In this presentation we are going to talk about monitoring, measuring and the quantification of carbon stocks in tropical peatland forests.
• By way of introduction, we will see why we care about peatlands, the importance of forest carbon, and the threats of tropical peatlands.
• This topic will extensively discuss how carbon in all compartments of the ecosystems will be assessed.
• With all that in mind we are also reminded what we need to do for long-term monitoring.
Why do we care about peatlands and peat swamp forests?

• Peatlands of the world cover only about 3% of the earth's land area but contain about 30% plant soil carbon.

• Ecosystem carbon stocks of tropical peatlands are among the largest of all carbon stocks of any ecosystem on earth. Many of the sites have over 2000 tonnes of carbon per hectare.

• Finally when these tropical peat swamp forests are disturbed, the emissions of greenhouse gases are exceptionally high.

• Peatlands are unique ecosystems that provide numerous services for human beings.
One very important ecosystem service is their function as global carbon sinks.

- You can see from this figure that the carbon stocks in tropical peat forests exceed that of almost any other terrestrial ecosystem on earth.
- This is far higher than the carbon stocks you would find in upland forests on mineral soils.
The dominant threats to tropical peat swamp forests include
- deforestation, followed by
- drainage, and fire

These are largely related to land-use/land-cover change such as conversion to oil palm plantations.
In order to assess the carbon stocks in various pools you need a scheme:

- Break it down into meaningful compartments such as that suggested by the IPCC guidelines
- Partitioning forest ecosystems into the carbon pools listed here may be used.
Here is our general plot layout modified from the protocol available mangrove ecosystems.

- It has been successfully used to assess ecosystem carbon stocks of tropical peatland forests in Indonesia and Micronesia.

- Six plots in every peat forest stand are established along a 250 meter transect. An estimate of total ecosystem carbon stocks is derived in each of the six plots.
  - Trees are measured in a 10 meter radius circular plot.
  - Downed wood is measured in four transects in each of the six plots.
  - Litter on the forest floor in 2 micro-plots in each of the six plots.
  - And finally soils were sampled in the center of each of the six plots (for measurement of bulk density and carbon concentration).
  - Soil measurements include depth to the peat layer and actual peat sample collections.

- Let’s discuss the procedures for measurement in the field one by one.
Let’s start by talking about how to measure the biomass, structure, and carbon pools of trees in tropical peat swamp forests.
• Six circular plots in each samples stand may be established to measure carbon stocks of live and dead trees.
• All trees that are greater than 5 cm in diameter are measured in the 10 meter radius plot.
• The smaller trees less than 5 cm in diameter are measured in 2 meter radius nested plot.
• Tree diameters are measured at 1.3 meters above the ground.
• This is defined as the diameter at breast height (DBH).
• But when trees have stilt roots or buttresses, we measure diameter at 20 cm above the buttress or stilt roots.
• You can see from the diagrams here where we might measure trees with unusual trunk shapes.
Once data are collected in the field, tree biomass is determined using allometric equations.

- We use Chave et al. (2005) equation for tropical wet forest as shown here
- Tree biomass is multiplied by carbon fraction (0.47) to calculate carbon mass.
- If reliable local regional ecosystem specific equations are available we would recommend that you use them.
- Usually aboveground biomass is determined using its relationship with tree diameter and if you can identify the species, its wood density.
Belowground biomass

Following Cairns et al. (1997):

Root : shoot ratio for tropical forests biomass:
mean ± 0.76; median ± 0.71,
LQ = 0.14, UQ = 0.31

Root biomass density for tropical forest biomass:
\[ RBD = \exp(-1.085 + 0.9256 \ln(AGB)) \]

where AGB is aboveground biomass (Mg/ha).
Multiply belowground biomass by 0.39 to convert to belowground C stock.

Note: since the C fraction of belowground biomass is different from aboveground biomass, the simple root : shoot ratio cannot be applied to estimate belowground C directly.

