

METHODOLOGY FOR NFI

**STRATIFICATION, PLOT DESIGN AND
ESTIMATION OF PLOT NUMBERS TO
MEASURE**

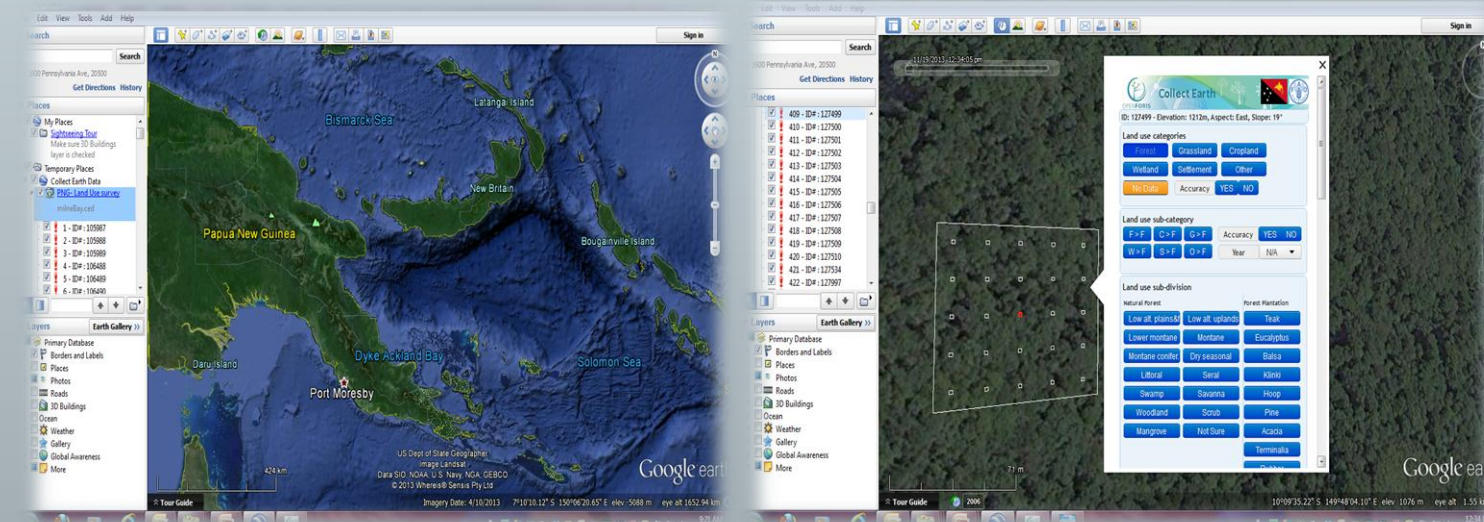
NFI Workop No.3
20 – 23rd May, 2014, Hotel Hodava,
Port Moresby

STRATIFICATION

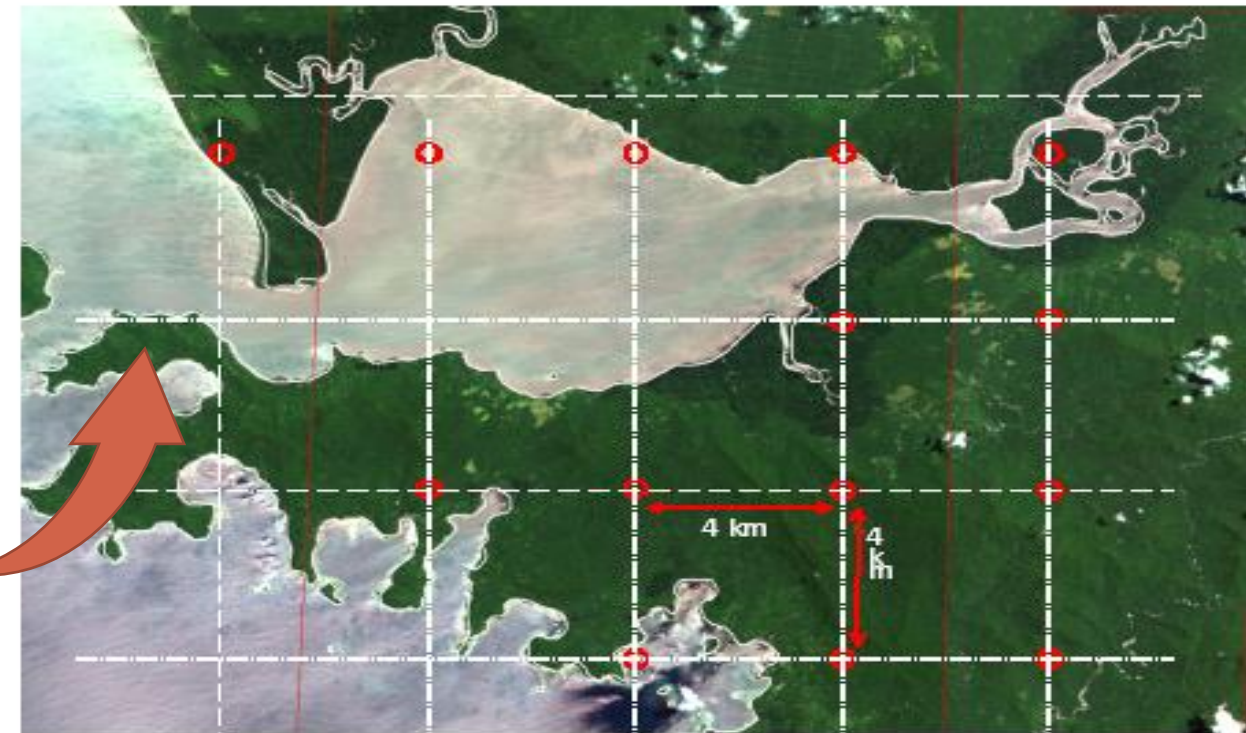
- Land use
- Forest

- At the second NFI preparatory workshop, the NFI was decided to be progressed in two-phases.
- The phase 1 is the remote sensing based assessment to determine the most appropriate stratification and number of plots per strata for the phase 2 (field measurement).
- Based on this decision, the first phase assessment was commenced in October 2013 and completed in March 2014 using Collect Earth, which is Google Earth plugin developed by FAO for forest sampling analysis in synchronism with Google Earth Engine.

