Report of COST Short-Term Scientific Mission

An user friendly application to select the best tree species in urban areas

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1 Introduction

The natural ecosystem, which involves urban green and agro-natural areas that the city has incorporated, is a precious capital that a city should consider. A good environmental management of the city should not overlook this heritage and, specially, should not forget the alive character of ecosystems, made up of interdependent parts, of which the city needs to ensure a good standard of healthy living.

The management of green areas is divided into a mosaic of different aspects, which requires a correct combination, to gain the maximum effectiveness and achieve the pre-set targets. A careful selection of species is one of the most important and problematic issues, that should be based on the awareness of the needs and reachable benefits.

In support of the technicians that manage urban green areas, there is a need of a flexible information technology platform that summarizes the characteristics of different tree species and dynamically collects knowledge on this issue, in a user-friendly format.

The STSM was designed to develop, taking contacts with other European research institutions, a web application to evaluate the urban tree ecosystem services at a European level.

That goal is reached mainly by searching information to qualify the potential benefits of each species, by collecting data and methodology from different institution databases and their research results.

2 Methods

Throughout the STSM, the priority was given to a research of information sources. The data was collected both directly, mainly from plant databases (in internet or published papers) including morphological and physiological characteristics of European tree species usable in the application without any adapting procedures, and indirectly, making contact with institutions holding data or projects on the estimate of urban tree value and benefits, and taking advantage from networks among different research bodies.

In order to present the project objectives, at the beginning of the STSM it was presented to mostly interested researchers of CIEMAT (host institution). The presentation, supported by slides summarizing the aims and the material already produced, found particular interest of several participants, with whom interactions for possible collaborations were established.

From that experience and the check of the quality and quantity of available data, different lines of development have arisen, which involve the collection and analysis of data relating to:

1. climatic conditions and pollutant concentrations for main European cities;
2. allergenic potential of several tree species;
3. emission BVOC (Biogenic Volatile Organic Compounds) of tree species;
4. removal of air pollutants (gaseous and particulate).

2.1 Locality information

While developing the first point mentioned above, databases freely provided by European Climate Assessment & Dataset (ECA&D)[1], European Environment Agency (EEA AirBase)[2] and GeoNames[3] were identified.

From the last database the information of 5165[4] EU cities has been extracted. In addition, the population was limited to minimum of 150,000 inhabitants, introducing some exceptions for municipalities with distinctive characteristics, and trying to represent almost all the different urban climate conditions in Europe.

From other databases, data were extracted of measurements carried out by 6830 monitoring stations of air pollutants and 8,017 weather stations, limiting the data to all the measurements taken after 2005 or at least five years after 1995.

Values were grouped by city and weighted according to the distance and difference of elevation between the station and the centre of the city using the following equation:

$$\left(1 - {}^{d}/_{25}\right)^{2} \cdot \left(1 - {}^{h}/_{75}\right)^{4}$$

where: h is the height calculated as the absolute difference between the station and city elevation
d is the distance estimated with the equation:

$$2\tan^{-1}\left\{\sqrt{\sin^2[0.5(lat2 - lat1)] + \cos(lat1) \cdot \cos(lat2) \cdot \sin^2[0.5(lon2 - lon1)]}\right\} \cdot r$$

(*lat* = latitude; *lon* = longitude; *r* = earth radius)

It was also given a preference to stations directly linked to the city, bearing its name.

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[1] European Climate Assessment & Dataset (ECA&D) project is the benchmark of climate data node in the Regional Climate Centre (RCC) for WMO Region VI (Europe and the Middle East) since 2010.
Klein Tank, A.M.G. and Coauthors, 2002. Daily dataset of 20th-century surface air temperature and precipitation series for the European Climate Assessment. Int. J. of Climatol., 22, 1441-1453.
Data and metadata available at http://www.ecad.eu

[2] AirBase is the European air quality database maintained by the EEA (European Environment Agency) through its European topic centre on Air pollution and Climate Change mitigation. The EU Member States are bound under Decision 97/101/EC to engage in a reciprocal exchange of information (EoI) on ambient air quality. Data freely available for non-commercial research at www.eea.europa.eu

[3] GeoNames is a geographical database available for download at www.geonames.org
Data sources licensed under a Creative Commons Attribution 3.0 License.

[4] The values in the report are approximate, since the databases are subject to continuous updating and correction.

