Layman’s Report

LIFE13 ENV/IT/000813
Smart4Action
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In cooperation with sub-contractors

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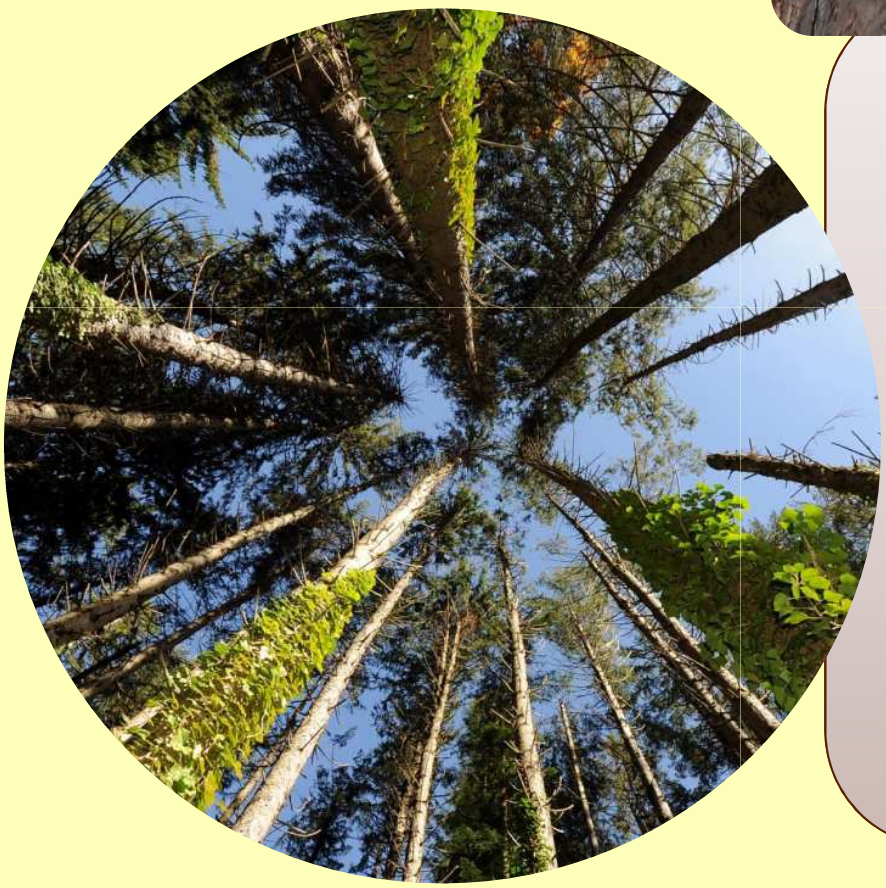
FORESTS NEED A HOLISTIC VIEW

Air pollution is a serious threat to human health, the quality of ecosystems and the conservation of artifacts. Atmospheric pollutants move with the masses of air across national borders, and therefore it is not possible to imagine an air pollution control policy limited to one country. Therefore in 1979 the European countries, the United States and Canada agreed a common policy to reduce air pollution by stipulating a specific Convention for the reduction of cross-border pollution. The signatory countries have therefore committed for reducing emissions through concrete measures, such as filters on chimneys, catalytic converters, use of less polluting fuels. These measures have an important cost and therefore in the Convention programs to measure the effects of pollution reduction have been organized, to assess whether these have been effective and whether others should be implemented. One of these "Integrated Cooperative Programs", called ICP-Forests, assesses the effects of atmospheric pollution on forests and began in 1997. Within the ICP-Forests there are two monitoring networks, extended to the whole of Europe. A network, called level I, consists of many measuring points (about 260 in Italy) to assess the intensity and extent of any damage to forests due to air pollution. A second network, called level II, instead has a reduced number of sites (in Italy 31), where the processes that regulate the interaction of the forest with pollutants are studied. In Italy, the two networks were organized by the former Corpo Forestale dello Stato (now Carabinieri Forestali) in collaboration with Research Institutes and Universities, and called "CONECOFOR" (Forest Ecosystem Control).

The European Union financed the commissioning of the network, from 1997 to 2006, through Regulation 2152/2003 / EC ("Forest Focus") and a program to improve the analytical quality and comparability of results between different countries through the project LIFE07 ENV / D / 000218 (FutMon), from 2009 to 2011. Thanks to another LIFE project, Env Europe (LIFE08 ENV / IT / 000399), the level 2 CONECOFOR network sites have become an integral part of the long-term ecological research network (LTER). Subsequently, a careful analysis of the situation of the CONECOFOR networks showed that the information collected was very numerous and could be better exploited for management and scientific purposes, provided that they were made more available to citizens, professionals and researchers. Moreover, in a historical period characterized by a reduction in the availability of funds for the environment, the maintenance of the CONECOFOR network required an analysis of costs and results to try to reduce spending without undermining the validity of the results obtained.

European Union LIFE funding is LIFE for forests

Until 2007 and subsequently, from 2009 to 2011, forest monitoring in Europe was financially supported by ad *hoc* EU regulations (e.g. the Forest Focus regulation). Subsequently, this specific support failed, replaced by the LIFE financial instrument for the environment. The LIFE + program (2007-2013) supported projects "Nature and Biodiversity", "Environmental Policy and Governance" and "Information and Communication" with a total budget of over 2 billion euros.



The LIFE + SMART4ACTION project was approved in 2013 under the "Environmental Policy and Governance" component with an EU funding of € 1,099,213.00, out of a total budget of € 2,206,527.00. Smart4Action focused on the financial sustainability of the forest monitoring system in Italy, redesigning its structure without affecting soundness and scientific reliability of data and results.

The LIFE+ project Smart4Action LIFE13 ENV/IT/000813

The monitoring of forest conditions in Italy is carried out through a network of two types of test areas belonging to the ICP Forests International Program: Level I (253 sites) and Level II (31 square areas of 50 meters per side inside the main forest ecosystems). In the test areas, chemical-physical and biological measurements are carried out, to study the health status of woods through the analysis of: biodiversity, tree growth, crown conditions, leaf chemistry, chemical composition of air, precipitation and of liquids present in the soil. The LIFE Smart4Action project aims at reshaping the network in order to reduce operating costs, while continuing to guarantee data scientific soundness. In addition, the project introduces citizens to the data collection that takes place in the forestry areas, making them the direct protagonists of sampling activities, through a "citizen-science" action, the science of citizens applied to nature. Smart4Action is financed by the LIFE instrument of the European Union. Actions on which the Smart4action Project was organized are listed below.

Action A

1 Preparatory action to survey the interested categories, gathering information for the involvement of several stakeholders in forest monitoring, from citizens to administrators.

Actions B

4 Project implementation actions through analysis, evaluation and testing of forest indicators: biological responses, chemical data, meteorological data and design of the new forest monitoring system.

Actions C

2 Actions to monitor the impact of the project on the environment and socio-economic factors.

Actions D

3 Communication actions and dissemination of the project topics through the organization of meetings, courses, publications, web tools and smartphone applications.

Actions E

6 Actions to manage and monitor the progress of the project.

SMART4ACTION STUDY AREAS

ABR1

The ABR1 area is located at an altitude of 1500 m a.s.l., on a mountain slope, in the Selva Piana locality of Collelongo (AQ). It is a beech high forest (*Fagus sylvatica*), characterized by the typical conformation of the Apennine beech forests, with a subatlantic climate (average annual rainfall 1300mm, average annual temperature 7.5° C) and on acid soil.

CAL1

The CAL1 area is located at an altitude of 1100 m a.s.l, in the Piano Limina area of the Municipality of Giffone (RC), on the edge of the Aspromonte National Park. Also this area is represented by a beech high forest (*Fagus sylvatica*); the site is remarkably rainy (average annual rainfall 1300mm) and this balances for the relatively southern location of this beech population. The average annual temperature is around 10° C.

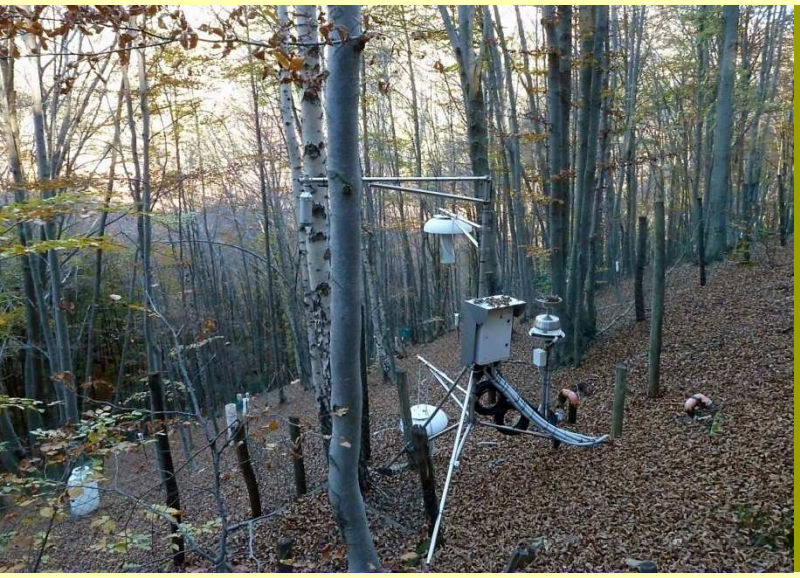
EMI1

The EMI1 study area is located at 200 m a.s.l. inside the Boschi di Carrega Regional Park (Cittadella - Sala Baganza, PR). It is a typical oak forest (*Quercus petraea*) of the northern Apennines. The site is on an alluvial plain. The average annual rainfall is about 1200 mm, the average annual temperature is around 12° C.

SMART4ACTION STUDY AREAS

LAZ1

The LAZ1 area is located within the Regional Natural Reserve of Monte Rufeno, in the municipality of Acquapendente (VT), at an altitude of 690 m a.s.l. The dominant and representative tree species of the station is the Turkey oak (*Quercus cerris*). The forest was subject to logging in the past, but the forest management was interrupted, so today the forest structure is an aged coppice. Average annual rainfall is 1000 mm, average annual temperature is 12° C.



PIE1

The PIE1 area is located in the municipality of Bioglio (BI), in Selletto Grosso, at an altitude of 1150 m a.s.l. Also this area is represented by the beech (*Fagus sylvatica*), and the structure of the forest from abandoned coppice is going to become a high forest. Average annual rainfall is 1500 mm, average annual temperature is 8° C. The plot is located within a state-owned forest, whose management is entrusted to the Region Piemonte.

VEN1

The VEN1 area is located at an altitude of 1100 m a.s.l, in Vallone Vallor - Piano di Cansiglio, Municipality of Vittorio Veneto (TV). This study area is represented by a beech (*Fagus sylvatica*) high forest. The average annual rainfall is very abundant (about 1900 mm), the average annual temperature is about 5° C. This monitoring forest area is included inside a Biogenetic State Reserve.

ACTIONS AND METHODS: METEOROLOGY

METEOROLOGY

Monitoring of climate variables in the CONECOFOR network began in 1997. Measuring the main climatic parameters in the woods is essential to understand the effect of climate on the growth and on the state of health of trees. Data collection, integrated with the survey of several other variables, supports integrated studies on forest ecology and plant physiology and, more generally, contributes to defining the status of health of Italian forests.

