LULUCF reporting

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LULUCF: Land representation

A consistent land representation is needed to estimate emissions and removals of greenhouse gases associated with *Land Use, Land Use Change and Forestry* (LULUCF):

- *the use of IPCC categories ensures comparability between countries in reporting*
- *further disaggregation by strata may be needed to assign emission factors*

The land representation has to be complete:

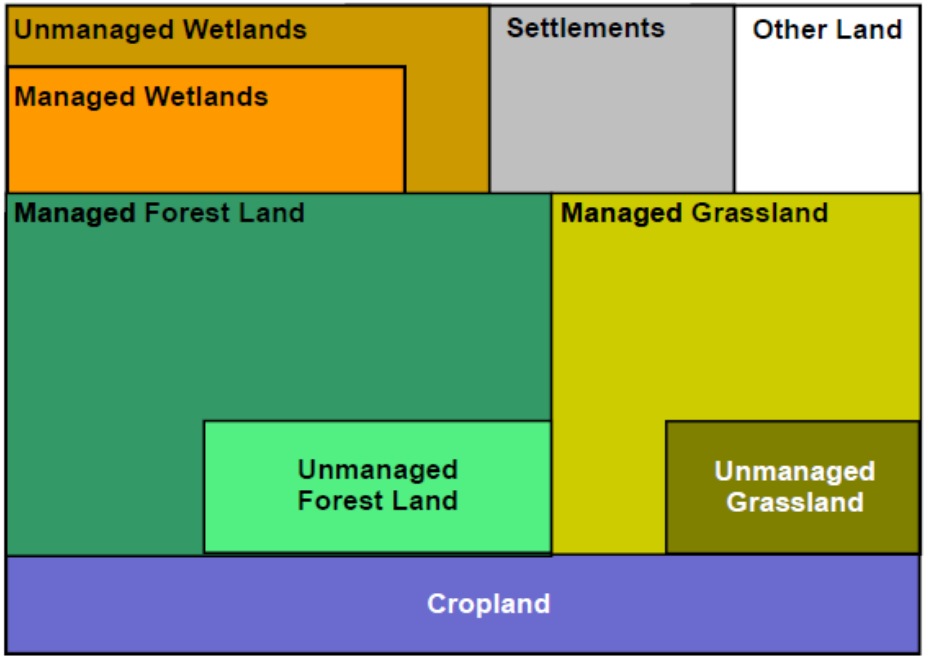
- *total land area of country has to be represented*
- *managed and unmanaged land has to be reported*

All relevant anthropogenic activities have to be included in land representation.

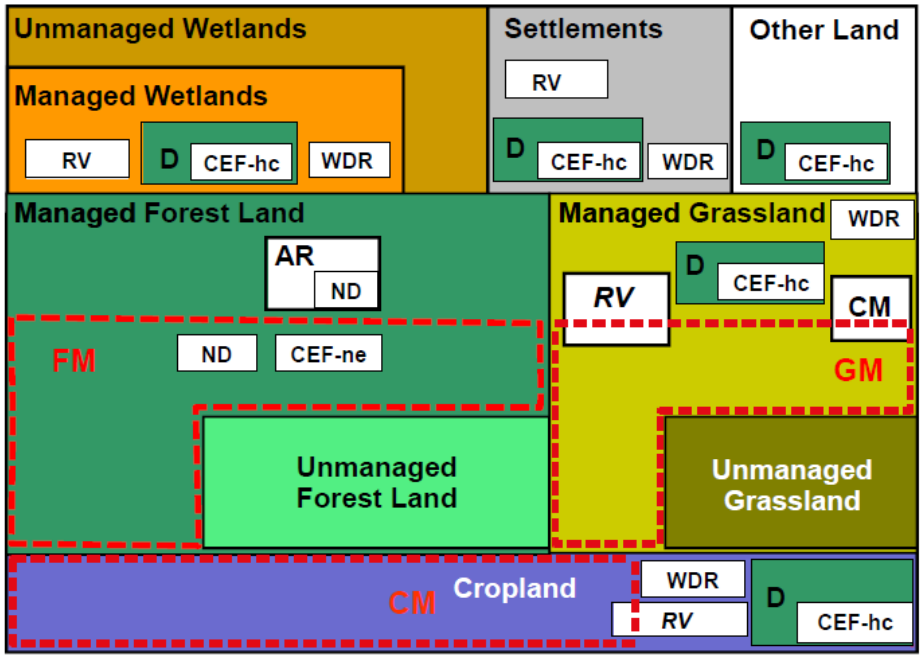
Transparency is needed

- *data sources, definitions, methodologies and assumptions should be clearly described*

