Project of Strategic Interest NEXTDATA

Deliverable D1.7.2: WP1.7 activities in 2014

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D1.7.2.1: Mountain butterflies and mammals as ecosystem indicators of climatic changes

A) Spatial analysis of a geo-referenced checklist of butterflies in the Himalayas (Bhutan).
A checklist of butterflies of Bhutan has been compiled through the collection of field and bibliographic information. Subsequently, all locations of the data collection have been geo referenced, obtaining a total of 1,740 records for 448 species in 100 locations. Using R scripts, the following data have been analyzed:
- collecting locations, closest to a predefined threshold (10 km), in order to obtain lists of species also using sporadic data collection;
- number of records and species according to altitude (altitudinal gradients in species composition);
- geographical distribution and altitudinal biogeographical classes (species with eastern distribution, Himalayan, Palearctic and widespread) that characterize the lepidoptera fauna of Bhutan.

B) Determinants of species richness in high altitude ecosystems: the importance of the island effect and its temporal evolution.
The response of a selected group of taxa (*Lepidoptera: Papilionoidea, Coleoptera: Carabidae* and *Orthoptera*) to the spatial structure and to the temporal evolution of the Holocene Italian-mountain ecosystems has been estimated. The starting point for the collection of information distribution was CKmap version 5.3.8. An approach based on Voronoi tessellation has been used. This made it possible to georeference a total of 102,252 records (*papilionoidei* 69926, 12960 and 19366 *carabids Orthoptera*). The high altitude ecosystems were selected using a mapping of ecosystems at national scale. By means of an Indicator Species Analysis, the species that showed a particular affinity for these ecosystems have been identified (*papilionoidei* 68, 56 and 31 *carabids Orthoptera*, respectively 7906, 1794 and 2633 records). In order to estimate the temporal evolution of the individual islands during the Holocene (the last 11.000 years), a scale model of the millennium using the same methodology used by Marta et al., 2013 (*Journal of Biogeography*, 40, 1767-1779) has been developed.

C) Study of the change of the trophic niche of Barn Owl in relation to the potential distribution of its prey and environmental variables such as latitude and altitude using a data set based on bibliographic data of small mammals in Italy by barn owl pellets (*Tyto alba*).
It was performed a research online (ISI Web of Knowledge and Google Scholar) to obtain bibliographic sources from which to draw data on the analysis of the diet of the barn owl (*Tyto alba*) through the use of owl pellets (regurgitation of undigested parts its preys). From this research, we got about 1300 results, however only 50 of them have been proven potentially suitable. The reasons for the exclusion of the items were as follows: (i) the absence of geographical indications (location names) (ii) Cumulative data relating to different roost, and (iii) the absence of tables with the frequencies of individual prey. Each site collection was georeferenced obtaining the geographic coordinates and altitude, starting from the location name and using the maps available on http://www.pcn.minambiente.it. From the selected articles it was possible to extract and use a total of 279 indications. The data revealed the existence of a significant correlation between the magnitude of the trophic niche of the predator and the sample size ($r = 0.299$; $P < 0.0001$). Taking into account the sample size was a significant difference between geographical areas along a latitudinal gradient and amplitude of the trophic niche of the predator. This difference is not dependent on a specialization in intraspecific foraging strategies of predator instead we believe that the differences most probably reflect the structure of the community of small mammals preyed. Indeed, by comparing the distribution of mammal species obtained from barn owl pellets with the potential distributions of small mammals in the same areas (data from Maiorano et al., 2013), it is possible to obtain similar trends.

D1.7.2.2: Monitoring of biodiversity in the north-western Italian Alps

Main Objectives

Topic of this study is the assessment of changes in biodiversity and ecosystems in high-altitude mountain areas, by statistical analysis and comparisons of data collected during the project with earlier data, made available in the course of the Project.

In this framework, this study aimed to apply and to improve monitoring and data storage methodologies, devoted to explore relationships between animal biodiversity, climate and land use at different spatial scales in alpine protected areas. Long term purpose is to create the baseline against which assessing future changes with a monitoring program that is planned to be repeated every five years.

The study is characterised by 2 different steps:

- conduction of new monitoring campaigns;
- analysis of data on terrestrial biodiversity in the western Italian Alps.

This monitoring project was promoted by Gran Paradiso National Park in 2006 and continued with the cooperation between CNR-ISAC and other two protected areas in NW Italian Alps, Orsiera Rocciavré Natural Park and Veglia Devero Natural Park.

During the time frame January-December 2014, we developed the following activities:

1) Conduction of the new monitoring campaign, devoted to the collection of data about animal biodiversity along altitudinal gradients.

2) Implementation of laboratory activities, devoted to the analysis of the material, collected during the previous years.

3) Compilation of the databases (data and metadata).

4) Preparation and analysis of the spatial layers, necessary for the following step in the analysis.

1. *Conduction of the new monitoring campaign (April-October 2014)*

Field activities have been carried out in fixed plots, already subjected to monitoring during 2007-2008 and 2012-2013. They represent the implementation and continuation of a previous existing *in situ* project, promoted by Gran Paradiso National Park (PNGP) in 2006 and continued with the cooperation between CNR-ISAC and two other protected areas in the NW Italian Alps, Orsiera Rocciavré Natural Park (PNOR) and Veglia Devero Natural Park (PNVD). Aim of the research is the development of an historical dataset, on the base of already existing data, and to improve some of the methodologies applied to the monitoring of animal biodiversity.

The two-year monitoring, planned following the original protocol developed by PNGP, has finished in 2013. Consequently, in 2014 only selected activities have been carried out in the long term fixed plots. Two taxa have been chosen, to be yearly monitored, in order to create a continuous dataset (from 2006 onwards): butterflies (*Lepidoptera Rhopalocera*) and birds (*Aves*). During 2014, butterflies have been monitored in 17 plots, along 3 altitudinal gradients (Orco Valley, 7 plots, from 1200 to 2400 m asl; Soana Valley 6 plots, from 1200 to 2200 m;

Foresto xerothermic area, 4 plots, from 500 to 1100 m). Birds have been monitored in all the sampling stations, located in PNGP and PNOR (30 plots in PNGP and 20 plots in PNOR). We used semi-quantitative census techniques that are, as much as possible, easy to apply, standardized, cheap and repeatable. Birds were monitored by means of point counts and each plot was visited twice during the reproductive season, for a total of 100 counts (50 plots*2). We sampled butterflies using linear transects along one diameter of the plot (200 m in length), walked at uniform speed, executed from April/May to September/October, for a total of 105 sampling sessions (each plot was visited between 10 to 5 times, depending on altitude, which strongly influence the length of the season and the phenology of butterflies).

All field activities were done during mid April-mid October 2014. During the same period, we collected micro-climatic data, through the positioning of temperature data-logger (iButton DS1922), one per each sampling station, located in field at the beginning of the sampling season.

During 2014, a detailed characterization of the vegetation present in the PNGP monitored plots (30 circular plots, each of ~ 3.14 ha) was carried out. We followed the same protocol applied during 2006-2007, in order to identify main changes and to obtain an important tool for the explanation of animal biodiversity patterns (monitored in the same plots and during the same time frame).

Our analysis was characterised by 2 parallel levels:

i. The *identification of vegetation types*, covering the plot's surface;

ii. the *floristic analysis*, of herbaceous and shrubs species.

The *identification of vegetation types* was carried out through 2 steps and the main result was the production of digital maps, obtained by high resolution land cover polygons.

At first, we analysed the most recent aerial photographs for the study area (2010) and digital delimited the polygons, corresponding to broad land cover categories (Table 1).

Land Cover Category	*Description*
Wood	High canopy cover (> 80%)
Light wood	Low canopy cover (between 40 and 80%)
Shrub	Shrub cover dominant
Meadow	Herbaceous cover, generally located near to urbanised areas at the bottom of the valleys, mown almost once per year
Pasture	Herbaceous cover with stony cover less than 40%
Rocky pasture	Herbaceous cover accompanied by evident stony cover, larger than 40%
Scree	Stony debris
Rocky place	Rock and massif outcrop (but not debris)
Lake	Water body
Glacier	Surface occupied by glacier
Urban area	Residential building or infrastructure

Tab. 1. Broad land cover categories, identified through the inspection of aerial photographs.

In order to verify our classification, we checked a subsample of the delimited polygons in the field.

Moreover, to achieve a more detailed categorization of the vegetation types, we applied the phytosociological methodology proposed by Daget and Poissonet (1969) to further classify meadows and pastures into the different pastoral facies (variants related to altitude, slope, soil type, grazing management and characterised by a typical association of dominant herbaceous species, following Cavallero et al., 2007). We executed 36 semi-quantitative linear transects, located in exactly the same places as in 2006-2007. Our transects are characterised by a length of 25 m and along them, every 50 cm, we recorded all the present species. We completed our survey, listing other species present along the transect and missed with our standardized methodology and recording current management practices.

The *floristic analysis* was carried out in 5 selected points per each plot, corresponding to the position of the pitfall traps. In a 5 m radius circle around each of these points, we listed all the species, consequently obtaining 150 floristic lists.

Comparisons between the results of the 2006-2007 and 2014 vegetation monitoring allowed us to draw some inferences. We observed only few differences through time (2006-2007 vs 2014). Important differences are limited to a low number of plots and due to sudden changes, related to anthropic activities (i.e. reshape of the herbaceous layer, through the intensive seeding of new species) or to natural phenomena (i.e. landslide).

In 2013, the three other national parks of the Italian Alps (Val Grande National Park – PNVG, Stelvio National Park – CPNS and Dolomiti Bellunesi National Park – PNDB), decided to share the objectives of the monitoring activities promoted by PNGP in 2006 and to follow the sampling protocols already adopted by PNGP, PNOR and PNVD. During 2014, all the monitoring activities, planned by the protocol disposed by PNGP and subscribed in 2013, were carried out. In Table 2 we show the activities carried out by each Park during this second year. Each park had its field operators; as chief of the project PNGP offered the support and supervision of all the monitoring activities, in order to obtain comparable data.

	Transects	Plots	Temperature	Birds	Butterflies	Grasshoppers	Macro-arthropods
PNDB	2	11	X	X	X	X	X
CPNS	6	30	X	X	X	X	X
PNVG	3	17	X	X	X	X	X

Tab. 2. Monitoring activities carried out by each Park. Transects represent the number of altitudinal gradients under study, and Plots the total number of monitored sampling stations.

2. Laboratory activities

During January-March 2014, we finished the analysis of the entomological material, collected during 2013. In the case of the selected groups of surface-active macro-invertebrates (*Arachnida Araneae*, *Coleoptera Carabidae*, *Coleoptera Staphylinidae*, *Hymenoptera Formicidae*), collected in the test areas, we identified them at the morpho-species level. All specimens were stored and preserved in alcohol 70%, and given to expert taxonomists. Concerning *Arachnida Araneae*, *Coleoptera Staphylinidae* and *Hymenoptera Formicidae*, the determination are not yet finished, but the taxonomists have identified more than 75% of the specimens.

After the field work (October 2014-December 2014), we performed the laboratory analysis of the material collected during 2014 (butterflies and plant materials).

In 2014 we also continued the measurements related to the changes in body-size along altitudinal gradient of selected taxa (*Coleoptera Carabidae*).