2.2 *Low allergenicity*

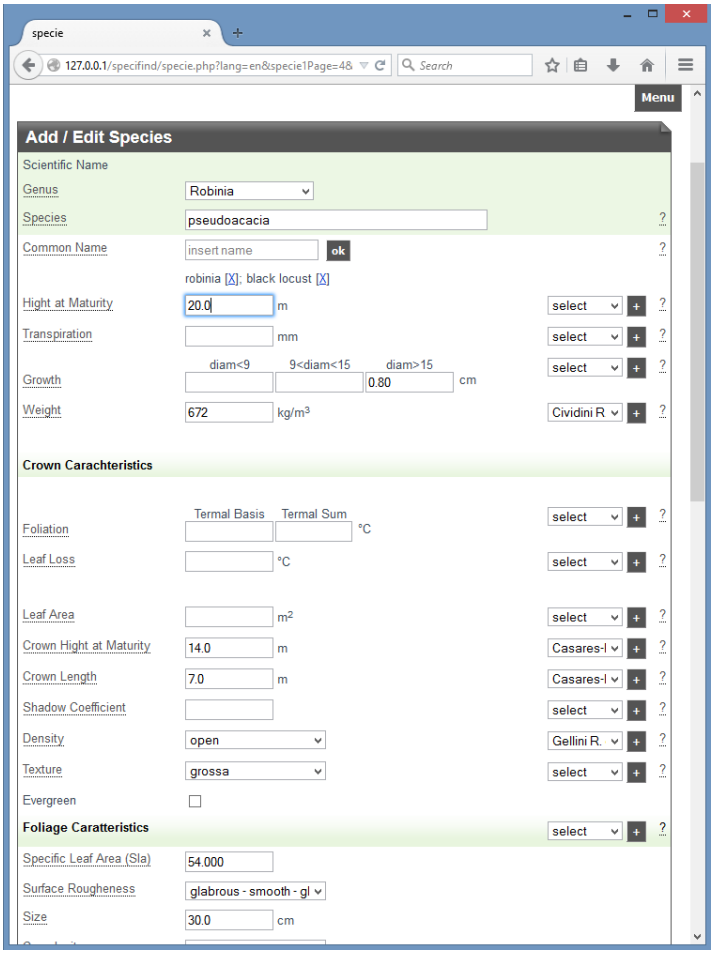
For the estimation of the allergenic potential, the index of allergenicity[5] was identified as the best solution. The index is calculated based on a scale of allergenic potential, strategy of pollination and length of the pollen season and crown height.

To obtain the data required, the Department of Botany, University of Granada, was contacted and they kindly provided the parameters for estimating the index for the main European species. The received data, not published yet, will be kept confidential until their official publication. The results obtained were compared with those reported in the study of the project "Citree"[6], without highlighting particular problems.

2.3 *Emission BVOC*

To respond to the point three, several papers[7] indicated by researchers of CIEMAT (ES), IBAF-CNR (IT) and CNR-IBIMET (IT) were collected. From these papers, isoprene and monoterpene standardized emission factors per unit of leaf dry mass were obtained for different tree species.

The data from different sources were compared and the ones reported more often were selected, accepting a reasonable tolerance and giving preference to the measures carried out more recently and on a wider sample population.



[5] Cariñanos P., Casares-Porcela M., Quesada-Rubio J.-M., 2014. Estimating the allergenic potential of urban green spaces: a case-study in Granada, Spain. Landscape and Urban Planning, 123: 134– 144

[6] Citree is an web application for classification of urban tree location types considering human needs and site conditions for trees. Department of Forest Science, Professorship in Forest Biometrics and Forest System Analysis, Technische Universität Dresden.
https://141.30.134.137/citree/database.php?language=en#

[7] e.g. of database with emission list: Benjamin M.T., Sudol M., Blochi L., Winer A.M., 1996. Low-emitting urban forests: a taxonomic methodology for assigning isoprene and monoterpene emission rates. Armospheric Ewironmenf 30 (9): 1437-1452
Keenan T., Niinemets Ü.,Sabate S., Gracia C., Peñuelas J., 2009. Process based inventory of isoprenoid emissions from European forests: model comparisons, current knowledge and uncertainties. Atmos. Chem. Phys. Discuss., 9: 6147–6206

In addition, a research was started to integrate a model for estimating BVOC emissions for the selected city instead of carrying out a simple comparison with the standard emission. The estimate should be based on the equation proposed in the model UFORE[8], that takes into account the temperature and PAR (Photosynthetically Active Radiation) as main parameters.

2.4 Removal of atmospheric pollutants

This last point is certainly the most critical issue to address. For this reason, a particular attention was focused on finding information to correct and validate a the used methodology for estimating of air pollutant removal (CO, NO_2, O_3, SO_2, PM10).

The application is based on the model proposed by the application Species Selector within the i-Tree[9] software suite, where the estimate is based on empirical mean values, derived from data recorded in the United States urban areas.

During the STSM, an important effort was focused on collecting information from different articles to validate the parameters of the equation related to the(average pollutant removal and the parameters that characterize each species: LAI, transpiration and morphological characteristics, like leaf complexity, size, roughness and crown density and texture. The aim was to increase the model precision without losing consistency.