✓Agency responsible for research: Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria – Centro di Ricerca Foreste e Legno; Roma (Silvano Fares, Luca Salvati, Valerio Moretti, Tiziano Sorgi).

METHODS

Meteorological variables are sampled by means of automatic stations. A typical climate monitoring station consists of a control unit located in the permanent forest area and another, in an "open field", within a radius of 2 km from the "in the plot" one. The main parameters recorded at the weather-climate stations are

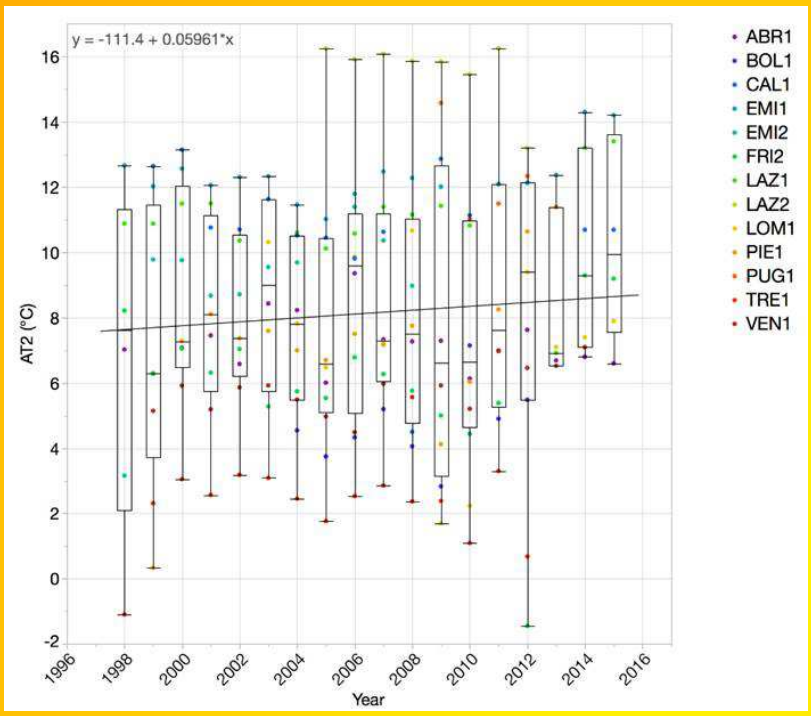
1. Wind speed (10 and 2 m height from the ground) and wind direction (10 m height from the ground);
2. Solar radiation (2 m height from the ground);
3. Temperature and relative air humidity (10, 2 and 0,1 m height from the ground);
4. Soil temperature (20 cm height from the ground);
5. Precipitation;
6. Snowfall;
7. Soil humidity and temperature (10, 30 and 60 cm height from the ground).

Monitoring stations inside the Smart4Action areas: dataloggers used to acquire data and information totem set up within institutional sites visited by citizens close to forest study areas.

The LIFE Smart4Action project enabled technical solutions to reduce the costs of sampling and data processing, in particular with virtual and remote connections. The areas ABR1, VEN1, LAZ1 and EMI1 have been equipped in this way, allowing to exclude the presence of an operator in the field. Illustrative and interactive totems for citizens were installed near offices and forest stations close to the study areas.

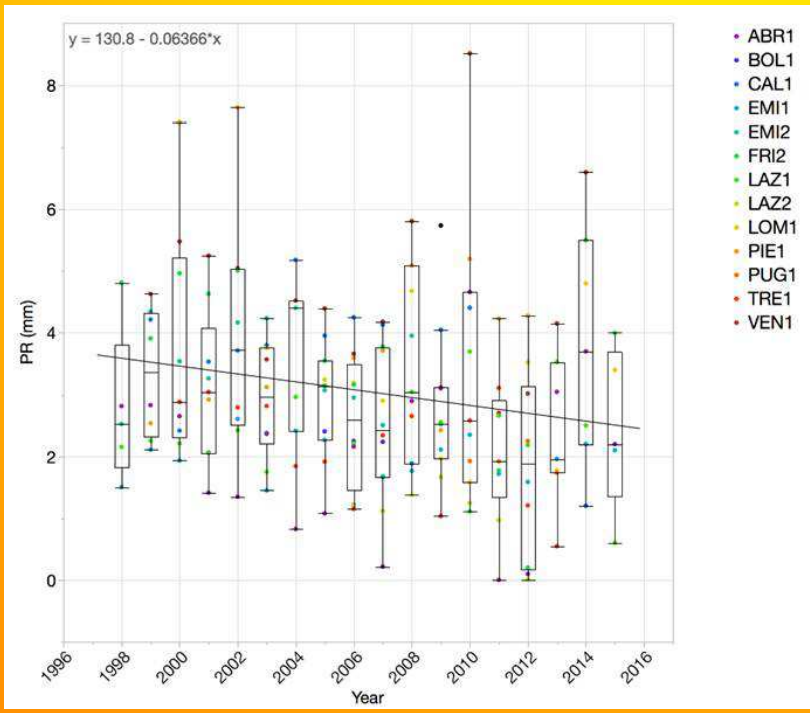
ACTIONS AND METHODS: METEOROLOGY

RESULTS



Trend and distribution of mean annual temperature at 13 CONECOFOR plots.

The graph shows the temperature trend (1996-2016) in 13 Level II CONECOFOR areas, including the 6 Smart4Action study areas. There is a slight increase in the average temperature over time (about 0.06 ° C per year), as well as high space variability in precipitation, with decreases located in some forest contexts (-5%) and slight increase of extreme events.



Trend e distribution of mean annual precipitation at 13 CONECOFOR plots.

ACTIONS AND METHODS: CROWN CONDITIONS

CROWN CONDITIONS

The health of trees is defined through the parameter of "defoliation", which indicates the percentage of missed leaves in the crown of the tree, in comparison with one ideal “healthy” tree.

Defoliation depends from genetic variability, different degree of tolerance to stress, the quality and fertility of the soil, climate, interactions between plant and parasites. The shape and density of the foliage are the result of the equilibrium of a plant with its environment, therefore, changes year after year in defoliation can be indicative of an alteration of the quality of the environment.

The purpose of this monitoring activity is to identify, in the long term, the responses of the trees to the abiotic and biotic stresses they entail an alteration of their vitality.

✓Agency responsible for research: University of Florence (Filippo Bussotti, Martina Pollastrini); Linnaea Ambiente (Davide Bettini, Enrico Cenni)

METHODS

To determine the level of defoliation of the tree we use "photoguides", that are manuals with photo examples to be considered as a reference.

Defoliation is evaluated according to a system of proportional classes with a width of 5%, from 0, which indicates a tree with an intact crown, to 100, which indicates a dead plant.

The estimate of defoliation is entrusted to the subjective evaluation of surveyors.

To obtain reliable results, intercalibration courses are carried out annually, in the month of June, before starting with the field activities, in order to harmonize the evaluation criteria.

Defoliation in an oak tree crown.

With a loss of leaves equal or less than 25% the plant is considered healthy, within a range of natural variability. Over 60% of defoliation, trees are considered severely damaged.

ACTIONS AND METHODS: CROWN CONDITIONS

INDAGINE ANNUALE SULLO STATO DI SALUTE DELLE FORESTE ITALIANE

SCHEDA DI VALUTAZIONE A - ANNO 2016

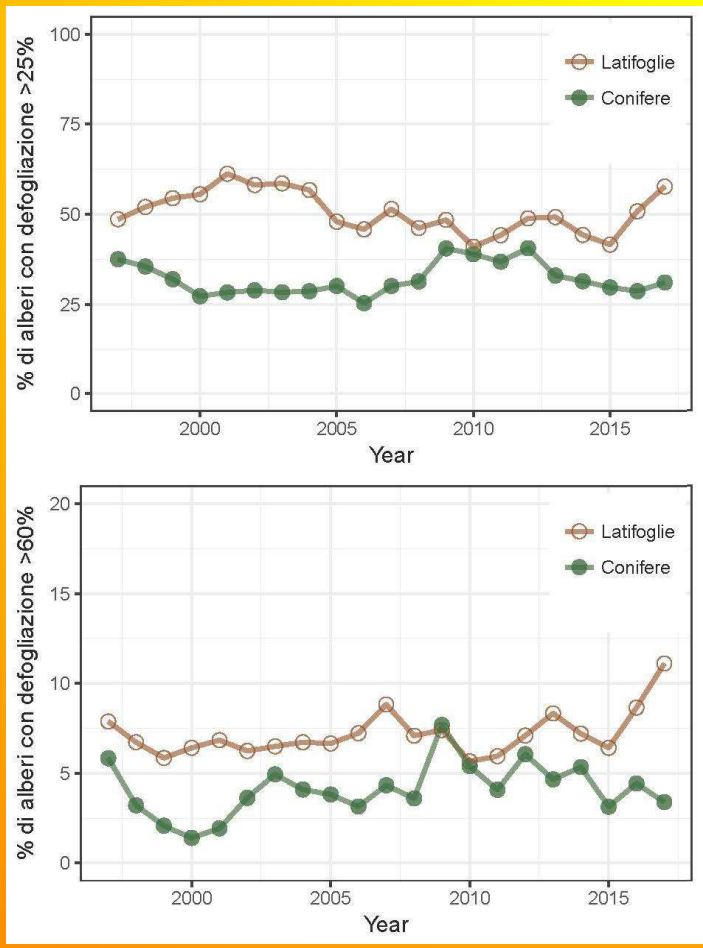
Rete Nazionale Italiana: CONtrollo ECOsistemi FORestali — CON.ECO.FOR. - **Livello I**

Data dell'osservazione	
ID Punto	

	Specie																
N° albero	Cod.	nome latino	Dendrotipo [5]	D1 (cm)	D2 (cm)	Azimut (°)	Distanza (m)	Rimozione e mortalità	Trasparenza	Fruttificazione	Parte della pianta danneggiata	Sintomo/Segno	Età del danno	Agente	Nome dell'Agente	Diffusione	Note

Abstract from the tree crown conditions sampling sheet

RESULTS



Defoliation (>25% and >60%) in the period 1997-2017, on broadleaves and conifers

From the graph on the left, it can be seen that the defoliation is always greater in broadleaves than conifers. It also varies over time with trends that are apparently conflicting between the two functional groups. The chestnut crisis has increased in recent years. This species shows a peak of defoliation between 2012 and 2014, due to the infestation by the Asian vespa. The beech has undergone a strong increase in defoliation in recent years, especially above the threshold> 60%, due to the late frosts (2016 and 2017) and the summer drought of 2017.

ACTIONS AND METHODS: FOLIAR NUTRIENTS ANALYSIS

✓ Agency responsible for research: Consiglio Nazionale delle Ricerche – Istituto di Biologia Agro-ambientale e Forestale – Monterotondo (Giorgio Matteucci, Bruno De Cinti).