Body-size is directly related to thermoregulation, energy and mass acquisition, life-history and fecundity. Consequently, understanding the links between body size and environmental heterogeneity will help to identify key traits that shape the potential of a species to respond to climate change and provide insights into thermal tolerances, information that is currently lacking for most species, in particular for insects. In this framework, we measured 11 morphological parameters on 2376 specimens, belonging to 5 species (390 *Carabus depressus*, 266 *Calathus melanocephalus*, 725 *Pterostichus flavofemoratus*, 532 *Pterostichus externepunctatus*, 463 *Pterostichus multipunctatus*), all Coleoptera Carabidae. These species have been selected because they are widespread along the altitudinal gradient (1200-2600 m) and well-represented inside the geographic areas of interest (NW Italian Alps). Our main objective is to explore the relative role of abiotic factors (altitude, temperature and rainfall) and biotic factors (nutrition/food availability, competition/facilitation) in shaping body-size (and its phenotypic variability) along the altitudinal gradient and to hypothesize future responses to climate change. Abiotic and biotic factors are available for the same areas in which we collected and measured the selected specimens, thanks to the detailed monitoring project we carried out. To reduce bias, each body size measurement was repeated by three different operators. We have currently measured 80% of the specimens and prepared all the explicative variables that we will use in our models. In particular, we quantified food availability as the amount of arthropod biomass collected with the pitfall traps, during the sampling season and measured through the protocol we developed in 2012 (standardised weight and volume). We used our vegetation data to quantify microhabitat heterogeneity, considering this as a potential measure of competition reduction (higher microhabitat heterogeneity allows for a higher number of species to coexist). Finally, competition has been quantified as the number of species and the abundance of other carabid species in the same plot.

3. Common databases

The biodiversity data, collected since 2006 and made available in the course of the NextData Project, have been prepared for the inclusion in the General Portal (Tab. 3). Also the related metadata are now almost ready. We prepared them in accordance with EnvEurope (LTER-Europe)/ExpeER Metadata Specification for Dataset Level based on EML (Ecological Metadata Language) specification. Our metadata are referred both to the biological databases, the sites of data collection (synthetic information about the three protected areas, PNGP, PNOR, PNVD) and the persons involved in data collection/determination (skills and point of contact of the expert taxonomists).

In particular, metadata of the biological databases include: i) a title and an abstract describing the main purpose of each database; ii) the extent of the data collection in time and space; iii) a detailed description of the field methodologies adopted to obtain them and of the identification procedures (e.g., the identity of the expert taxonomist who identified the specimens, the nomenclature system that was followed); iv) the contact point for the databases (author and owner of the data, both the database and the collected specimens) and its use limitations.

Moreover, the ecological databases are not only related to the presence and abundance of different species in selected plots and time, but also contain some important information: i) a value corresponding to the quality of the data (some specimens can be determined only at the genus or family level, lowering the quality of the determination); ii) the ecological characteristics of each species (derived both from literature and expert opinion, and the related references we used); iii) information, if available, about the single specimens (age classes, sex, behavioural observation).

Data	Group	Time period	Spatial Coverage
Fauna	Coleoptera Carabidae	2006, 2007, 2012, 2013	PNGP (30 plots), PNOR (20 plots), PNVD (24 plots)
Fauna	Coleoptera Staphylinidae	2006, 2007, 2012, 2013	PNGP (30 plots), PNOR (20 plots), PNVD (24 plots)
Fauna	Araneae	2006, 2007, 2012, 2013	PNGP (30 plots), PNOR (20 plots), PNVD (24 plots)
Fauna	Hymenoptera, Formicidae	2012, 2013	PNGP (30 plots), PNOR (20 plots), PNVD (24 plots)
Fauna	Lepidoptera Rhopalocera	2006, 2007, 2012, 2013	PNGP (30 plots), PNOR (20 plots), PNVD (24 plots)
Fauna	Lepidoptera Rhopalocera	2006-2014 (continuous)	PNGP (selected areas)
Fauna	Aves	2007, 2008, 2012, 2013	PNOR (20 plots), PNVD (24 plots)
Fauna	Aves	2006-2014 (continuous)	PNGP (30 plots)
Fauna	Orthoptera	2006, 2007, 2012, 2013	PNGP (30 plots), PNOR (20 plots), PNVD (24 plots)
Temperature	-	2006, 2007, 2012, 2013	PNGP (30 plots), PNOR (20 plots), PNVD (24 plots)
Temperature	-	2006-2014 (continuous)	PNGP (selected areas)
Vegetation	-	2007, 2014	PNGP (30 plots)
Vegetation	-	2007	PNOR (20 plots), PNVD (24 plots)

Tab. 3. List of the data already prepared for the inclusion in the General Portal. The time period and the spatial coverage of each type of data are shown.

The datasets, first available in Excel archives, have been converted in relational databases, through the use of PostgreSQL 9.1 with Postgis extension. PostgreSQL is an object-relational database management system, open-access and open-source, which uses the SQL language for data querying. All the data are stored as tables, with external keys, which can be used to linked related data. Postgis is its spatial extension and allow an easy visibility of the relational databases.

4. Data Analysis

4a) Indicator of Climate Change

The main purpose is to outline a modelling framework at high spatial resolution, which will be useful for the development of management strategies. In particular, we will focus on identifying taxa, functional groups and areas that are more vulnerable to environmental changes, for which it is necessary to focus the most intense conservation efforts.

As a first step, during January-December 2014, we prepared the starting data, in particular the occurrence data and the environmental layers necessary to model the distribution of target species.

The data coming from the monitoring campaign previously described will be used as occurrence starting data. For each of the taxa monitored inside our field campaign (*Orthoptera, Lepidoptera Rhopalocera, Coleoptera Staphylinidae, Coleoptera Carabidae, Hymenoptera Formicidae, Araneae, Aves*), we selected key-indicator species, covering different functional groups and both altitudinal specialists and generalists. We collected data on their bioclimatic limits, obtained from primary literature, expert opinion and our field data.

The simulations will be carried out at a high-resolution spatial scale, inside each of the three monitored protected areas (PNGP, PNOR, PNVD). To obtain the necessary land cover and climatic layers, we covered each protected area with a continuous grid (250x250 m), in which we calculated information about:

- *topography* (mean altitude, prevalent slope, prevalent aspect);
- *land cover*;
- *climate data* (temperature).

For each layer, we consequently need data, which should be homogenous among protected areas and at a sufficiently high spatial resolution.

Topography has been calculated using as a starting point a Digital Elevation Model (Tinitaly/01, Tarquini et al. 2007), available at national scale, and developed through the use of the Italian Regional Topographic maps, satellite-based global positioning system points, ground based and radar altimetry data. This DEM is consequently highly precise (overall root mean square error of 3.5 m) and it is characterised by high spatial resolution (10 m).

Land cover has been quantified using the three different sources currently available for the whole territory of the 3 protected areas:

- Corine Land Cover (CLC, European Environment Agency 2007);
- forestry and other land-use categories map of the Piedmont Region (FPM);
- a physiognomic map, recently developed for the NW Italian Alpine Region (SAT, Martinasso 2012).

The CLC is a European digital map obtained from satellite images recorded in 2006, available for the whole Europe. The nominal scale is 1:100000, the minimum polygon width is 100 m and it classifies land cover in broad categories (15 of them are present inside the parks). The FMP has a higher resolution and a more precise classification (29 land cover categories); it is available only for the Piedmont Region, but, for the parts of PNGP in the Aosta Valley, a similar land cover map has been built by the Park botanists. The physiognomic map has been developed through the analysis of satellite data coming from three time period (1988, 2001, 2009); land cover has been classified into 9 categories at a spatial resolution of 30x30 m. Such a map is particularly useful for two reasons: i) its relatively high spatial resolution; ii) the possibility to quantify changes through time (1988-2009) and consequently giving a starting point to simulate future changes.

At first, we carried out prior equalization of the spatial and thematic characteristics of each of the 4 maps (CLC, FMP, SAT, photointerpretation). We resampled them to a common spatial resolution (5x5 m) and classified land cover in a coherent and comparable way between them, identifying 8 common categories:

- coniferous forests;
- broad-leaved forests;
- shrubs;
- herbaceous layers;
- rock and screes;
- glaciers;
- water;
- urban areas.

We compared them, over the whole areas of the Parks, identifying common points and differences. In particular, we observed that FPM and the physiognomic map are more similar than the CLC maps and that differences are stratified as a function of altitude. The largest difference is localised below and around 1400 m asl for coniferous and broad-leaved forests and above 2000 m for the herbaceous layer. Coniferous forests are the less problematic land cover type (the lowest root mean square error between maps), while shrubs presents the largest differences.

As a second and fundamental step, we validated these 3 maps with photo-interpretation data coming from selected plots, distributed all over the areas of the Parks and used as reference points. The selected plots are 46 (30 in PNGP and 16 in PNOR) circular areas, with a radius of 100 m (about 3.14 ha), and distributed along the altitudinal gradient (1200-2600 m), consequently covering the variability in vegetation patterns, present inside the protected areas. The size of the plots is comparable with the dimension of the cells, used as starting point for the subsequent modelling activities.

To validate the maps, we covered each plot with a regular grid (5x5 m) and assigned to each cell a value corresponding to the cover type, following each maps in turn (interpreted orthophoto, FPM, CLC, the physiognomic map). Then we compared the observed values per cell (per pixel) between each map and the interpreted orthophoto (our reference). To identify the most problematic land cover type, we used contingency table (Tab. 4) and to quantify the amount of error and to identify the best land cover map, we followed the approach suggested by Pontius and Santacruz (2014), using the R package *diffeR* (Pontius and Santacruz 2015).

As can be seen, the FMP provides the best map, due to the lowest error, both concerning overall error and its components (Tab. 5, Fig. 1). In any case, a relatively high percentage of error occurs also in this kind of classification map, determining the existence of potential biases in each modelling approach based on such land-cover classifications.

Concerning the proportion of correct land-cover type classification (Tab. 4), we observed that some categories are extremely difficult to determine. In particular, the presence of water/humid areas has never been identified by the maps. Also, rock seems to be difficult to be properly assigned, in particular for CLC. Concerning vegetation type, shrubs represent the most difficult category, with a low percentage of correct classification in each land-cover map.

Tab. 4. Contingency table, representing the number of pixel per land-cover type of the Corine Land Cover map (CLC), the physiognomic map from satellite data (SAT), and the forestry and other land-use categories map of the Piedmont Region (FPM).. Their pixel per category are indicated in the columns, while for the reference map in the rows. The last column represent the percentage of correct classification per category.

CLC	Water	Shrubs	Conifer	Broad-leaved	Rock	Urban areas	Herbaceous layer	% pixel
Water	0	227	0	0	0	0	131	0
Shrubs	0	495	0	433	0	0	3392	11.46
Conifer	0	4498	6379	0	0	0	546	55.84
Broad-leaved	0	0	1114	4052	0	0	1363	62.06
Rock	0	222	354	109	92	0	2511	2.80
Urban areas	0	24	0	48	0	0	429	0
Herbaceous layer	0	2045	1721	853	700	0	25882	82.95

SAT	Water	Shrubs	Conifer	Broad-leaved	Rock	Urban areas	Herbaceous layer	% pixel
Water	0	0	0	0	3	0	128	0
Shrubs	0	1470	868	116	205	0	1663	34.01
Conifer	0	1119	6063	446	35	0	1996	62.77
Broad-leaved	0	208	1302	2222	18	0	2786	33.99
Rock	0	155	130	0	1149	0	1549	38.52
Urban areas	0	0	36	0	0	0	465	0
Herbaceous layer	0	1514	1225	65	369	0	27850	89.77

FMP	Water	Shrubs	Conifer	Broad-leaved	Rock	Urban areas	Herbaceous layer	% pixel
Water	**0**	**0**	**227**	**0**	**58**	**0**	**73**	**0**
Shrubs	**0**	**1251**	**488**	**433**	**750**	**0**	**1399**	**28.95**
Conifer	**0**	**1578**	**8782**	**201**	**92**	**0**	**782**	**76.80**
Broad-leaved	**0**	**613**	**1234**	**4184**	**0**	**0**	**505**	**64.01**
Rock	**0**	**65**	**439**	**111**	**1814**	**0**	**861**	**55.14**
Urban areas	**0**	**0**	**24**	**57**	**0**	**34**	**386**	**6.79**
Herbaceous layer	**17**	**478**	**1269**	**406**	**2583**	**24**	**26454**	**84.70**

	CLC	Mean-CLC	FMP	Mean-FMP	SAT	Mean-SAT
N	57620	1252.61	57672	1253.74	55155	1199.02
Overall	35.96	36	26.27	26.31	29.74	29.75
Quantity	10.84	33.07	5.26	22.64	10.08	24.67
Shift	10.74	0.63	7.67	0.94	2.28	1.3
Exchange	14.38	2.29	13.34	2.74	17.38	3.78

Tab. 5. Error of each map in comparison with the reference. N=number of cells (pixel, 5x5 m) analysed. Overall=total error in map comparison. Quantity=error due to differences in the amount of the same cover type between maps. Shift=error due to shift in position. Exchange=the remaining part of the error.

