Manual for tree allometric equations
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Expert meeting on tree volume, biomass allometric equations

• Manual for tree allometric equations

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May 21-23, 2013
Turrialba, Costa Rica
From the idea….(in 2005)

- Students are not familiar with the appropriate and up-to-date fitting techniques
- the “magic” R2 is usually preferred to the biological meaning of the equations
- Models are fitted without considering the structure in the data set (source of variations)
- Outliers are too easily removed from the data set while they can bring information on the structure of the dataset

And so on ….

There was then a strong need to make a new review on the methods to build tree allometric equations

Including biological concepts, up-to-date statistical procedures and training examples
......To the result (2012)


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Available in French, English and Spanish

G. Validation of the model and prediction of trees volume or biomass

A. Selection of trees biomass explanatory variables and the area of validity of the equation

B. Design of the sampling and selection of the trees to be measured

C. Preparation and implementation of field and laboratory measurements

E. Graphic exploration of the dataset

F. Fitting of the allometric equation

D. Data entering and shaping
1 Tree growth, biomass partitioning and biomass allocation - Biological concepts

Tree and stand growth: case of even-aged and monospecific forests

A- Stand production

- Eichhorn’s rule
  - Wood production (volume) of a given tree species at a given stand mean (or top) height should be identical for all site classes.
  - Soil fertility (site index) determines the time need to attain this height and volume.

- Assmann’s yield level theory
  - There are some range of variations of wood production at a given top height (variations related to the stockability issue)

- Langsaeter Hypothesis
  - Losses in productivity if the standing stock is too low
2 Sampling strategy and stratification

Sampling strategy

Some theoretical considerations, case study relating tree volume to $D^2H$

Taking $E=5\%$, a tree volume of $2\text{m}^3$, $\mu=5\text{m}^3$ and $\tau=1\text{m}^3$ .... $n=98$ trees

Is there a way to lower this number of trees, ie, to optimize the sampling?

Minimize this value (but difficult to do in practice on the field)

Maximize this value = sampling the extreme trees....

And $n=10$ trees
3 Field work

Step 2

- Above-ground biomasses

Sampling of cross-sections regularly along the trunk. The width of the cross-sections should be fixed for all heights within the trees. For multi-stem trees, take cross-sections in all stems.

Stump:
- Top limit = above-ground point where the tree was cut
- Down limit = where the roots could be clearly individualized

Example, Rubber tree in Thailand

Mixing leaves before taking a sample
4 Data recording and checking

How data resulting from inventory and monitoring efforts will be acquired, managed, processed, checked, analyzed, distributed, and archived.

Objective:
To transfer field data into ONE electronic database

Different types of software:
- Microsoft Office
- Access
- MySQL

http://science.nature.nps.gov/im/datamgmt/index.cfm
5 Data analysis and graphical exploration of the structure in the data sets

Different relations between two variables X and Y

(a) Linear relation and constant variance of the residue,
(b) Non linear relation and constant variance
(c) Linear relation and non constant variance of the residue
(d) Non linear relations and non-constant variance of the residue
6 Model fitting

Goodness of fit

- How to assess the goodness of fit (for linear and non-linear models)

Example errors with heteroscedasticity
7 Model use and biomass prediction

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)

\[
\bar{Y}(X) \pm t_{(1-\alpha/2)} \cdot \sqrt{\delta^2 + \hat{\sigma}_e^2 \cdot X^2}
\]

\[
\bar{Y}(X) \pm \frac{t_{(1-\alpha/2)}}{\sqrt{n}} \cdot \sqrt{\hat{\sigma}_x^2}
\]

Confidence interval for the mean

Confidence interval for an individual prediction

with:

- \( \delta^2 = \left( \frac{\partial Y}{\partial \beta} \right)^T \hat{\Sigma}_\beta \left( \frac{\partial Y}{\partial \beta} \right) \) The variance for \( \bar{Y} \)

- \( \frac{\partial Y}{\partial \beta} \) The matrix of the derivative of \( Y \) toward the model parameters

- \( \hat{\Sigma}_\beta \) The covariance matrix of the parameters

- \( \hat{\sigma}_x^2 \) The variance of errors of the given compartment

- \( \hat{\sigma}_e^2 \) The variance of errors of the given compartment regarding the whole system of equation

- \( X^2 \) The weighting function
Training courses

- Third set in Ecuador (Ecuador, Panama, Paraguay) after Vietnam (Vietnam and Indonesia) and Zambia (Zambia and Tanzania)

- 84 persons from more than 20 institutions
Objectives

- to present the current and up-to-date knowledge for building allometric equations including courses on the related theory, field operations, fitting and use of the allometric equations,

- to propose technical exercises aiming at identifying gaps (knowledge, allometric equations and raw data) to report carbon stocks and carbon stock changes at the country level,

- to propose practical works on raw data to get familiar with the statistical software and to build allometric equations from their own data sets,

- to help participants in elaborating their road map at national level (general scheme illustrating the required information and data fluxes from the forest stratification to the carbon stock assessments, identification of the existing raw data and allometric equations, bringing to light the gaps, quality control procedures, elaboration of a preliminary road map),

- to elaborate a translational network of experts on allometric equations.
G. Validation of the model and prediction of trees volume or biomass