FOLIAR NUTRIENTS ANALYSIS

Foliar chemistry is an important indicator of tree's mineral nutrition. The availability of each single element is important for the tree because each nutrient plays an important role in its complex metabolism:

nitrogen (N) is the major constituent of proteins and, together with phosphorous (P) is the most limiting element for terrestrial vegetation. calcium (Ca) is present in structural components of foliage such as cell walls, potassium (K) has role in stomatic functions and in biological loading pumps. It is also involved to determine some important plants attitudes as frost and drought resistance. The photosynthesis is closely connected to magnesium (Mg). Leaves nutrients concentration is not only influenced by soil availability but by several other factors. Plant absorption capacity for example play an important role.

METHODS

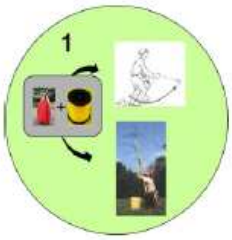
The analysis of foliar nutrients is performed every two year. The procedure for foliage sampling and analysis follows the protocols listed in the Manual adopted at European level.

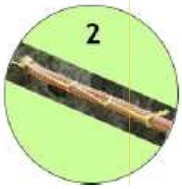
Mature leaves or needles developed in full light condition are collected from the upper third of the canopy.

The most effective method to collect the samples is the operator's ascent by tree-climbing techniques.

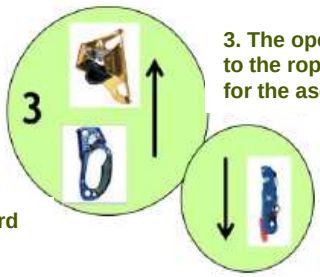
In the laboratory, samples are treated according to the ICP-Forests protocol: prepared and analyzed by specific techniques for each element investigated.

1. A guide lanyard with a weight is launched (manually or with a slingshot)





2. A rope is fastened to the lanyard and got up into the canopy



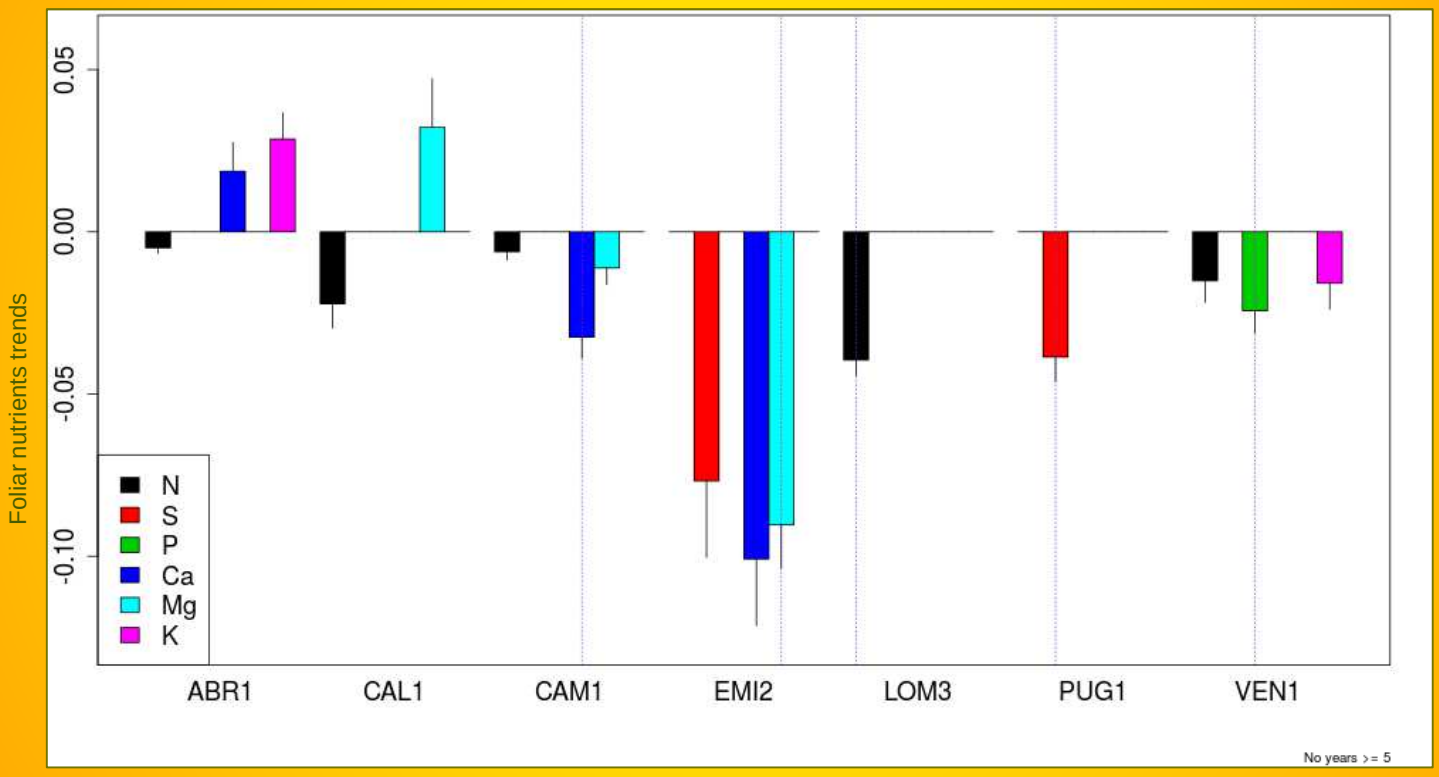
3. The operator anchors himself to the rope, using specific tools for the ascent and the discent

Operating steps of the "tree climbing" technique used in the collection of leaves samples.

ACTIONS AND METHODS: FOLIAR NUTRIENTS ANALYSIS

RESULTS

The foliar nutrient concentrations data collected by the monitoring were compared to the standards value for each species. It enabled to (i) define the nutritional status of the forest and (ii) investigate the presence of long-term trends.



GRAPH: trends identified for each element (increasing if the segment is above 0, decreasing if the segment is below 0; long segments = high changes, short segments = moderate changes)

As part of the LIFE Smart4Action project, the increase or decrease in the amount of fundamental foliar nutrients has been studied over a 18 years period. The data of the different tree species present in the 6 study areas were compared, also with the other ICP Forests monitoring sites.
In the above chart of beech sites, we see that: 1) the most important nutrient, nitrogen (N), is decreasing in the areas of ABR1, CAL1 and VEN1 (in the remaining sites there are no clear indications); 2) the site (EMI2) has strong decreases in sulphur (S), calcium (Ca) and magnesium (Mg); 3) for other elements such as potassium (K) there is no common trend.

ACTIONS AND METHODS: GROUND VEGETATION

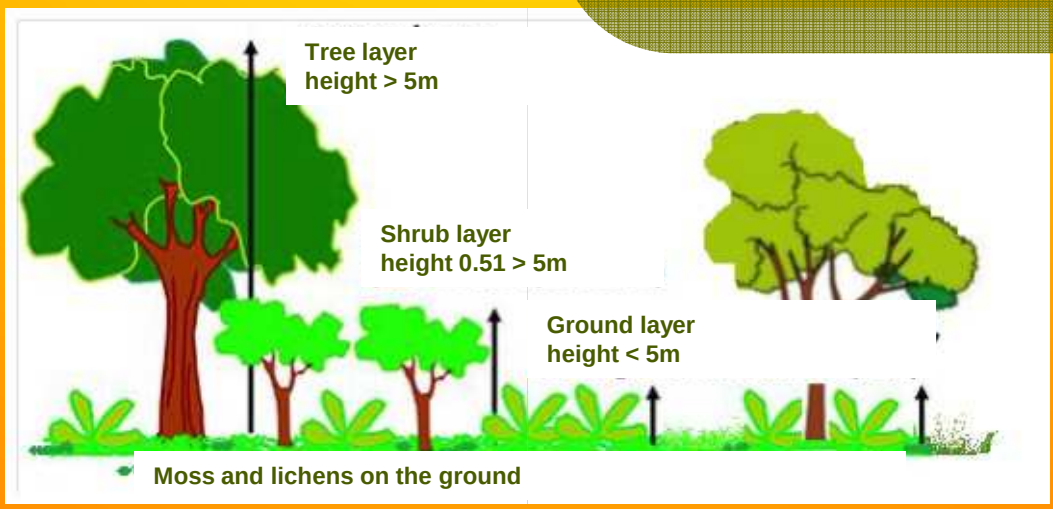
ANALYSIS OF GROUND VEGETATION

The "Maintenance, conservation and appropriate improvement of biological diversity in forest ecosystems" is one of the six internationally established criteria to guarantee ecological sustainability in forest management. Plant diversity can be considered according to different aspects. The term "flora" refers to the set of individual plant species that grow in a given environment, while "vegetation" refers to the complex of species that make up the plant communities (woods, grasslands, bushes) and their way of combining based on relations with the environment. The floristic composition of a forest is an indicator of its complexity, as it identifies which and how many species are established (with their relative values, functions, etc.) and provides information on ecological conditions. The disturbing factors, including those due to global changes, are reflected in the variations of these characters, at different spatial and temporal scales.

✓ Agency responsible for research: University of Camerino (Roberto Canullo).

METHODS

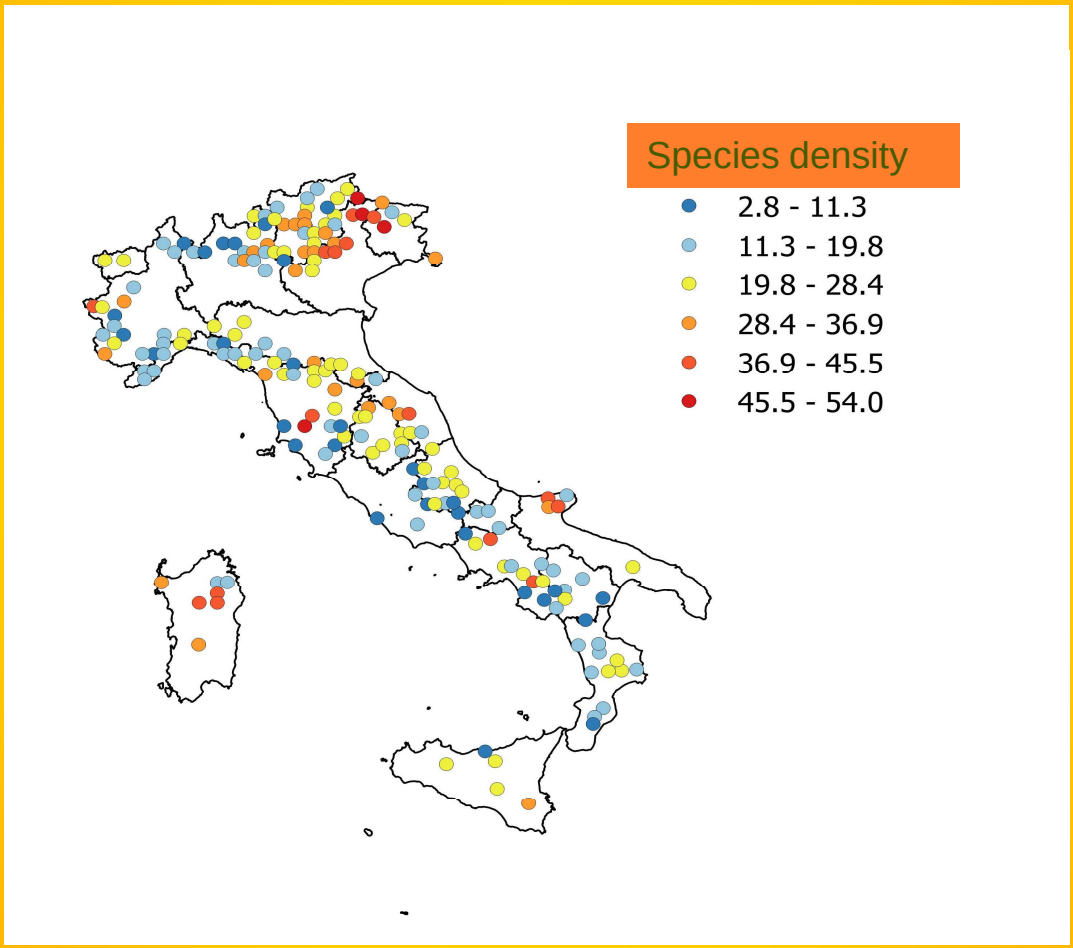
The monitoring of plant diversity (at Level II permanent plots 2500 m² wide or at Level I circular areas 2000 m² large) is carried out in 10x10m squares: all species of trees, shrubs, grasses, mosses and lichens are recorded which vegetate on the ground and each is given its percentage coverage with respect to the surface (according to the Braun-Blanquet method). Thanks to these data, we calculate the biodiversity indexes or the differentiation of organisms according to functional, biological and ecological characters. Since 1999 the methods are standardized and the detectors are trained and calibrated to maintain the comparability of the national CONECOFOR data and the pan-European ICP Forests network.