Land Classification



under UNFCCC



under Kyoto Protocol

Land use classification: data sources

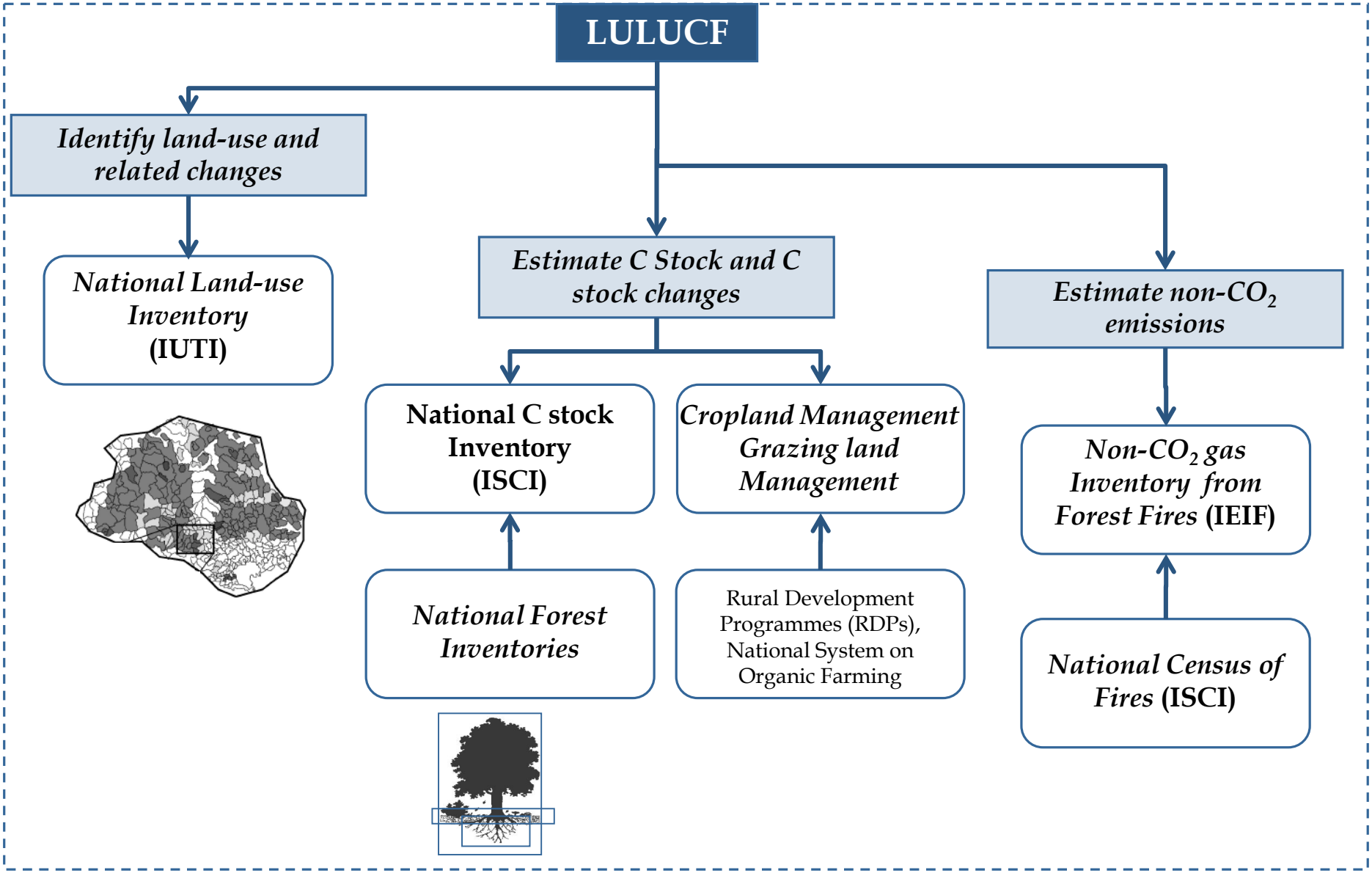
The areas subject to the different land uses, according the IPCC definitions, have to be classified through the use of the existing data sources. The definitions of IPCC categories may be tailored to meet national circumstances.

Several data sources may be used to classify land following the IPCC definition.

Category	*Data source*	*Ancillary information*
Forest land	*- National and regional forest inventories* *- National statistical surveys/census* *- Corine Land Cover*	*-Corine Land Cover* *-Land Identification Parcel System (LPIS)* *- FAO statistics* *- remote sensed data (ESA, NASA, etc.)* *- European Soil Database (Mineral and Organic Soils)*
Cropland	*-National statistical surveys/census* *-Corine Land Cover* *-Land Identification Parcel System (LPIS)*	*-Corine Land Cover* *-FAO statistics* *- remote sensed data (ESA, NASA, etc.)* *- European Soil Database (Mineral and Organic Soils)*
Grassland		
Wetlands		
Settlements		

The IPCC guidance provides methods to ensure consistency of the time series (including the land uses area); fillings gaps in activity data may be needed.

Land representation in Italy: the national registry for carbon sinks



Land representation: National Land-use Inventory (IUTI)

A consistent land representation is crucial to estimate emissions and removals of greenhouse gases related to LULUCF sector. Land classification and IPCC categories identification is based on the data from ***National Land-Use Inventory (IUTI).***

IUTI is based on a survey of sample points throughout Italian national territory considered as a population of points, and on the classification of the land use coupled with the sampling points.

The following set of multi-temporal orthophotos was used as basis of photo-interpretation process:

→ *1990, the black and white high resolution full national coverage aerial photography database was used to produce orthophotos in scale 1:75.000, spatial resolution of 1 m (the aerial photos, taken on 1988/89, have the same image acquisition standard adopted by USGS-National High Altitude Program at that time: panchromatic film, 400 lines per millimeter);*

→ *2000, TerraItaly 2000 dataset, digital color aerial orthophotos with spatial resolution of 1 m;*

→ *2008, TerraItaly 2008 dataset, digital color aerial orthophotos with spatial resolution of 0.5 m.*

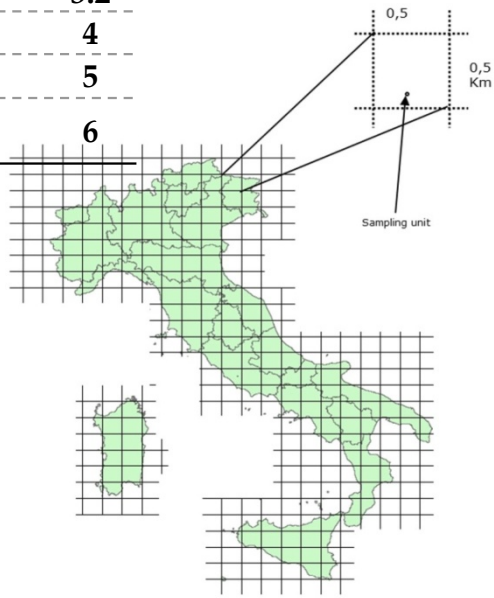
→ *2012, AGEA color and infrared digital orthophotos with spatial resolution 0.5 m; years 2010-12.*

Furthermore, visual interpretation was supported by ancillary information from available thematic forest and land use maps at regional and sub-regional scales.