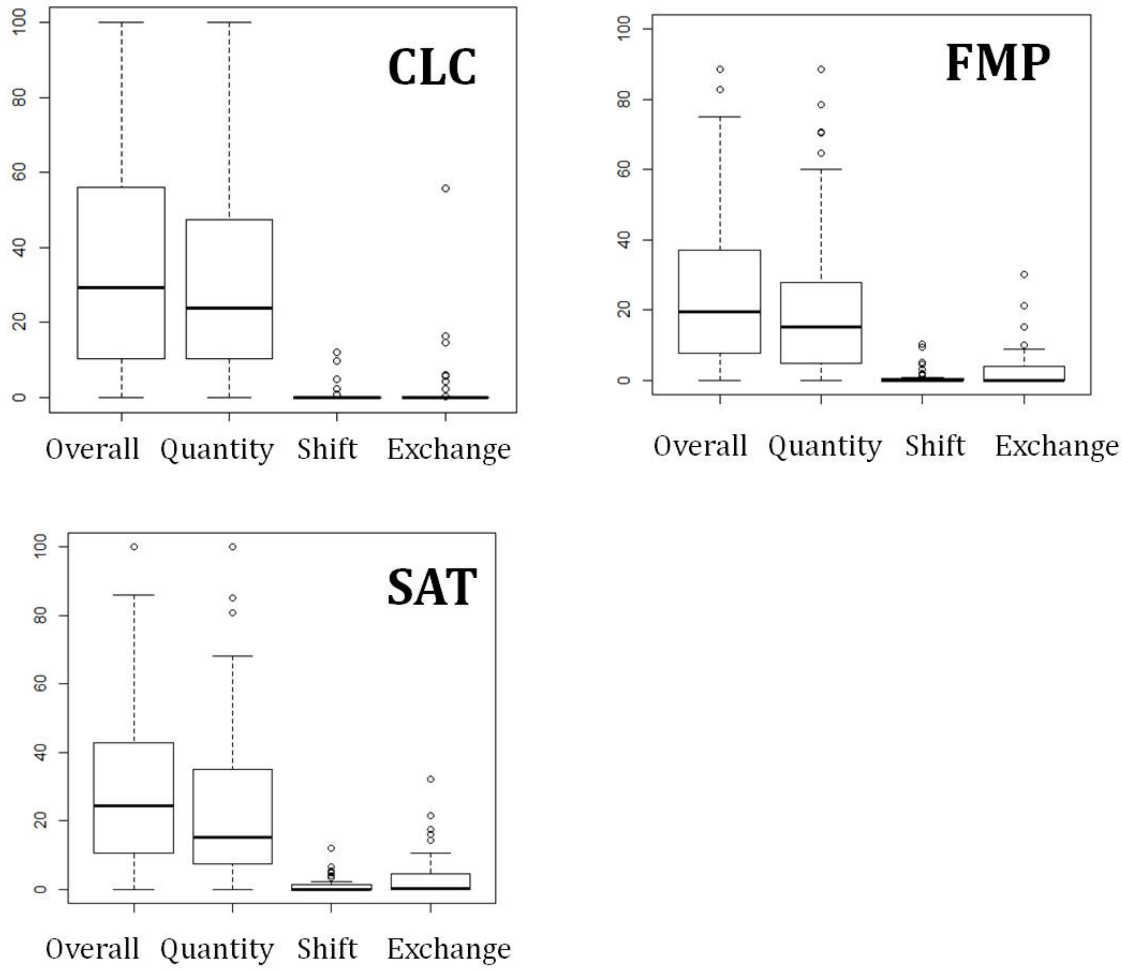

Fig. 1. Differences between each land-cover map and the map used as a reference. The error is decomposed in its 3 components (quantity, shift and exchange).

Regarding *climate data*, we developed a high resolution temperature map (250x250 m), over the three target protected areas. This map has been created using available point temperature data: 66 regional weather stations, ARPA Piedmont; 15 regional weather stations, ARPA Aosta Valley; 74 datalogger iButtons DS 1922 Maxim Products, located in field at the centre of our fixed plots.

The data has been subjected to quality check, assuring the absence of logical, climatological and range errors. All data that were not deleted after quality check were used for developing the maps. We obtained 3 daily values (minimum, mean and maximum temperature) for the reference period 2000-2013, over all the territory of each protected area. We applied a method of local interpolation and used as response variable both altitude, aspect (in its sin and cos components) and main vegetation cover (following suggestions proposed by Joly et al., 2011 and Brunetti et al., 2014). Consequently, we developed a local regression model (one per each protected area), for each month and for each parameter (minimum, mean and maximum temperature) and we used parameter estimates to extrapolate temperature data to the whole territory of each protected area.

Monthly values have been used to calculate bioclimatic variables, following Metz et al. (2014):

- Bio1 (annual mean temperature, °C*10);
- Bio2 (mean diurnal range, °C*10);
- Bio3 (isothermality);
- Bio4 (temperature seasonality *100);
- Bio5 (maximum temperature of the warmest month, °C*10);
- Bio6 (minimum temperature of the coldest month, °C*10);
- Bio7 (temperature annual range, °C*10);
- Bio10 (mean temperature of the warmest quarter, °C*10);
- Bio11 (mean temperature of the coldest quarter, °C*10).

As an example, in the following figures (Fig. 2, Fig. 3, Fig. 4), one bioclimatic variable is represented for each protected area.

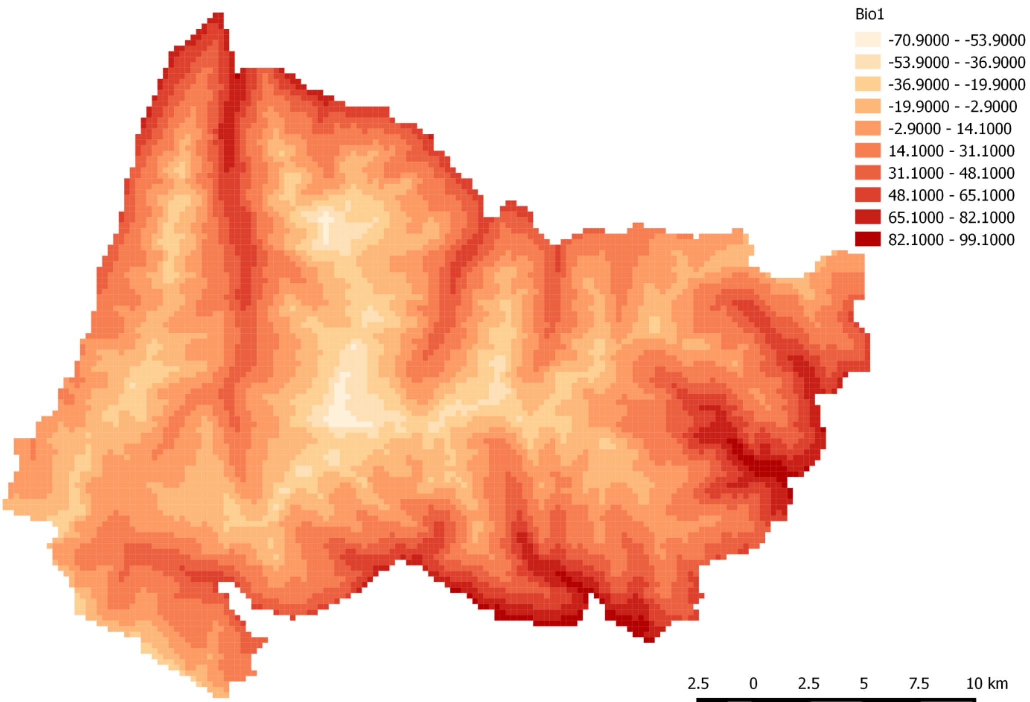

Fig. 2. Bio1, over the PNGP territory (250x250 m).

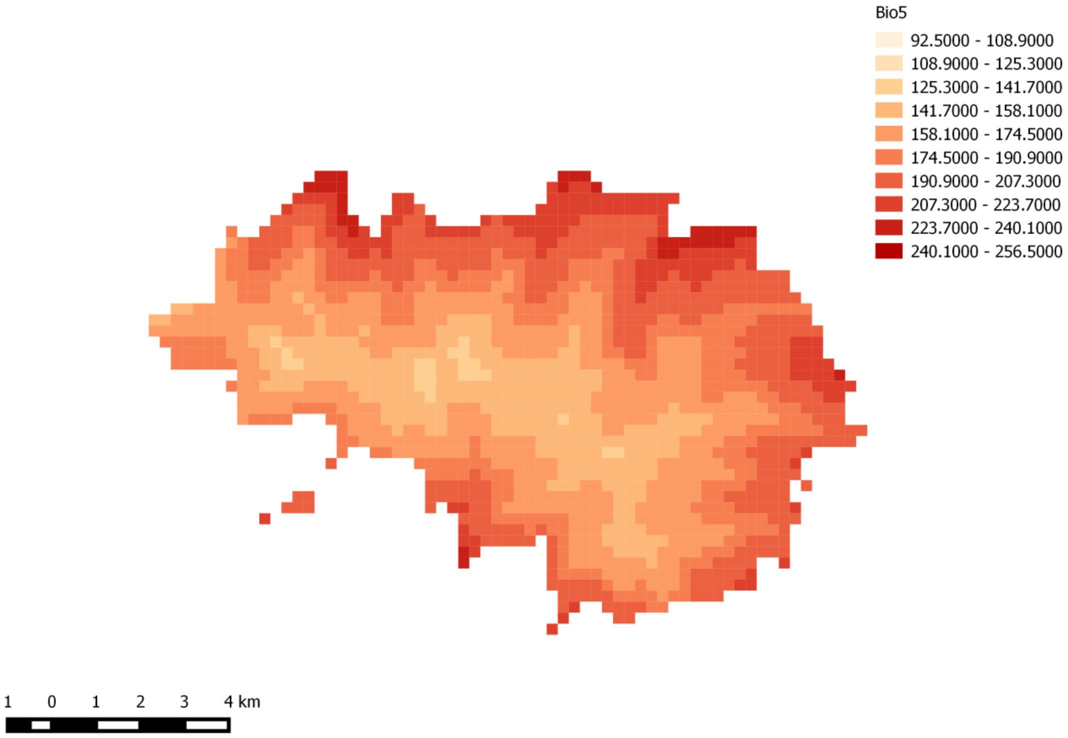

Fig. 3. Bio5, over the PNOR territory (250x250 m).