Other models were also studied to evaluate their possible application in this project, with a focus on the Dry Deposition module of the EMEP MSC-W model[10]. The main objective was to search for a correlation between the specific species transpiration and the relative parameters in the model.

2.5 Other data collected

In addition to the main working line, information was collected on other attributes about urban forests, in particular regarding the phenology of the different species[11], the growth rate, the characteristics of the canopy (Leaf Area, density, texture, ...), and the weather-climatic and soil influence and limitations, paying attention to the spatial scale and limiting conditions.

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[8] The UFORE model - Urban FORest Effects - was developed in the late 90s by researchers of the Northeastern Research Station (NRS) of the USDA (Syracuse). This model is currently available through i-Tree-ECO tool, within the i-Tree software suite, to estimate urban forest structure and ecosystem services and benefits.
More information at www.nrs.fs.fed.us/tools/ufore/

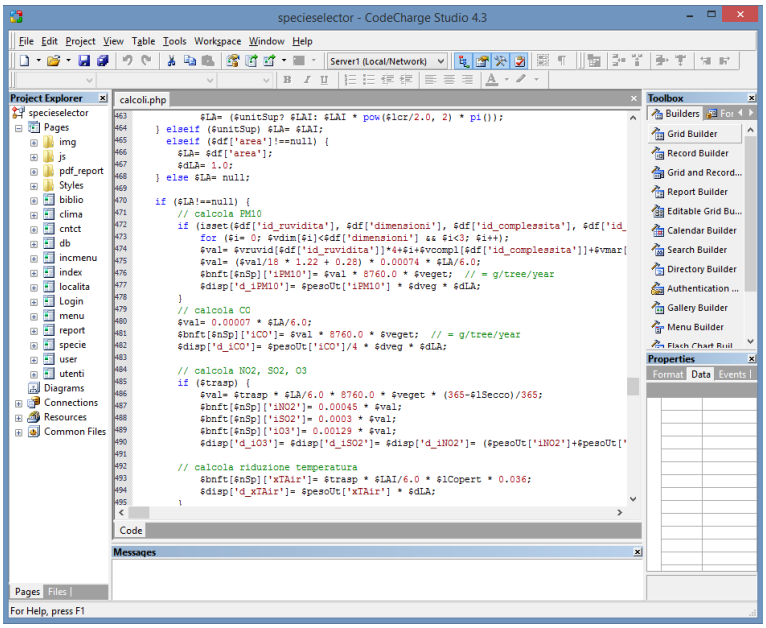
[9] i-Tree is a state-of-the-art software suite from the USDA Forest Service that provides urban forestry analysis and benefits assessment tools. www.itreetools.org

[10] EMEP -European Monitoring and Evaluation Programme- European program of science based on political leadership, has been created under the Convention on Long range Transboundary Air Pollution (adopted in Geneva, November 13, 1979).
EMEP MSC-W -Meteorological Synthesizing Centre West- is a semi-empirical model that estimates dry deposition, assuming the absorption of gaseous pollutant or downfall of the particulate on a uniform canopy.

[11] Thermal basis and thermal sum needed for foliation and leaf loss temperatures, data needed to define the length of the period of leaves presence.

3 Main results

As stated in the objectives of the project, during the STSM the application of tree selection based on desired functional benefits was expanded, both on the database and on the functions, updating the whole developed model.



The functions integrated into the web platform are implemented in PHP, using the software NotePad++, YesSoftware CodeCharge Studio and CodeLobster PHP, and are supported by the MySQL database.

All pages are designed to operate multilingual. Currently it is possible to operate in English and Italian languages. During the STSM, form English tips were compiled too.

The application is designed and developed with the idea of providing maximum flexibility to subsequent improvements, which may include additions of features, corrections and improvements of the calculation equations, optimization of functions, etc. .

The functions of the calculation of the rank are structured for the ordinary management of several species and provide the possibility to include specific optimization functions for the database accesses to obtain high speed in generation of the results report.

