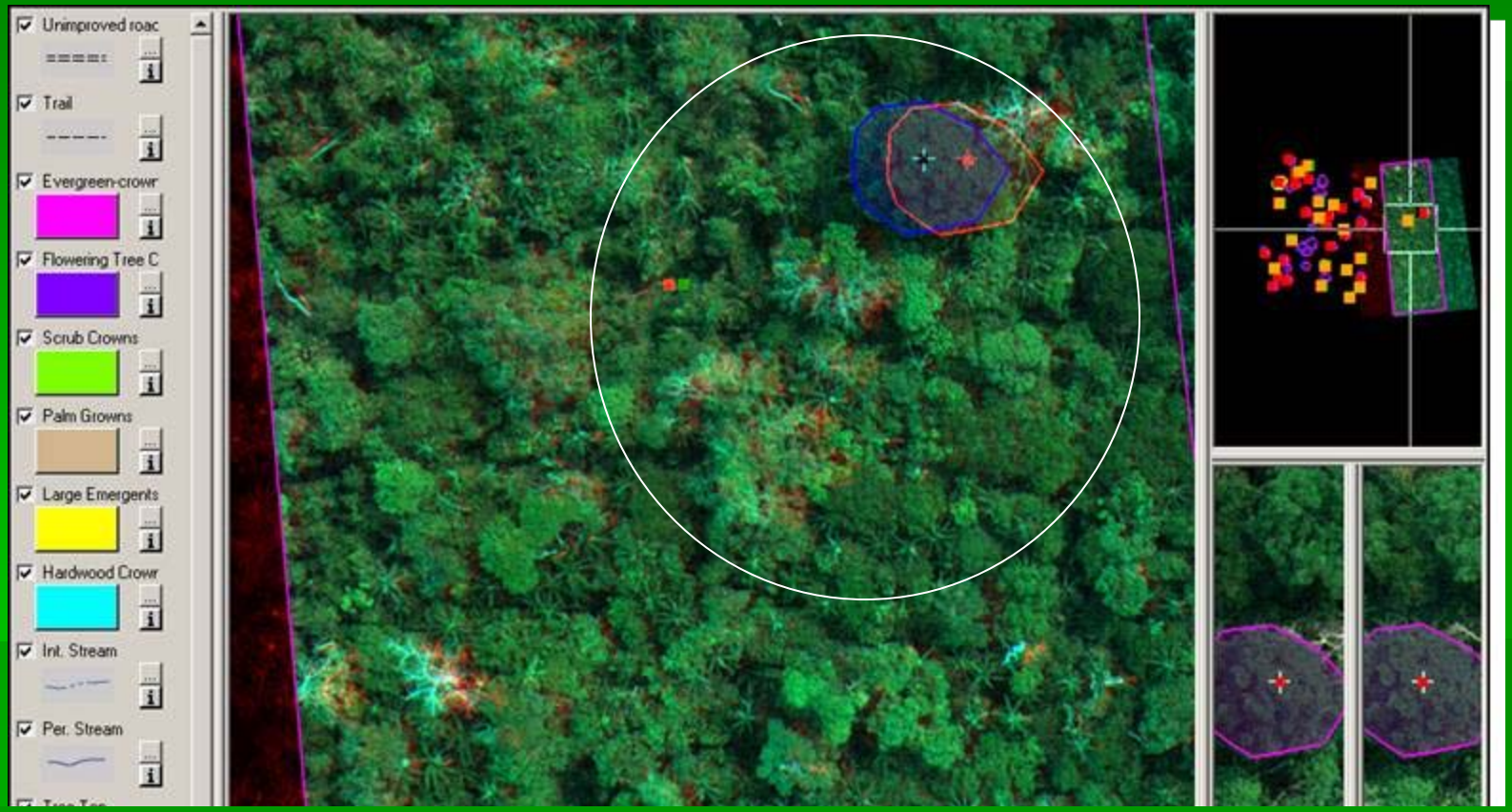
Effect of scale of remote sensing data for biomass estimation



Effect of scale of remote sensing data

10 cm resolution imagery vs. 4-m Ikonos
Ikonos not high enough resolution to identify individual crowns

