Overview

National Inventory of Forests and forest Carbon pools – INFC2005
Second Italian national forest inventory

Short description of methods and measured variables

The following text summarizes the main aspects of the data collection and computations carried out at plot level by the Italian NFI, relevant for a correct understanding of the data of the second Italian NFI (reference year 2005; acronym INFC2005) that can be downloaded from dati.inventarioforestale.org. The text only aims to facilitate a correct understanding of the data and does not intend to be exhaustive and complete about the Italian NFI sampling design and survey protocols. Symbols in brackets are those used in the data archives. More detailed explanations may be found in the references cited through the text, as well as in the documents (feasibility study, protocols, field manuals, etc. – in Italian) available here.

Data origin

The Italian NFI adopted a three-phase sampling design for stratification. Phase 1, carried out by photo-interpretation on approximately 301,000 sample points with an unaligned systematic distribution on a 1 × 1 km grid, allowed for a preliminary estimate of the extent of forest and other wooded land (F and OWL respectively, according to FAO-FRA definition) at a national and regional level and to define the second phase strata. Phase 2 sample was randomly selected by administrative region and its size was proportional to the extent of F and OWL in each region. Phase 2 field survey was carried out at 30,000 sample points across the country (one point for every 349 ha of F and OWL).
Phase 2 survey aimed primarily to check for correct attribution of land use and cover, included refinement of the vegetation type classification and collection of information on many qualitative attributes, with reference to different sample units. For administrative and legal attributes, as also for accessibility and altitude, the sample unit coincided with C, the NFI sample point. For the survey of the descriptive attributes of the vegetation (forest category – FC –, culture type, development stage, mixing degree, etc.), and of the site characteristics with the exception of the altitude, accessibility and health conditions of the vegetation, a circular sample unit of area 2.000 m2 was used instead (Figure 1).

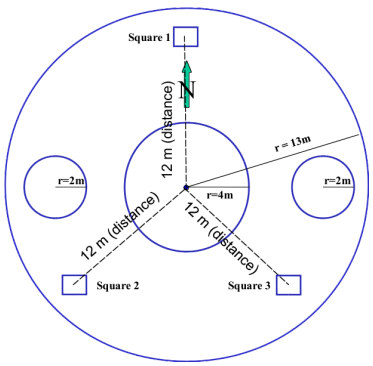

Figure 1. Sample plot configuration

Taking measurements on trees, regeneration, shrubs, stumps and coarse woody debris was the main purpose of Phase 3 survey. During this survey campaign, qualitative observations were also made on the measured variables (e.g. species, vitality, decay class of trees). Phase 3 sample was randomly selected from the Phase 2 sample points so that the number of points in each region (6,865 in total across the country – one point for every 1,276 ha of F) is proportional to the extent of the different forest categories. Phase 3 concerned only the portion of forest area that satisfies the definition of F adopted by the national forest inventory, which includes the three inventory categories of High forest, Timber plantations and Temporarily unstocked areas. The data was collected in circular plots that involved surface portions of various size (figure 1), as to the type of attribute to be surveyed or to some size thresholds. Consequently, variables are marked by different expansion factors (EFha) to get the estimates per hectare. A supplementary field survey (called Phase 3+;), was carried out to sample litter and soil for determining their organic carbon content on a subsample of 1,499 Phase 2 NFI sample points, stratified by administrative region and forest category. Litter was collected from within three 30 cm x 30 cm squares, 12 m distance from the NFI sample point (figure 1). Soil (organic layer and a mineral soil sample thickness of 30 cm) was sampled using the

excavation method within the square areas used for litter collection (see Gasparini and Di Cosmo, 2015). Phase 3+ also aimed to collect data and laboratory samples that would allow the conversion of Phase 3 deadwood volume estimates into deadwood biomass and to convert measurements of tree regeneration and shrubs to biomass. In addition, fine deadwood was measured for the first time.