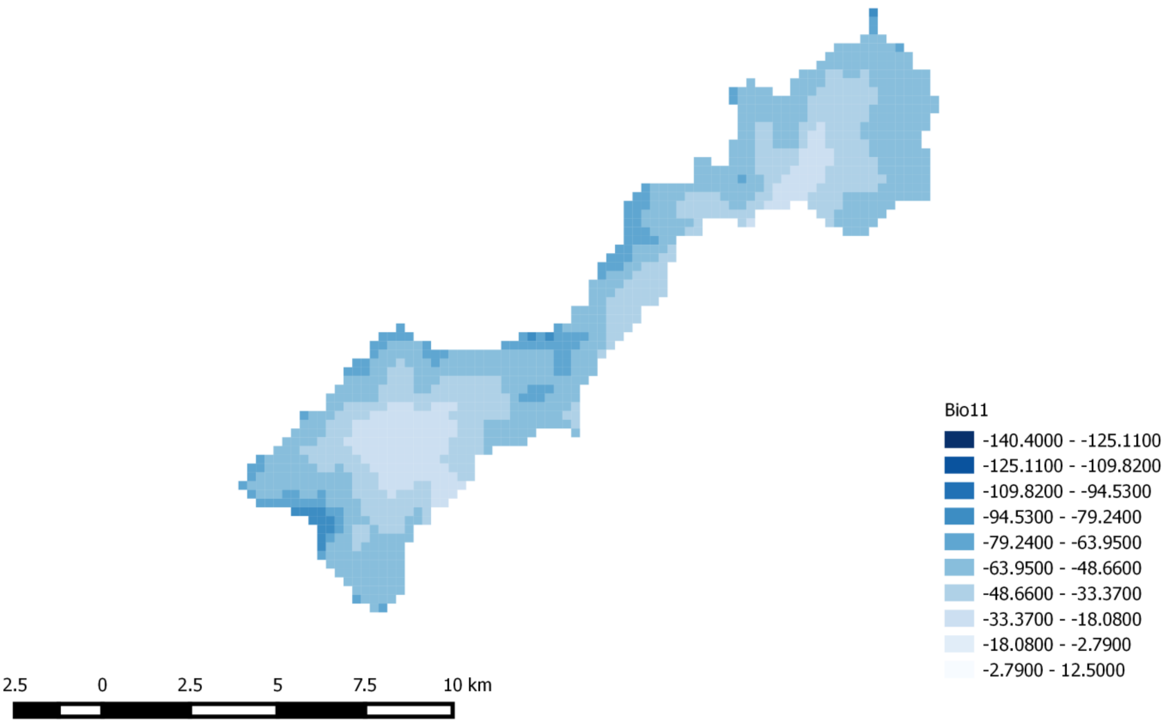

Fig. 4. Bio11, over the PNVD territory (250x250 m).

To validate the maps, we compared them with data recorded by the weather stations located in the corresponding cell and we quantified differences using the root mean square error (*rmse*; Tab. 6). We calculated the same statistic for the high resolution climatic maps currently available at European scale (Metz et al., 2014). We observed a low *rmse* for our maps, which also showed a better performance than the other maps currently available (Tab. 6).

Climatic Maps	Bio1	Bio2	Bio5	Bio6
rmse – Modis	11.29	18.51	32.29	76.14
rmse – maps	8.78	17.54	24.48	17.57

Tab. 6. Root mean square error (*rmse*), calculated comparing the values recorded by the weather stations and the values estimated in each cell, using our maps (*rmse* – maps) and also the maps currently available at high spatial resolution for the European territory (Metz et al., 2014; *rmse* – Modis). The *rmse* has been shown for the variables indicated in the columns (Bio1, Bio2, Bio5, Bio6).

The meteo-climatic and land-use data of the protected areas are now available for subsequent analysis, in particular for the modeling at community level and for the individuation of indicators of climate change.

We are now going to apply and compare different modeling approaches (Maximum Entropy Models, Boosted Regression Trees, Hierarchical Bayes Models), in order to improve forecasting ability and to understand which are the most useful models for forecasting biodiversity in mountain ecosystems.

4b) Time series: Butterflies and birds

We have now prepared the databases and layers.

In the future, we will analyse butterfly data coming from 9 monitoring years (2006-2014) in 13 selected sampling stations, located along the altitudinal gradient (1200-2400 m) in 2 valleys of the Gran Paradiso National Park. The main objective is to analyse this time series, in order to identify the species, the habitat and the altitude at which the strongest changes appear. Butterfly are used because they respond faster than other groups to environmental changes, and because they can act as indicator of changes for other taxa.

Birds data will be analysed in a broader framework, comparing data coming from PNGP, PNOR and PNVD to datasets available for the Lombardia Region, collected since 30 years ago. The main purpose is the identification of the species which suffered the highest altitudinal shift through time and the analysis of potential causes.

References

BRUNETTI M., MAUGERI M., NANNI T., SIMOLO C., SPINONI J., (2014): High-resolution temperature climatology for Italy: interpolation method intercomparison. *Int J Climatol*, 34: 1278-1296.

CAVALLERO A., ACETO P., GORLIER A., LOMBARDI G., LONATI M., MARTINASSO B., TAGLIATORI C., (2007): I tipi pastorali delle Alpi piemontesi. Alberto Perdisa Editore, Bologna.

DAGET P., POISSONET T., (1969): Analyse phytologique des praisies. INRA, Montpellier Document 48.

European Environment Agency (2007) CLC 2006 technical guidelines. EEA Technical Report No 17/2007.

JOLY D., BROSSARD T., CARDOT H., CAVAILHES J., HILAL M., WAVRESKY P., (2011): Temperature interpolation based on local information: the example of France. *Int J Climatol*, 31, 2141-2153.

MARTINASSO B., (2012): Cartografia fisionomica da foto-interpretazione di un'area campione nei territori di Ceresole Reale, Noasca e zone di confine con la Regione Valle d'Aosta. Programma Alcotra 2007-2013. Progetto n. 88 GALLIFORMI ALPINI. I galliformi alpini sulle alpi occidentali come indicatori ambientali. Monitoraggio, conservazione e gestione delle specie

METZ M., ROCCHINI D., NETELER M., (2014): Surface Temperatures at the Continental Scale: Tracking Changes with Remote Sensing at Unprecedented Detail. *Remot Sens*, 6, 3822-3840.

PONTIUS R., SANTACRUZ, (2014): Quantity, exchange, and shift components of difference in a square contingency table. *Int J Rem Sens*, 35, 7543-7554.

PONTIUS R., SANTACRUZ, (2014): diffeR: Difference Metrics for Comparing Pairs of Maps. R package version 0.0-2. http://CRAN.R-project.org/package=diffeR

TARQUINI S., ISOLA I., FAVALLI M., MAZZARIN F., BISSON M., PARESCHI M.T., BOSCHI E., (2007): TINITALY/01: a new Triangular Irregular Network of Italy. *Ann Geophys*, 50, 407-425.

D1.7.2.3: Data from LTER Italian Mountain sites (Data-LTER-Mountain)

Task 1: Data tools and standards.

The objective of the Deliverable is twofold:

- to sketch the architecture of the IT system that will archive, manage and access the data (and related metadata) collected by the partners of the Special Project and by the bio-ecological participants in NextData.

- to reports on the metadata and dataset already stored in the LTER Europe facilities at the beginning of the Special Project (background).

Reference objectives in Data-LTER-Mountain

The NextData Project will develop a distributed system of archives and access services to data and metadata collected in Long Term Ecological Research (LTER) sites located in mountain ecosystems in Italy. Archives and services will be developed starting from the experience of the EnvEurope Project and will be harmonized to national and international approaches, in connection with NextData tools. All sites are included in the LTER-Italy network.

One objective of the Project is to provide mountain LTER sites of their own data and metadata, according to defined standards and models, in compliance with LTER Europe practices; metadata and data (already available and collected in new campaigns) will be entered in an IT infrastructure, allowing discovery, access and exploitation.

A system composed by different, distributed web services will be designed and implemented, to allow partners to store their own selected datasets, to deliver them in an interoperable way, and to let them being geoviewed and analyzed. It will allows connection with NextData facilities.

Part 1: First proposal of system architecture for bio-ecological dataset in NextData

1.1 Requirements after the executive program

Following the executive program defined at D-LTER-m approval, the requirements to be met are:

· in the development of a network of LTER mountain sites, archives should be autonomous and distributed with services allowing access to observations; archives and services should be in connection with NextData infrastructure.

· Archives/services must be populated with dataset of ecological and biological variables of mountain LTER sites (and related metadata).

1.2 System architecture presented at the Kick-Off Meeting

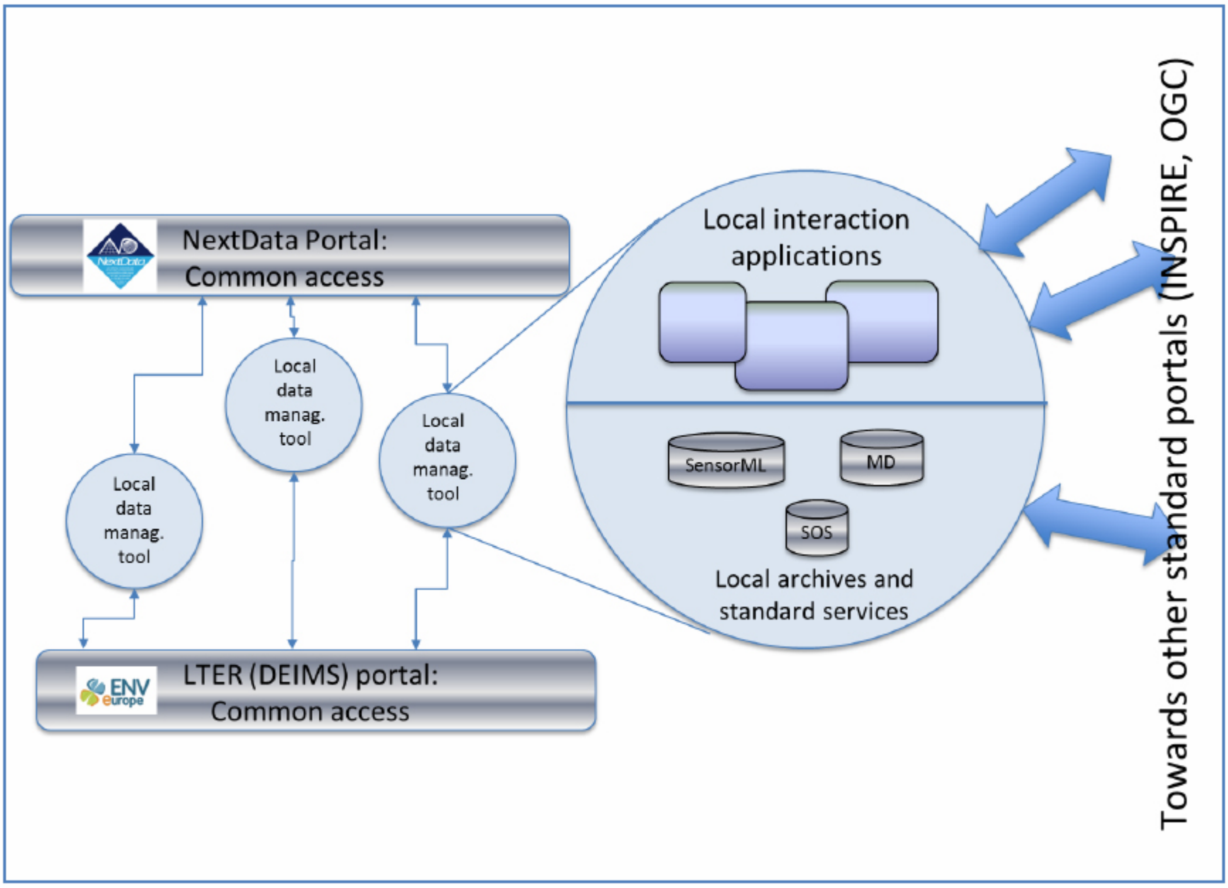

Fig. 1. System architecture presented at the Kick-Off Meeting

With the above requirements in mind, the architecture proposed by Task 1 at the Kick-Off Meeting (KoM) is illustrated in Figure 1. The vision was to promote a bottom-up approach, in order to create 'local' system in view of a future maintenance and sustainability beyond LTER and D-LTER-m.

In that framework, a fully distributed architecture was proposed, in which each involved site could be equipped by an autonomous local data management and distribution tool, containing local archives for dataset (observations) and metadata, standard services to distribute them, and applications to interact with the archives and the services. Each local tool aimed at enabling each site to both autonomously manage its own observations and be included in infrastructures adopting the same European and international standards.

