# Work package 3:

# Ecosystem carbon and nitrogen pools Protocol

## 1. Aims

The aim of WP 3 is i) to quantify ecosystem carbon and nitrogen pool sizes and their major components in differently managed mountain ecosystems and ii) to assess their seasonal and inter-annual variability.

## 2. Deliverables

* Size of ecosystem carbon and nitrogen pools and their major components and their seasonal and inter-annual variability
* Long-term data sets for litter decomposition
* Seasonal variation of hemi-surface plant area indices
* Data sets of stratified plant area index and phytomass and its components

## 3. Tasks

In summary, the tasks of WP3 are:

| No. | Work description |
|---|---|
| 1 | Below-ground carbon and nitrogen pools will be determined separately for soil, roots and inorganic pools by taking soil cores. Soil carbon and nitrogen pools of surface humus will be measured by collecting the humus material within a frame of 30x30 cm. |
| 2 | Above-ground carbon and nitrogen pools will be determined by stratified harvesting as well as by harvesting of above-ground phytomass as a whole. |
| 3 | Plant area index will be measured in a non-destructive way by using optical sensors and appropriate inverse models of radiative transfer. |
| 4 | For assessing in situ rates of litter decomposition the litter-bag method will be used. |

### 3.1 Task 1: Below-ground carbon and nitrogen pools:

The carbon and nitrogen pools of soil will be determined at least once a year (summit of vegetation period). Roots and soil will be measured separetely by taking soil cores. As far as inorganic pools are expected, also organic and inorganic soil pools will be determined separately. The soil cores will be divided into pre-defined layers (0-3 cm, 3-8 cm, 8-13 cm, 13-23 cm, 23-38 cm, 38-53 cm, >53cm). In addition, the soil horizon of each layer will be recorded in order to also assure the sampling of each horizon.
Soil carbon and nitrogen pools of surface humus will be determined by collecting the humus material within a frame of 30x30 cm. Frequency is the same as for above-ground pools.

| Compartiment | site/land-use | Frequency | Replicates | Unit |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Mineral soil | all types | 1 (summit of vegetation period) | 5 | g $m^{-2}$ |
| Roots / below-ground phytomass | all types | 1 (summit of vegetation period) | 5 | g $m^{-2}$ |
| Superficial humus | meadow | see above-ground phytomass: Harvesting of the whole canopy | 6 | g $m^{-2}$ |
| | pasture | see above-ground phytomass: Harvesting of the whole canopy | 6 | g $m^{-2}$ |
| | aband. area | see above-ground phytomass: Harvesting of the whole canopy | 6 | g $m^{-2}$ |

### 3.2 Task 2: Above-ground carbon and nitrogen pools:

Above-ground carbon and nitrogen pools will be determined using two methods: Stratified harvesting and harvesting of the whole canopy.

#### Stratified harvesting

The partner-teams can select between two approaches differing in the level of detail:

**Level I:**
Analysis of canopy structure and carbon and nitrogen pools of each layer is done by stratified harvesting for each site on one representative point of time. The results are used to create a representative illustration of the canopy of each management type. The minimum area to be harvested is 0.5x0.5 m². Layer thickness is adapted to plant area density, thicker canopy areas requiring a higher resolution, ie. smaller layers, and *vice versa*. Generally layer thickness will range between 0.025 and 0.1 m. The following components are to be distinguished within each harvested layer: leaves, stems, reproductive organs, dead plant material and cryptogams. Leaves are further separated into the most dominant species, the remaining leaves are pooled into herbs, grasses and dwarf shrubs. Stems are separated into grasses, herbs and dwarf shrubs, for the later distinction is made between photosynthetically active and inactive ones.