• Belowground biomass is also estimated using allometric equations.
• There is far less information on the biomass of roots in tropical peatlands than aboveground biomass.
• Nevertheless, it is important to provide the best estimate possible for this carbon pool.
Belowground carbon

Belowground C can be calculated directly using the equation:

\[ BGC = AGC \times 0.216 \]

Where:

- \( BGC \) = belowground C
- \( AGC \) = aboveground C,

0.216 is the ratio of \( BGC \) to \( AGC \)

(Calculated from Cairns et al. (1997)

default root:shoot of 0.26,
default %C AGB=0.47 and default %C
BGB=0.39)
Dead trees – are partitioned by decay class.

- We separate live trees from dead trees in our sampling.
- Dead trees are broken down into three status classes:
  - Status one and two trees are those most recently dead.
  - Status three trees are usually little more than trunks and main stems remaining.
Dead wood is another potentially important carbon pool.

• It certainly is an important ecological feature of most forests.

• As such, it is always important to measure this component.

• We use the nondestructive planar intercept technique.
Dead and downed wood is usually measured using the planar intercept technique.

- Do not measure the first 2 meters of the transect
- All large wood particles (>7.6 cm) are measured along a 12 meter transect.
- Smaller pieces are measured in nested lengths along this transect as described above.
  - (2.5–7.6) are counted along 5 meters of the transect from 9 to 14 meters.
  - < 2.5 cm pieces of wood can be ignored in the planar intercept and alternatively be combined and sampled with the litter fraction.
- In each plot, we measure 4 transects to determine the mass of the downed wood. This totals 24 transects for each plot.
• Here is a simple equation used to determine volume and biomass of downed wood.
• Basically you determine wood volume from the measurements.
• Then you multiply volume by specific gravity of the dead wood to determine biomass.
• Determination of the specific gravity of dead wood will be necessary.
• The forest floor is another important ecological component of tropical wetland forests.

• It consists of fallen leaves, seeds, bark chips and other freshly fallen materials that are immediately above the peat horizons.

• We typically collect the forest floor from 2 micro-plots (50 x 50 cm²) in each of the six large plots to determine litter mass.
• Litter sampling should be done in 2 micro-plots in each of the 6 plots at each sampled site.
• We recommend collecting litter samples at about 7 to 10 meters along two of the wood transects.
• You can see in this photo that herbaceous plants may also be collected in these micro-plots.
Finally, let’s talk about methods to sample soil carbon stocks in tropical wetlands.  
• Samples are collected to determine carbon concentration and soil bulk density in each of the 6 plots  
• Sampling depths are 0 to 15 cm, 15 to 30 cm, 50 to 100 cm, 100 to 300 cm, and every 2 meters beyond 300 cm until you get to the bottom of the peat layers.
• Here is a description of how we sample soils depth with three measurements near the plot center.

• The peat depth is measured using a soil auger to determine the depth to the mineral soils.
• Typically we use a Russian style peat auger or a modified open-face peat auger.
• Here are some photos of our approaches to collecting the soil samples.
• Upon selection in the field soil samples are transported to the laboratory.
• Here we drive them in a drying oven and determine bulk density and their carbon concentration.
• It is best to use an automated carbon analyzer such as an induction furnace.
Having gone through the technical details of measurements there are a number of issues that need to be considered for long-term monitoring:

- Taking GPS coordinates is critical.
- Sometimes it may be important to sample tree heights, although this is very difficult.
- Canopy cover may be of interest. This can be measured using a densitometer or fish eye lens.
- Of course photos at all plots can be very important. This can be used to document long-term vegetation change.
References


References


Thank you

The sustainable wetlands adaptation and mitigation program (SWAMP) is a collaborative effort by USAID, the USDA Forest Service, and the Oregon State University with support from USAID.

How to cite this file

Photo credit
Boone Kaufman/Oregon State University, Daniel Mudiyarsa/CIFOR, Matt Warren/USFS, Neil Palmay/CIFOR.