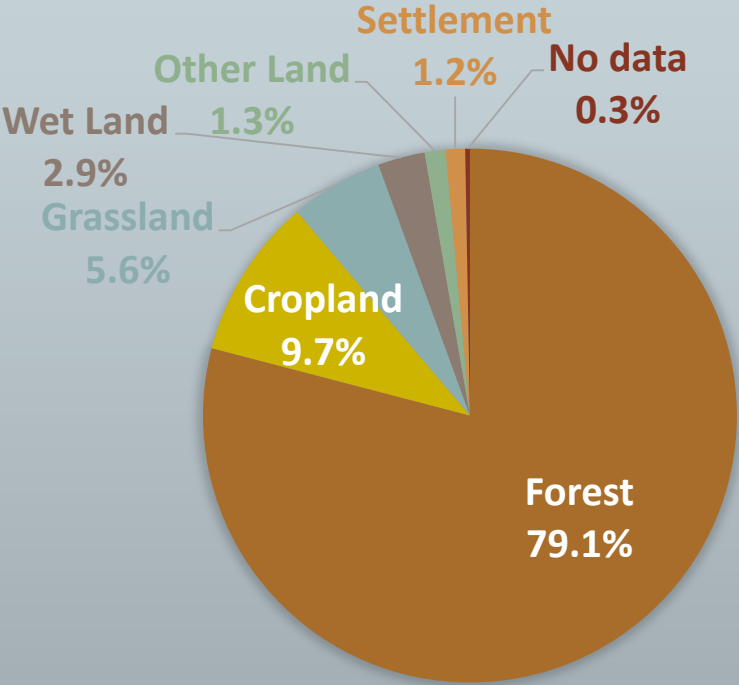
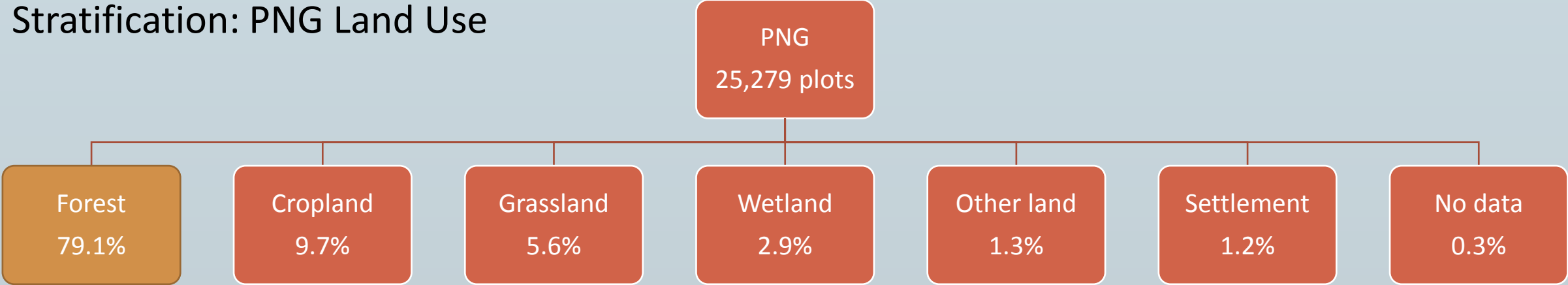
25,279 plots were assessed!



