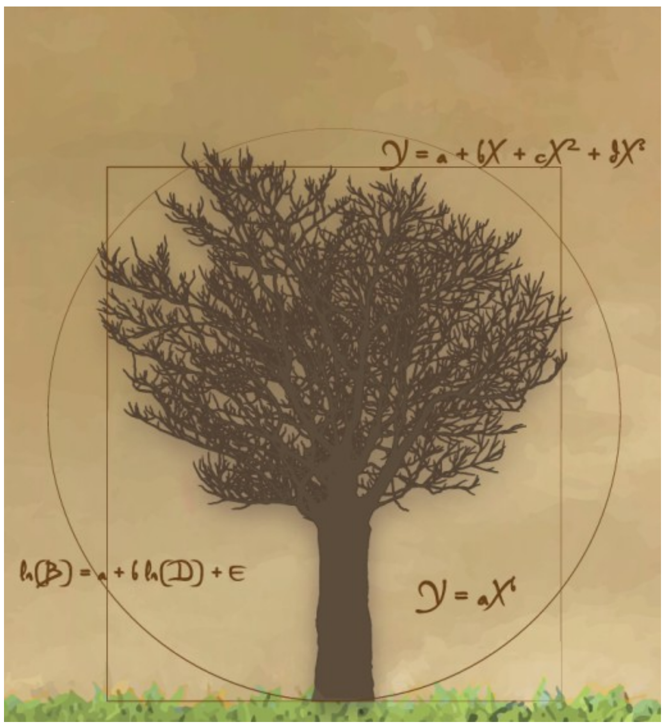
Use and prediction

Laurent Saint-André, Gael Sola, Matieu Henry, Nicolas Picard

Use and prediction



- Dr. Laurent Saint-André, Gael Sola, Dr. Matieu Henry, Dr. Nicolas Picard

Training on tree allometric equations, December 10-14th 2012, Lusaka, Zambia

Using a biomass/volume equation

- Range of calibration
- Confidence intervals for the predictions
  - Linear regression

Confidence interval for the mean

$$\bar{Y}(X) \pm t_{1-\alpha/2}\,\hat{\sigma}\sqrt{\frac{1}{n} + \frac{(X-\bar{X})^2}{\sum_i (X_i-\bar{X})^2}}$$

Confidence interval for an individual prediction

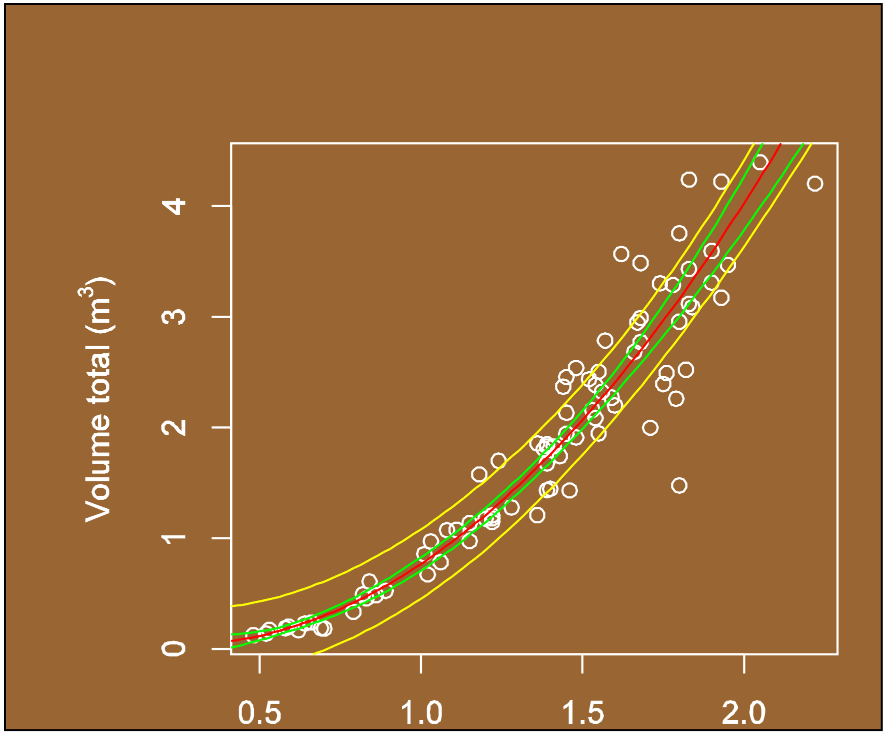
$$\bar{Y}(X) \pm t_{1-\alpha/2}\,\hat{\sigma}\sqrt{\frac{n+1}{n} + \frac{(X-\bar{X})^2}{\sum_i (X_i-\bar{X})^2}}$$

$t_{1-\alpha/2}$ quantile at the level 1-α/2 for the student low at n-2 degrees of freedom

UN-REDD PROGRAMME

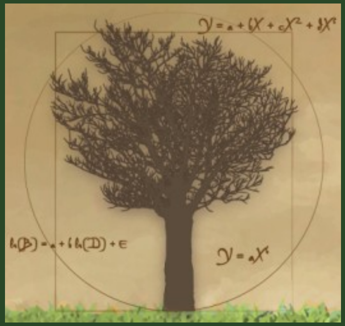
Using a biomass/volume equation

- Example: *Isoberlinia doka*



Red – model
Yellow – confidence interval for an individual tree
Green – confidence interval for the mean

UN-REDD PROGRAMME



Using a biomass/volume equation

- Confidence intervals for the predictions
  - General case for linear and non linear regression, utilization of the delta-method (Serfling, 1980)

Confidence interval for the mean

$$\bar{Y}(X) \pm t_{(1-\alpha/2)} \cdot \sqrt{S_{\bar{y}}^2}$$

Confidence interval for an individual prediction

$$\bar{Y}(X) \pm t_{(1-\alpha/2)} \cdot \sqrt{S_{\bar{y}}^2 + \hat{\sigma}^2 . \hat{\sigma}_{c,c} . X^{\hat{z}}}$$

with : $S_{\bar{y}}^2 = \left(\frac{\partial Y}{\partial \beta}\right)' . \hat{\Sigma}_{\beta} . \left(\frac{\partial Y}{\partial \beta}\right)$ **The variance for** $\bar{Y}$

$\left(\frac{\partial Y}{\partial \beta}\right)$ **The matrix of the derivative of Y toward the model parameters**

$\left(\frac{\partial Y}{\partial \beta}\right)'$ **The transposed matrix of** $\left(\frac{\partial Y}{\partial \beta}\right)$