ACTIONS AND METHODS: GROUND VEGETATION

RESULTS

One of the results of the study of vegetation in the Level I network is the assessment of plant biodiversity (indicated by the average number of vascular species on 100 m^2), produced for the first time in a representative way for the entire Italian forest territory.



Within the LIFE Smart4Action project, in the CONECOFOR monitoring areas, and in particular in the 6 study areas, some effects on vegetation concern the reduction of characteristic species in years of particular aridity or specific events (phytophagous insects in Lazio - LAZ1). Moreover, the excess of nitrogen in precipitation causes a hypersensitivity of the plants to drought: it reduces the coverage of species that tolerate cooler environments and increases the species that prefer dry habitats. Some functional characteristics of undergrowth plants, such as the need for greater photosynthetic efficiency (SLA) and lower height, are linked to unpredictability in seasonal temperature.

ACTIONS AND METHODS: ATMOSPHERIC DEPOSITIONS

ATMOSPHERIC DEPOSITIONS

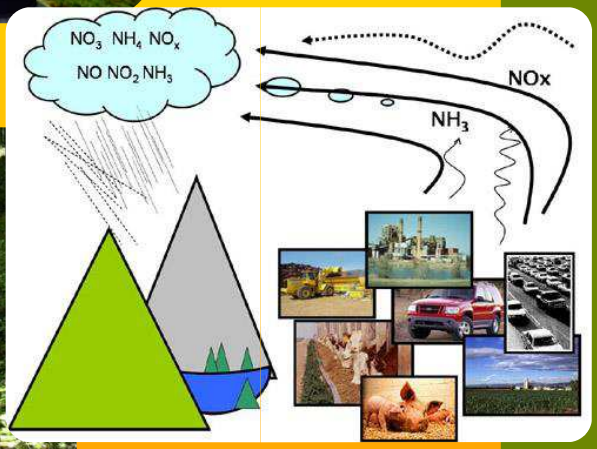
The analysis aims at studying the chemistry of atmospheric depositions using the Level II network, sufficiently wide to enable the knowledge of the phenomenon of depositions of pollutants and nutrients on a national scale and to establish the influence of these substances on the general state of forest ecosystems.

✓ Agency responsible for research: Consiglio Nazionale delle Ricerche - Istituto di Ricerca Sulle Acque – Verbania Pallanza (Aldo Marchetto).

METHODS

Atmospheric deposition (rain, snow, etc.) is collected in the study areas (deposition under the canopy) with 16 collectors formed by a funnel, a filter and a polyethylene bottle. Another three collectors placed in a clearing sample the deposition in the open field. In the beech woods, deposition flowing along the stems of 3-4 trees is also collected. In winter, deposition is collected with open cylinders. Every Tuesday, the operators send a part of the collected deposition to the CNR laboratory in Verbania for analysis, and wash the collectors with de-ionized water. In the laboratory, the pH, electrical conductivity and alkalinity of the water collected are measured, as well as the concentrations of calcium, magnesium, sodium, potassium, ammonium, nitrate, sulfate, chloride, total nitrogen and dissolved organic carbon. The analyzes are verified by internal quality control procedures (check of the ion balance and calculated conductivity) and external (ring tests at the European level).

Sampling of depositions by Carabinieri forestali

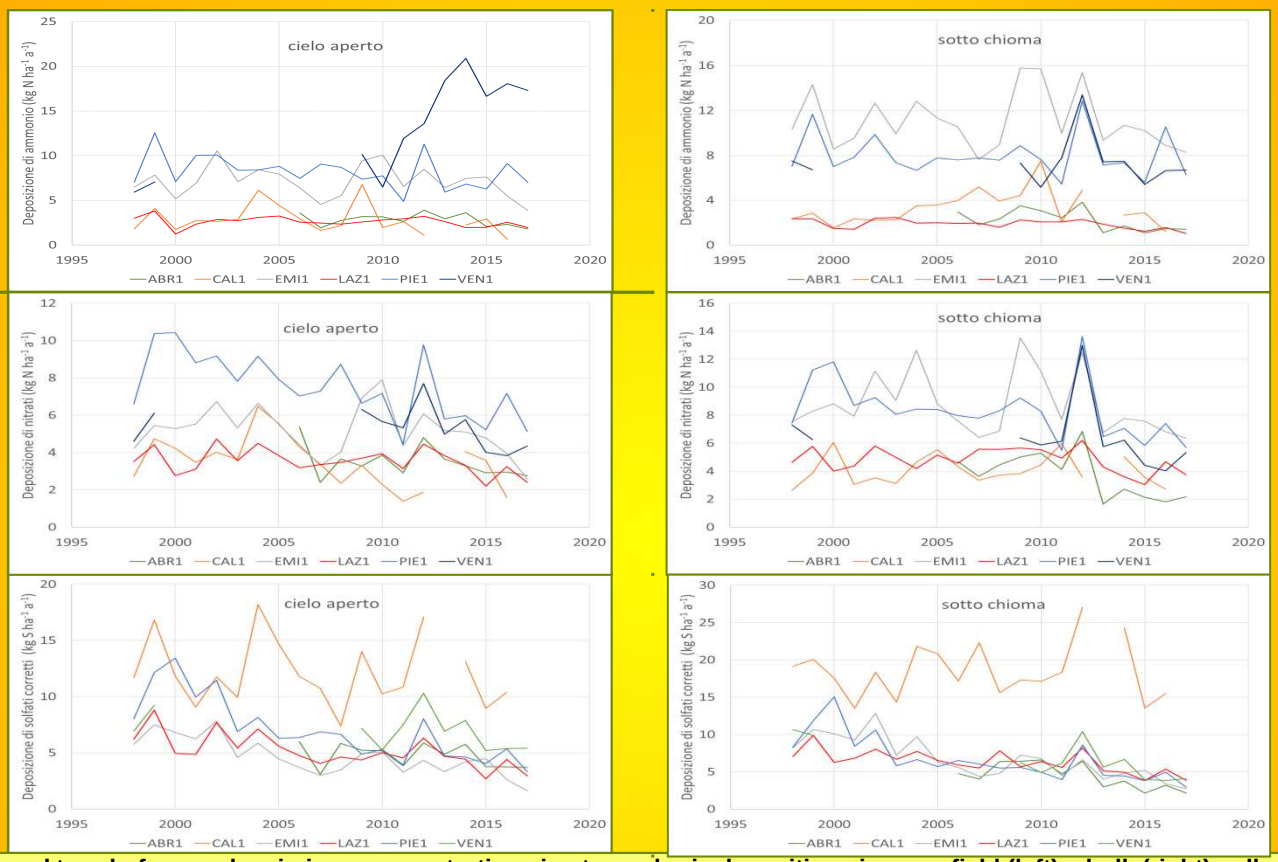


An increase in nitrogen causes the growth of trees and the acceleration of photosynthesis; the carbon moves from the roots to the wood; the decomposition slows down and the litter accumulates on the ground; increases sensitivity to pathogens and wind; The biodiversity of the understory decreases.

Bulk samplers

ACTIONS AND METHODS: ATMOSPHERIC DEPOSITIONS

RESULTS



Temporal trend of annual main ions concentrations in atmospheric depositions in open field (left) e bulk (right) collectors.

The SMART4Action project examined the trends over time of the composition of atmospheric depositions and soil solutions, verifying that the depositions of sulfur compounds, deriving from sulfur oxides emitted into the atmosphere with the combustion of coal and sulfur-containing petroleum derivatives, have decreased significantly in recent decades thanks to emission reduction measures adopted throughout Europe. This reduction has also led to a reduction in the acidity of atmospheric depositions, thanks to the stability of the depositions of elements that buffer the acidity (calcium, magnesium, sodium and potassium); the depositions of oxidized nitrogen compounds, deriving from high temperature combustion both industrial and vehicular (especially diesel engines), have shown a tendency to decrease only in recent years. Ammonium depositions, mainly deriving from agricultural and farming sources, remained stable.

ACTIONS AND METHODS: SOIL SOLUTION CHEMISTRY

✓ Agency responsible for research: University of Florence, Dipartimento di Scienze della Terra (Guia Cecchini, Stefano Carnicelli, Anna Andreetta).

SOIL SOLUTION CHEMISTRY

The analysis of soil solution chemistry represents the necessary complement to the study of atmospheric deposition chemistry. In fact, this analysis allows the measurement of the reactions caused by the atmospheric pollutants in the soil and the evaluation of the effects on it and, consequently, on the forest.

METHODS

The sampling of soil solutions is carried out on a bi-weekly basis through two different types of samplers:

a gravity sampler, which conveys water to a funnel and then into a collection vessel. This sampler is used between the two surface organic horizons ("litter" and "humus") and the underlying horizons of mineral soils;

a voltage sampler, which forms a closed system, in which a light vacuum is produced that is able to draw water from the ground into the collecting vessel.

Example of soil solution chemistry voltage sampler

General aim: explore the specific impacts of peculiar atmospheric deposition on forest soil ecosystem in Italy as representative of Mediterranean region

Specific objectives:

A)

- to evaluate **the long term trends** in soil solution elemental concentrations in relation to depositions trends;
- to capture **nutrient fluxes** into and out of forest ecosystems;

→ To individuate whether **soil acidification** is, or not, an active process

- to estimate **mineral N soil fluxes** and compare them with N depositions and critical loads

B)

→ to identify sites where the **transfer of reactive N** from atmospheric N pollution to fresh- or ground-waters is a real concern.

Scheme of the general and specific objectives in the study of the impacts of depositions on italian forest soils.