A NextData portal has been conceived, to allow a common point of access to data distributed by the local tools; due to standard exploitation, the same metadata and data could be accessed also by the already established LTER Europe facilities (see the following 2.1).

1.3 Requirements after the KoM and new proposal of the system architecture

During the KoM of Special Projects, NextData coordination and the D-LTER-m coordinator and partners expressed the following new requirements:

· having a centralized base of data (repository);

· mirroring distributed (if any) repositories at the NextData hardware facility based at DTA CNR, so as all information provided by partners could be duplicated;

· creating an end-point to be linked by the overall project portal under the section 'Data';

· including in the process ecological data from all Special Projects in NextData to be accessed through the same access point.

This new situation has driven towards a new architecture proposal, sketched in Figure 2.

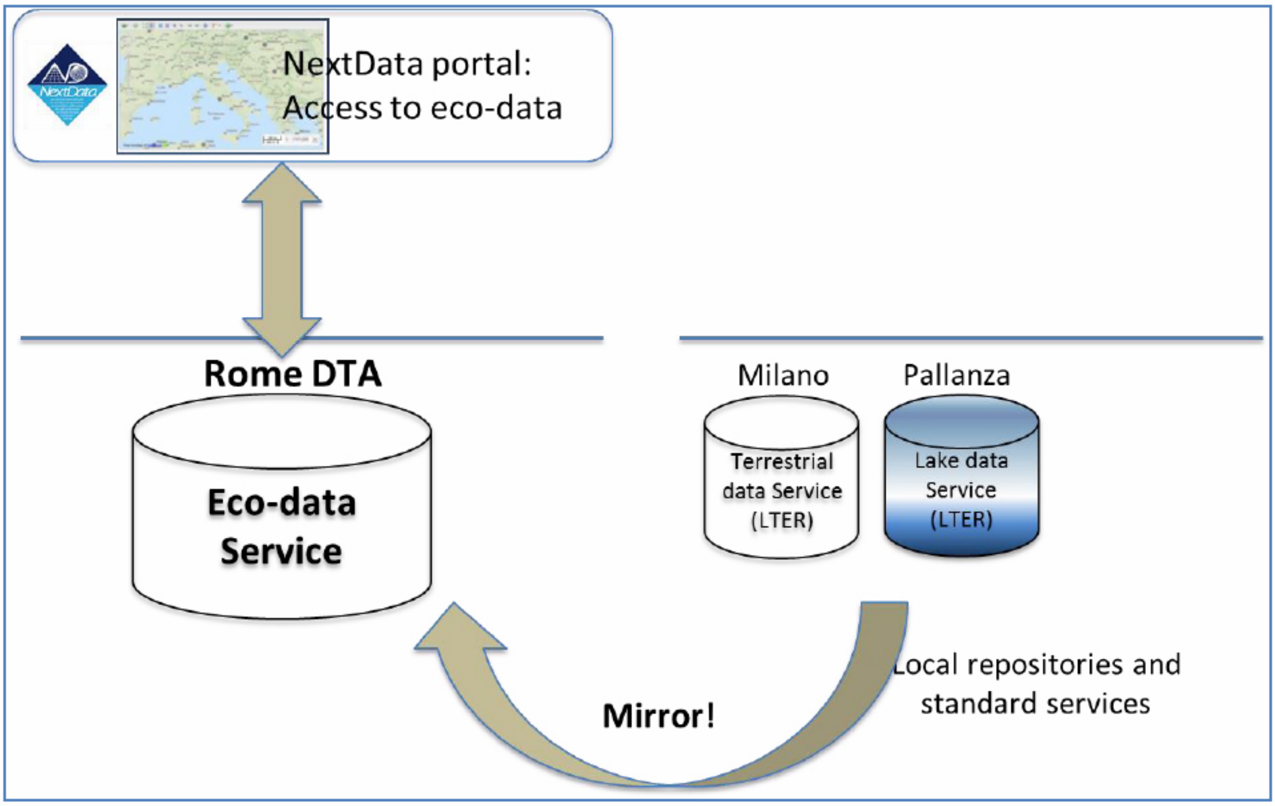

Fig. 2. New system architecture after KoM requirements

This new architecture foresees the creation of two local repositories and standard services at CNR ISE, Pallanza (for lake observations) and at CNR IREA, Milano (for terrestrial observations), respectively. Data services (virtual machines) have to be mirrored in the NextData central server in Rome, to allow access by the general NextData portal. This configuration has been discussed and approved by the technical staff in charge of NextData server at DTA CNR.

Task 1 is in charge of connecting these above components of the architecture to LTER Europe facilities, by filling metadata of sites and persons in the DEIMS tool created in EnvEurope. The creation of OGC services and the filling of metadata of dataset (and sensors, if needed) can be performed by exploiting solutions not already developed within EnvEurope. These last metadata should be then harvested into the DEIMS catalogue. This way, the complete architecture is sketched in Figure 3.

Exploitation of OGC standards (mainly SOS, i.e. Sensor Observation Service, but also Web Map Service and Web Feature Service) allows an interoperable access to data deployed by Pallanza and Milan services through the LTER portal.
Metadata entered in the DEIMS facility (of dataset, sites and persons) allow discovery of resources by LTER Europe and other related infrastructures, external to both LTER Europe and NextData.

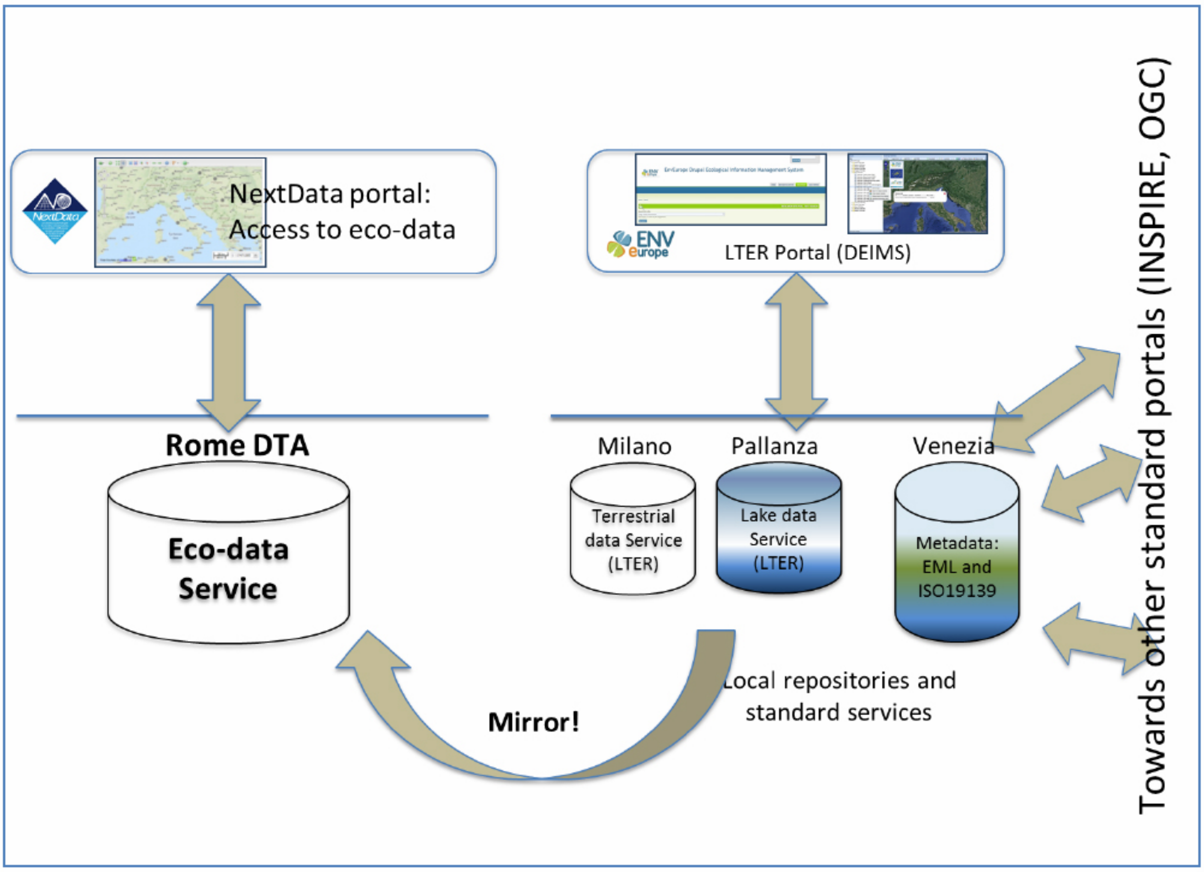

Fig. 3. New system architecture with connections to LTER Europe

Part 2: Summary of the current metadata and dataset of partners stored within LTER Europe facilities

2.1 Short description of the LTER Europe facilities created in EnvEurope

With respect to the objectives of D-LTER-m, the main facility of LTER Europe created in EnvEurope is DEIMS, i.e. Drupal Ecological Information Management System1; other facilities are: the LTER Europe WebSite2, ECOPAR (an interactive database of parameters and methods for LTER) 3 and EnvThes (the thesaurus for common language in ecology) 4.
DEIMS is an online metadata entry and management tool developed to enable partners and stakeholders of ILTER, LTER-Europe and EnvEurope Projects to share metadata. It is meant to collect the metadata and its implementation has been realized as an extension of the DEIMS developed by US LTER. Its content types, views and modules support all EnvEurope partners in the lifecycle of ecological metainformation, i.e. collection, search, display results and distribution of metadata. An indexed and controlled thesaurus for information retrieval has been developed as well, and it aims to define a common list of ecological concepts/terms. It is based conceptually on the terminology used within LTER community and technically on semantic web standards.
With DEIMS the users can describe, discover, view and download information about data sets, Research/observation sites, Bibliographic references, Personnel information including research topics and expertise; in particular, it offers to the end-user the following functionalities:
• DISCOVERY provides searching and displaying facilities for the created dataset and site description (based on metadata). Discovery provides more interfaces to define various types of queries to be sent to the metadata database as well as displaying of the results. Simple and Advanced metadata search for the data sets as well browsing for the persons and sites information is provided;
• GEOVIEW (Figure 4) provides data portrayal on a map and view of attributes of individual features (i.e. research sites, data sets). All research stations and EnvEurope sites, where data are actually collected, may be portrayed on a reference map and linked with their metadata;

Fig. 4. Snapshot of DEIMS-GeoView

1 http://deims.enveurope.eu/
2 http://www.lter-europe.net/
3 http://www.ufz.de/lter-d/index.php?en=32141&contentonly=1
4 http://vocabs.lter-europe.net/EnvThes3.html

• The DATASET METADATA EDITOR provides entry forms for authorised users to create metadata description in accordance with EnvEurope (LTER-Europe)/ExpeER5 Metadata Specification for Dataset Level based on the EML (Ecological Metadata Language) specification. Regarding the dataset metadata model (Figure 5), user requirements for the content were harmonized with the INSPIRE metadata regulation and implemented using EML metadata specification, version 2.1.1. EnvEurope focused on the EML metadata standard (stemming from the US LTER activities) but also provided an interface to discover ISO compliant metadata based on both the XSLT transformation EML2ISO developed in the Project and the Geonetwork opensource CSW implementation;