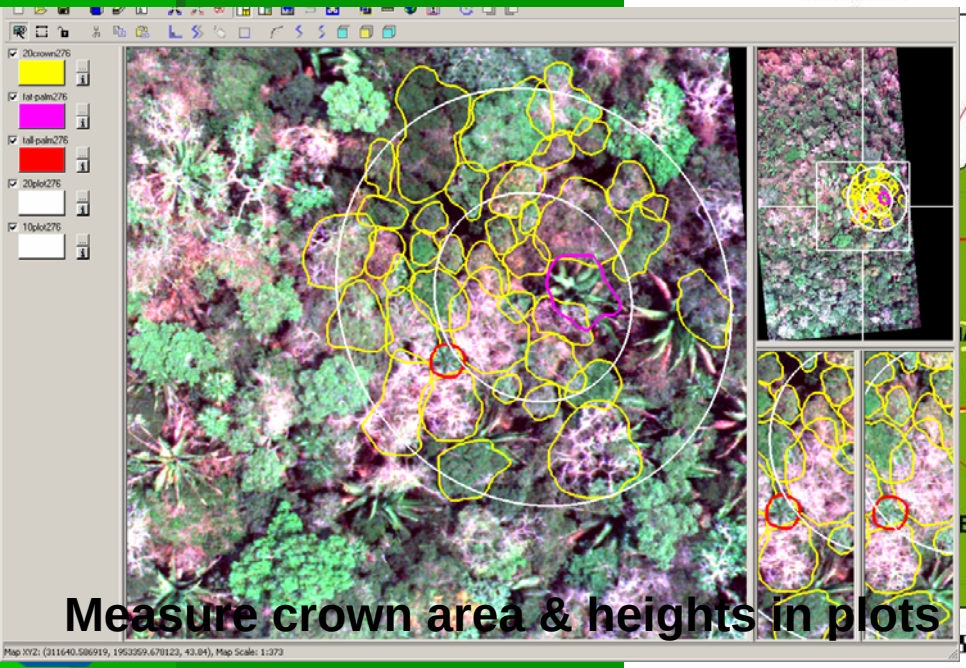
Estimating carbon stocks from high resolution imagery (10-15 cm)



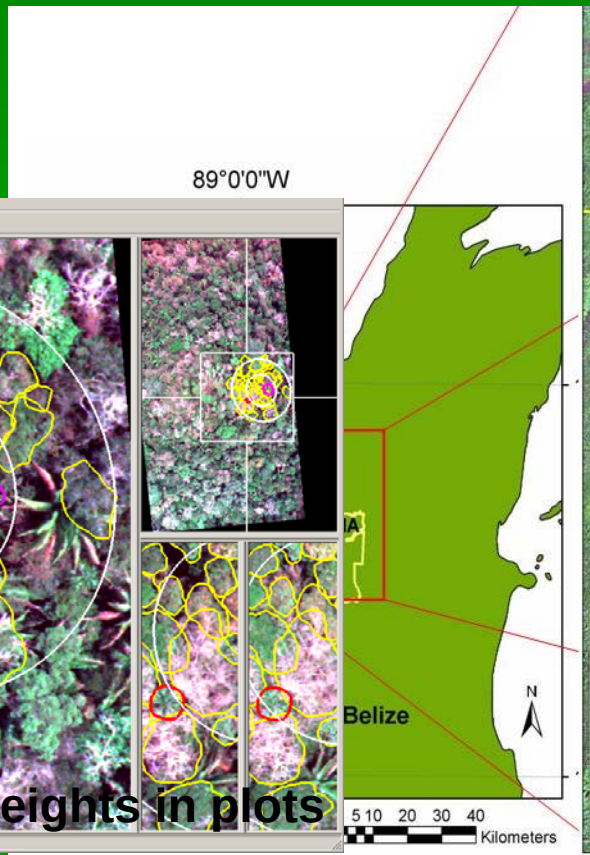
Individual trees are measured for height, crown area, and in some cases species—combine with equation of biomass of tree vs crown area x height or crown area alone