National Land-use Inventory (IUTI)

The sampling grid and the relative sample plots (1,206,000 sampling points) is uniformly distributed throughout the entire Italian national territory, using a non-aligned systematic sampling. The set of sample points was extracted using a 0.5 km square grid, for a total of about 1,206,000 geo-referenced points randomly located in each square cell and fully covering the Italian territory. A subset of the IUTI sample is represented by the 301,300 first phase sample points of the national forest inventory (INFC).

IPCC Category Level I	IUTI Category Level II	IUTI Subcategory Level III	Code
1. Forest land	*Woodland*		**1.1**
	Wooded land temporarily unstocked		**1.2**
2. Cropland	*Arable land and other herbaceous cultivations*		**2.1**
	Arboreal cultivations	*Fruit orchards and plant nurseries*	**2.2.1**
		Wood product plantations	**2.2.2**
3. Grassland	*Grassland, pastures and uncultivated herbaceous areas*		**3.1**
	Other wooded land		**3.2**
4. Wetlands	*Marshlands and open waters*		**4**
5. Settlements	*Urban development*		**5**
6. Other land	*Non-productive areas or areas with scarce or absent vegetation*		**6**



National Land-use Inventory (IUTI)

A **classification hierarchy** has been established to facilitate land use classification.

The first step is related to a land classification, following artificial land level.

Distinctions are therefore made between urbanized and agricultural territories, and natural and semi-natural territories (forest, pre-forest and herbaceous formations, open water, rocky areas).

At the subsequent levels, the classification process follows the prevalent use of land in the category of artificial territories, while the discriminating element for natural and semi-natural territories is essentially given by the vegetative cover degree, considering canopy, shrub and herbaceous cover.

A. LAND WITH ITS ORIGINAL CHARACTERISTICS OF PHYSIOGNOMY AND VEGETATION SIGNIFICANTLY MODIFIED BY HUMAN ACTION, CULTIVATED, CLEARED OR SUBJECT TO URBANIZATION WORK, AND DOMINATED BY ANTHROPIC ARTEFACTS DUE TO RESIDENTIAL, INDUSTRIAL, SOCIO-CULTURAL AND AGRICULTURAL ACTIVITIES.

AI. **Land occupied by other agricultural cultivations**

AI1. Herbaceous cultivations in open fields, subject to regular rotation, for the production of cereals, pulses, other food products or forage.

ARABLE

AI2. Arboreal cultivations not subject to regular rotation, destined permanently to the production of fruit or wood products.

AI2a. *Arboreal cultivations destined prevalently to the production of fruit for nutritional purposes (apple orchards, vineyards, olive groves, etc) or for the production of arboreal or shrub species for ornamental purposes*

ORCHARDS and NURSERIES

AI2b. *Arboreal cultivations destined prevalently to the production of wood products or of woody biomass for energy generation purposes*

ARBOREAL CULTIVATIONS FOR WOOD PRODUCTS

AII. **Areas with residential and industrial buildings and services, transport routes, infrastructures and urban green areas (parks and gardens)**

SETTLEMENTS

B. NATURAL OR SEMI-NATURAL LAND NOT SIGNIFICANTLY MODIFIED BY HUMAN ACTION OR IN PHASE OF RENATURALIZATION.

BI. **Formations constituted by trees able to reach the height on maturity *in situ* of 5 m, but temporarily lacking in canopy cover following accidental events or anthropic action.**

WOODED LAND TEMPORARILY WITHOUT ABOVE-GROUND COVER

BII. **Formations constituted by trees able to reach the height on maturity *in situ* of 5 m and procuring a degree of canopy cover on the terrain of ≥ 5%.**

BII1. Formation with a degree of cover < 10%

OTHER WOODED AREAS

BII2. Formation with a degree of cover ≥ 10%

WOODLAND

BIII. **Formations never as above**

BIII1. Formations constituted by shrubs or trees not able to reach a height on maturity *in situ* of 5 m, and procuring a degree of canopy cover on the terrain of ≥ 10%

OTHER WOODED LAND

BIII2. Formations constituted by shrubs or trees not able to reach a height on maturity *in situ* of 5 m and procuring a degree of canopy cover on the terrain of < 10%, and silvi-pastural formations with canopy cover from trees able to reach a height on maturity *in situ* of 5 m but with cover < 5%

BIII2a. *Natural herbaceous formations of ground species with a degree of herbaceous cover of ≥ 40%.*

PASTURES, MEADOWS and UNCULTIVATED HERBACEOUS AREAS

BIII2b. *Natural herbaceous formations with a degree of herbaceous cover of < 40% or land completely lacking herbaceous cover*

BIII2b1. *Land without vegetation or with sporadic herbaceous vegetation. Rocky outcrops and beaches.*

OTHER LANDS

C. AREAS WITHOUT VEGETATION AND COVERED BY STILL OR FLOWING WATER OR AREAS OCCUPIED BY PARTICULAR ECOSYSTEMS OTHER THAN TERRESTRIAL ECOSYSTEMS (FLOATING VEGETATION, WET VEGETATION, SALTWATER VEGETATION, ETC).