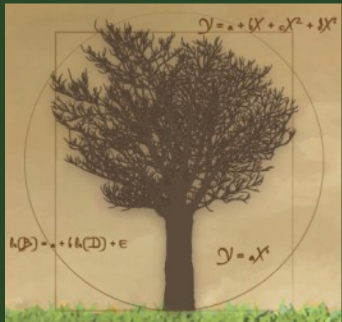
$\hat{\Sigma}_{\beta}$ **The covariance matrix of the parameters**

$\hat{\sigma}^2$ **The variance of errors of the given compartment**

$\hat{\sigma}_{c,c}$ **The variance of errors of the given compartment regarding the whole system of equation**

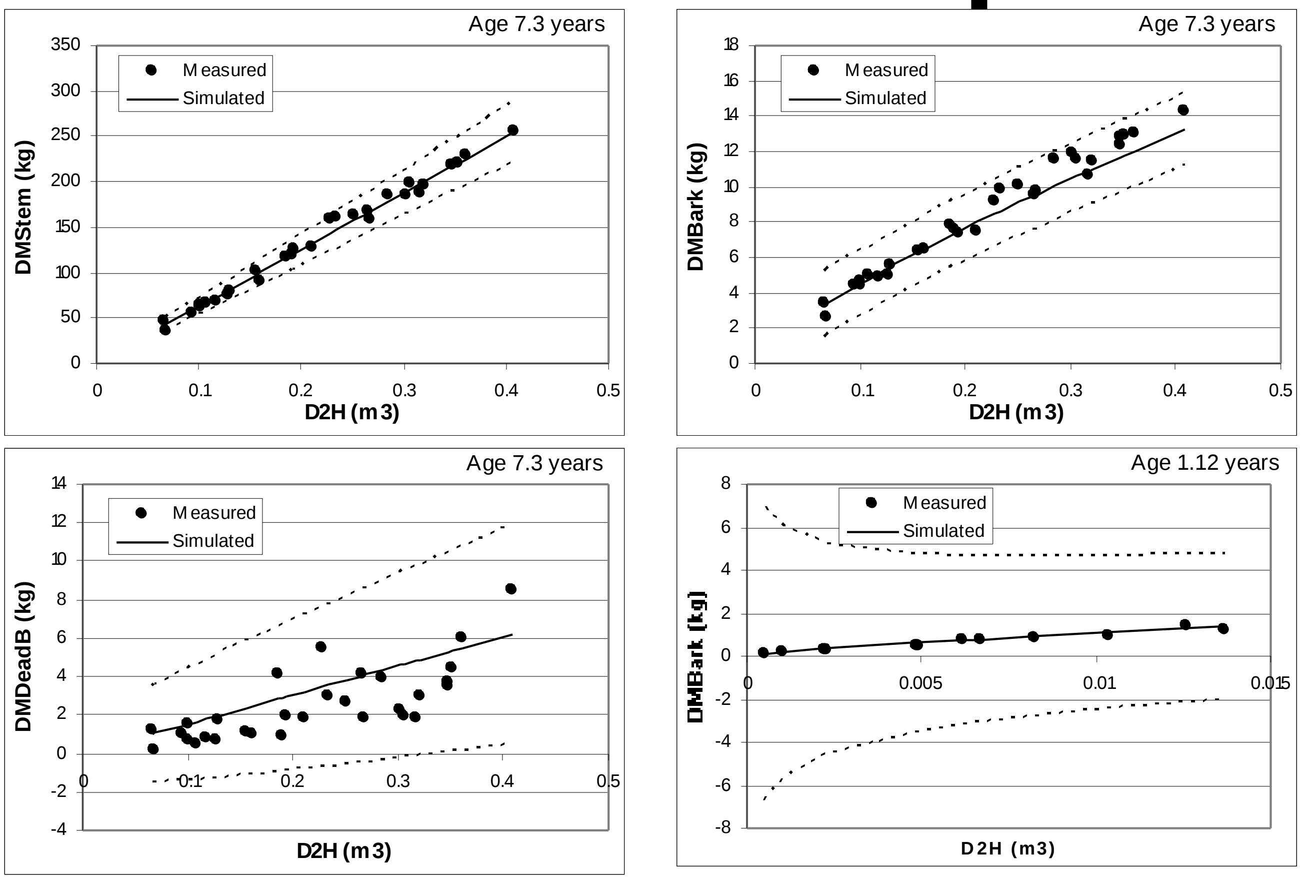
$X^{\hat{z}}$ **The weighting function**

UN-REDD PROGRAMME

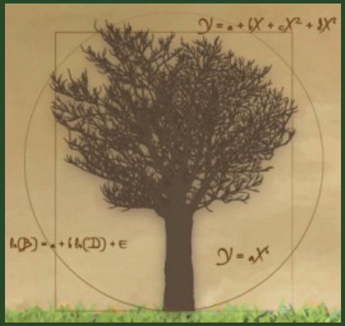


Using a biomass/volume equation

- Example : Eucalyptus in Congo (Saint-André et al 2005)



UN-REDD PROGRAMME



Using a biomass/volume equation

- From the tree to the stand, Monte-Carlo simulations

$$\varepsilon = N(0, \gamma_1 (d^2 h)^{\gamma_2})$$

Model for variance

$$Y = f(\beta, X) + \varepsilon(\gamma, X)$$

Model for mean

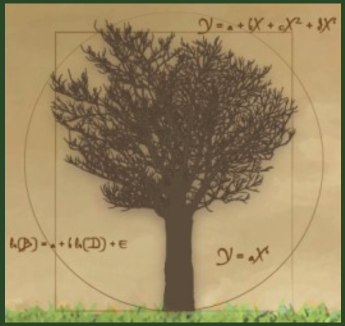
$$\mu = \beta_1 + (\beta_2 - \beta_3 age + \beta_4 e^{-\beta_5 age}) d^2 h$$

Y = f(input data, parameters, error term)

Diameter (d) and height (h). Both contained errors. We assumed that
σ=0.3 cm for diameter
σ=3% of height if less than 15 m
σ=1 m if above 15 m

β, γ : estimated by the fitting procedure. We got their mean and their asymptotic standard deviation.
They are correlated (within a given compartment and between compartments)