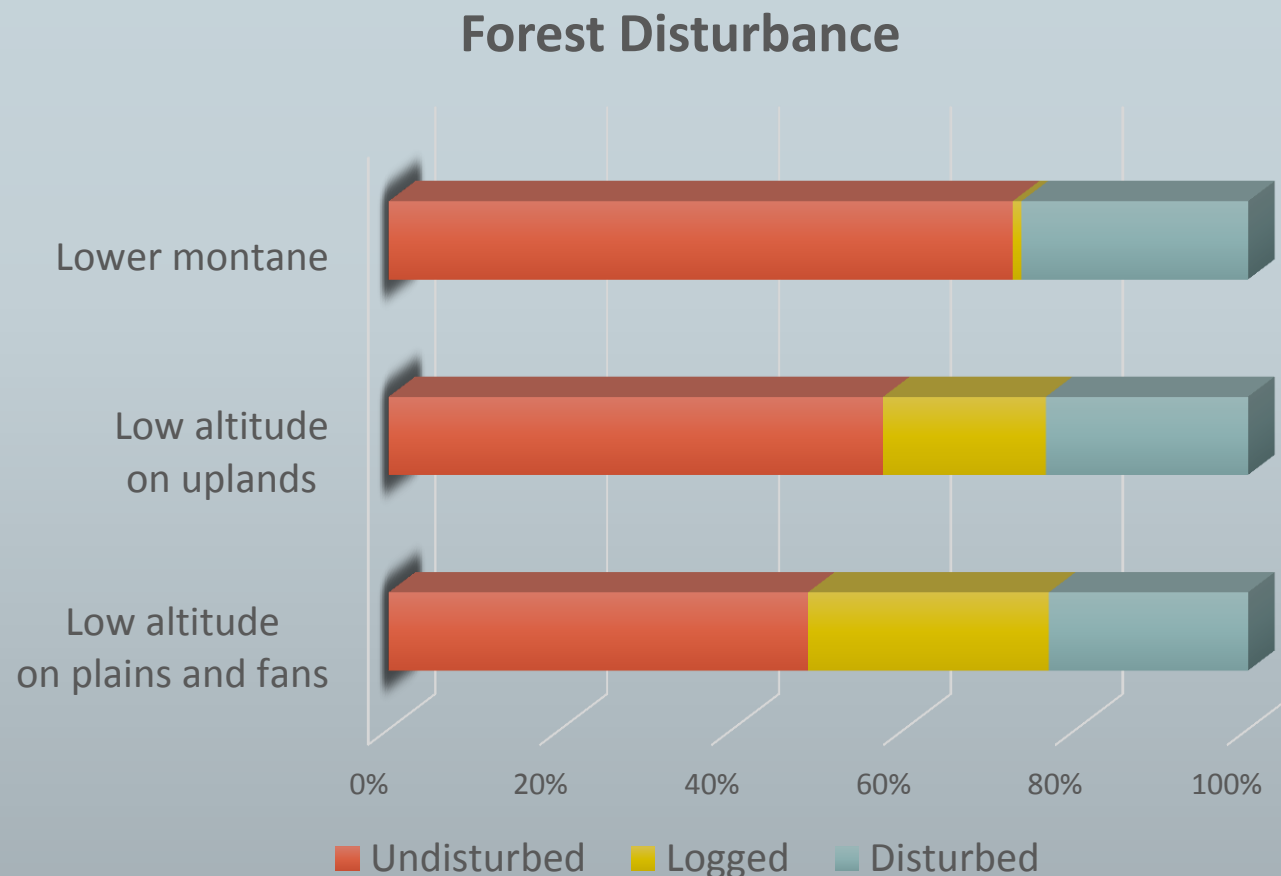
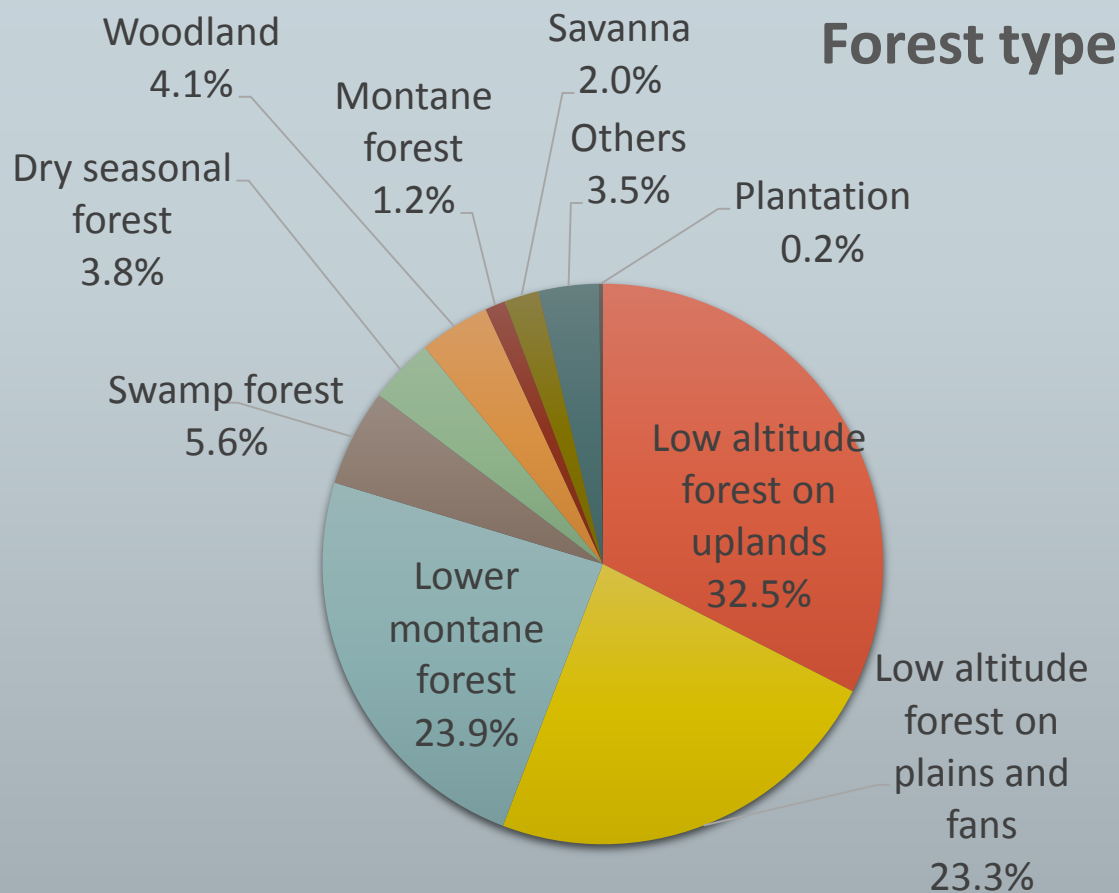
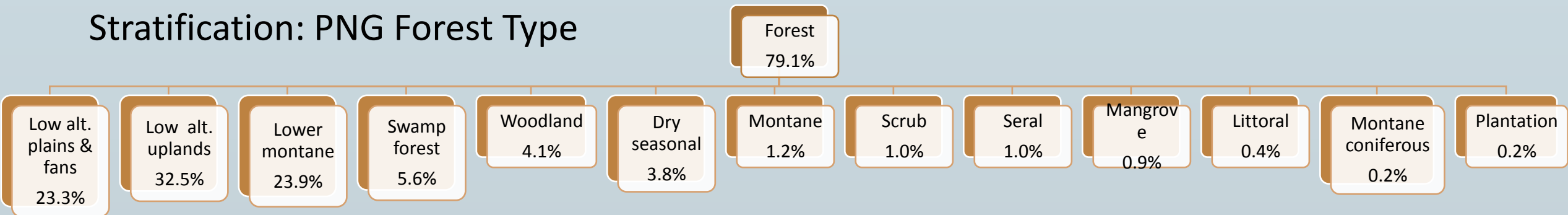
grids of 4x4km