MARSHLANDS AND OPEN WATERS

National Land-use Inventory (IUTI)

To achieve land use classification, a 0.5 ha neighborhood of the sample plot is investigated; for each point, the land use category, defined according to the classification system, has to be established.

A grid, composed of 9 squares (3 x 3) of 2500 m² each, for an overall surface area of 22,500 m² is used. This graphic object, at the centre of which the sampling point must be situated, allows to assess whether area intercepted by the sampling point has an extension equal to or greater than the established threshold (equivalent to the surface area of 2 of the 9 cells displayed).

If the surface area value is very close to the threshold and the use of the cells still leaves doubts, a graphic tool for surface area measurement is used for the classification process. The contour of the polygon containing the sampling point is mapped, computing the extent of the area.

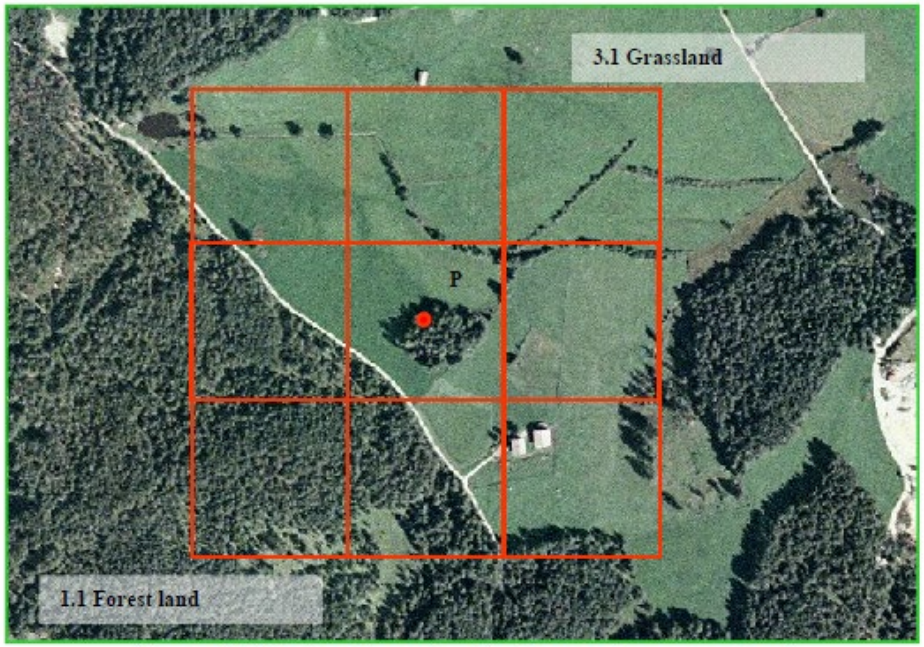


Figure A10.1: Land use classification system - grassland

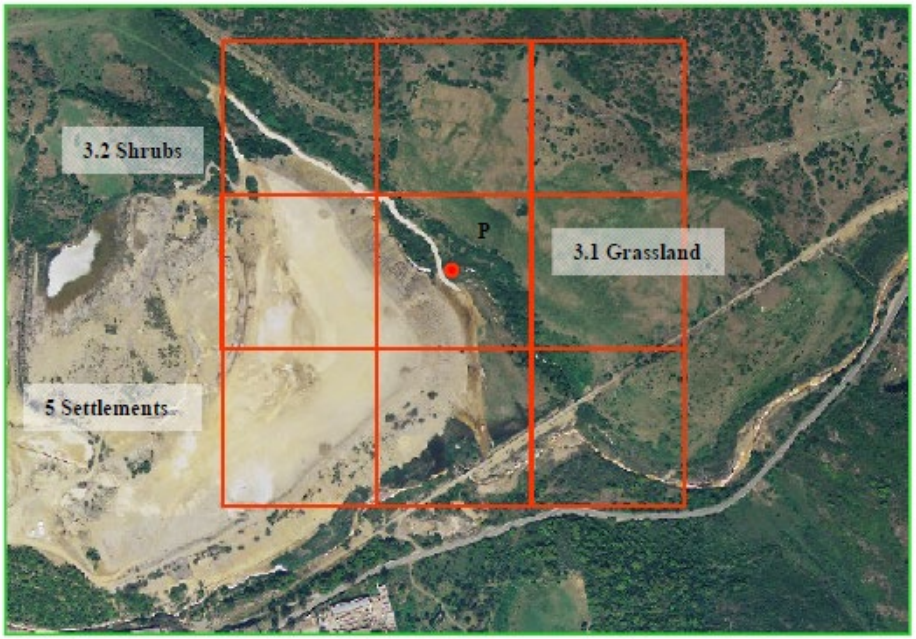


Figure A10.3: Land use classification system – grassland

Land use classification

IUTI has been carried out in **1990**, **2000** and **2008**, on a sampling grid of 1,206,000 points; in **2012** land use has been assessed on a subgrid (i.e. 301.300 points), in the framework of the III NFI.

Due to the technical characteristics of the IUTI assessment (i.e. classification of orthophotos), it was not possible clearly distinguish among some subcategories in cropland and grassland categories (e.g. *annual pastures* vs *grazing land*). Therefore, although the total aggregated area of the 2 categories *cropland* and *grassland* together is derived from the IUTI data, the area of each of their subcategories is disaggregated using as proxies the national statistics on *annual crops, perennial woody crops, grazing land* and *grassland*. The data from the NFI have a higher hierarchical order than that of IUTI, so that differences among the two datasets have been reconciled by adjusting the grassland category (subcategory natural grassland).