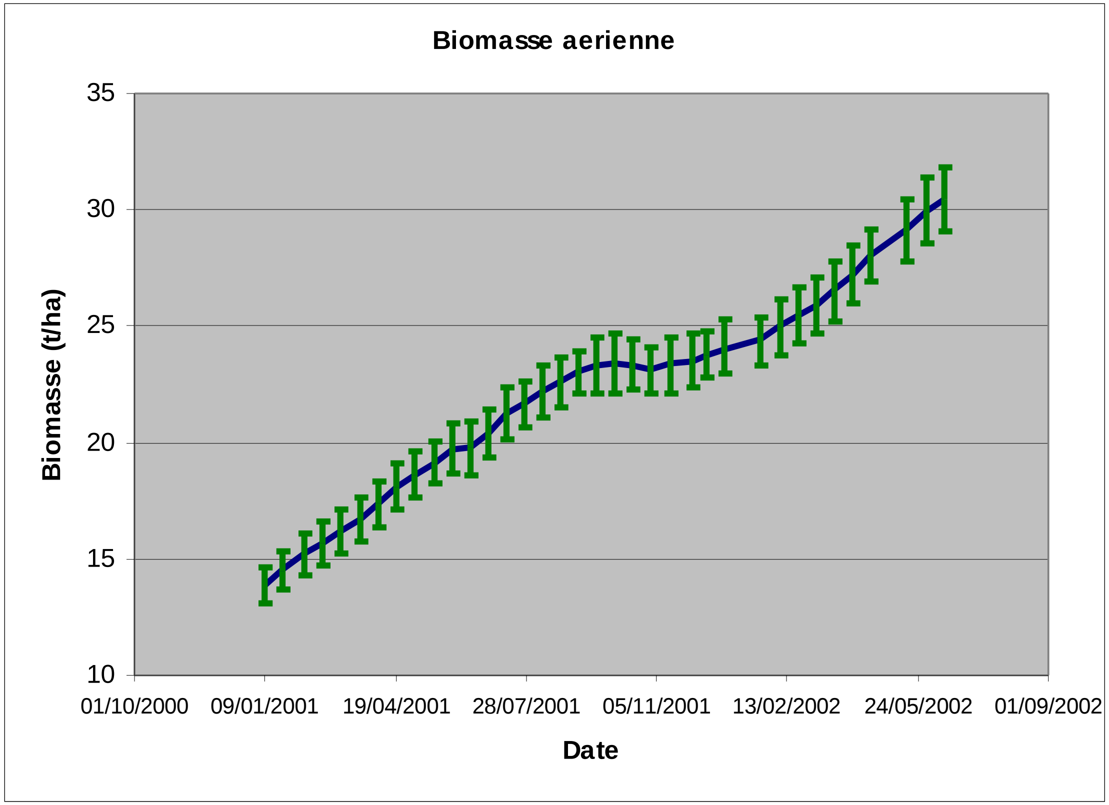
UN-REDD
PROGRAMME



Using a biomass/volume equation

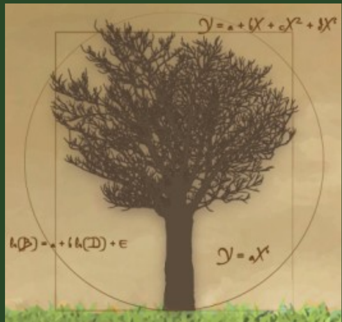
- From the tree to the stand, Monte-Carlo simulations