**Level II:**
In order to get more detailed results stratified harvesting is done on more than one point of time. Frequency depends on the management type and follows the approach of harvesting of the whole canopy.

| **Site/land-use** | **Frequency** | **Replicates per harvest** | **Unit** |
|---|---|---|---|
| **Level I** | | | |
| all types | 1 | 1 | g $m^{-2}$ |
| **Level II** | | | |
| all types | see above-ground phytomass: Harvesting of the whole canopy | 1 | g $m^{-2}$ |

**Harvesting of above-ground phytomass**

Above-ground carbon and nitrogen pools will be determined from harvesting at least twice a year, depending on the site. Above-ground phytomass will be collected within a frame of 30x30 cm and separated into living and dead. The living material will be divided into grasses/herbs, legumes, dwarf shrubs and mosses/lichens.

| Site/land-use | Frequency | Replicates per harvest | Unit |
|---|---|---|---|
| meadow | variable (spring, before 1st mowing, after 1st mowing, before 2nd mowing, before 3rd mowing etc.) | 6 | g $m^{-2}$ |
| pasture | variable depending on duration of grazing and livestock units; the development of above-ground phytomass without grazing is analysed by setting up cages | 6 | g $m^{-2}$ |
| aband. area | at least 2 (spring, summit of vegetation period) | 6 | g $m^{-2}$ |

### 3.3 Task 3: Non-destructive determination of plant area index

In addition to stratified harvesting, the vertical distribution of the plant area index is determined bi-weekly in a non-destructive fashion using optical sensors and appropriate inverse models of radiative transfer. The vertical resolution should adhere to the one used for destructive harvesting. Cross-calibration of both methods is achieved by making optical measurements on the same spots prior to harvesting.

### 3.4 Task 4: Litter decomposition

For assessing *in situ* rates of decomposition the litter-bag method will be used. Therefore the litters are placed in net bags at the research sites and retrieved after a suitable period to determine the losses and changes that have taken place.
The litter-bags are made of Estal Mono PE 95HC net cloth, with a mesh size of 0.1 mm. The Bags are c. 15 x 10 cm, containing c. 10 g of dry litter.
Depending on the possible amount of work done by the single partner-teams two approaches are proposed for determining the decomposition rates:

Level I:
For standardisation, plant biomass ("green litter"), representative for the single plots, will be harvested at the summit of the vegetation period and filled, after drying at 80°C to constant weight, in the litter bags. On half of the bags will be put out at a single starting date, for example the first of august. Subsequently 20 of the bags will be retrieved at the same time when above-ground carbon pools are recorded. Additionally a sequential re-sampling is planned, where as one set of bags will be retrieved a new set (of the second half) will be put out to replace it.

Level II:
If it is practicable to collect sufficient quantities of dead material it is recommended to produce additional litter bags each time when harvesting occurs. The bags should be dried and quickly reintegrated to the measuring sites to investigate the decomposition-rate of the "real litter" between two harvesting dates.

Level III:
Complementary the determination of the basic chemical constituents of the litters (N, P, K, Ca, other nutrients, soluble carbohydrates, soluble phenolics, cellulose, lignin) at the start and at some of the retrieval times would be of great interest, to assess the patterns of decomposition of different constituents and the effects of initial composition on overall decay rates.

The litter-bags are placed to mimic the position of natural litter when freshly fallen. This is on the soil surface if there is no widespread litter layer or on the litter surface or on the moss layer in sites with a deep moss layer on the surface. The vegetation has to be removed to fix the bags with wire brackets in good contact with the ground surface.
On retrieval, bags are dried at 80°C to constant weight, weighed, and the mass loss over the sample period calculated.

| **Site/land-use** | **Frequency** | **Replicates per harvest** | **Unit** | |
|---|---|---|---|---|
| meadow | see above-ground phytomass: Harvesting of the whole canopy | 20 | % | g $m^{-2}$ $a^{-1}$ |
| pasture | see above-ground phytomass: Harvesting of the whole canopy | 20 | % | g $m^{-2}$ $a^{-1}$ |
| aband. area | see above-ground phytomass: Harvesting of the whole canopy | 20 | % | g $m^{-2}$ $a^{-1}$ |