An additional assessment of IUTI is currently ongoing, with reference to year 2016. The ongoing assessment is using the Collect Earth tool for the data collection. Collect Earth is a free and open source software for land monitoring developed by the FAO which facilitates access to multiple freely available archives of satellite imagery, including archives with very high spatial resolution imagery (Google Earth, Bing Maps) and those with very high temporal resolution imagery (e.g., Google Earth Engine, Google Earth Engine (GEE) Code Editor).

Italy uses the IPCC default land use transition period of 20 years for each land-use change category. Consequently, in order to determine the area of lands converted to other land uses categories for the inventory years 1990-2009, land use change matrices have also been prepared for the period 1971-1989.

LULUCF reporting

Estimates of emissions and removals, for each pool/categories

Activity data collection (i.e. fires, harvest…)

Land-use classification (IUTI, NFI)

GREENHOUSE GAS SOURCE AND	ACTIVITY DATA			IMPLIED CARBON-STOCK-CHANGE FACTORS							CHANGES IN CARBON STOCK AND NET CO_2 EMISSIONS/REMOVALS FROM							Net CO_2 emissions/ removals[(6)] [(7)]
Land-use category	Total area[(1)] (kha)	Area of mineral soil (kha)	Area of organic soil (kha)	Carbon stock change in living biomass per			Net carbon stock change in dead wood	Net carbon stock change in litter per	Net carbon stock change in soils		Carbon stock change in living biomass[(2) (4)]			Net carbon stock change in dead	Net carbon stock change in litter[(4)]	Net carbon stock change in soils[(4) (5) (6)]		
				Gains	Losses	Net change			Mineral soils[(5)]	Organic soils	Gains	Losses	Net change			Mineral soils	Organic soils	
				(t C/ha)							(kt C)							(kt)
A. Total forest land	9360.02	9360.02	NO	2.47	-1.45	1.03	0.01	0.01	0.00	NO	23164.58	-13533.46	9631.12	78.38	130.70	0.00	NO	-36080.72
1. Forest land remaining forest land	8007.45	8007.45	NO	2.43	-1.42	1.01	0.01	0.01	NO,NA	NO	19426.93	-11353.75	8073.18	66.43	110.76	NO,NA	NO	-30251.34
unstocked forest area	212.95	212.95	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
stands	2647.45	2647.45	NO	2.72	-1.57	1.15	0.01	0.02	NA	NO	7205.76	-4165.58	3040.18	23.41	45.82	NA	NO	-11401.16
coppices	4234.73	4234.73	NO	2.39	-1.34	1.05	0.01	0.01	NA	NO	10133.27	-5681.69	4451.58	38.31	56.74	NA	NO	-16670.99
plantations	148.14	148.14	NO	1.19	-0.67	0.52	0.00	0.01	NA	NO	175.95	-99.41	76.54	0.16	0.84	NA	NO	-284.34
riparian forest	764.17	764.17	NO	2.50	-1.84	0.66	0.01	0.01	NA	NO	1911.95	-1407.08	504.87	4.54	7.36	NA	NO	-1894.86
2. Land converted to forest land[(8)]	1352.57	1352.57	NO	2.76	-1.61	1.15	0.01	0.01	0.00	NO	3737.65	-2179.71	1557.94	11.95	19.93	0.00	NO	-5829.38
2.1 Cropland converted to forest land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.2 Grassland converted to forest land	1352.57	1352.57	NO	2.76	-1.61	1.15	0.01	0.01	0.00	NO	3737.65	-2179.71	1557.94	11.95	19.93	0.00	NO	-5829.38
2.3 Wetlands converted to forest land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.4 Settlements converted to forest land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.5 Other land converted to forest land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Utilizzazioni [m³]	fustaie	cedui	piantagioni	totale
1990	5,382,261	6,243,791	1,971,908	13,597,960
1991	5,149,174	6,228,585	2,109,367	13,487,126
1992	4,919,474	6,305,187	2,151,632	13,376,292
1993	4,921,724	6,815,031	1,800,380	13,537,135
1994	4,822,328	6,948,887	2,184,485	13,955,700
1995	4,784,144	7,147,6		
1996	5,204,329	7,686,0		
1997	5,338,302	7,852,1		
1998	6,116,619	8,107,2		
1999	4,891,985	9,031,3		
2000	4,723,078	8,487,7		
2001	3,944,793	7,996,4		
2002	4,188,244	7,395,9		
2003	4,514,274	8,474,3		
2004	3,928,038	8,993,0		
2005	3,992,224	8,564,8		
2006	4,304,961	8,645,5		
2007	4,165,779	8,583,4		
2008	5,082,241	9,063,4		
2009	4,015,755	8,212,6		
2010	3,896,115	7,937,9		
2011	3,875,492	8,335,0		
2012	3,654,296	7,427,6		
2013	4,035,244	7,413,8		
2014	3,691,978	6,758,6		
2015	3,585,173	5,217,0		
2016	3,770,798	6,463,1		