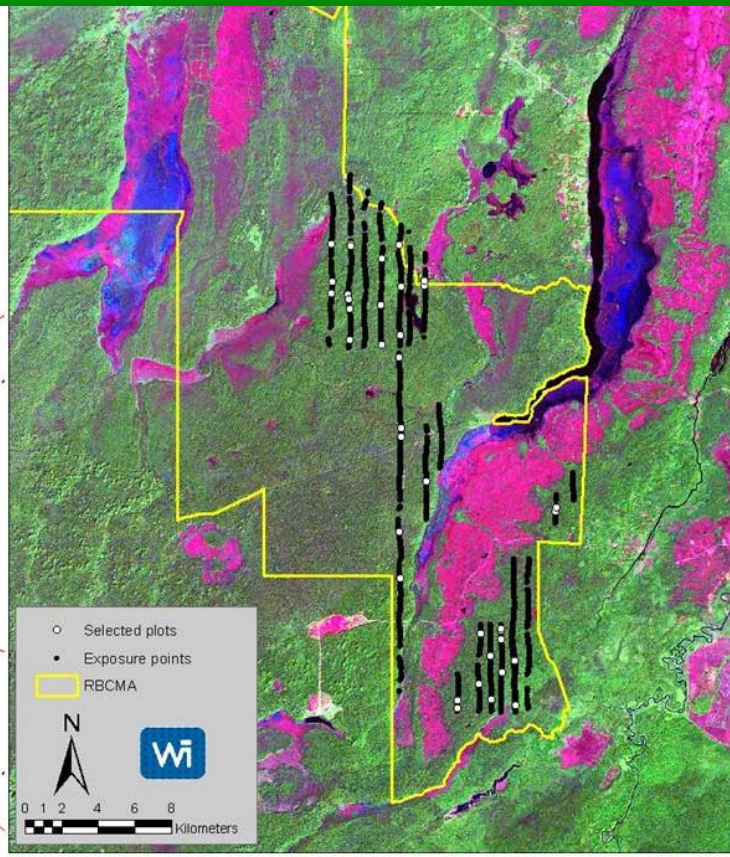
Example of application to closed forest in Belize

- Fly parallel transects & systematically locate image "plots"
- Can be used for sampling areas under threat for deforestation