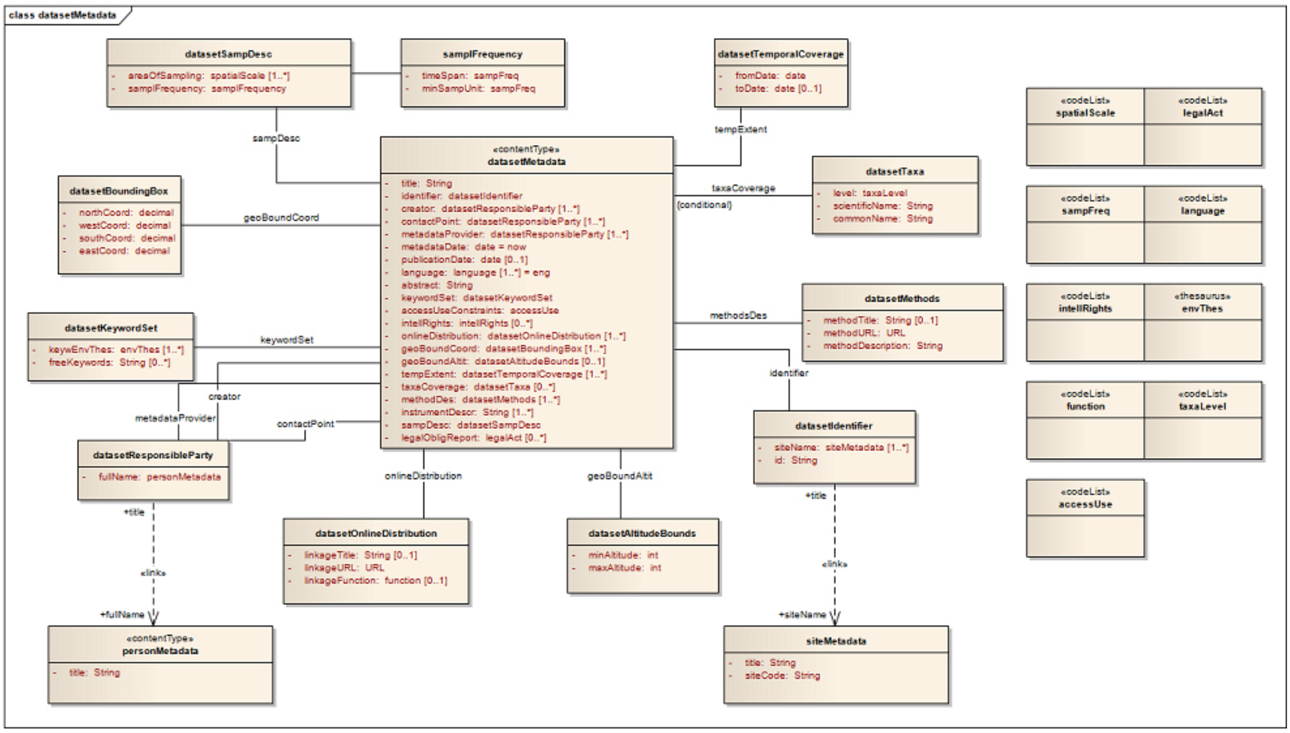

Fig. 5. Dataset metadata model of EnvEurope

• The SITE INFORMATION METADATA EDITOR provides entry forms for authorised users to create metadata description for sites in the ILTER, ExpeER, and GEO-Bon6 networks. The research site metadata model (RSMM), sketched in Figure 6, is based on LTER InfoBase model, firstly developed in the frame of ALTER-Net7 and completed with respect to new requirements, needed for the evaluation of the site network, which arose in EnvEurope and were included to provide a consistent and comprehensive description of the site characteristics;

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5 ExpeER is a European project, in the field of Ecosystem Research, which aims to bring together the major observational, experimental, analytical and modelling facilities in ecosystem science in Europe. (http://www.expeeronline.eu)
6 GEO-Bon is a global initiative of the Group of Earth Observations (GEO) that coordinates activities relating to the Societal Benefit Area (SBA) on Biodiversity of the Global Earth Observation System of Systems (GEOSS) (http://www.earthobservations.org/geobon_a.shtml)
7 ALTER-Net is Europe's biodiversity research network that assesses changes in biodiversity, analyses the effect of those changes on ecosystem services and informs the public and policy makers about this at a European scale. http://www.alter-net.info).

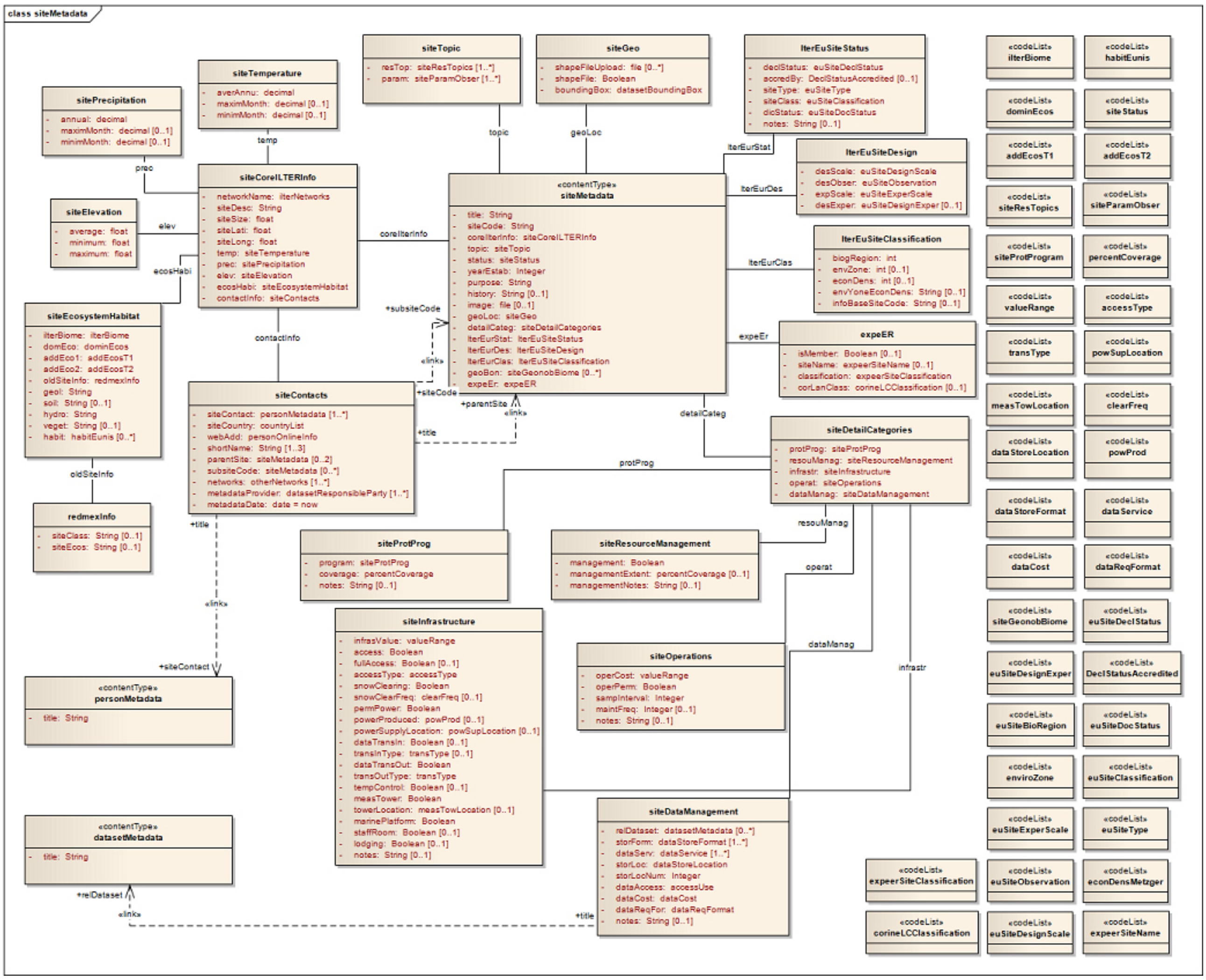

Fig. 6. Research site metadata model of EnvEurope

• The PERSONNEL DATABASE METADATA EDITOR provides entry forms for researchers to create or edit information about their contact information and research expertise. The person metadata model (PMM), sketched in Figure 7, is based on the US LTER model and updated with the user requirements of EnvEurope. The person data repository serves as a personnel directory, allowing individuals to add information about their specialties, subjects investigated, national LTER network, and networks in which they participate in addition to LTER-Europe. Persons can be associated with both related site and dataset metadata.

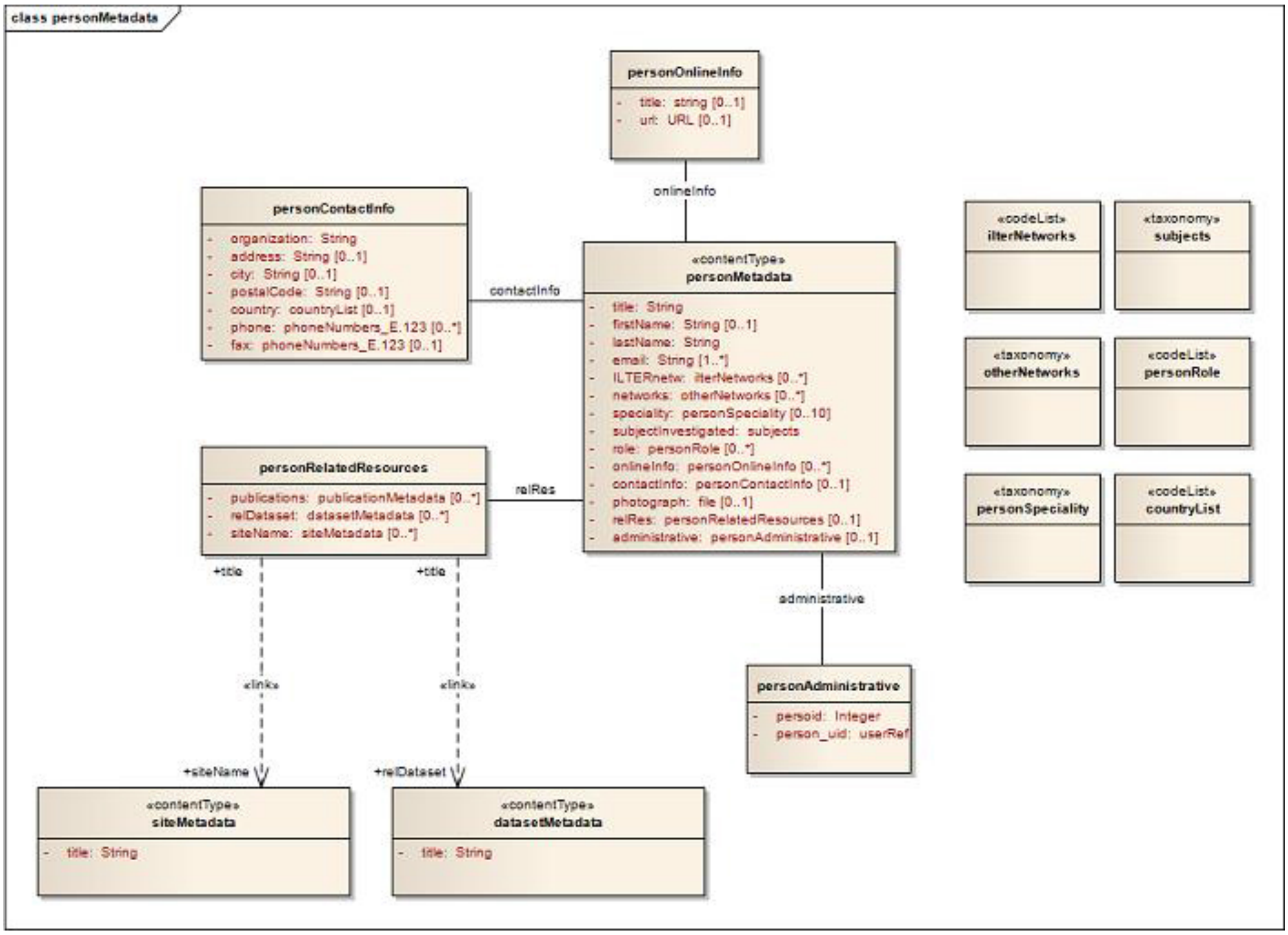

Fig. 7. Person metadata model

2.2 Sites of D-LTER-m in LTER Europe facilities: inventory of datasets and metadata

The inventory (datasets and metadata) presented in this Deliverable refers only to the sites directly involved in the D-Lter-m Project.