Extensive surveys of alive trees and standing dead trees

The stem diameters were measured for all plants, live or dead, of woody species (trees, shrubs and lianas (indicated simply as trees hereafter) falling within 4m radius plot and 13m radius plot (figure 1). The minimum callipering thresholds were respectively 4.5 and 9.5 cm. The stem diameters were conventionally measured at 1.30 m above ground (DBH) (Dapv - Dapm). For plants with DBH < 9,5 cm a single diameter was measured, while two orthogonal diameters were measured for trees with DBH ≥9.5 cm. Diameters for stems larger than 65 cm were measured using a diameter tape. Diameters values were recorded rounding to the nearest centimetre unit. Accordingly with the diameter value (first DBH measured less or equal/above 4.5 cm) and the tool used for measuring (caliper or tape) the diameter reported in the data archives is the value recorded or the mean DBH.
The botanical species (SPcod) was recorded with reference to the NFI list of woody species in Italy (file d2_05_SPcod).
The evaluation of the vitality and of integrity (VITcod) of stem and crown for the trees was done by sight, assigning each tree to one of the seven classes established, five of which are reserved for live trees and two for standing dead trees (file d2_05_VITcod). In the case of standing dead trees, data on vitality was completed by an indication of wood decay according to a 5 classes evaluation system (file d2_05_DEcod). In the case of standing dead and broken trees, the tree height was measured with a Vertex (Hapm).

Surveys on sample trees: total tree height and current annual increment

In the 4m and 13 m radius plots, sample trees were selected to measure total tree height, in order to gather enough data to model the relationship between height and DBH, and to collect tree cores to measure the five most recent ring widths. The five trees closest to the plot centre were first selected as sample trees. Trees continued to be selected until they included the three largest trees in the plot as well as the two rarest trees in terms of species or DBH. As a result, the number of sample trees varied from five to ten per sample point.
Total tree height was measured with a Vertex. Using the hypso-diametric information collected during the inventory campaign, 55 equations to predict total height, differing by species or groups of species were constructed. Those equations were used to predict the total height of not-broken living trees and standing dead trees given in the data archives (Hapv and Hapm).
The sample trees were cored with a Pressler increment borer at 1.30 m above ground. One core per sample tree was taken along the plot centre direction. On the core samples the thickness of the rings for the last five seasons was measured, excluding the current one.

Tree volumes and dry weights predictions

Volume of trees that were not broken (either alive - Vapv - or dead - Vapm) was calculated using species specific equations that use DBH and total tree height as independent variables (Tabacchi et al., 2011). That is the volume of stem plus large branches down to a minimum diameter of 5 cm. Volume of broken trees was calculated, conventionally, as half a cylinder-shaped stem, using the DBH and the measured tree height at the break section.
Dry weigh of not-broken living trees was calculated using species specific equations that use DBH and total tree height as independent variables (Tabacchi et al., 2011). The equations allow to estimate the dry weight of stems plus large branches (W1apv), the dry weight of small branches (W2apv), the dry weight of tree stump (W3apv) and the total above-ground tree dry weight (W4apv). Dry weight of living broken trees was calculated converting the volume into biomass using wood density values derived, for each species, from the ratio of predicted biomass to predicted volume using the entire NFI tree dataset of not-broken trees. This is still indicated as W4apv in the data archive as it refers to the dry weight of the total above-ground tree portion, although it can't be directly compared to the W4apv of intact trees in terms of trees components (stump, stem+large branches, small branches). Dry weight of dead trees, either broken or not, was calculated converting the volume into biomass by means of the basic-density values determined using the samples collected during the Phase 3+, that are specific for deadwood component, (standing dead trees - SDT, coarse woody debris - CWD, stumps), species group (conifers and broadleaves) and decay class (Di Cosmo et al., 2013). For this reason, in case of intact trees, the dry weight refers to the stem+large branches whereas in case of broken trees it refers to the total above-ground tree portion with little reference to the tree component (stump, stem+large branches, small branches).
Volume and dry weight of trees harvested in the 12 months before the field survey (Vut_ha, Wut_ha) were computed following the same procedures described for volume and total above-ground tree biomass of not broken live trees, after predicting the DBH through two equations, one for conifers and one for broadleaves (Gasparini and Tabacchi, 2011) and the total tree height as above described for any not broken tree measured by the NFI.
Current annual increment prediction
The current annual increment of volume of the trees measured in a plot was predicted by the following steps: firstly, the percent volume increment of each sample tree in the plot was estimated; secondly, the percent volume increment of all the trees sampled in the plot were used to calculate the mean weighed percent increment of the plot; finally, the current annual increment of any generic tree callipered in the plot (ICVapv) was obtained by multiplying its volume by the mean weighed percent volume increment for the trees in the plot.