Some results from the CONECOFOR network and the SMART4ACTION project: atmospheric depositions (rain, snow) in Italy are rich in nitrogen compounds. The Level II monitoring network confirms that nitrogen depositions in Italy are among the highest in Europe;

- the nitrogen applied to the forests from the atmospheric depositions contributes with a fertilizing effect, which allows plants to grow more quickly but
- nitrogen depositions also cause imbalances in tree nutrition and probably contribute to soil acidification: they must therefore be considered pollutants;
- the decrease in sulfur polluting depositions leads to a lower acidity in the circulating solutions which is accompanied by a recovery of the functionality of the soils;
- the recovery of soil functionality is not on going at the site close to the "hot spot" of the Po Valley (EMI1), due to strong nitrogen depositions.

ACTIONS AND METHODS: SOIL SOLUTION CHEMISTRY

RESULTS

The graphs show the trends of pH and concentrations of basic cations, sulphates and nitrates in soil solutions for EMI1, LAZ1, PIE1 and VEN1 sites. *, ** and *** indicate significant decreases / increases in concentrations, while n.s. indicates that the changes are not significant. The data were obtained from the samplers placed at 0 (below the organic horizons), 20 and 60 cm deep. The map depicting Italy represents the pH trends of the solutions and highlights an increase in the pH in Alpine sites (PIE1 and VEN1) and no variation for the other two sites (EMI1 and LAZ1).

ACTIONS AND METHODS: TREE GROWTH

TREE GROWTH

The unsteady conditions of the growth medium (atmosphere and soil) and the human activity, may influence both in a positive and negative way tree growth rate and its course. The periodical measurement of tree growth is able to explain its biological response to what occurred in between.

This is why tree growth is considered a response or explanatory variable, that is to say able to detect the effect of growth medium conditions.

Tree growth highlights therefore in a sensitive way both health and vitality of trees building up the forest ecosystem.

Its repeated measurement over time (every 5 years and in the course of the year) gets a lot of information.

✓ Agency responsible for research: Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria – Centro di Ricerca Foreste e Legno; Arezzo (Gianfranco Fabbio, Giada Bertini, Andrea Cutini, Maurizio Piovosi)

METHODS

Tree radial growth is measured every 5 years on all the living trees in the plot by a metal rule at the reference height of 1.3 m. The stem circumference is determined with the accuracy of 0.1 cm (Fig.1).

The intra-annual growth is measured on a sample of 15 dominant trees per plot by tree girth bands installed on the stem at the reference height of 1.3 m. The accuracy is 0.01 cm (Fig. 2). Tree height growth is estimated by an optical device on a sample of small-sized to large-sized trees representative of tree population living in the plot. The accuracy is 0.1 m.

.

Fig. 1

Fig. 2

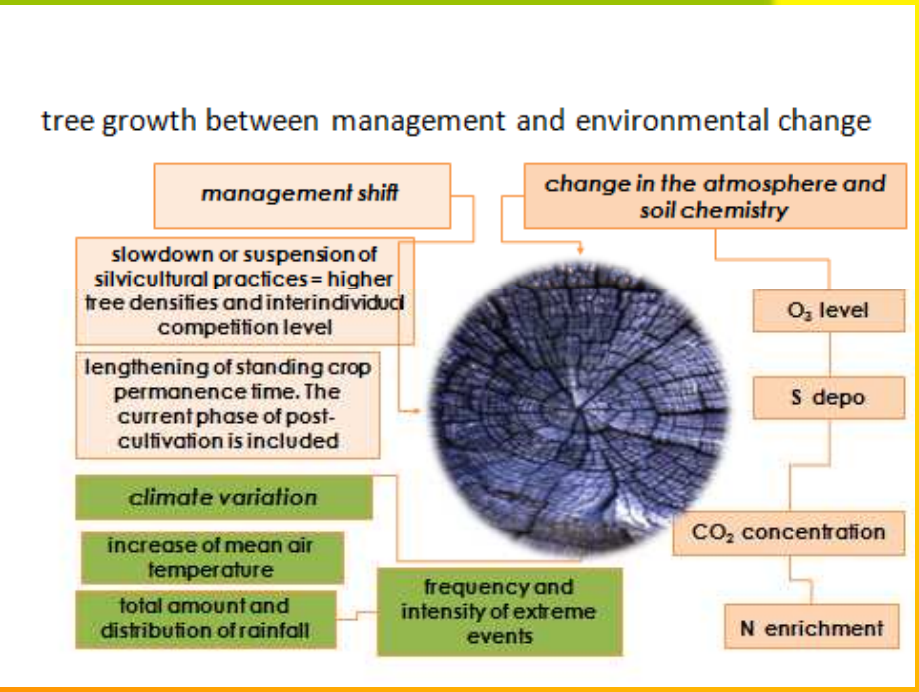


Fig. 3

Connections between the forest and the environment. The ecological meaning of tree growth. Fig. 3 shows the main variables of the growth environment (atmosphere, soil and human activity), which affect the tree growth rate and course.

ACTIONS AND METHODS: TREE GROWTH

RESULTS

Consequences on growth, evident in the short term, are those associated with the occurrence of seasonal variations in climate on a geographical, regional and local scale.

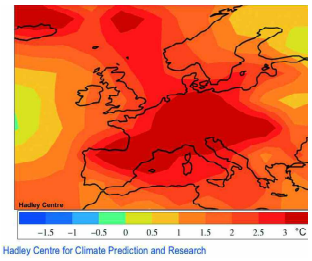
The first variation is due to the heat wave that developed at the continental level in the summer of 2003, which represented a considerable disturbance and produced a lower average annual increase of over 30% (40-50%) compared to the previous period. Greater summer temperatures associated, in 2003, with a noticeable reduction in precipitation.

The next phenomenon, on a regional scale, occurred between 2005 and 2009 on the Alpine arc, with repeated anomalous seasons for average and extreme temperatures and for precipitation quantity and interval. Also in this case, the average growth reductions recorded in the period are over 30% and mainly localized in the Alpine area, especially in coniferous forests.

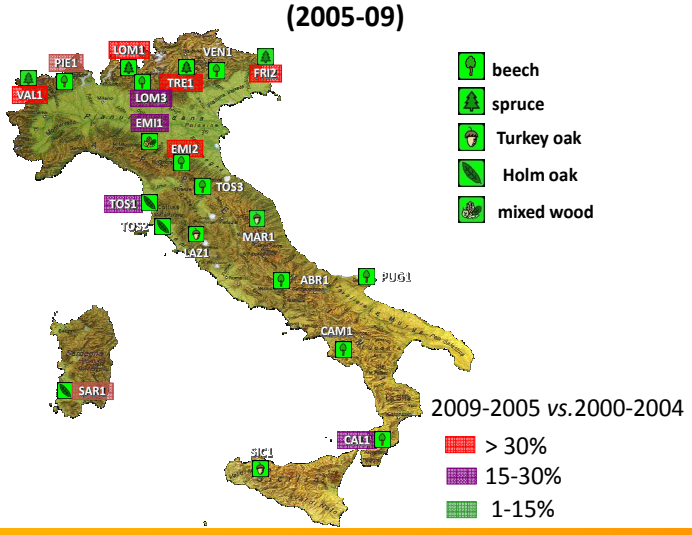
Continental heat wave 2003

Area	AT Estate 2003 (%)	PR Estate 2003 (%)
ABR1	+17	0
CAL1	+8	-49
EMI1	+20	-71
EMI2	+13	-24
FRI2	+12	+24
LAZ1	+12	-50
PIE1	+11	-28
TRE1	+14	-35
VAL1	+25	-28
VEN1	+19	-15
TOS2	+13	-68
BOL1	+31	-57
PIE2	+15	-18
PIE3	+23	-45

Macro-Area	AT Estate 2003 (%)	PR Estate 2003 (%)
Nord	+18	-30
Centro	+14	-39
Sud	+8	-49



Evidence of growth decrease in the alpine region (2005-09)



A significant deviation at the local level occurred at the plot Smart4action EMI1

CHANGE AT THE LOCAL SCALE

the case-study of Smart4action plot EMI1

The plot EMI1 is located in the Regional Park Boschi di Carrega (Sala Baganza-Parma). It was established at the beginning of the CONECOFOR programme in 1995. Twenty years later, there is clear evidence that even major phenomena may occurr in a few years time.

The plot EMI1 lies on the Southern border of the Po valley at 200 m asl. The semi-natural forest is a mixture of two deciduous oaks, European oak and Turkey oak.

European oak is more demanding of air humidity and moisture in the soil compared with Turkey oak.

The historical presence of both species at the EMI1 site, points out a physical environment well fitting the auto-ecology of both oaks as for the air temperature, the rainfall amount and regime, the water availability in the soil, the absence of prolonged drought periods in the summer time, the lack of frost in winter.

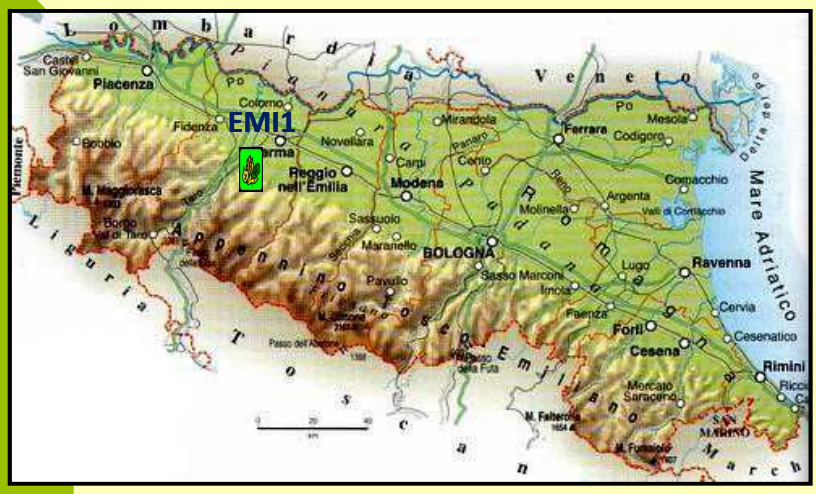


Fig. 1 Geographical location of EMI1 study area

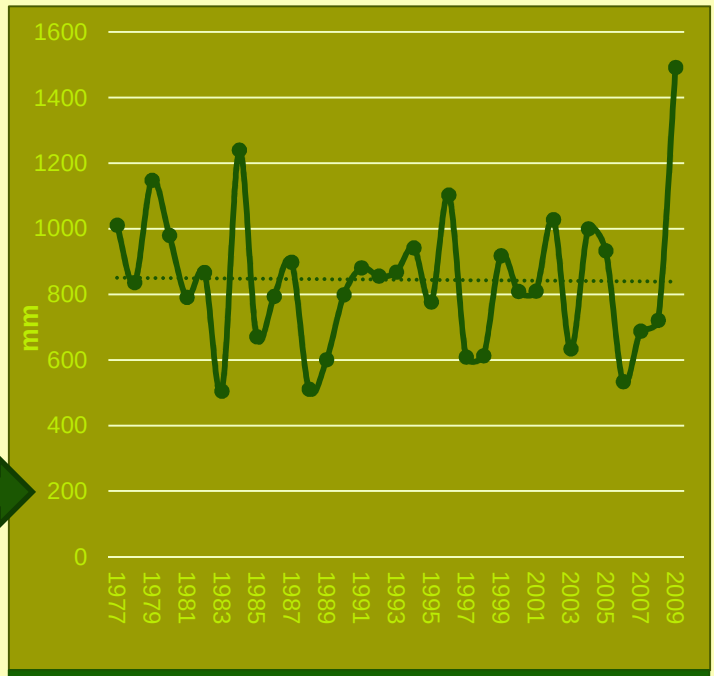
Fig. 2 e 3
The stand structure and the arrangement of devices for the collection of depositions and leaf litter.