The dataset and metadata of D-Lter-m already stored in DEIMS are related to five Parent Sites and their eighteen Research/Simple Sites, as in Table 1.

Parent Site	Research/Simple Site	Site Manager	Short Name	Long Name
IT01- Apennines - High elevation Ecosystems	LTER_EU_IT_025	Cutini, Maurizio	IT01-002-T	Appennino centrale: Velino-Duchessa
	LTER_EU_IT_022	Stanisci, Angela	IT01-001-T	Appennino centro-meridionale: Majella-Matese
	LTER_EU_IT_023	Rossi, Graziano	IT01-004-T	Appennino settentrionale
	LTER_EU_IT_021	Pompei, Enico	IT01-003-T	Appennino centrale: Gran Sasso d'Italia
IT02-Forests of the Alps	LTER_EU_IT_027	Confalonieri, Mauro	IT02-003-T	Passo Lavazè TRE1
	LTER_EU_IT_029	Minerbi, Stefano	IT02-002-T	Renon BOL1
	LTER_EU_IT_028	Calvo, Enrico	IT02-001-T	Val Masino LOM1
	LTER_EU_IT_026	Pompei, Enrico	IT02-004-T	Tarvisio FRI2
	LTER_EU_IT_085	Motta, Renzo	IT02-005-T	Valbona
IT03-Forest of the Apennines	LTER_EU_IT_032	Pompei, Enico	IT03-002-T	Piano Limina CAL1
	LTER_EU_IT_033	Canullo, Roberto	IT03-003-T	Montagna di Torricchio
	LTER_EU_IT_031	Matteucci, Giorgio	IT03-001-T	Collelongo-Selva Piana ABR1
IT09-Mountain Lakes	LTER_EU_IT_046	Rossetti, Giampaolo	IT09-001-A	Lago Santo Parmense
	LTER_EU_IT_047	Rossetti, Giampaolo	IT09-002-A	Lago Scuro Parmense
	LTER_EU_IT_088	Rogora, Michela	IT09-003-A	Lago Paione Inferiore
	LTER_EU_IT_089	Rogora, Michela	IT09-004-A	Lago Paione Superiore
IT19-Western Alps (High Elevation)	LTER_EU_IT_076	Freppaz, Michele	IT19-001-T	Istituto Scientifico Angelo Mosso (MOSSO)
	LTER_EU_IT_077	Cremonese, Edoardo	IT19-005-T	Comune di Torgnon (Tellinod)

Tab. 1. List of Parent and Research/Simple Sites of D-LTER-m

Each Parent Site has been queried on DEIMS to verify the presence and consistence of metadata (date of query 19-09-2014).

All Parent Sites have stored people (i.e. site manager) and site metadata (see Table 2).

Parent Site	Metadata - Parent Site	Metadata - People
IT01- Apennines - High elevation Ecosystems	Yes	Yes
IT02-Forests of the Alps	Yes	Yes
IT03-Forest of the Apennines	Yes	Yes
IT09-Mountain Lakes	Yes	Yes
IT19-Western Alps (High Elevation)	Yes	Yes

Tab. 2. Available Parent Site metadata

A new Parent Site, called Parco Nazionale Gran Paradiso, has been included in the Italian LTER network. Metadata of this site have not been yet inserted in DEIMS, this action will be taken during the activity of this Special Project. Also each Simple Site has been queried on DEIMS to verify the presence and consistence of dataset and metadata (date of query 19-09-2014).

All Simple Sites have stored people and site metadata but only LTER_EU_IT_46 Lago Santo Parmense, LTER_EU_IT_47 Lago Scuro Parmense and LTER_EU_IT_026 Tarvisio have stored some dataset and the relative dataset metadata are available (Table 3).

Parent Site	Simple Site	Long Name	Metadata - Dataset	Metadata - Simple Site	Metadata - People
IT01- Apennines - High elevation Ecosystems	LTER_EU_IT_025	Appennino centrale: Velino-Duchessa	NO	YES	YES
	LTER_EU_IT_022	Appennino centro-meridionale: Majella-Matese	NO	YES	YES
	LTER_EU_IT_023	Appennino settentrionale	NO	YES	YES
	LTER_EU_IT_021	Appennino centrale: Gran Sasso d'Italia	NO	YES	YES
IT02-Forests of the Alps	LTER_EU_IT_027	Passo Lavazè TRE1	NO	YES	YES
	LTER_EU_IT_029	Renon BOL1	NO	YES	YES
	LTER_EU_IT_028	Val Masino LOM1	NO	YES	YES
	LTER_EU_IT_026	Tarvisio FRI2	YES	YES	YES
	LTER_EU_IT_085	Valbona	NO	YES	YES
IT03-Forest of the Apennines	LTER_EU_IT_032	Piano Limina CAL1	NO	YES	YES
	LTER_EU_IT_033	Montagna di Torricchio	NO	YES	YES
	LTER_EU_IT_031	Collelongo-Selva Piana ABR1	NO	YES	YES
IT09-Mountain Lakes	LTER_EU_IT_046	Lago Santo Parmense	YES	YES	YES
	LTER_EU_IT_047	Lago Scuro Parmense	YES	YES	YES
	LTER_EU_IT_088	Lago Paione Inferiore	NO	YES	YES
	LTER_EU_IT_089	Lago Paione Superiore	NO	YES	YES
IT19-Western Alps (High Elevation)	LTER_EU_IT_076	Istituto Scientifico Angelo Mosso (MOSSO)	NO	YES	YES
	LTER_EU_IT_077	Comune di Torgnon (Tellinod)	NO	YES	YES

Tab. 3. Available Simple Site metadata

In particular, LTER_EU_IT_46 Lago Santo Parmense has stored dataset and relative dataset metadata on: Air temperature, Dissolved oxygen Ammonia, Chlorophyll-a, Density of phytoplankton, Dissolved oxygen, Nitrate, pH, Precipitation, Reactive silica, Reactive phosphorus, Secchi disk and Water temperature. All these dataset cover a temporal extent that span from 2012/05/18 to 2012/10/16. The dataset metadata are summarized in Table 4. It is worth noticing that the dataset storage format reported in the metadata is "paper or spreadsheet" but dataset are not accessible; indeed in the "dataset online distribution" metadata section there is an indication of a web address that is not running and also there is no indication of available services to retrieve it. LTER_EU_IT_047 Lago Scuro Parmense has stored dataset and relative dataset metadata on: Density of phytoplankton, Dissolved oxygen, pH, Total phosphorus and Water temperature. All dataset cover a temporal extent that span from 2012/06/25 to 2012/10/18. The dataset metadata are summarized in the following Table 5. It is worth noticing that even here the dataset storage format is "paper or spreadsheet", but dataset are not accessible because in the "dataset online distribution" metadata section there is a web address not reachable and also there is no indication of services to retrieve it; moreover the dataset keyword set, which could be used for discovery of data and metadata, is different from that of LTER_EU_IT_046 Lago Santo Parmense (i.e. Data keyword set LTER Site and lakes not reported in LTER_EU_IT_47).

It is also worth noticing that LTER_EU_IT_026 Tarvisio FRI2 has stored dataset and relative dataset metadata on air temperature of other different simple sites, i.e. LTER_EU_IT_037 Bosco Fontana, LTER_EU_IT_031 Collelongo-Selva Piana, LTER_EU_IT_026 Tarvisio and LTER_EU_IT_034 Monte Rufeno.

Associated Dataset	Dataset keyword set	Dataset temporal extent	Dataset metadata date	Dataset online distribution
IT_SI001230_Lake Santo_pH_20130227	lakes LTER Site ph limnology	Fri, 2012/05/18 - Tue, 2012/10/16	05/07/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Santo_SRP_20130227	lakes LTER Site soluble reactive phosphorus limnology	Fri, 2012/05/18 - Tue, 2012/10/16	27/02/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Santo_Air Temperature_20130227	lakes LTER Site Temperature air	Sun, 2012/01/01 - Mon, 2012/12/31	27/02/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Santo_Precipitation_20130227	lakes LTER Site precipitation	Sun, 2012/01/01 - Mon, 2012/12/31	27/02/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Santo_Water T_20130227	lakes LTER Site water temperature limnology	Fri, 2012/05/18 - Tue, 2012/10/16	27/02/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Santo_Chla_20130227	lakes LTER Site chlorophyll a limnology	Fri, 2012/05/18 - Tue, 2012/10/16	27/02/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Santo_Conductivity_20130227	lakes LTER Site conductivity limnology	Fri, 2012/05/18 - Tue, 2012/10/16	27/02/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm) Web address function: Online information about the resource (Web page of related project, research site, institute, etc.)
IT_SI001230_Lake Santo_O2_20130227	lakes LTER Site dissolved oxygen limnology	Fri, 2012/05/18 - Tue, 2012/10/16	27/02/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm) Web address function: Online information about the resource (Web page of related project, research site, institute, etc.)
IT_SI001230_Lake Santo_SDT_20130227	lakes LTER Site secchi depth limnology	Fri, 2012/05/18 - Tue, 2012/10/16	27/02/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Santo_NO3_20130306	lakes LTER Site nitrate limnology	Fri, 2012/05/18 - Tue, 2012/10/16	06/03/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Santo_NH4_20130307	lakes LTER Site ammonium limnology	Fri, 2012/05/18 - Tue, 2012/10/16	07/03/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Santo_Phytoplankton_20130307	lakes LTER Site phytoplankton limnology	Fri, 2012/05/18 - Tue, 2012/10/16	07/03/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)

Tab. 4. LTER_EU_IT_46 dataset metadata

Associated Dataset	Dataset keyword set	Dataset temporal extent	Dataset metadata date	Dataset online distribution
IT_SI001230_Lake Scuro_SRP_20130228	soluble reactive phosphorus Permanent oligotrophic lakes, ponds and pools	Mon, 2012/06/25 - Thu, 2012/10/18	28/02/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Scuro_Water T_20130228	Temperature: water Permanent oligotrophic lakes, ponds and pools	Mon, 2012/06/25 - Thu, 2012/10/18	28/02/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Scuro_Chla_20130228	chlorophyll a Permanent oligotrophic lakes, ponds and pools	Mon, 2012/06/25 - Thu, 2012/10/18	28/02/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Scuro_pH_20130228	ph Permanent oligotrophic lakes, ponds and pools	Mon, 2012/06/25 - Thu, 2012/10/18	28/02/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Scuro_SDT_20130301	secchi depth Permanent oligotrophic lakes, ponds and pools	Mon, 2012/06/25 - Thu, 2012/10/18	01/03/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Scuro_Conductivity_20130301	conductivity Permanent oligotrophic lakes, ponds and pools	Mon, 2012/06/25 - Thu, 2012/10/18	01/03/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm) Web address function: Online information about the resource (Web page of related project, research site, institute, etc.)
IT_SI001230_Lake Scuro_O2_20130301	dissolved oxygen Permanent oligotrophic lakes, ponds and pools	Mon, 2012/06/25 - Thu, 2012/10/18	01/03/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Scuro_NO3_20130307	nitrate Permanent oligotrophic lakes, ponds and pools	Mon, 2012/06/25 - Thu, 2012/10/18	07/03/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)
IT_SI001230_Lake Scuro_NH4_20130307	ammonium Permanent oligotrophic lakes, ponds and pools	Mon, 2012/06/25 - Thu, 2012/10/18	07/03/2013	Web address: Northern Apennine Lakes Dataset (http://www.dsa.unipr.it/rossetti/metadata.htm)

Tab. 5. LTER_EU_IT_47 dataset metadata

2.3 To-do-list of activities

The inventory of LTER Europe facilities, dataset and metadata, on sites directly involved in the D-Lter-m project, established that:

· DEIMS is currently the main tool for metadata managing in LTER Europe.