Aree percorse da incendi [ha]	Foresta	Altre terre boscate	totale
1990	1,584	920	2,503
1991	535	311	846
1992	799	464	1,263
1993	2,121	1,232	3,354
1994	818	475	1,293
1995	328	191	519
1996	348	202	551
1997	1,154	670	1,823
1998	1,313	762	2,075
1999	664	386	1,050
2000	1,056	613	1,670
2001	676	393	1,069
2002	365	212	577
2003	790	459	1,248
2004	384	223	607
2005	369	214	584
2006	287	167	454
2007	2,065	1,199	3,265
2008	415	186	600
2009	468	256	724
2010	235	174	408
2011	457	322	778
2012	1,249	611	1,859
2013	239	113	352
2014	359	162	521
2015	380	153	532
2016	556	246	803

		1990						total 1989
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1989	Forest	**7,511**				0.72		*7,512*
	Grassland	78.68	**8,891**	0.00	0.00	1.73		*8,971*
	Cropland		0	**10,841**	0.00	25		*10,866*
	Wetland				**510**			*510*
	Settlements					**1,616**		*1,616*
	Other Land					0.00	**658**	*658*
total 1990		*7,590*	*8,891*	*10,841*	*510*	*1,644*	*658*	30,134
Land converted to:		78.7	0.0	0.0	0.0	27.6	0.0	

20 years matrix		1990						total 1971
		Forest	Grassland	Cropland	Wetlands	Settlements	Other Land	
1971	Forest	**6,901**				14.4		*6,916*
	Grassland	689	**8,566**	136	0.00	33		*9,423*
	Cropland		325	**10,704**	0.00	174		*11,203*
	Wetland				**510**			*510*
	Settlements					**1,423**		*1,423*
	Other Land					0.00	**658**	*658*
Total 1990		*7,589.8*	*8,890.9*	*10,840.5*	*510.1*	*1,644.0*	*658.3*	30,134
Land converted to:		688.5	325.0	136.1	0.0	220.8	0.0	

Carbon Stock Changes in Land-Use categories

Emissions and removals of CO_2 for the LULUCF sector, based on changes in ecosystem C stocks, are estimated for each land-use category (including both land remaining in a land-use category as well as land converted to another land use).

Applying the same equation to each land-use category results in

$$\Delta C_{LULUCF} = \Delta C_{FL} + \Delta C_{CL} + \Delta C_{GL} + \Delta C_{WL} + \Delta C_{SL} + \Delta C_{OL}$$

For each land-use category, carbon stock changes are estimated for all strata or subdivisions of land area

Subdivisions should be done according to differences in the carbon dynamic and in the magnitude of fluxes that ecosystem C stocks show (e.g. *forest typology, ecotype, soil type, management regime* etc.) chosen for a land-use category.

EQUATION 2.2
ANNUAL CARBON STOCK CHANGES FOR A LAND-USE CATEGORY AS A SUM OF CHANGES IN EACH STRATUM WITHIN THE CATEGORY

$$\Delta C_{LU} = \sum_i \Delta C_{LU_i}$$

Where:

ΔC_{LU} = carbon stock changes for a land-use (LU) category as defined in Equation 2.1.

i = denotes a specific stratum or subdivision within the land-use category (by any combination of species, climatic zone, ecotype, management regime etc., see Chapter 3), i = 1 to n.

Carbon stock change in carbon pools

Carbon stock changes for a land use category are the sum of changes in all pools:

$$\Delta C_{LUi} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{LI} + \Delta C_{SO} + \Delta C_{HWP}$$

Where the subscripts denote the following carbon pools:

ΔC_{LUi} = *carbon stock change for the land use "i"*
AB = *aboveground biomass*
BB = *belowground biomass*
DW = *deadwood*
LI = *litter*
SO = *soils*
HWP = *harvested wood products*

TABLE 1.1
DEFINITIONS FOR CARBON POOLS USED IN AFOLU FOR EACH LAND-USE CATEGORY

Pool		Description
Biomass	Above-ground biomass	All biomass of living vegetation, both woody and herbaceous, above the soil including stems, stumps, branches, bark, seeds, and foliage. Note: In cases where forest understory is a relatively small component of the above-ground biomass carbon pool, it is acceptable for the methodologies and associated data used in some tiers to exclude it, provided the tiers are used in a consistent manner throughout the inventory time series.
	Below-ground biomass	All biomass of live roots. Fine roots of less than (suggested) 2mm diameter are often excluded because these often cannot be distinguished empirically from soil organic matter or litter.
Dead organic matter	Dead wood	Includes all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps, larger than or equal to 10 cm in diameter (or the diameter specified by the country).
	Litter	Includes all non-living biomass with a size greater than the limit for soil organic matter (suggested 2 mm) and less than the minimum diameter chosen for dead wood (e.g. 10 cm), lying dead, in various states of decomposition above or within the mineral or organic soil. This includes the litter layer as usually defined in soil typologies. Live fine roots above the mineral or organic soil (of less than the minimum diameter limit chosen for below-ground biomass) are included in litter where they cannot be distinguished from it empirically.
Soils	Soil organic matter[1]	Includes organic carbon in mineral soils to a specified depth chosen by the country and applied consistently through the time series[2]. Live and dead fine roots and DOM within the soil, that are less than the minimum diameter limit (suggested 2 mm) for roots and DOM, are included with soil organic matter where they cannot be distinguished from it empirically. The default for soil depth is 30 cm and guidance on determining country-specific depths is given in Chapter 2.3.3.1.