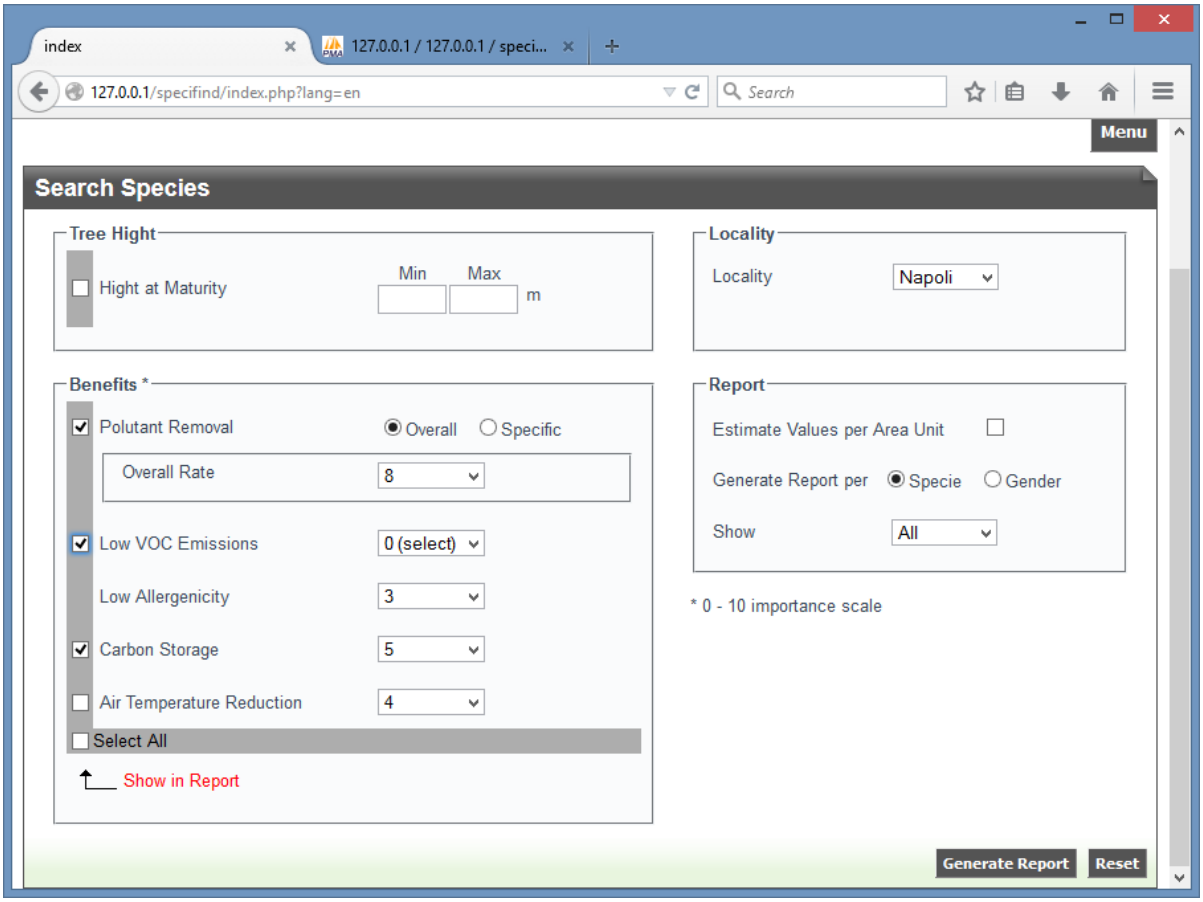
The database of the application at the moment has been integrated with:

- The climate values[12] and concentration of air pollutants (CO, NO2, O3, SO2, PM10) of more than 270 European cities, representative of the various urban environments in the EU.
- The parameters for the classification of low allergenicity of more than 80 species and 20 genius of common urban trees in EU.
- Values of standardized emission BVOC (isoprene and monoterpenes) for over 100 species.
- Estimates of the value of transpiration.
- Several parameters characterizing the species, specially linked to soil and climate limits, using data provided by the database of the project "Citree", of the Dept. Forest Biometry and Systems Analysis of Dresden University of Technology.
- Morphological leaf characters, including roughness, amount of waxes, and other physical aspects, carried out by CNR-IBIMET.

The tools programming code has been mainly modified on the function to estimate the gaseous and particle pollutants removal.

[12] The climate data include: the annual mean of temperature, the monthly mean of daily minimum and maximum temperature, the annual and monthly precipitation sum, the Penman-Monteith potential evapo-transpiration and the growing season length. All the index are retrieved from hourly data measures.

Currently, the application has not been published yet on the internet, waiting to finish the data processing and the correction of all the software functions. It is expected to finish processing and thus make publicly available the application within a few weeks. The tool will be included in the Greeninurbs website (www.greeninurbs.com) with integration of pages structure and link on the main menu.



4 Future activities

Although the important contribution of the activities held during the STSM, the project of the application development is not intend to be concluded, as there are still many aspects to be improved and some goals not fully achieved. So we plan future collaboration with the research institution, in particular with CIEMAT (hosting institute), to exchange useful information and data to integrate the values.

It is also planned to carry out a project inside a CIEMAT programme, in order to compare the results obtained with the application with measurements carried out in an experimental area and a subsequent creation of different scenarios, taking advantage of the application, for the evaluation of the pollutants removed by trees in the hypothesis of having species different from those currently present.