Stratification: PNG Land Use



Stratification: PNG Forest Type



Disturbance in three major forest type in each province

| Plot_File | Low altitude forest on plains and fans | | | | | | Low altitude forest on uplands | | | | | | Lower montane forest | | | | | |
|---------------------------|--|------|---------|-----------|-------|------|--------------------------------|------|---------|-----------|-------|------|----------------------|------|---------|-----------|-------|------|
| | Logging | Fire | Grazing | Gardening | Other | None | Logging | Fire | Grazing | Gardening | Other | None | Logging | Fire | Grazing | Gardening | Other | None |
| 4x4_Hela.ced | | | | | | | | | | 16 | 1 | 45 | | | | 36 | 14 | 278 |
| 4x4_SouthernHighlands.ced | | | | 2 | | 24 | 2 | | | 39 | 5 | 229 | | 1 | | 63 | 21 | 215 |
| central.ced | 36 | 6 | | 29 | 24 | 122 | 41 | 5 | | 21 | 14 | 399 | 2 | 3 | | 17 | 17 | 316 |
| chimbu.ced | | | | | | | | | | 9 | 5 | 45 | | 1 | | 49 | 15 | 80 |
| easternHighlands.ced | | | | | | | | 1 | | 2 | 10 | 18 | | 1 | 1 | 74 | 73 | 151 |
| eastNewBritain.ced | 40 | | | 18 | 13 | 81 | 104 | | | 37 | 16 | 190 | 12 | | | 12 | 1 | 119 |
| eastSepik.ced | 34 | 11 | 1 | 26 | 129 | 350 | 20 | 1 | | 63 | 101 | 305 | 3 | | | 1 | 23 | 94 |
| enga.ced | | | | | 1 | | | 2 | | 8 | 9 | 11 | | 2 | | 127 | 23 | 177 |
| gulf.ced | 223 | | | 14 | 11 | 303 | 100 | | | 17 | 7 | 404 | | 1 | | 14 | 2 | 76 |
| jiwaka_2x2.ced | | | | | | 2 | 13 | 1 | | 34 | 23 | 96 | 8 | 2 | | 121 | 35 | 271 |
| madang.ced | 60 | 8 | | 80 | 53 | 144 | 22 | 1 | | 107 | 74 | 210 | | | | 40 | 54 | 162 |
| manus.ced | 61 | | | 36 | 55 | 22 | 30 | | | 48 | 35 | 19 | | | | | | |
| milneBay.ced | 21 | 6 | | 23 | 19 | 98 | 14 | 5 | | 27 | 10 | 179 | 1 | | | 10 | 2 | 62 |
| morobe.ced | 12 | | 1 | 21 | 33 | 28 | 25 | 2 | | 49 | 59 | 234 | 6 | 4 | | 73 | 96 | 540 |
| newIreland.ced | 29 | | | 29 | 22 | 9 | 60 | | | 40 | 62 | 54 | 8 | | | 2 | 3 | 42 |
| northern.ced | 25 | 3 | 1 | 30 | 52 | 93 | 14 | 2 | | 41 | 38 | 269 | | 1 | | 7 | 20 | 227 |
| northSolomons.ced | | | | 40 | 16 | 21 | | | 1 | 67 | 31 | 39 | | | | 11 | 20 | 18 |
| western.ced | 388 | 3 | | 16 | 94 | 773 | 159 | | | 26 | 89 | 537 | | | | 7 | 12 | 126 |
| westernHighlands_2x2.ced | | | | 10 | | 1 | | 2 | | 12 | | 26 | 2 | 3 | | 97 | 15 | 196 |
| westNewBritain.ced | 221 | | | 16 | 52 | 12 | 365 | | | 23 | 33 | 90 | 4 | | | | 1 | 28 |
| westSepik.ced | 156 | 2 | | 10 | 63 | 190 | 259 | 1 | | 36 | 172 | 331 | 2 | | | 7 | 61 | 252 |

| Region | Low altitude on plains and fans | | | Low altitude forest on uplands | | | Lower montane forest | | |
|-----------------|---------------------------------|-------|-------|--------------------------------|-------|-------|----------------------|-------|-------|
| | Logging | Other | None | Logging | Other | None | Logging | Other | None |
| Highlands | 0 | 13 | 27 | 15 | 179 | 470 | 10 | 724 | 1,368 |
| Southern | 693 | 331 | 1,389 | 328 | 302 | 1,788 | 3 | 113 | 807 |
| Niugini Islands | 351 | 297 | 145 | 559 | 393 | 392 | 24 | 50 | 207 |
| Momase | 262 | 438 | 712 | 326 | 666 | 1,080 | 11 | 359 | 1,048 |