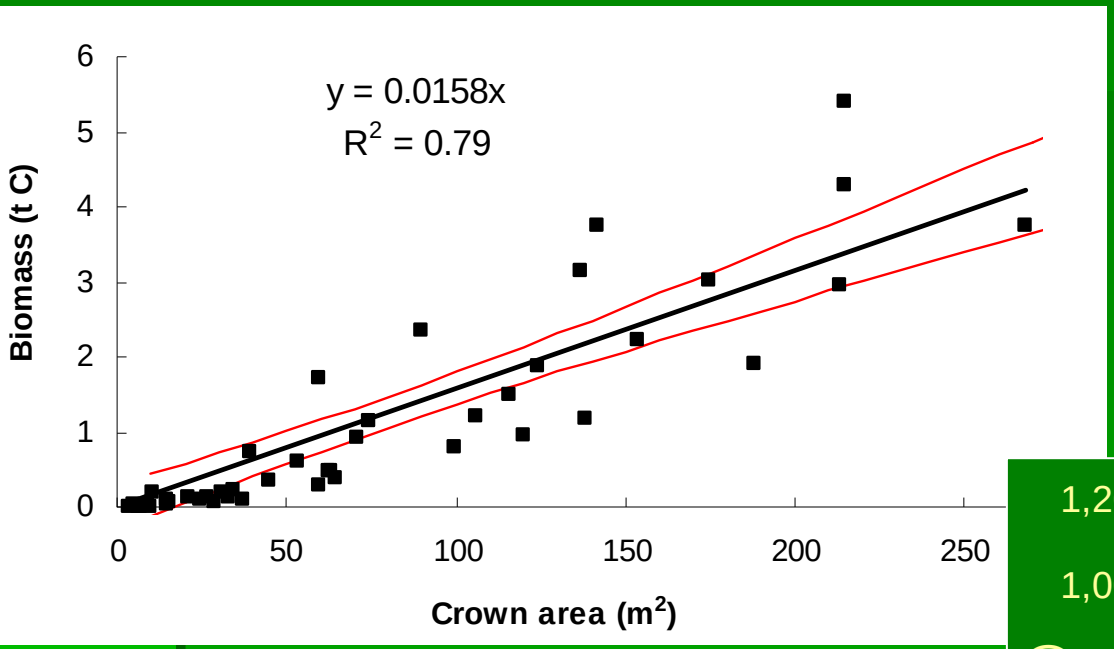


Measure crown area & heights in plots



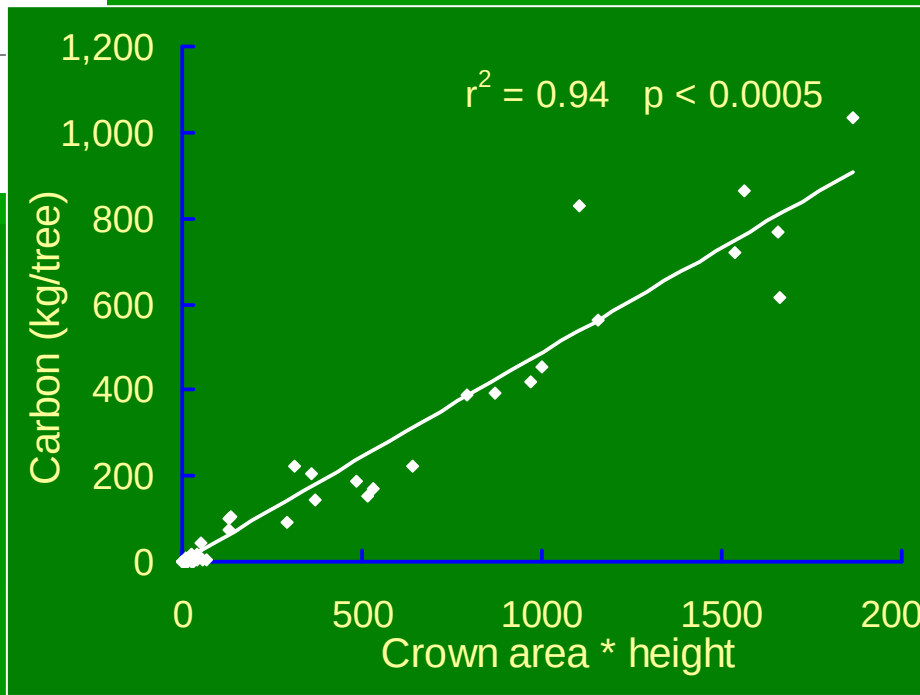


Develop new allometric equations based on crown area & height

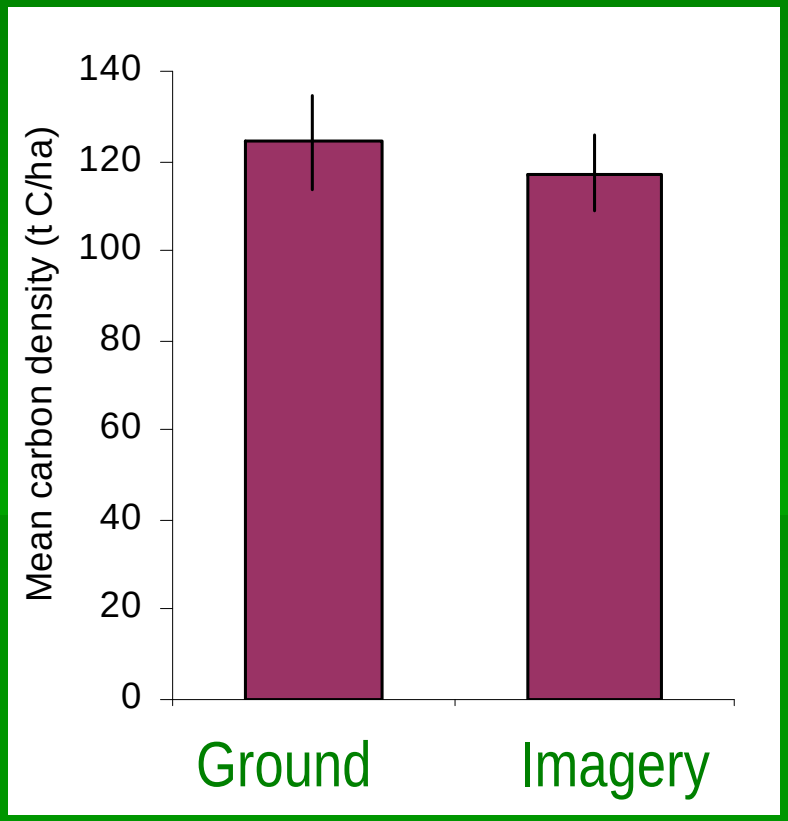


Broadleaf

Tropical pine



Estimate biomass-carbon for all plots



Number of plots required to estimate biomass-carbon to within <10% of mean with 95 % confidence

116 25

Conclusions (1)

- Public funds are becoming available for increasing capacity in developing countries to participate in REDD activities through the World Bank's FCPF
- Need to have a robust and transparent monitoring system to quantify reference case and future changes in emissions of GHGs
- Methods and procedures for estimating emissions from deforestation and degradation exist in IPCC reports

Conclusions (2)

- Remote sensing data available for many land cover changes and many developing countries since 1990s and deforestation can be measured from space with confidence
- Need C stock estimates with low uncertainty to ensure overall uncertainty low
  - There are no accepted standard practices for measuring forest carbon stocks using satellite remote sensing data;
  - To produce emission estimates with high certainty need to focus carbon stock measures on areas undergoing change
  - Investments and increased capacity are required to expand inventories of forest carbon stocks –either on the ground or with imagery

Thank You!

- For more information see:
  - http://www.winrock.org/Ecosystems/tools.asp
- Or contact me:
  - sbrown@winrock.org