Only the error term vary



$Y = a + b.X + N(0,\sigma)$

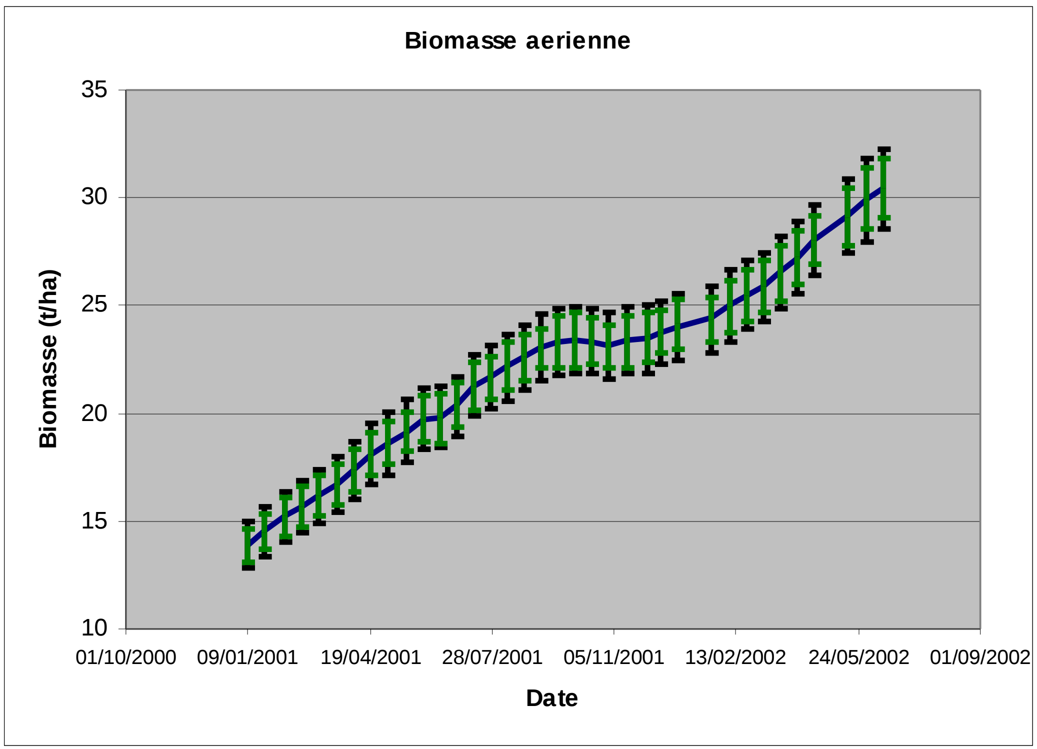
UN-REDD PROGRAMME



Using a biomass/volume equation

- From the tree to the stand, Monte-Carlo simulations

Error term & parameters of the mean vary

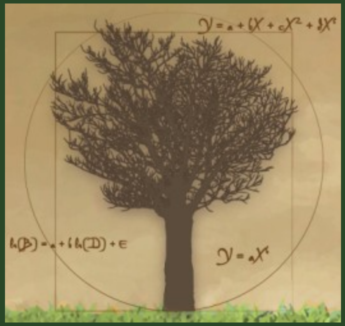


$Y = a + b.X + N(0,\sigma)$

$a \rightarrow N(\alpha, \sigma\alpha)$

$b \rightarrow N(\beta, \sigma\beta)$

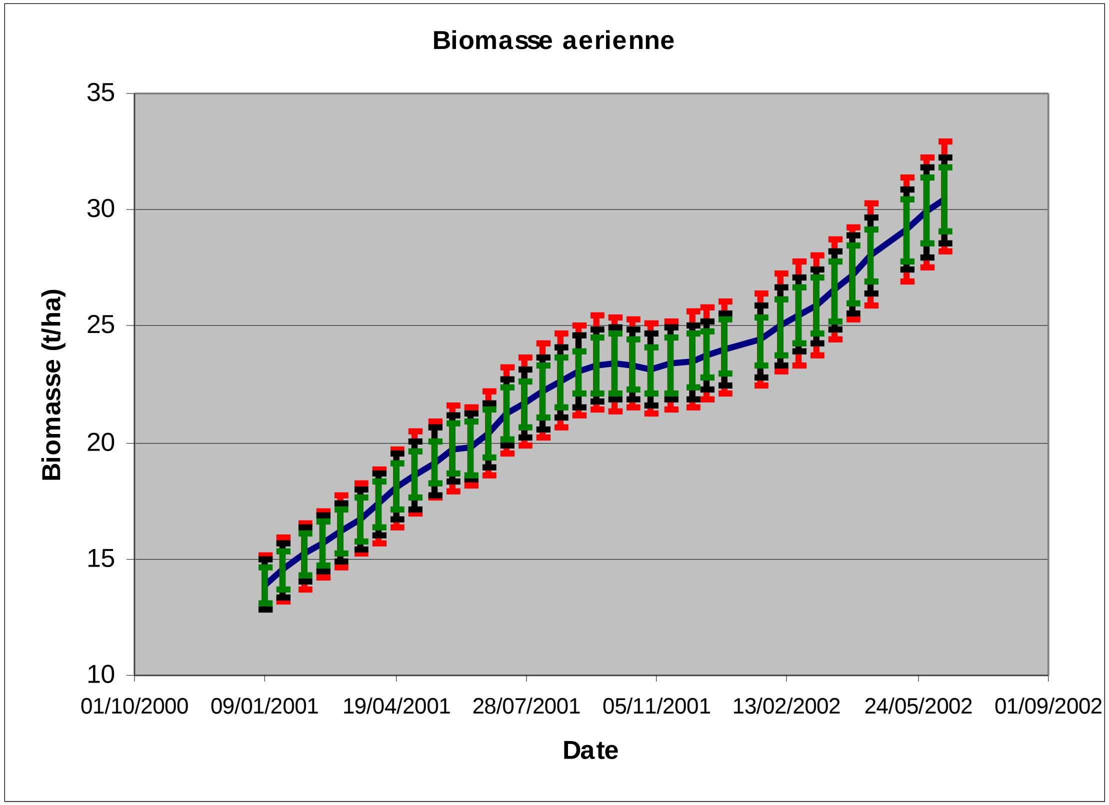
UN-REDD PROGRAMME



Using a biomass/volume equation

- From the tree to the stand, Monte-Carlo simulations

Error term, parameters of the mean, and input data vary



$$Y = a + b.X + N(0,\sigma)$$

$N(\alpha, \sigma\alpha)$

$N(\beta, \sigma\beta)$

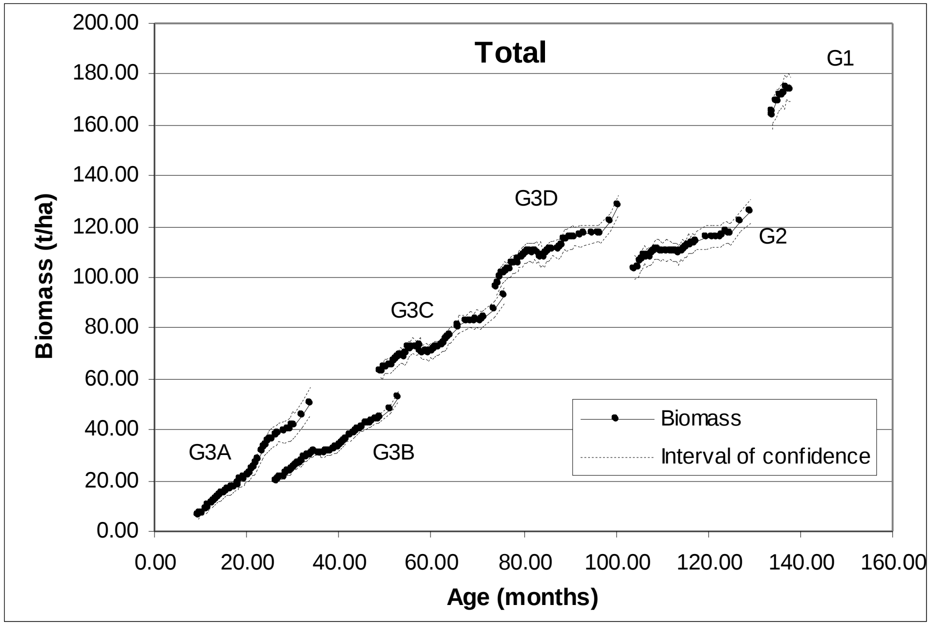
$N(\Xi, \sigma\xi)$

UN-REDD PROGRAMME

Using a biomass/volume equation

- From the tree to the stand, Monte-Carlo simulations

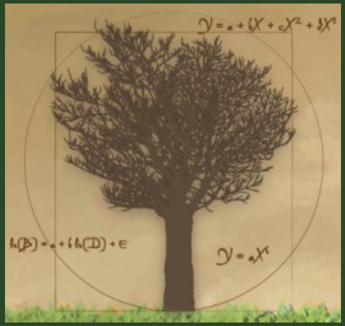
For most compartments, standard errors were small with regard to standing biomass (below 10%)



At 100 months :

Total biomass = 128 ± 1.9 t/ha
Above-Ground = 104 ± 1.8 t/ha
Below-ground = 24 ± 1 t/ha

