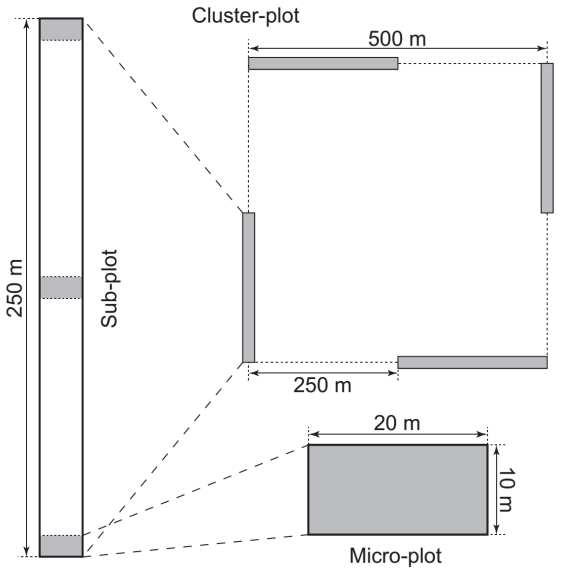
Sampling Trees

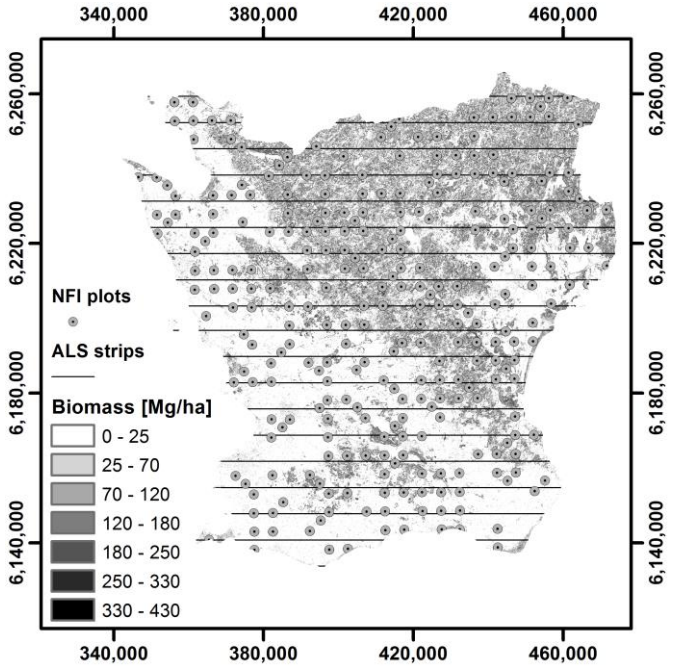
Sampling units in tree inventories

- Trees are the population elements
- Impractical to sample individual population elements
- Sampling frames for indirect access are needed
  - Aerial sampling frame
    - Fixed area plots
    - Angle count method
    - Sample lines
    - Sector plots
  - List sampling frame
    - Administrative units
    - Pixels
    - Tree rows



Sampling design

- How to select/distribute sampling units
- One-phase sampling
  - Simple random sampling, systematic sampling
  - Stratified sampling
  - Unequal probability sampling
  - Balanced sampling
- Multiple phases
  - Two-phase sampling for stratification
  - Two-stage sampling



Estimation design

- Calculation rule that produces the estimates from the collected data
- Specific to the sampling design
- Often several options
- Possible to incorporate auxiliary data to improve estimates
  - Model-assisted estimation
  - Model-based estimation