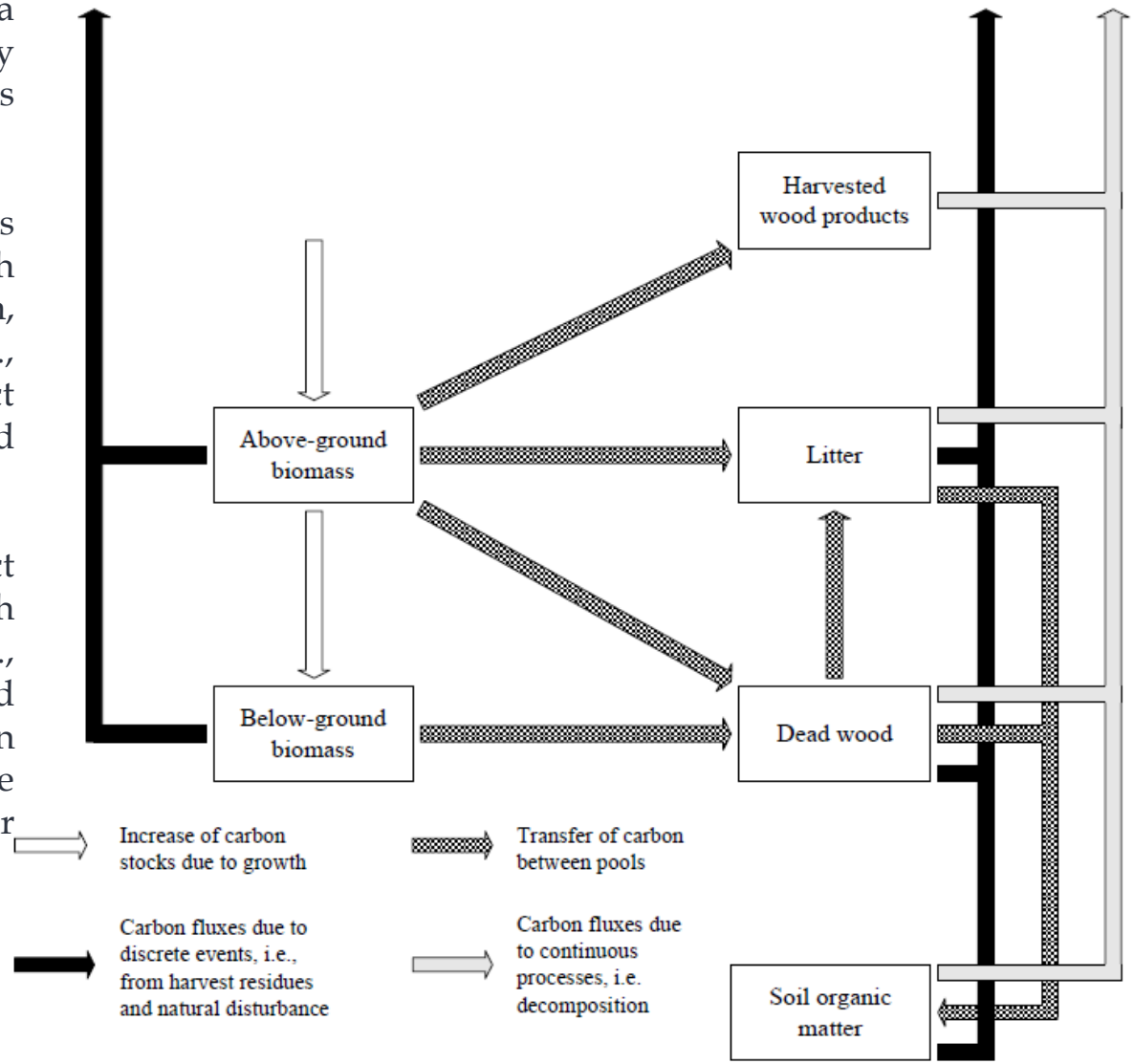
Carbon fluxes

Figure 2.1 **Generalized carbon cycle of terrestrial AFOLU ecosystems showing the flows of carbon into and out of the system as well as between the five C pools within the system.**

Carbon stock changes within a stratum are estimated by considering carbon cycle processes between the five carbon pools

The carbon cycle includes changes in carbon stocks due to both continuous processes (i.e., growth, decay) and discrete events (i.e., disturbances like harvest, fire, insect outbreaks, land-use change and other events).

Continuous processes can affect carbon stocks in all areas in each year, while discrete events (i.e., disturbances) cause emissions and redistribute ecosystem carbon in specific areas (i.e., where the disturbance occurs) and in the year of the event.