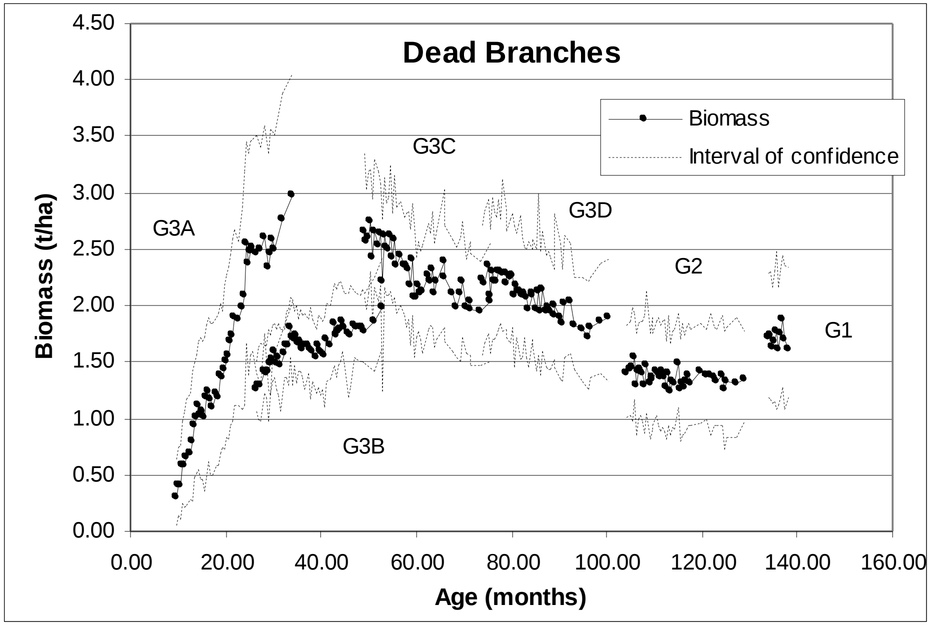
UN-REDD PROGRAMME



Using a biomass/volume equation

- From the tree to the stand, Monte-Carlo simulations

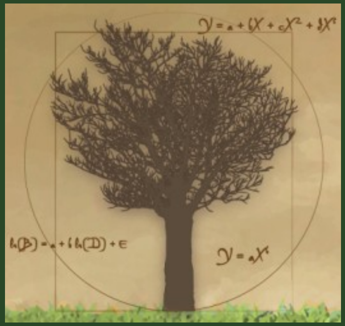
Except for the dead branches biomass (worst model)



At 100 months :

Dead B = 1.9 ± 0.3 t/ha

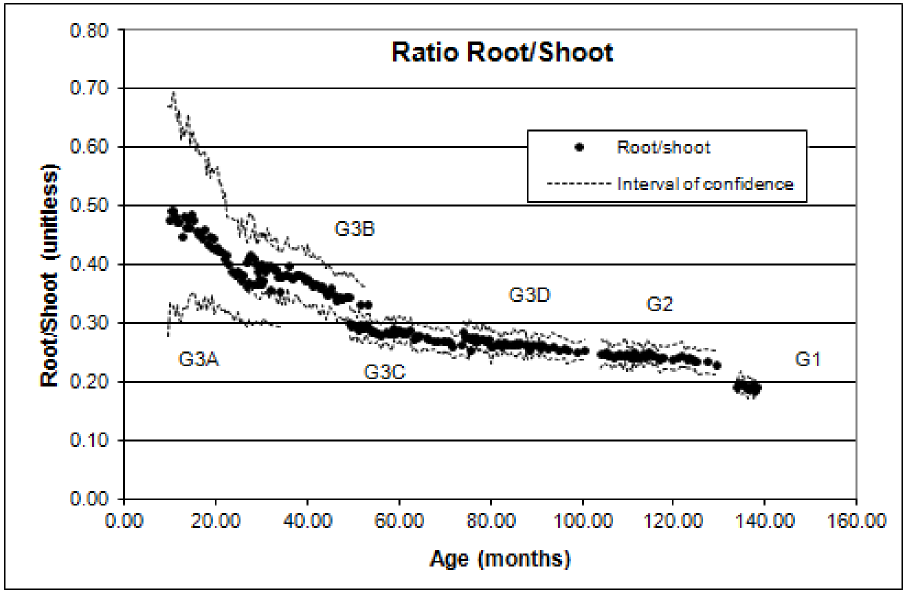
UN-REDD PROGRAMME

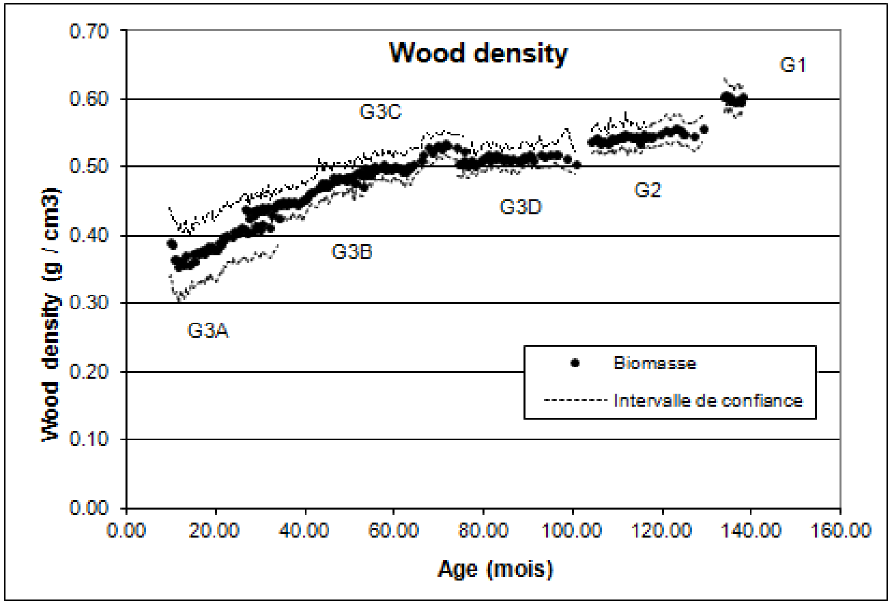


Using a biomass/volume equation

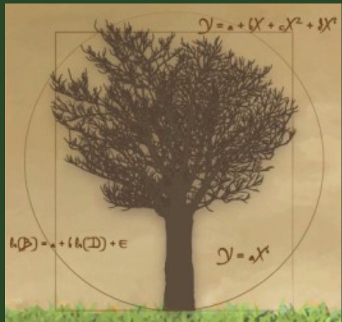
- From the tree to the stand, Monte-Carlo simulations

Same principles of simulations can be applied also to ratios (root-shoot, wood density, etc.)