$$\hat{t}_{\mathrm{GREG}} = \sum_{U} \hat{y}_k + \sum_{s} \frac{e_k}{\pi_k}$$

Volume, biomass and carbon estimation

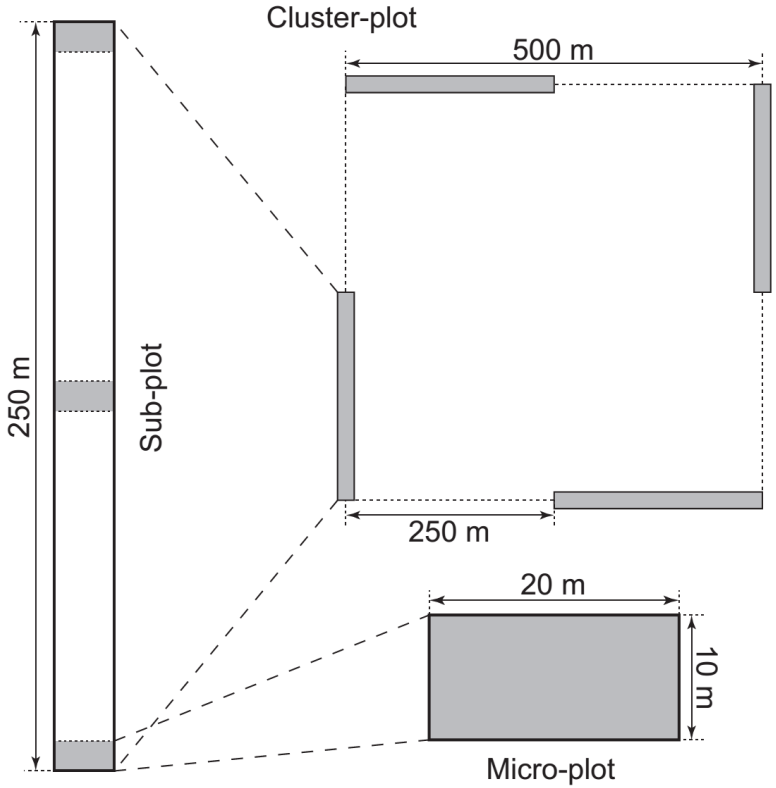
- Key variables in forest or TOF inventories
- Rely on models for an estimation at the single tree level
- Models build from variables that are easy to measure (diameter, height, wood specific gravity)
- General lack of such models for TOF
- Models from forest grown trees as a replacement
- Over or underestimation
- Suggestions to apply averaged equations or multi-species pan-tropical equations
- Destructive sampling for verification