The corresponding increment in terms of total above-ground tree dry weight (ICWapv) was obtained through biomass expansion factors that are NFI forest category specific (table 1 in Gasparini and Di Cosmo, 2015).

Surveys on the lower vegetation strata: tree-regeneration and shrubs

The survey of woody vegetation with diameter less than the callipering threshold was done in two satellite plots with radius of 2m (figure 1). The survey consisted in counting the plants, separately by species and three size classes. In some special cases where the counting was not possible due to very dense and tangled vegetation, it was replaced by recording the percentage of the 2m radius plot (25%, 50%, 75%, 100%) densely covered.
Lower vegetation individuals belonging to tree species were later on referred as regeneration and their number per hectare and size class is given in the data archive (Nrin1_ha, Nrin2_ha, Nrin3_ha). Statistics on shrubs are not given in terms of number per hectare since the "uncountable" state considered by the field survey protocol in fact occurred, so that the maximum number of shrubs is undetermined.
The mean dry to fresh weight ratio for the three broad groups of conifers, broadleaves and shrubs, by dimension class, determined using the samples collected during the Phase 3+ allowed to convert the number of individuals found in each of the Phase 3 plots to dry weight (see Di Cosmo et al., 2013), either for regeneration (Wrin1_ha, Wrin2_ha, Wrin3_ha) and for shrubs (Warb1_ha, Warb2_ha, Warb3_ha).

Survey of lying deadwood (coarse woody debris) and stumps

The survey of lying deadwood involved the material (complete trees, stems, branches, etc.) on the ground within the 13m radius plot (figure 1) and with smaller diameter of at least 9.5 cm (coarse woody debris - CWD). The elements to be measured were ideally divided into regular fragments of length up to two meters and for each fragment the values of two orthogonal diameters at both terminal sections were recorded, as well as the distance between the two sections (length). Each element was classified as belonging to conifers or broadleaved species, and the decay condition were classified using the same five classes adopted for standing trees (file d2_05_DEcod). The volume of each fragment was calculated by assimilating it into a truncated cone and then the total volume per hectare was calculated (Vne_ha).
The survey of stumps was carried out in AdS13 (figure 1) and involved all base stem portions still rooted but not reaching a height of 1.30 m and with diameter at least 9.5 cm. These were the remains of cut trees but also included stumps originating from natural falls. For each stump, two orthogonal diameters at the cutting section were measured as well as the height above ground level (two measurements, the minimum and maximum height). Consistently, the stump diameter (Dce) and the stump height (Hce) reported in the data archives are mean values. The volume of stumps (Vce) were calculated considering them cylindrical shaped, by convention. The species (SPcod) (see d2_05_SPcod) and the state of decay (DEce), were also recorded. Lastly, an evaluation was given whether the cutting had occurred in the twelve months before the survey (ETAce) or earlier, so as to estimate the amount of harvest in the last year.
The volume of CWD and of stumps were converted to dry weights (Wne, Wce) using the basic-density values determined using the samples collected during Phase 3+, that are specific for deadwood component, (SDT, CWD, stumps), species group (conifers and broadleaves) and decay class.

Survey of fine woody debris

Fine woody debris (FWD) consists of all deadwood pieces lying on the ground with end diameters between 2.5 cm and 9.4 cm and includes dead and still-standing trees with a DBH between 2.5 cm and 4.4 cm (they were downed before the FWD recording). FWD was surveyed within the 4m radius plot (figure 1) in terms of fresh weight. Samples dried in the laboratory allowed to get the dry to fresh weight ratio used to estimate the dry weight per hectare (Wnef_ha).

Carbon estimations

The organic carbon content of each ecosystem woody component has been calculated multiplying its dry weight by the carbon fraction of dry matter (0.5), proposed by IPCC (2003).

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