UN-REDD PROGRAMME



Using a biomass/volume equation

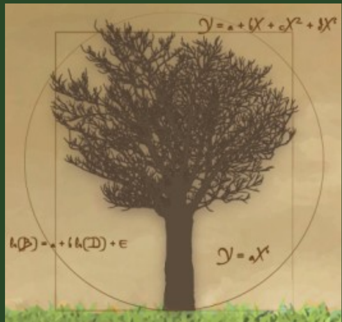
- From the tree to the stand, Monte-Carlo simulations

Biomass increments

Plot	Age (months)	Year	Start date	End date	Total biomass increment (t/ha)
G3A	9 to 22	2001	23/03/2001	23/03/2002	19.5 □ 1.6
G3A	22 to 34	2002	23/03/2002	02/04/2003	25.6 □ 3.3
G3B	26 to 38	2001	08/01/2001	27/12/2001	12.0 □ 0.9
G3B	38 to 49	2002	27/12/2001	28/11/2002	12.9 □ 1.0
G3C	49 to 61	2001	12/01/2001	11/01/2002	9.6 □ 1.9
G3C	61 to 74	2002	11/01/2002	31/01/2003	15.3 □ 2.4
G3D	74 to 86	2001	13/01/2001	11/01/2002	14.7 □ 2.9
G3D	86 to 99	2002	11/01/2002	31/01/2003	10.9 □ 2.8

Standard errors where relatively large (from 7 to 25 % of the biomass increment)

For the eddy-correlation site, Δ biomass2002 = 12.9 □ 1.0 t/ha/year

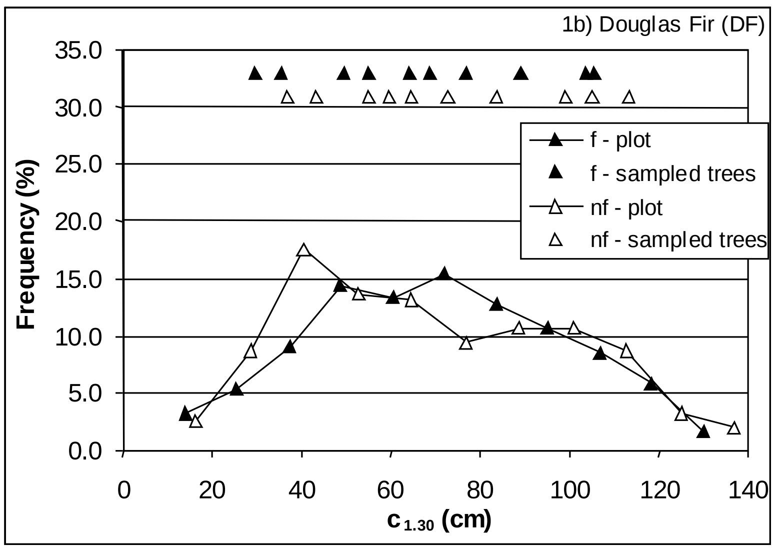


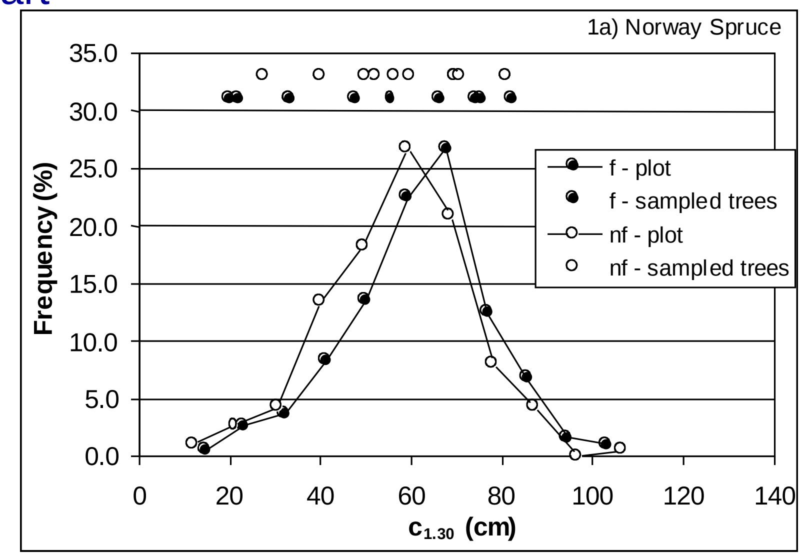
Using a biomass/volume equation

- Behind the single estimation of biomass, the understanding of the ecosystem functioning

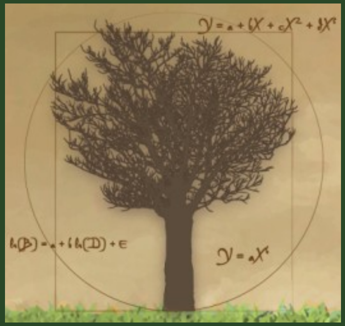
Example Sicard et al. 2005 (accepted in Trees, Structure and Function).
Fertilization effect on Spruce and Douglas fir

Step 1 : analysis of the bar chart





UN-REDD PROGRAMME

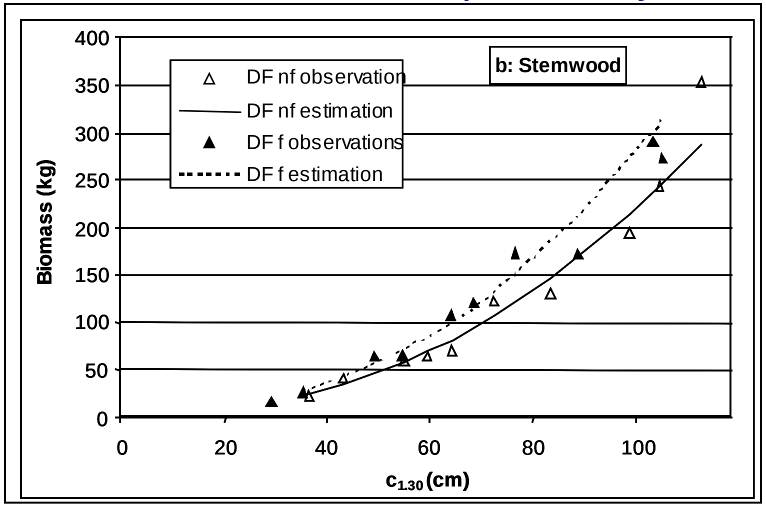


Using a biomass/volume equation

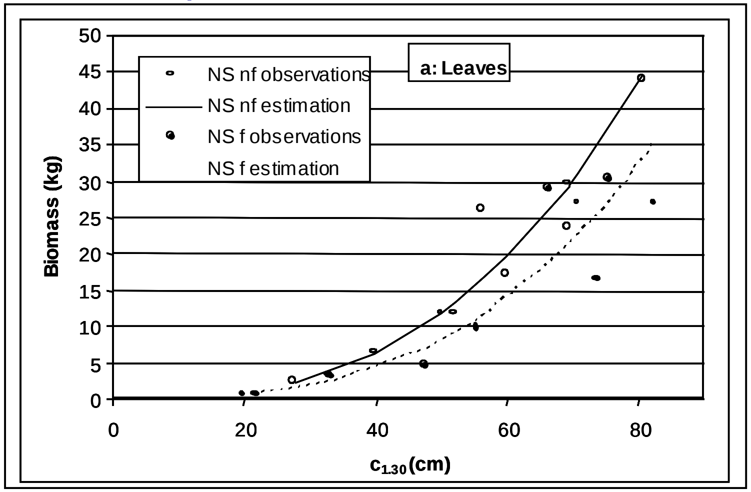
- Behind the single estimation of biomass, the understanding of the ecosystem functioning