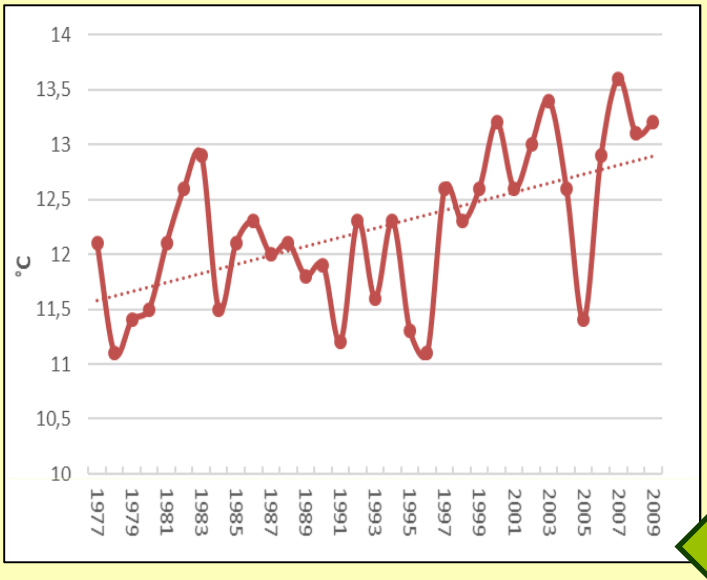
RESULTS FROM MONITORING ACTIVITY AT THE EMI1 SITE

local climate and recent deviations

Values of annual rainfall over the period 1977 to 2009 are reported in **Fig. 4**.

The interannual variability is high. Rainfall values do not show any increasing or decreasing trend over the observed period (dotted line).





The trend of mean annual air temperature over the same time span is reported in **Fig. 5.**

It shows vice versa a significant increase of mean temperature (dotted line) with a peak in the early '80 and three following peaks close to each other in the years 2000, 2003 and 2007.

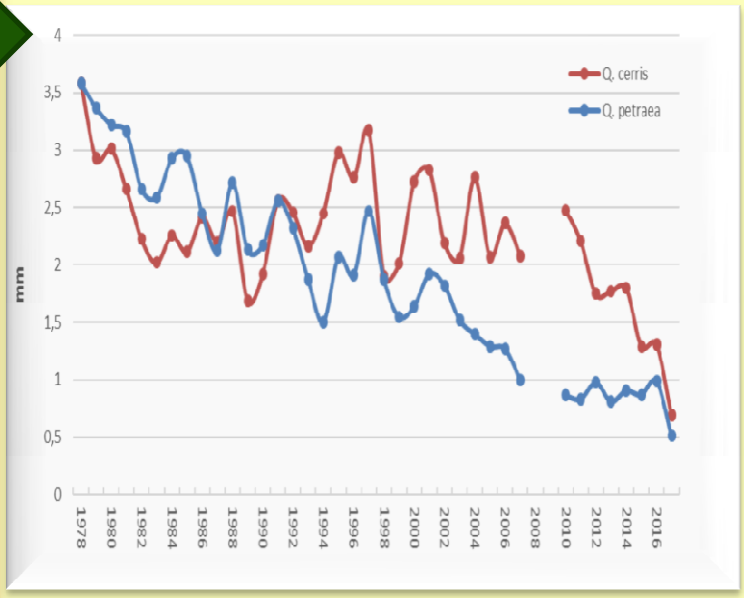
The year 2003 is well-known over Europe because of the big 'heat wave' that produced heavy stress at many forest types and the related evidence of tree growth reduction, especially where a prolonged drought overlapped the high air temperature time. EMI1 too underwent such an extreme event. Mean annual tree growth rate was reduced more than 30%.

RESULTS FROM MONITORING ACTIVITY AT THE EMI1 SITE

tree growth change and difference between the two oak species

- The trend of the annual stem diameter growth over the last 40 years is shown in **Fig. 6** for both the oaks concerned.

  Trends show the higher growth rate of European oak (Q. petraea) up to the early '90 compared with Turkey oak (Q. cerris) and the similar annual course.
- Afterwards and for the following 10 years, the specific growth rate is reversed. Close to the year 2000, the more demanding species, i.e. European oak, begin to show clear stress sympthoms. The growth rate of Turkey oak too, shows a sharp drop since 2010.
- Climate deviation, and especially the significant increase of mean air temperature, is the driver of growth reductions. High peaks as in 2003 are associated to a clear rainfall variability, but also to years of short-term, repeated, reduced precipitations (2003 and 2006).



The measuring of radial stem growth proves to be a reliable and explanatory response index of the shifted ratio between site conditions and own ecological demands of the two oak species.
Forest composition, throughout centuries of human forest use, showed the evidence of a crisis for both oaks due to recent climate deviations. This occurred on a very short time-span as compared to the life cycle of trees.

RESULTS FROM MONITORING ACTIVITY AT THE EMI1 SITE

effects on tree mortality and tree specific composition

- The above changes had an evident effect on two related phenomena: the specific tree mortality rate and the forest tree composition. Turkey oak, i.e. the less demanding species, showed a very low mortality, whilst a much higher and increasing mortality occurred for the less tolerant species for dry and hot environments (Europ. oak). All of this highlights the different biological response, specific of the own ecological requirements.
- Less than 20 years are needed to reduce the European oak presence from 60 to 30% (Fig. 7). The description of this stand today is changed to oak stand with prevalence of Turkey oak and European oak as a complementary species. That means the exact contrary of what tree composition resulted only a few years ago.
- This new definition means the change of the forest stand following the deviation of the growth medium parameters. This is the achievement of monitoring activity in a real time.
- It well describes how important may be the changes in sites especially sensitive to current deviations and how monitoring may detect such changes even over short time spans, as in the case here described.

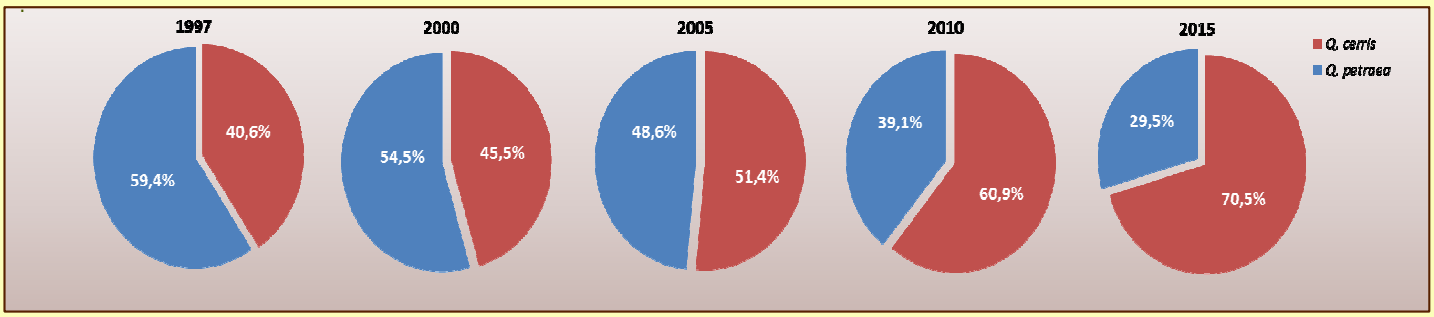
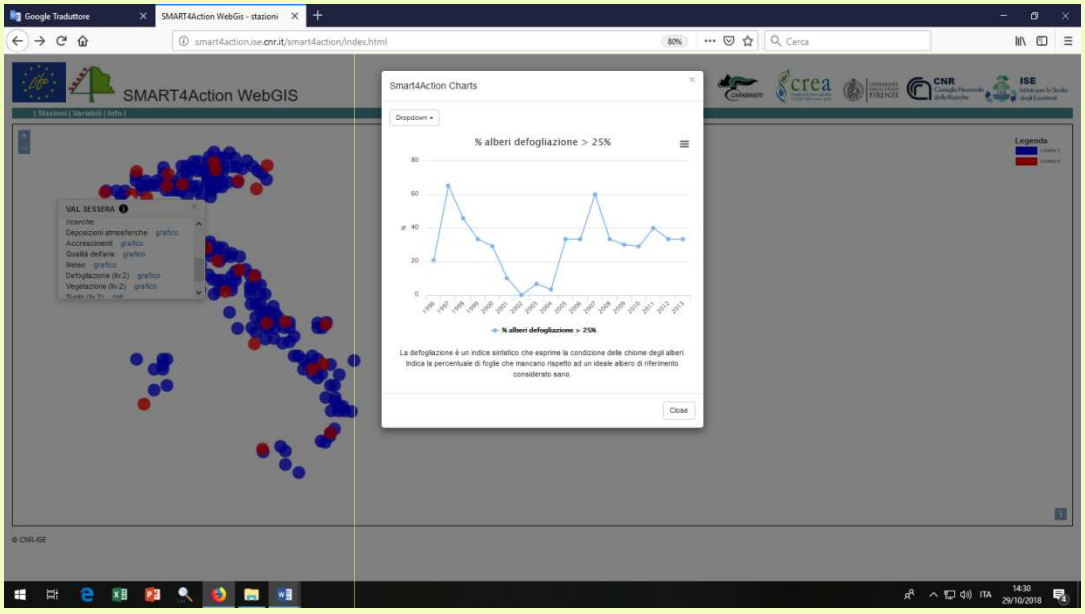


Fig. 7 Change in specific composition expressed in % of basal area. It signifies the actual occupancy of growing space by each tree species across the repeated inventories.

APP & WEB SERVICES

The Smart4Action project also aims to improve the dissemination of forest monitoring results to end users and citizens, in summary form, without the need for expert input for data interpretation. The tools used to disseminate forest monitoring data to professionals, forest managers and public authorities mainly include:

- a **WebGIS**, on line at the following URL: http://smart4action.ise.cnr.it
- web services allowing more experienced users to integrate monitoring data directly into GIS projects: Open Geospatial Consortium (OGC), Web Feature Service (WFS), ensuring interoperability and the possibility of common processing with other. The link **GetCapabilities** for this service is on-line at the following URL: http://smart4action.ise.cnr.it/cnrise-webservices/services/smart4action_wfs?service=WFS&request=GetCapabilities
- a service of **discovery INSPIRE**, enabling data research through a catalog http://smart4action.ise.cnr.it/cnrise-webservices/services/csw?service=CSW&request=GetCapabilities)



6.245 users navigated the web gis during one year (july 2017- july 2018).