| | | | |
|--------------------------------|----------|------------------------|-------|
| Low altitude on plains & fans | Primary | Southern | 1,389 |
| | | Highlands, NGI, Momase | 884 |
| | Degraded | Logged | 1,306 |
| | | Other disturbance | 1,079 |
| | Degraded | Southern | 1,024 |
| | | Highlands, NGI, Momase | 1,361 |
| Low altitude forest on uplands | Primary | Southern | 1,788 |
| | | Highlands, NGI, Momase | 1,942 |
| | Degraded | Momase | 992 |
| | | NGI | 952 |
| | | Southern & Highlands | 824 |
| | Degraded | Logging | 1,228 |
| | | Other disturbance | 1,540 |
| Lower montane forest | Primary | Highlands | 1,368 |
| | | Others | 2,062 |
| | Degraded | | 1,294 |



Matter for discussion

Which stratification should we apply?

There will be 6-15 strata in the three major forest type.

| Forest type | Plot # |
|--|--------|
| Low altitude forest on plains and fans | 4,658 |
| Low altitude forest on uplands | 6,498 |
| Lower montane forest | 4,774 |
| Montane forest | 234 |
| Dry seasonal forest | 752 |
| Littoral forest | 81 |
| Seral forest | 193 |
| Swamp forest | 1,119 |
| Savanna | 402 |
| Woodland | 817 |
| Scrub | 198 |
| Mangrove | 178 |
| Montane coniferous forest | 43 |
| Plantation | 39 |
| Forest / Total | 19,986 |



There will be 12-22 stratum in total.

| Forest type | Plot # | Precision |
|--|--------|-----------|
| Swamp forest | 1,119 | 5% |
| Woodland | 817 | 10% |
| Dry seasonal forest | 752 | 10% |
| Savanna & Scrub | 600 | 10% |
| Littoral & Seral | 274 | 20% |
| Montane including M/coniferous above 3000m (8 plots) | 242 | 20% |
| Mangrove | 178 | 20% |

Suggested stratification, Stratum and Number of Plots

| | | | Number of plot | Required precision | Required number of clusters* |
|--|---|-------------------|----------------|--------------------|------------------------------|
| Low altitude forest on plains & fans | Primary | | 2,273 | 5% | 80 |
| | Degraded | Logged | 1,306 | 10% | 20 |
| | | Other disturbance | 1,079 | 10% | 20 |
| Low altitude forest on uplands | Primary | | 3,730 | 5% | 80 |
| | Degraded | Logging | 1,228 | 10% | 20 |
| | | Other disturbance | 1,540 | 10% | 20 |
| Lower montane forest | Primary (including 21 montane coniferous forest) | | 3,451 | 5% | 80 |
| | Degraded (including 14 montane coniferous forest) | | 1,358 | 10% | 20 |
| Swamp forest | | | 1,119 | 10% | 20 |
| Woodland | | | 817 | 10% | 20 |
| Dry seasonal forest | | | 752 | 10% | 20 |
| Savanna & Scrub | | | 600 | 10% | 20 |
| Littoral & Seral | | | 274 | 20% | 5 |
| Montane including M/coniferous above 3000m (8 plots) | | | 242 | 20% | 5 |
| Mangrove | | | 178 | 20% | 5 |