Example Sicard et al. 2005 (accepted in Trees, Structure and Function). Fertilization effect on Spruce and Douglas fir

Step 2 : analysis of the biomass equations

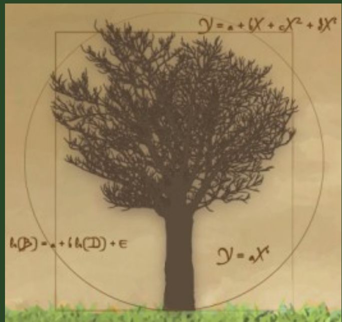


Douglas differences are only significant for the TRUNK



Spruces differences are only significant for the LEAVES

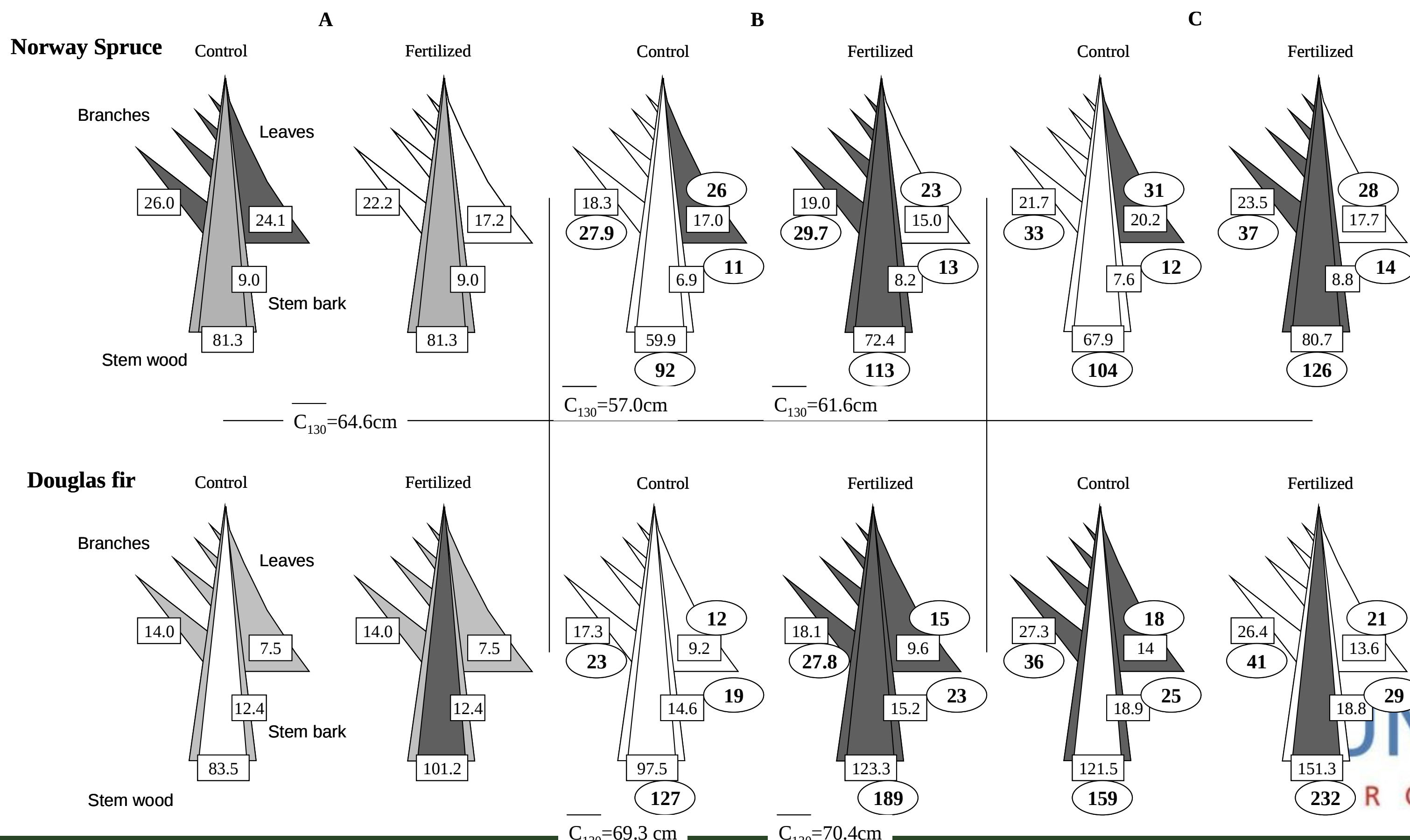
UN-REDD
PROGRAMME



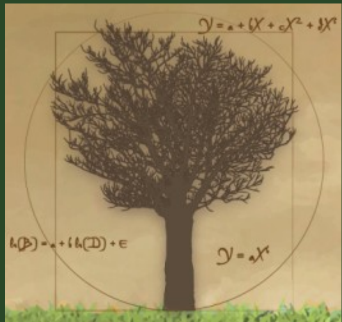
Using a biomass/volume equation

- Behind the single estimation of biomass, the understanding of the ecosystem functioning