A. Selection of trees biomass explanatory variables and the area of validity of the equation

B. Design of the sampling and selection of the trees to be measured

C. Preparation and implementation of field and laboratory measurements

E. Graphic exploration of the dataset

F. Fitting of the allometric equation

Complexity of tree growth and biomass allocation

Sampling strategy and stratification

Field work: example from case studies

Data entering, data management and QC

Graphical analysis and first data interpretation

Practical cases and issues related to model fitting

Use and prediction

Identification of the data to be used for the exercise
Planning

**DAY 1: Overview of the current status of the development of allometric equations in the countries**

<table>
<thead>
<tr>
<th>Presentation</th>
<th>Resource persons/facilitator</th>
<th>Presentations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation of the content of the training</td>
<td>Matieu</td>
<td><a href="https://dl.dropbox.com/u/6896677/Content%20of%20the%20training-web.pdf">https://dl.dropbox.com/u/6896677/Content%20of%20the%20training-web.pdf</a></td>
</tr>
<tr>
<td>Forest types and ecological stratification of Vietnam (Including presentation on the structure of the forest based on data from previous NFI cycles) and AE development plan under UN-REDD Vietnam</td>
<td>Vietnam Study Team (including 20 min presentation by Phuong, RCFEE)</td>
<td><a href="https://dl.dropbox.com/u/6896677/2012_VTP_Forests%20and%20AE%20development.pdf">https://dl.dropbox.com/u/6896677/2012_VTP_Forests%20and%20AE%20development.pdf</a></td>
</tr>
<tr>
<td>Current status of knowledge on volume and biomass assessment (including description of the database, methodology used, sources, quality of the raw data, wood density, etc.)</td>
<td>Vietnam Study Team (including 20 min presentation by Hung, FIFI)</td>
<td><a href="https://dl.dropbox.com/u/6896677/Current%20status%20of%20knowledge%20on%20volume%20and%20biomass.pdf">https://dl.dropbox.com/u/6896677/Current%20status%20of%20knowledge%20on%20volume%20and%20biomass.pdf</a></td>
</tr>
<tr>
<td>Experiences from destructive measurement field work and identified gaps overall</td>
<td>Vietnam (including 10 min *3 presentation from VFU, TNU, NW-Sub-FIFI)</td>
<td><a href="https://dl.dropbox.com/u/6896677/Experiences%20from%20destructive%20measurement%20fieldwork%20in%20Indonesia.PDF">https://dl.dropbox.com/u/6896677/Experiences%20from%20destructive%20measurement%20fieldwork%20in%20Indonesia.PDF</a></td>
</tr>
<tr>
<td>Forest types and ecological stratification of Indonesia (Including presentation on the structure of the forest based on data from previous NFI cycles)</td>
<td>Indonesia</td>
<td><a href="https://dl.dropbox.com/u/6896677/presentation%20in%20Vietnam-revised.pdf">https://dl.dropbox.com/u/6896677/presentation%20in%20Vietnam-revised.pdf</a></td>
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</tr>
</tbody>
</table>

**1. What are the steps and procedures for estimating national forest carbon stocks?**

**2. What are the gaps in steps and procedures in your countries for forest carbon stocks?**

**3. What are procedures for quality control and verification of AE?**

DAY 2: Development of allometric equations “state of the art”

Building tree allometric equation to assess volume and biomass: from the field to the prediction

- Complexity of tree growth and biomass allocation
  - Laurent

- Sampling strategy and stratification
  - Laurent

1. Which are the forest stratum without AE in your country?
2. Do those forest strata contribute significantly to emissions?
3. What is the max and min tree diameter sampled? How many tree sample per diameter class?

- Field work: example from case studies
  - Laurent / Matieu
  - https://dl.dropbox.com/u/6896677/Field%20work%20example%20from%20case%20studies.pdf

- Data entering, data management and QC
  - Matieu

- Graphical analysis and first data interpretation
  - Matieu

- Practical cases and issues related to model fitting
  - Laurent

- Use and prediction
  - Laurent

Discussions

- VN Table 1:
  - https://dl.dropbox.com/u/6896677/Presentation_Table_1_Day2.pdf

- VN Table 2:

- VN TNU:

- Indon 1:
Planning

**DAY 3: Exercises on development of allometric models**

- Installation of the statistical software
- Graphic exploration (different set of data)
- Model fitting with and without heteroscedasticity by tree compartment
- Model fitting for total aboveground biomass (with or without additivity)
- Biomass assessment using existing data and models (development of decisional trees)

1. Which are the different equation forms (the main commons)?
2. Which are the inputs in your equations?
3. Which are the statistical information you collected to describe those equations?

- Exercise using sample data
- SAS software installed per group (for the training only)

(exercise done on database)

Indonesia 1:
https://dl.dropbox.com/u/6896677/Answers%20Group%201-Model%20fitting.docx

VN 1:
https://dl.dropbox.com/u/6896677/PP_Huong.pptx
DAY 4: Interim models development (cont’d)

Graphic exploration (different set of data)
Model fitting with and without heteroscedasticity by tree compartment
Model fitting for total aboveground biomass (with or without additivity)
Biomass assessment using existing data and models (development of decisional trees)

By group
Exercise using national data
FSIV:
https://dl.dropbox.com/u/6896677/FSIV%27s%20group.pptx
TNU:
https://dl.dropbox.com/u/6896677/PP%2021.6%20-%20TNU.pptx

DAY 5: Interim models development (cont’d)

Proposed roadmap for improved national biomass assessment

Laurent and Matieu

Questions:
https://dl.dropbox.com/u/6896677/debate4.ppt
VN1:
https://dl.dropbox.com/u/6896677/PP%2022.6%20-%20TNU.pptx

VN2:
https://dl.dropbox.com/u/6896677/final%20day.pptx

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