19,986

435

* In the case of 0.1ha circular plot with five plots per cluster

SAMPLING & PLOT DESIGN

SAMPLING DESIGN

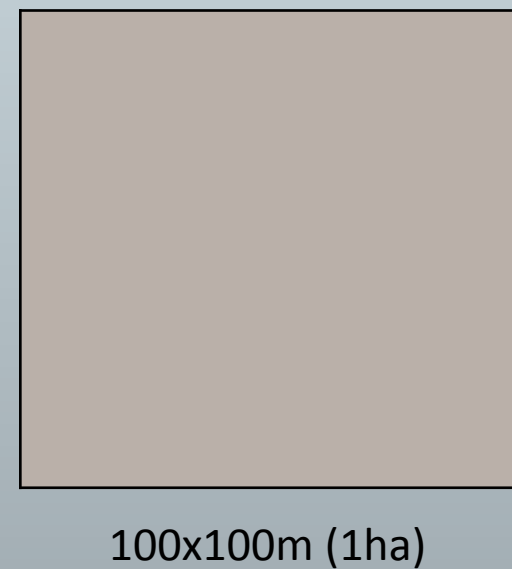
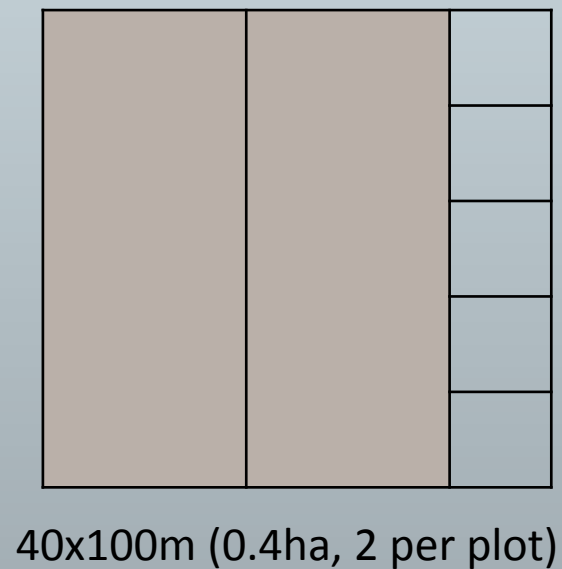
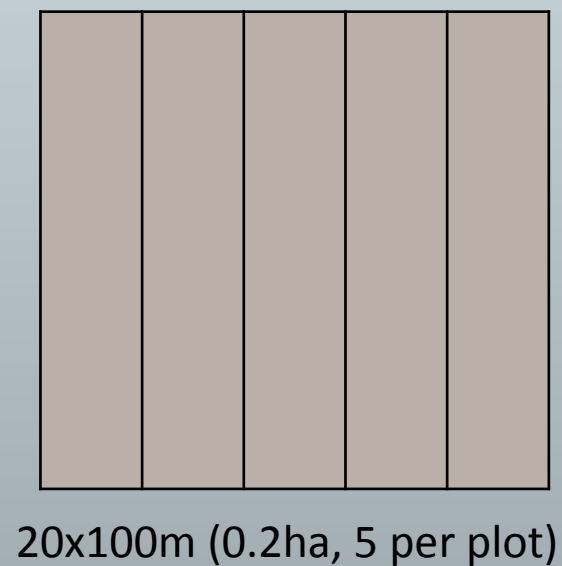
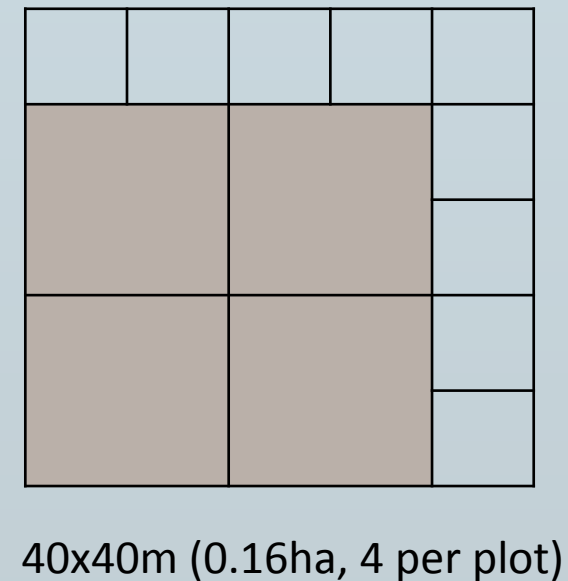
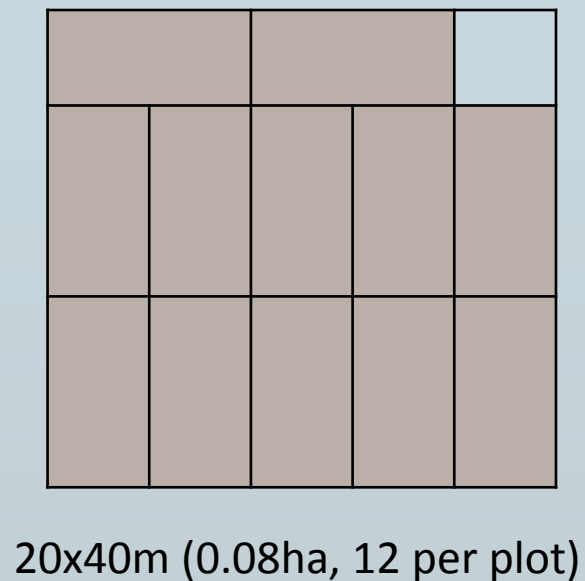
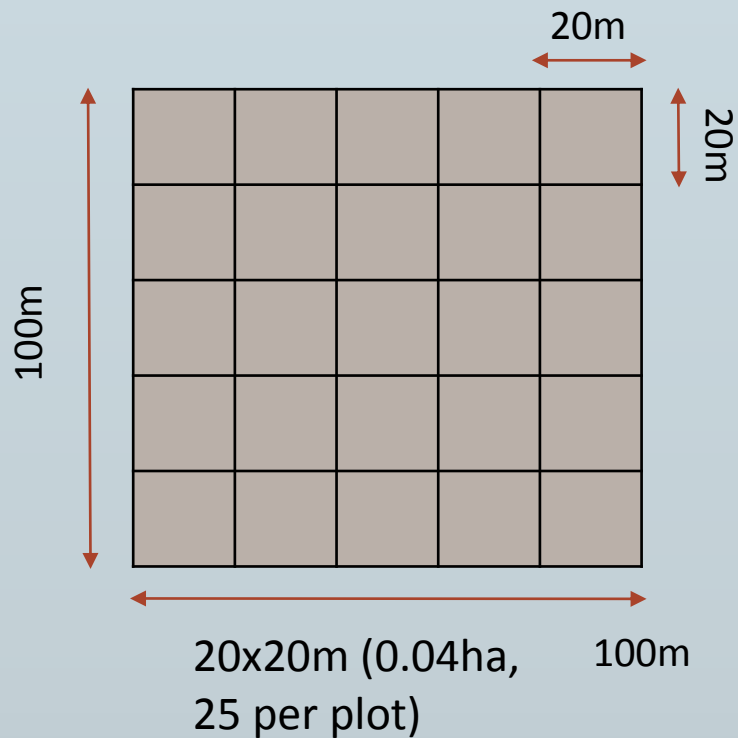
- Due to cost and time constraints, PNG's NFI will be implemented on a representative of the national forest land.
- The initial sampling method for developing a PNGFA NFI was the use of a systematic grid overlaid over the entire country and then screened and assessed using the Collect Earth, which is Google Earth plugin developed by FAO for forest sampling analysis in synchronism with Google Earth Engine.
- For PNG it is proposed that a “stratified restricted random sampling” approach be used when determining the number of plots to measure. As was agreed in earlier workshop, the sampling units will comprise circular plots forming clusters nested within a hectare plot located within each of the 4 x 4 km sampling points (tracts) to collect various information that are required (e.g., tree measurements, land use change information, soil, litter, socio-economic data, etc.)
- Most of these sample plots will be temporary (a one off measurements), while a selected number of them will be used as permanent plots for remeasures to determine stock change estimates for MRV purposes.
- However, prior to deciding what plot design to use we must firstly determine what information we need to collect from such plots.