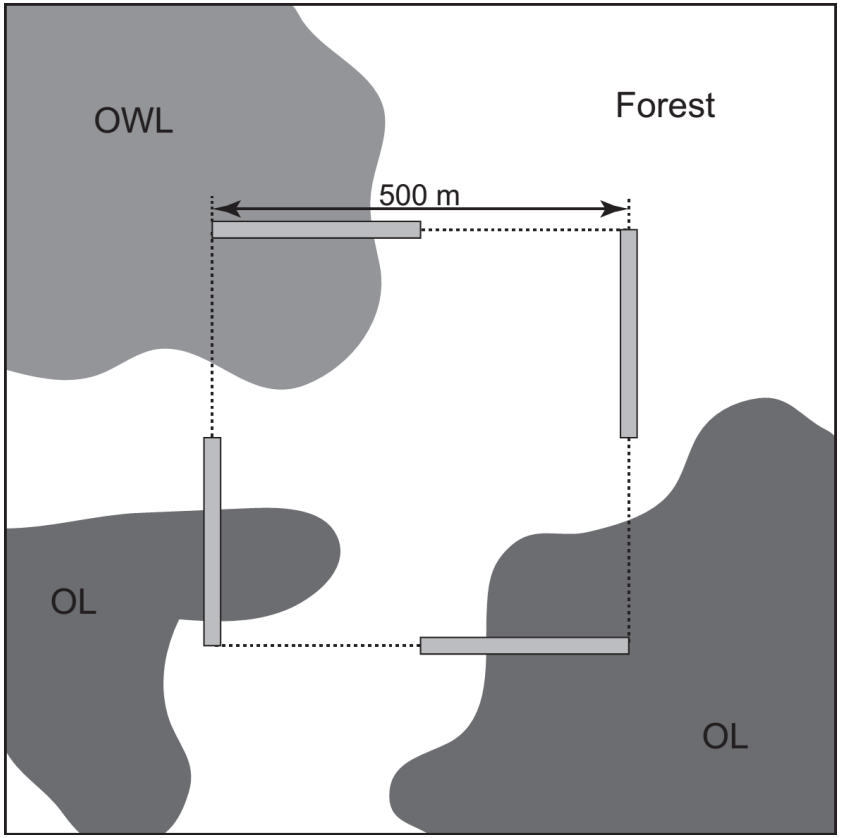
Case studies

Indian NFI

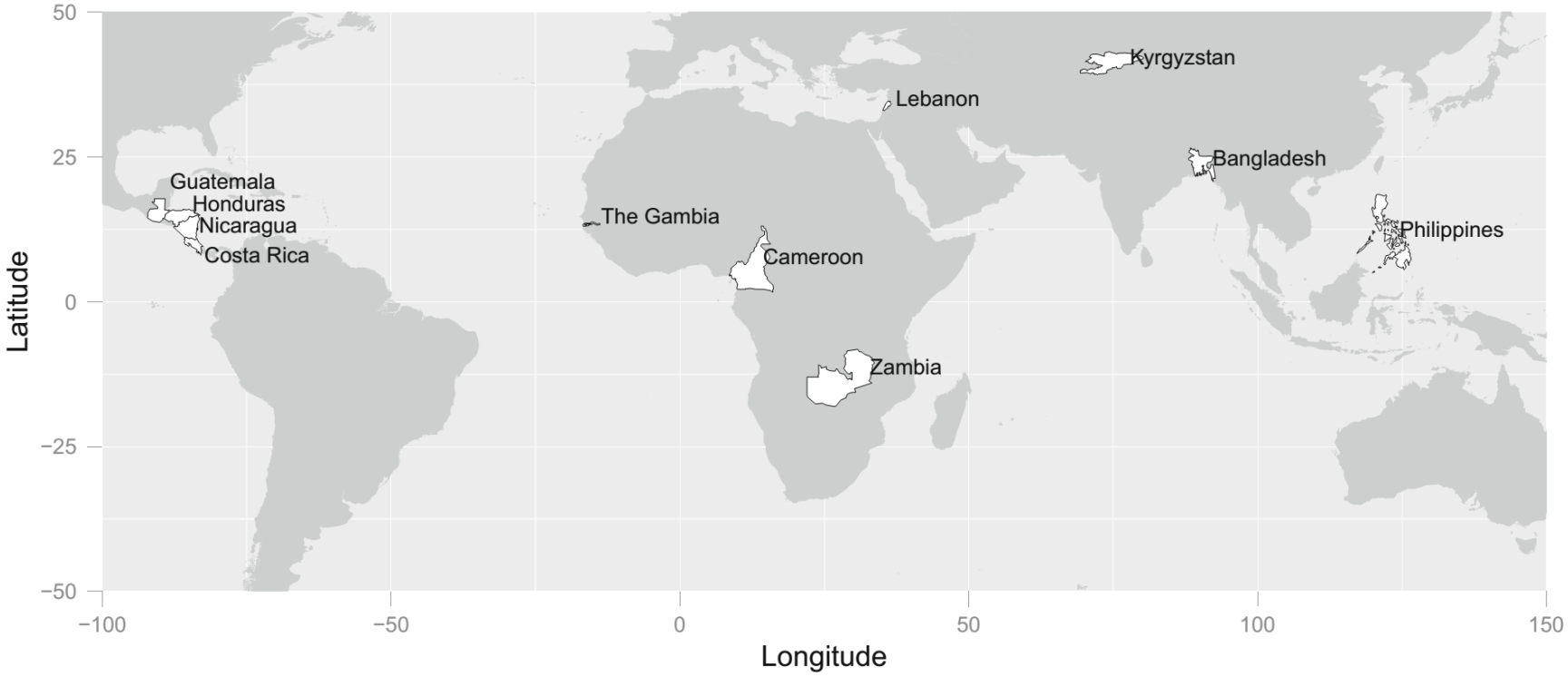
- Two-stage strategy
  - First stage: districts of India (10% sample)
  - Second stage: forests, urban TOF, rural TOF
- Urban areas
  - Divided into blocks (120 to 160 households)
  - All trees within a block are measured
- Rural areas
  - Stratified along spatial criteria (block, linear, and scattered tree formations)
  - Different plot size and shape for each stratum