LIFE SMART4ACTION FOR CITIZENS

For the youngest, the LIFE Smart4Action project has developed two applications for smartphones: one relating to data dissemination and awareness raising and one to allow citizens to contribute to extensive monitoring and to report and / or share images of forest damage with other users. possibly detected in the field. Considering that the possibility of using applications in the forest can be hindered by the absence of network coverage, the database is completely included in the application. The applications available for Andorid and iPhone have been uploaded to Goggle Play and iTunes.

Link to the project web site

Download the APPs of Smart4Action:
•"Smart4Action Citizen Involvement"
•"Smart4Action Reporting"

ANDROID APP ON Google play

Available on the App Store

APP & WEB SERVICES

LIFE SMART4ACTION FOR CITIZENS

DISSEMINATION

The Decree n. 177 of 19 August 2016 states the merging of the National Forest service into the Carabinieri Corps and assigns to it the relevant functions, such as the study of forest resources, the Forest Inventory, the monitoring of the health status of forests, the controls on the level of pollution of forest ecosystems. Monitoring activities are assigned to the Command for the Protection of Biodiversity and Parks, which carries them out through its territorial structures coordinated by the Studies and ProjectsOffice.

The LIFE Smart4Action project, started in 2014 under the coordination of the National Forest Service, is involved in this transition. Studies and Projects Office of the Carabinieri Command for the Protection of Biodiversity and Parks becomes the Coordinating Beneficiary of the project.

This explains why citizens have known the LIFE Smart4Action project under two different uniforms ...

Corpo Forestale dello Stato

CARABINIERI

LIFE SMART4ACTION FOR CITIZENS

The LIFE Smart4Action Project has, among its main objectives, the design of a new forest monitoring system to reduce costs and at the same time to improve communication and involvement of citizens in activities, through a participatory process. The project has therefore turned to citizens, schools and interested categories to share and disseminate information on the mechanisms that regulate forest ecosystems and the threats that affect them. In this way, it encourages an increase in awareness regarding the protection of the environment and the monitoring of forests as a tool for their sustainable management and their conservation as a common good.

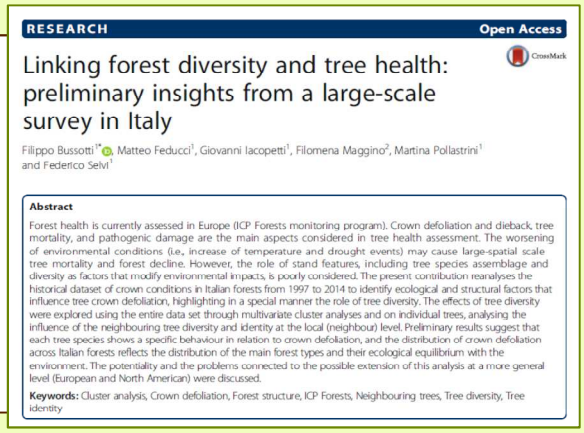
Dissemination activities

- Organization of events and dissemination days at study areas, workshops and conferences;
- Installation of explanatory panels at the entrance to the Smart4Action areas, inviting visitors to send a selfie to the coordinator;
- Creation of informative leaflets easy to read even for non-professionals;
- Distribution of gadgets.

INFORMATION

Information activities through:

- Web sites and interactive applications
  - www.carabinieri.it/arma/oggi/organizzazione/organizzazione-per-la-tutela-forestale-ambientale-e-agroalimentare/progetti-life
  - smart4action.ise.cnr.it/smart4action/
  - applications "Smart4Action Citizen Involvment" e Smart4Action Reporting
- Creation and dissemination of information factsheet on monitoring at Regional and National Level
- Production of scientific papers and dissemination literature (e.g. the "Manual for Citizens").



LIFE SMART4ACTION FOR CITIZENS

PARTECIPATION

6245 webGIS users in one year 7/2017-7/2018.

470 replies to the questionnaire concerning data use for different forest monitoring stakeholders categories.

Meeting and show at Expo2015, conference dedicated LIFE project 2018, meeting with FAO and other national and international organizations.

About 600 people (including children) partecipated to the study-day events at the Smarft4Action monitoring plots.

We asked visitors of the Smart4Action areas to send us a picture of their trip ... we have received about 100 selfies and others keep coming!

LIFE SMART4ACTION FOR CITIZENS

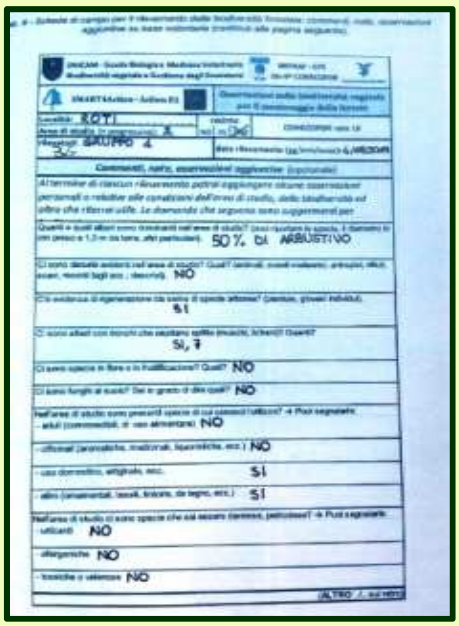
CITIZEN SCIENCE

Increasingly, projects funded by European Union, show actions that appear to involve the public, passionate but not expert, in the field observation and collection of data related to the natural world, collaborating with professional scientists. It is the "Citizen Science", the science of nature applied to citizens, called to provide reports autonomously through web services and dedicated smartphone applications and to participate in real surveying campaigns aimed at fueling official databases.

As part of Action D1 of the LIFE Smart4Action project, several dissemination events took place in the field, three of which were intended for Citizen Science activities for young people: elementary and middle school students who, opportunely guided in the field, experimented the ICP Forests - CONECOFOR surveys, acquiring greater awareness of environmental dynamics and sensitivity to behaviors that are more respectful of nature.

On 4 May 2017, at the CONECOFOR Level II MAR1 area (Matelica, MC) a field trial was held for the survey of forest biodiversity, for 50 high school students. The students, guided by the professors of the University of Camerino, followed the lessons in the woods, testing with the compilation of the ground vegetation survey form.

1ST



SMART4ACTION FOR CITIZENS

2 nd

On October 17, 2018 at the CONECOFOR Level II CAL1 area (Giffone, RC), 70 primary school children explored a beech forest served with study and observation stations directed by researchers, using the "Citizen's Manual for observation of the conditions of the trees, their growth and forest biodiversity ". The climatic conditions favorable to the beech (fresh, humid) and the muddy path have made the experience for the kids more concrete and true.

3 rd

On October 24, 2018 at the Level II PIE1 CONECOFOR area (Val Sessera, BI), 60 primary school children were led by researchers through the experience of Citizen Science.

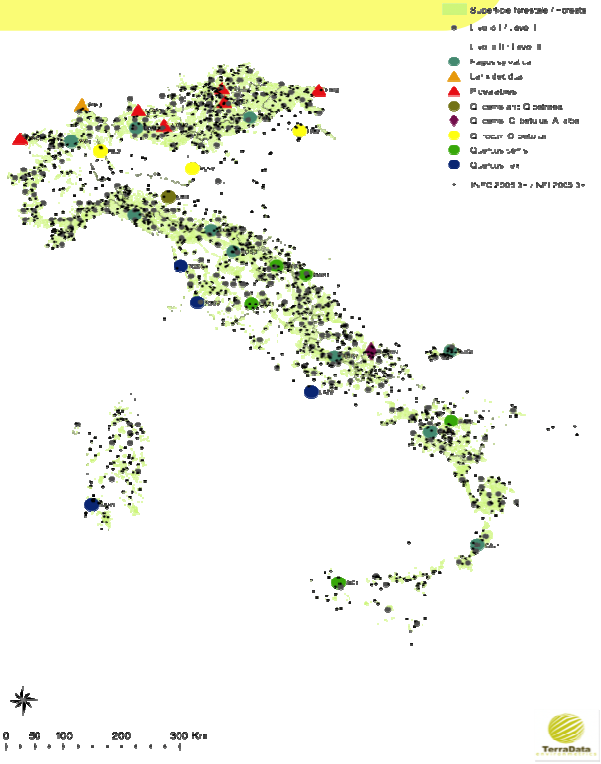
CITIZEN SCIENCE

PROJECT RESULTS
The new monitoring system of italian forests

The monitoring networks of forest conditions in Italy

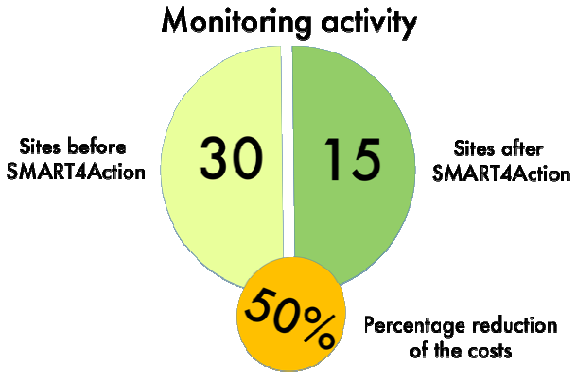
The continuous monitoring of forest conditions in Italy is assured by two networks of survey areas, namely Level I and Level II. The first one is useful to assess forest health, and it has about 260 survey areas; the second one, which constitutes the CONECOFOR (Forest Ecosystem Control) program, is based on 31 survey sites and aims to study more in detail our forests. A third denser network (301,000 photo-interpreted points; 6,865 survey sites with quantitative measures on the ground; 1,499 sites with carbon estimation surveys) is that of the National Inventory of Forests and Carbon Forest Reservoirs (INFC). Level I, Level II and INFC provide essential data in the context of international agreements ratified by Italy (e.g. long-distance pollution; Kyoto protocol).

✓ Agency responsible for research: TerraData environmetrics (Giorgio Brunialti, Luisa Frati, Marco Calderisi, Marco Ferretti, Valerio Amici, Federico Zuliani)



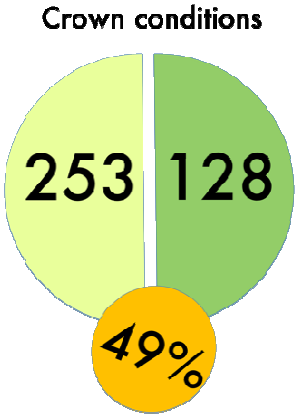
Spending review and networks optimisation

The LIFE SMART4Action project aims to redesign the monitoring networks to ensure their financial sustainability despite budget cuts, reducing the annual management costs by 30%, without losing their scientific validity and information value. To achieve this goal, two parallel paths were undertaken. The analysis of the time series of the previous data of the monitoring networks and the results of the surveys carried out in the 6 test sites of the project, allowed to optimise the number of monitoring sites, the frequency and distribution of activities and to maximise the collected information, identifying areas where monitoring and modeling can be integrated. The detailed analysis of the costs of each activity made it possible to identify the phases where it is possible to reduce the sampling or detection effort, and consequently the costs. The synthesis of the results of this process, for each activity of the Level I and Level II networks, is summarized in the following pages according to the diagram shown here on the right.