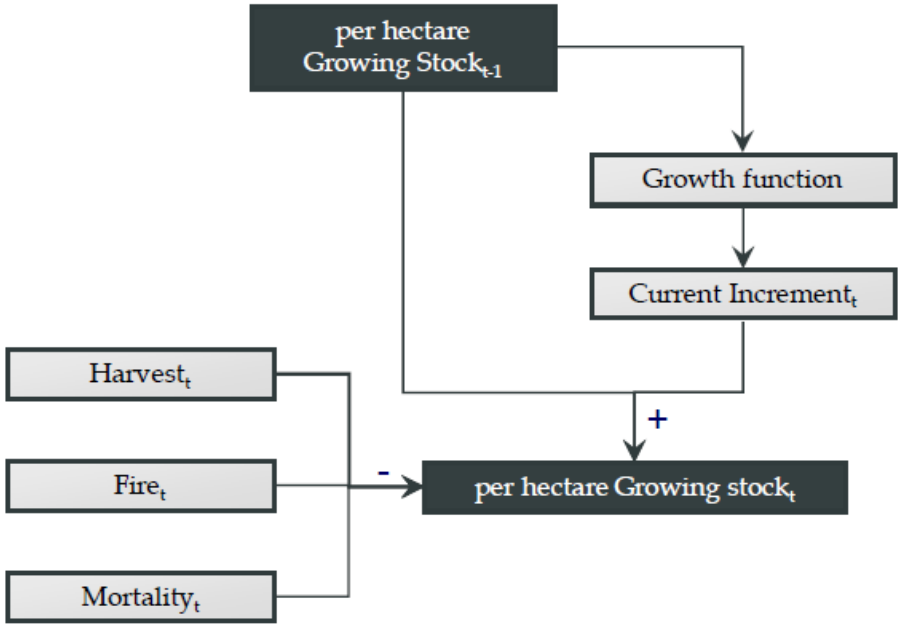
Forest Land: methodological issues

For-est is a bookkeeping model that calculates annually the C stock of the aboveground biomass pool by adding the annual net increment and subtracting annual losses associated with formal and informal harvest (industrial roundwood and fuelwood), forest fires and other mortality, which includes all other disturbances (i.e. drought, grazing, wind). Model input data for the forest area, per region and inventory typologies, are the Italian forest inventories (1985, 2005, 2015 (ongoing)).

Growing stock estimates:

→ starting from growing stock volume reported in the I INFI, for each year, the current increment per hectare is computed with the derivative Richards function, for every specific forest typology

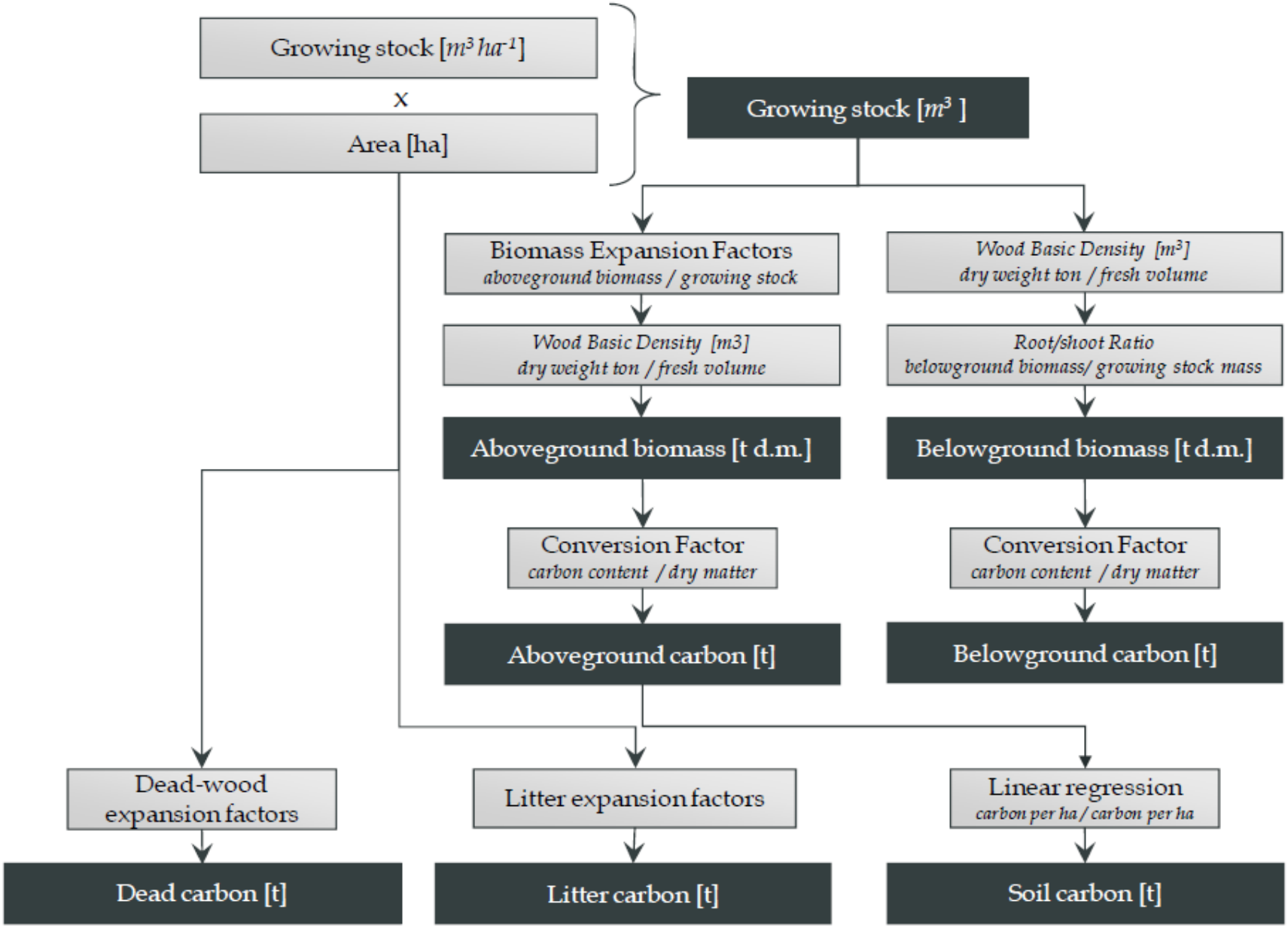
$$\frac{dy}{dt} = \frac{k}{v} \cdot y \cdot \left[1 - \left(\frac{y}{a} \right)^{v} \right] + y_0$$



Where y represents the growing stock of the stand, while the y derivative (*dy/dt*) is the correspondent increment computed with the Richards function - first derivative.

→ for each year, growing stock per hectare is computed from the previous year growing stock volume adding the calculated current increment ("y" value of the derivative Richards) and subtracting losses due to harvest, mortality and fire occurred in the current year.

Forest Land: For-est model flowchart



Thank you