Analyze PSP data to determine the optimum plot size and required numbers

- ▣ Numerical example of calculating number of plots:

$$N = (C*t/e)^2$$

- ▣ Where N= # of units required;
- ▣ C = coefficient of variation – a normalised measure of dispersion of a probability distribution. Defined as the ratio of the standard deviation to the mean;
- ▣ e= required precision; t= student's t at the nominated probability level and the appropriate # of degrees of freedom.



Number of PSP plots in different forest type and disturbance

| | | Forest type | | Disturbance | |
|----------|-----|----------------------------------|-----|-------------|-----|
| PSP plot | 135 | Lowland forest | 127 | Logged | 119 |
| | | | | Primary | 8 |
| | | Montane forest (> 1,000m asl) | 8 | Logged | 6 |
| | | | | Primary | 2 |

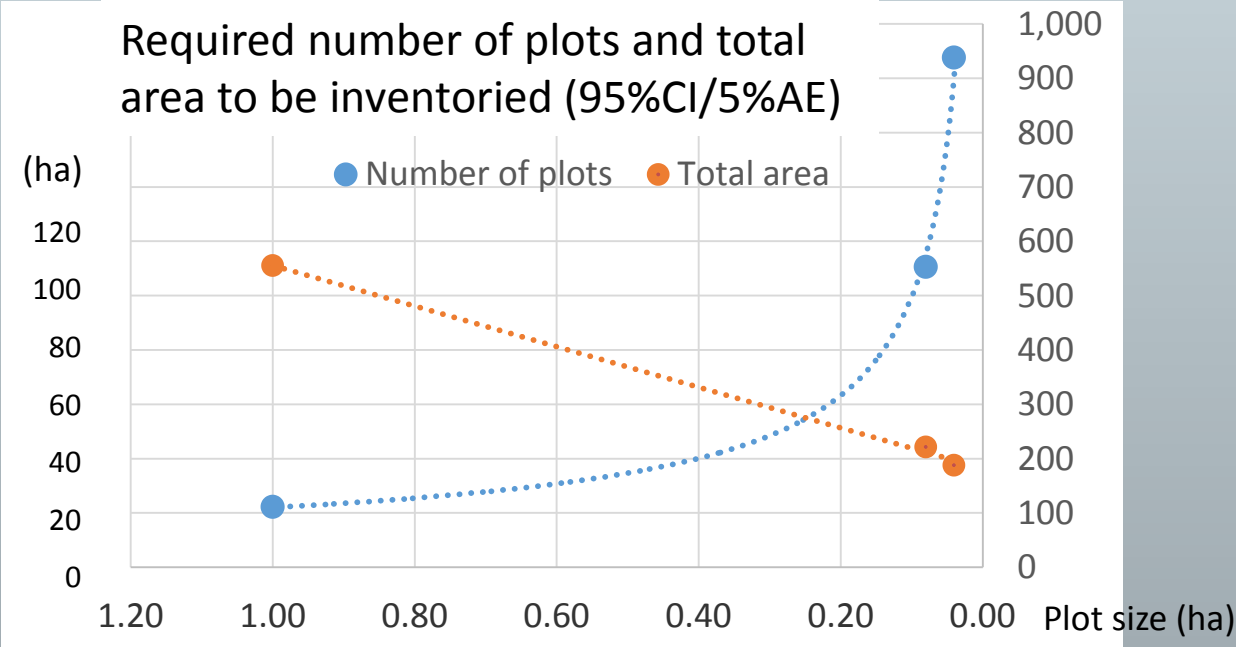
Number of plots for analysis in different plot size

| | | 100x100 m | 40x100 m | 20x100 m | 40x40 m | 20x40 m | 20x20 m |
|----------------|---------|-----------|----------|----------|---------|---------|---------|
| | | 1 ha | 0.4 ha | 0.2 ha | 0.16 ha | 0.08 ha | 0.04 ha |
| Lowland forest | Logged | 119 | 238 | 595 | 476 | 1,428 | 2,975 |
| | Primary | 8 | 16 | 40 | 32 | 96 | 200 |
| Montane forest | Logged | 6 | 12 | 30 | 24 | 72 | 150 |
| | Primary | 2 | 4 | 10 | 8 | 24 | 50 |

Required number of plots for logged over lowland forests

| | 100x100 m (1 ha) | | | 20x40 m (0.08 ha) | | | 20x20 m (0.04 ha) | |
|-------------------|------------------|---------|--|-------------------|---------|--|-------------------|---------|
| Number of samples | 72 | | | 538 | | | 1,992 | |
| Allometric model | Brown 1 | Brown 2 | | Brown 1 | Brown 2 | | Brown 1 | Brown 2 |
| Mean biomass(kg) | 178,254 | 191,660 | | 13,828 | 14,840 | | 7,020 | 7,561 |
| SD | 47,049 | 45,239 | | 8,294 | 7,608 | | 5,483 | 5,067 |
| SE | 5,545 | 5,331 | | 358 | 328 | | 123 | 114 |
| CV | 0.26 | 0.24 | | 0.60 | 0.51 | | 0.78 | 0.67 |
| t | 1.994 | 1.994 | | 1.960 | 1.960 | | 1.960 | 1.960 |
| 95%CI 5%E | 111 | 89 | | 553 | 404 | | 938 | 690 |
| 95%CI 10%E | 28 | 22 | | 138 | 101 | | 234 | 173 |
| 95%CI 20%E | 7 | 6 | | 35 | 25 | | 59 | 43 |