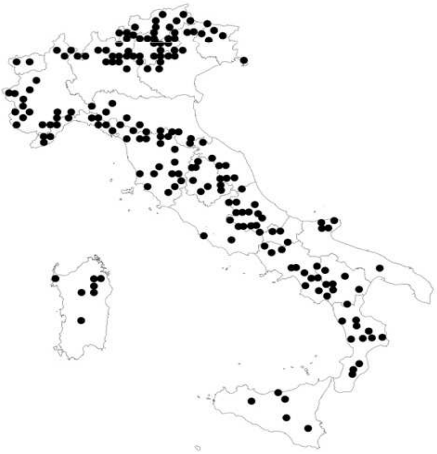
PROJECT RESULTS
The new monitoring system of italian forests: the Level I Network

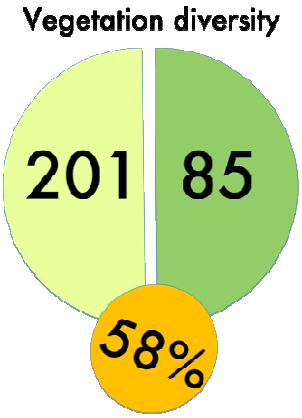
Crown conditions
Crown conditions is one of the Criterion 2 indicators of sustainable forestry. The health state of the tree crown is measured annually by means of the defoliation degree of the crown of the trees, the discoloration of the leaves, general symptoms of decline, and biotic and abiotic agents of damage.



The new design provides for a reduction from 253 (15x18 km) to 128 (30x18 km) sites. The continuity of the historical data series is assured with an acceptable margin of error.

Vegetation diversity
The diversity of vascular species is an important, robust, economic and easily understandable indicator for assessing vegetation diversity, which is a key component of forest biodiversity.

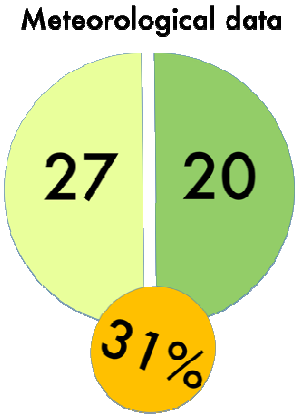




The new design allows to reduce 60% of the sites, maintaining a 95% representation of the species richness, although rare species are often potential indicators of the functioning of the forest ecosystem. The simulations performed on the Level II data showed that it is not possible to reduce the number of the sites of this network.

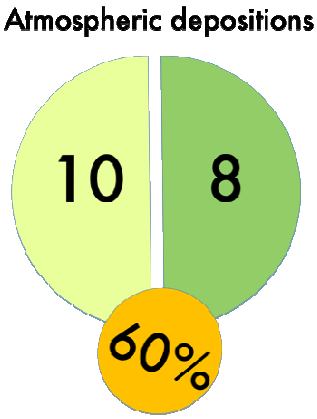
PROJECT RESULTS
The new monitoring system of italian forests: the Level II Network

Meteorological data
Meteorological data are essential for predicting forest and agricultural productivity potential, for assessing the extent of climate change and addressing the problems associated with it. The data collected by the meteorological stations installed in the permanent sites, through the analysis of the time series, have the potential to broaden the understanding of the long-term climate dynamics.



The new network design is based on a lower number of sites (20 out of 27), but the reduction is due only to sites externally managed free of charge. The 30% reduction in annual costs was achieved thanks to the update of the meteorological stations with a remote management and acquisition system of the climate data.

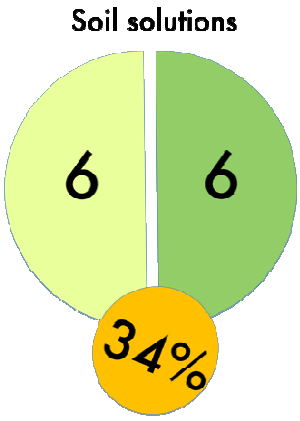
Atmospheric depositions
This activity concerns the analysis of atmospheric depositions of pollutants and nutrients (N, S acidity, other anions and cations) and of tropospheric ozone concentrations (O_3) with the aim of quantifying the inputs of pollutants and other elements that the forest ecosystem receives during the year.



The new scheme maintains the same sampling frequency (weekly) and almost the same number of sites, but it provides for the analysis of a composite sample (on a monthly basis) instead of 4 separate replicates.

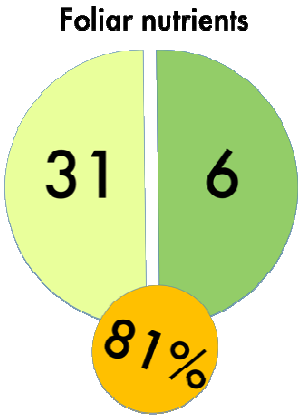
PROJECT RESULTS
The new monitoring system of italian forests: the Level II Network

Soil solutions
The chemistry of soil solutions is an important indicator of sustainable forest management (Criterion 2, forest health and vitality), since it reflects the variability of the chemistry of precipitations, and it provides early information on possible long-term effects on soil.



The new design has the same number of sites, the same sampling frequency and number of replicates, but it is based on the analysis of a composite sample instead of 5 separate replicates. Moreover, with respect to the list of ICP Forests parameters, it is planned not to detect DOC, Al, Fe and Mn.

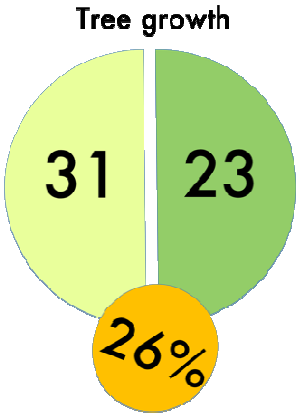
Tree mineral nutrition
The nutritional status of the tree crown is a very important indicator of sustainable forest management (Criterion 2) as it provides data on the presence and amount of the main nutrients (N, P, K, Ca, Mg) in the plant tissues, giving a key information on its health state.



The new design provides for a reduction in the number of sampling sites, compared to the initial Level II network structure, keeping those in common with atmospheric depositions and soil solutions, to ensure the continuity of information on the possible correlation among these indicators.

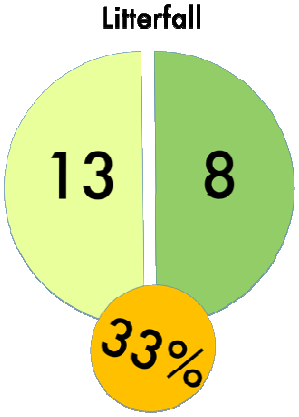
PROJECT RESULTS
The new monitoring system of italian forests: the Level II Network

Tree growth
The measure of tree growth provides interesting information from both an economic and ecological point of view, especially to assess the response of the forest to environmental stresses and endogenous processes of evolution. The evaluation of forest productivity is also useful for estimating the role of forests in removing carbon dioxide from the atmosphere.



The new scheme ensures the representativeness of the main forest types at the national level, while maintaining the information value of the network unaltered.

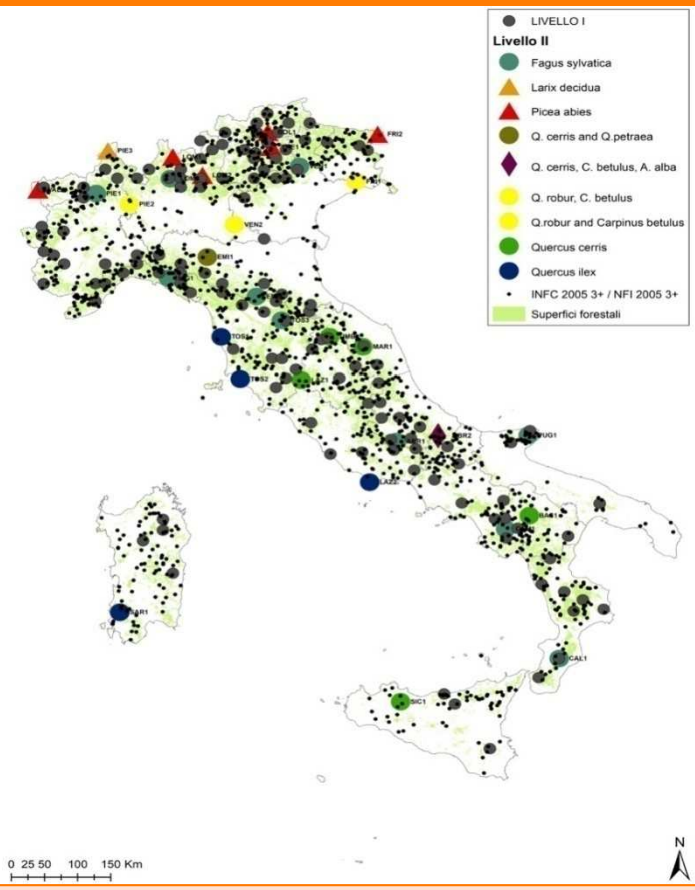
Litterfall
The annual production of litter (the set of leaves, flowers, fruits and branches produced annually by trees) is a useful indicator to monitor the properties and productivity of the tree crown. It is made by collecting the material that falls from the trees through appropriate samplers positioned within the sampling sites.



The reduction in the number of sampled sites ensures the continuity of the time series with an acceptable margin of error.

PROJECT RESULTS

The new monitoring system of italian forests: the design of the new network



The adoption of the new Italian forest monitoring system, proposed by SMART4Action, will allow an overall reduction of costs of 46% compared to the previous network structure, while guaranteeing the scientific validity and the informative value of the results.

The new Level II Network

●: sites after Smart4Action; ○: supplementary sites before di Smart4Action

Name of Location	ABR1 Selva Piana	BAS1 Monte Grosso	CAL1 Piano Limina	CAM1 Serra Nuda	EMI1 Bosco Carrega	EMI2 Brasimone	FRI1 Bosco Boscat	FRI2 Tarvisio	LAZ1 Monte Rufeno	LOM1 Val Masino	MAR1 Roti	PIE1 Val Sessera	PUG1 Foresta Umbra	SAR1 Marganai	SIC1 Ficuzza	TOS1 Colognole	TRE1 Passo Lavazè	UMB1 Pietralunga	VAL1 La Thuille	VEN1 Pian di Cansiglio	ABR2 Rosello	LAZ2 Monte Circeo	LOM2 Giovetto	LOM3 Valsassina	TOS2 Cala Violina	TOS3 Vallombrosa	BOL1 Renon	LIG1 Monte Zatta	PIE2 Bosco Vedro	PIE3 Devero	VEN2 Bosco Fontana
Crown conditions	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Ground vegetation	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Meteorology	●		●	●	●	○		●	●	●	●	●	●	●	●	○	●		●	●	●	●	○	○	○	●	○		●	●	○
Atmospheric Depositions	●		●		●				●			●				○				●					○	●					●
Soil solution chemistry	●		●		●				●			●								●											
Foliar Nutrients	●	○	●	○	●	○	○	○	●	○	○	●	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○
Tree growth	●	○	●	●	●	●	○	●	●	●	●	●	●	●	●	●	●	○	●	●	○	●	○	●	●	●	●	●	○	○	○
Litterfall	●		●	○	●			○	●			●	●				○		○	●						●	○				

NOTES

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