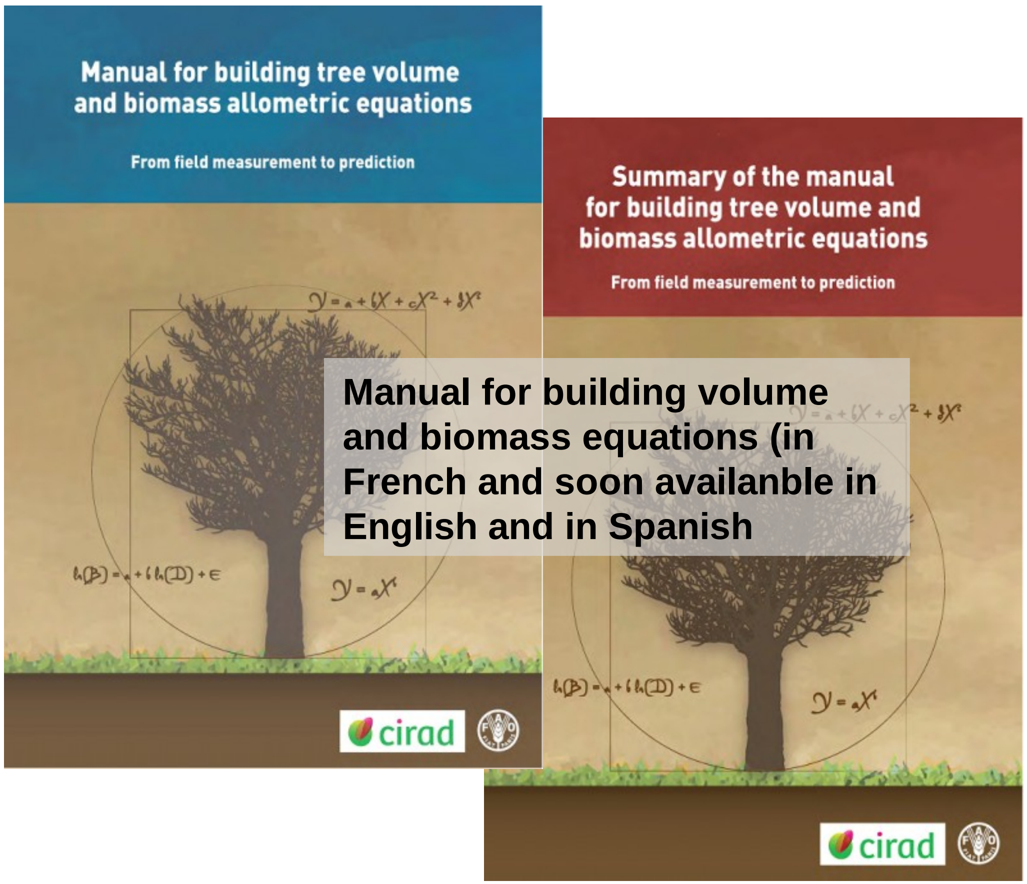
Step 3 : decomposition of the fertilization effect on a per hectare basis



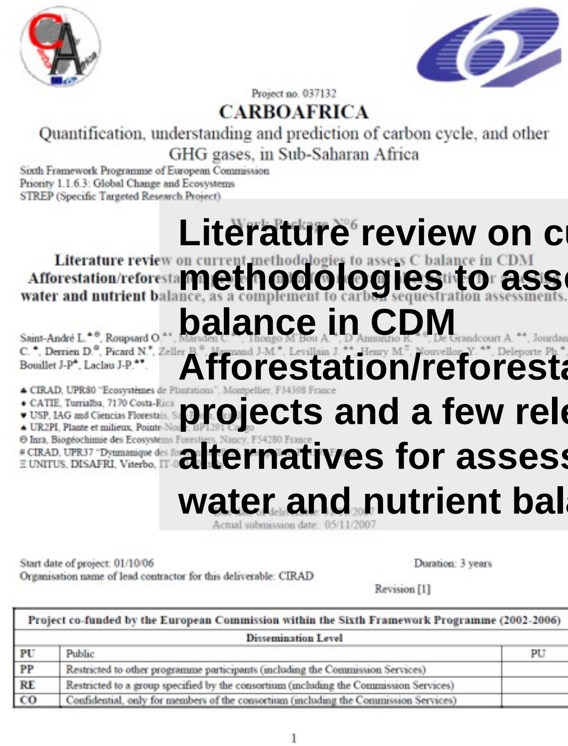
UN-REDD PROGRAMME



Additional Resources

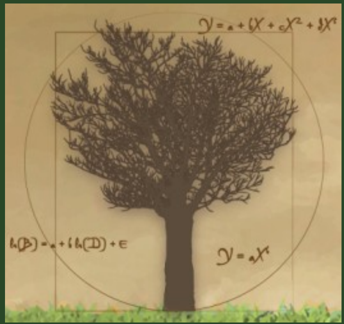


Manual for building volume and biomass equations (in French and soon availanble in English and in Spanish



Literature review on current methodologies to assess C balance in CDM Afforestation/reforestation projects and a few relevant alternatives for assessing water and nutrient balance

UN-REDD PROGRAMME

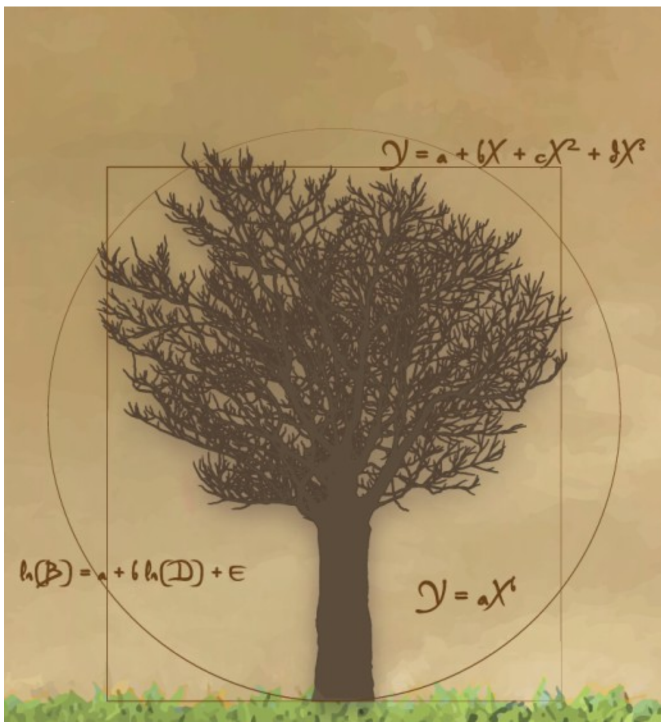


Many thanks to….

Dr. Stephen Adu-Bredu, Angela Amo-Bediako, Dr. Winston Asante, Dr. Aurélien Besnard, Fabrice Bonne, Noëlle Bouxiero, Emmanuel Cornu, Dr. Christine Deleuze, Serge Didier, Justice Eshun, Charline Freyburger, Dominique Gelhaye, Dr. Astrid Genet, Dickson Gilmour, Hugues Yvan Gomat, Dr. Christophe Jourdan, Dr. Jean-Paul Laclau, Dr. Arnaud Legout, Lawrence et Susy Lewis, Dr. Fleur Longuetaud, Dr. Raphaël Manlay, Jean-Claude Mazoumbou, Adeline Motz, Dr. Alfred Ngomanda, Dr. Yann Nouvellon, Dr. Claude Nys, Charles Owusu-Ansah, Thierry Paul, Régis Peltier, Dr. Jacques Ranger, Michaël Rivoire, Dr. Olivier Roupsard, Dr. Armel Thongo M'bou and Prof. Riccardo Valentini

UN-REDD
PROGRAMME

Use and prediction



- Thank you for your attention,

- Any question ?