NFMA – Plot design





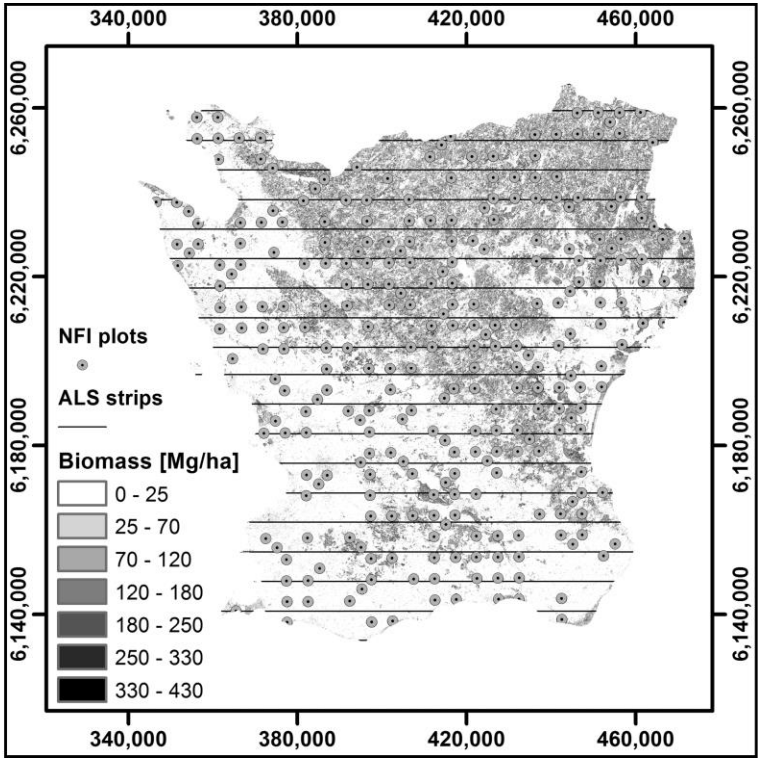
NFMA – Study sites



NFMA - Results

Country	Forest		OWL		OL	
	t ha^{-1} (%)	Percentage	t ha^{-1} (%)	Percentage	t ha^{-1} (%)	Percentage
Bangladesh	33.4 (21.5)	26.7	7.7 (79.5)	0.5	9.6 (8.6)	72.8
Cameroon	159.9 (2.9)	89.4	14.6 (9.9)	5.8	16.4 (15.4)	4.9
Costa Rica	104.0 (15.4)	93.0	0.0 (n/a)	0.0	8.5 (28.7)	7.0
Gambia	21.8 (10.9)	57.6	8.0 (15)	8.7	6.5 (13.5)	33.7
Guatemala	80.6 (14)	86.0	9.3 (15.6)	4.3	7.9 (16.9)	9.6
Honduras	79.2 (9.3)	91.0	9.3 (16.1)	2.9	6.5 (14.5)	6.0
Kyrgyzstan	30.2 (21.8)	84.2	1.0 (29.8)	2.6	0.2 (22.1)	13.2
Lebanon	24.6 (28.5)	51.6	4.6 (26.5)	7.9	3.4 (26.9)	40.5
Nicaragua	74.1 (6.3)	74.4	12.6 (10.9)	8.6	8.6 (9)	17.0
Philippines	82.6 (8.2)	69.0	10.5 (12.1)	4.5	12.3 (9.2)	26.5
Zambia	32.0 (5.3)	95.1	4.9 (21.2)	1.7	3.6 (16.5)	3.3

Simulating NTIs – Artificial population



Simulating NTIs – Layout

- Single-phase sampling
- Two-phase sampling for stratification
- Two-phase sampling with ALS strips
- Two options for incorporating auxiliary information
  - At the design stage: LPM, stratification
  - In the estimators through model-assisted estimation
- Each strategy was repeated 1000 times
- Estimators (total and variance) were evaluated towards their validity and precision

Simulating NTIs – Results

Single phase

Domain	HT	MA
Total	3.56	1.51
F	2.56	1.63
TOF	8.75	4.04
TOF_{OL}	10.08	4.95
TOF_{SM}	14.83	7.11

Two phase for stratification

Domain	HT	MA
Total	2.49	2.05
F	2.65	2.3
TOF	6.95	5.3
TOF_{OL}	7.68	6.23
TOF_{SM}	13.81	9.85

Two phase with strips

Domain	HT	MA	LPM
Total	14.21	14.45	3.22
F	15.40	15.62	3.58
TOF	12.18	9.81	6.93
TOF_{OL}	13.15	9.71	6.56
TOF_{SM}	22.86	17.35	15.34

What about dead wood outside forests (DWOF)?