Brown 1: $y = \exp(-2.134 + 2.530 \times \ln(D))$
Brown 2: $y = 42.69 - 12.800 \times (D) + 1.242 \times (D)^2$
(Brown 1997)

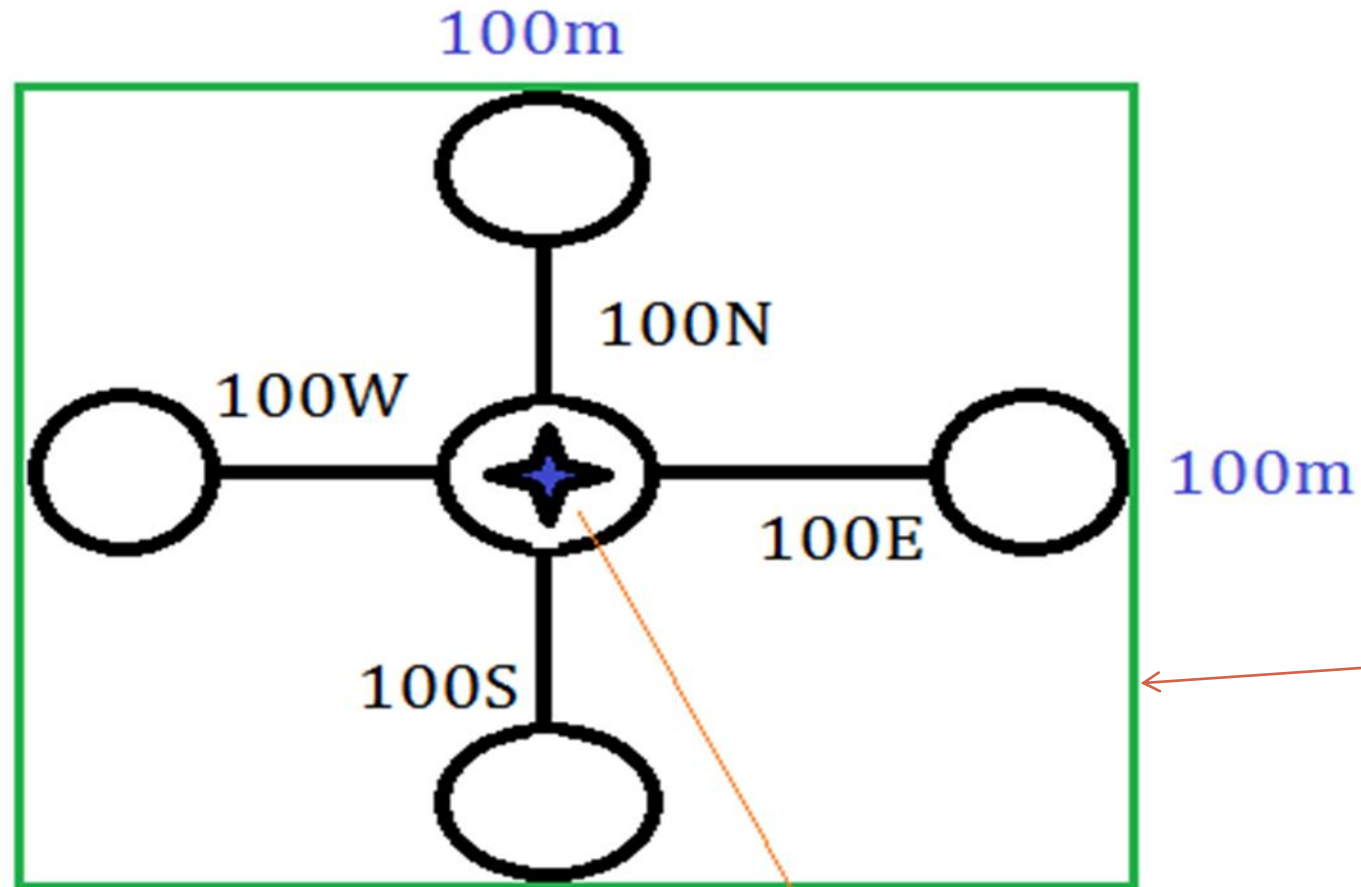


When plot size decreased, required number of plots increased but the total area surveyed decreased.

PLOT DESIGN

4km

Tract or sample point
(4 x 4km)



4km

1 ha plot

Initial Lat/Long. GPS Point
Plot Center

Table 1. Tree stem diameters and nested plot sizes

| Stem Diameter (cm) | Circular Plot Radius (m) |
|---------------------------|-------------------------------------|
| Saplings/Seedlings | 2 |
| 5 - 9.9 | 8 |
| 10 - 29.9 | 12.6 |
| >30 | 17.8 |

Tentative conclusions

- General preference of circular plot were observed at previous workshop.
- Circular plot is not appropriate where larger plot size is required.
- PSP data show that smaller size plot are more cost efficient.
- Five circular plots (0.1 ha) per cluster maybe the way to go.
- 400-500 plots are required if we want 95% CI & 5% precision with 0.1 ha circular plot.

ISSUES FOR DISCUSSIONS

1. The number of stratum to use
2. Sampling & Plot Design
3. Determining the Number of Plots Required to be measured
4. Parameters to be measured