· Available metadata are not normalized and are not optimized for discovery.

· Out of 18 simple sites only 2 of them have stored datasets and dataset metadata.

· A simple site has stored datasets and relative dataset metadata for other different simple sites.

· Dataset storage format is plain "paper or spreadsheet".

· Dataset are not accessible (i.e., no download, view, query is possible) and OGC interoperable observation services for dataset are not implemented yet.
Furthermore, in order to harmonize the future activities among Special Project partners, this Deliverable offers a rigorous definition of the term 'dataset' (see Annex 1).

List of actions to be performed
1. Simple site responsibles: all Simple Sites involved in D-LTER-m have to agree on the parameters to be collected for their case studies; beyond parameters they have to decide the temporal range and resolution of the collected measurements.

2. IREA CNR: After data collection, IREA CNR has to communicate to site responsibles the format(s) for dataset storage.

3. Simple site responsibles with support of IREA CNR: Dataset must be uploaded for all simple sites (dataset of LTER_EU_IT_46 Lago Santo Parmense, LTER_EU_IT_047 Lago Scuro Parmense must be updated).

4. IREA CNR: Dataset from all terrestrial Parent Sites involved (i.e. Parent Site IT01, IT02, IT03, IT19) must be inserted in the terrestrial data service (OGC SOS in Milan) and mirrored in Roma; mountain lake dataset (i.e. Parent Site IT09) must be inserted or moved to the lake data service (OGC SOS in Pallanza) and mirrored at DTA (Figure 8).

Parent Site	Simple Site	Long Name
IT01- Apennines - High elevation Ecosystems	LTER_EU_IT_025	Appennino centrale: Velino-Duchessa
	LTER_EU_IT_022	Appennino centro-meridionale: Majella-Matese
	LTER_EU_IT_023	Appennino settentrionale
	LTER_EU_IT_021	Appennino centrale: Gran Sasso d'Italia
IT02-Forests of the Alps	LTER_EU_IT_027	Passo Lavazè TRE1
	LTER_EU_IT_029	Renon BOL1
	LTER_EU_IT_028	Val Masino LOM1
	LTER_EU_IT_026	Tarvisio FRI2
	LTER_EU_IT_085	Valbona
IT03-Forest of the Apennines	LTER_EU_IT_032	Piano Limina CAL1
	LTER_EU_IT_033	Montagna di Torricchio
	LTER_EU_IT_031	Collelongo-Selva Piana ABR1
IT09-Mountain Lakes	LTER_EU_IT_046	Lago Santo Parmense
	LTER_EU_IT_047	Lago Scuro Parmense
	LTER_EU_IT_088	Lago Paione Inferiore
	LTER_EU_IT_089	Lago Paione Superiore
IT19-Western Alps (High Elevation)	LTER_EU_IT_076	Istituto Scientifico Angelo Mosso (MOSSO)
	LTER_EU_IT_077	Comune di Torgnon (Tellinod)

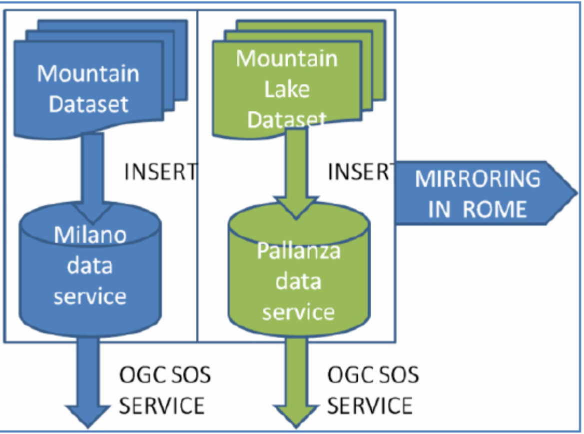

Fig. 8. Dataset activities

List of Metadata activities

1. Metadata of all Parent Sites must be checked and normalized. (i.e. check for Parent Site Id repeated several times, Subsite Code repeated several times and not all Subsite Code present, not all core metadata compiled).
2. Metadata of people for all Simple Sites must be checked, updated and normalized (i.e. check for link with Parent Site, insertion of address).
3. Metadata of simple sites for all Simple Site must be checked, updated and normalized (i.e. check for Parent Site Id not present, Subsite Code not present, not all core metadata compiled).
4. Metadata of datasets must be created for all datasets uploaded for each Simple Site (but LTER_EU_IT_46 Lago Santo Parmense, LTER_EU_IT_047 Lago Scuro Parmense where dataset metadata must be updated); all metadata dataset fields used for discovery service must be checked and normalized. The key fields actually identified for discovery are:
· dataset keyword set;
· dataset temporal extent;
· dataset geographic bounding coordinates.
5. Metadata of dataset for LTER_EU_IT_026 Tarvisio FRI2 must be reworked (i.e. creation of dataset metadata for the correct simple site).

Parent Site	Simple Site	Long Name	Metadata - Simple Site	Metadata - People	Metadata - Dataset
IT01- Apennines - High elevation Ecosystems	LTER_EU_IT_025	Appennino centrale: Velino-Duchessa	Check and normalize	Check and normalize	Metadata entry
	LTER_EU_IT_022	Appennino centro-meridionale: Majella-Matese	Check and normalize	Check and normalize	Metadata entry
	LTER_EU_IT_023	Appennino settentrionale	Check and normalize	Check and normalize	Metadata entry
	LTER_EU_IT_021	Appennino centrale: Gran Sasso d'Italia	Check and normalize	Check and normalize	Metadata entry
IT02-Forests of the Alps	LTER_EU_IT_027	Passo Lavazè TRE1	Check and normalize	Check and normalize	Metadata entry
	LTER_EU_IT_029	Renon BOL1	Check and normalize	Check and normalize	Metadata entry
	LTER_EU_IT_028	Val Masino LOM1	Check and normalize	Check and normalize	Metadata entry
	LTER_EU_IT_026	Tarvisio FRI2	Check and normalize	Check and normalize	
	LTER_EU_IT_085	Valbona	Check and normalize	Check and normalize	Metadata entry
IT03-Forest of the Apennines	LTER_EU_IT_032	Piano Limina CAL1	Check and normalize	Check and normalize	Metadata entry
	LTER_EU_IT_033	Montagna di Torricchio	Check and normalize	Check and normalize	Metadata entry
	LTER_EU_IT_031	Collelongo-Selva Piana ABR1	Check and normalize	Check and normalize	Metadata entry
IT09-Mountain Lakes	LTER_EU_IT_046	Lago Santo Parmense	Check and normalize	Check and normalize	
	LTER_EU_IT_047	Lago Scuro Parmense	Check and normalize	Check and normalize	
	LTER_EU_IT_088	Lago Paione Inferiore	Check and normalize	Check and normalize	Metadata entry
	LTER_EU_IT_089	Lago Paione Superiore	Check and normalize	Check and normalize	Metadata entry
IT19-Western Alps (High Elevation)	LTER_EU_IT_076	Istituto Scientifico Angelo Mosso (MOSSO)	Check and normalize	Check and normalize	Metadata entry
	LTER_EU_IT_077	Comune di Torgnon (Tellinod)	Check and normalize	Check and normalize	Metadata entry

Tab. 6. Metadata activities

Dataset upload and observation services

As noticed above, there are no facilities in DEIMS for facilitating the implementation of interoperable observation services in LTER Europe. IREA CNR offers to face this challenge by exploiting an open source software suite available from (Fugazza et al., 2014 and GitHub[8]) that provides a software environment for managing, editing and viewing geospatial data and observations. This suite can be used for the implementation of interoperable observation services (SOS) and related dataset upload. With this suite researchers will easily upload, manage and share geospatial data and observation, create and share interactive maps, browse and search for geospatial data and web services; it also offers a software environment for metadata managing, called EDI, that allows to create, modify and examine observation metadata. All services delivered so far are interoperable and OGC compliant so that the following services will be available: WMS, WFS, WCS for maps and layers, SOS for observations and CSW for discovery.

8 https://github.com/SP7-Ritmare/starterkit

Part 3: Action plan

Actions	Actors
Check and normalizations of Metadata (sites and persons)	Site manager (guide of CNR IREA)
Specific check and normalizations of metadata (dataset) only on the fields used for discovery	CNR - IREA Milano
Creation of observations service (SOS) in CNR ISE Pallanza	CNR - IREA Milano
Upload of new dataset of lake observations in the observations service (SOS) of CNR ISE Pallanza	Site manager (guide of CNR IREA and CNR ISE)
Creation of observations service (SOS) in CNR IREA Milano	CNR - IREA Milano
Upload of new dataset of terrestrial observations in the observations service (SOS) of CNR IREA Milano	Site manager (guide of CNR IREA)
Mirroring to NextData central server in Rome	CNR - IREA Milano

Annex 1: Definition of the term 'dataset'

Considering the prominence of the dataset term in the framework of this Special Project and in order to harmonize the activities, this Deliverable offers a rigorous definition of these. Adopting of this definition will help the Special Project partners to upload observations and fill out properly the metadata of those. For the purposes of this Special Project the definition suggested in EnvEurope Project LIFE08 ENV/IT/000339 (Kliment and Oggioni, 2011) was taken as starting point. Below the definition that will be adopted:
Dataset is a data collection produced as a result of fieldwork sensors (*in-situ*) or the analytical methods applied to the samples collected (*ex-situ*) in a specific site, station or plot and of one specific environmental parameter. It can be said that data has two sources: the fieldwork and the laboratory. A dataset represents one or more data table (text file, ascii file, spreadsheet, etc.), GIS layers or database views which the metadata describes.

References

FUGAZZA C., MENEGON S., PEPE M., OGGIONI A. & CARRARA P., (2014): The {RITMARE} Starter Kit - Bottom-up Capacity Building for Geospatial Data Providers. Proceedings of the *9th International Conference on Software Paradigm Trends - ICSOFT*, Vienna, Austria, 29-31 August, 2014. 169-176 pp. DOI: 10.5220/0004999801690176.

KLIMENT T. & OGGIONI A., (2011): EnvEurope (LTER-Europe) Metadata Specification for Dataset Level. Deliverable A.1.1.2b. 89 pp.

D1.7.2.5: Effects of climate change on alpine plants

The studies performed by University of Pavia team aim to evaluate the effects of climate change on seed germination and seedlings recruitment and survival of alpine plant species; to understand the impacts of extreme climatic events on plants and to highlight the effects of maternal environment and geographic origin in plasticity and adaptive capacity of plants. Data were collected both in the laboratory and in field experiments.

In order to investigate how and whether seedling emergence and survival could withstand a warming scenario, seeds of glacier foreland species were sown at the current growing site and 400 m of altitude downward in the glacier Dosdè foreland area. Seedling emergence and survival were monitored for two years. Our results suggest that warming will influence the recruitment of alpine species primarily via the extension of the snow-free period in spring, increasing seedling establishment and allowing a greater resistance to summer drought. However, interactions with other components of the plant community are still unknown (1).

Laboratory experiments involved seedlings of the arctic-alpine species *Silene suecica* and seeds of the wide distributed *Silene vulgaris*. These experiments highlighted the importance of the geographic origin of plants to cope with climate change. If the first case, the southern population of *Silene suecica* showed better capacity to avoid water loss in drought conditions, although the northern population showed higher plasticity (2).

In the second experiment a plastic responses for seed longevity to the local environment were highlighted for *Silene vulgaris*. Seeds of lowland population were significantly longer lived than those of alpine population. However, when alpine plants were grown in the common garden, longevity doubled for the first generation of seeds produced demonstrating that, although seed longevity has a genetic basis, it may show strong adaptive responses. Adaptive adjustments of seed longevity due to transgenerational plasticity may play a fundamental role in the survival and persistence of the species in the face of future climate change (3).

Finally, we considered the role of extreme climatic events on plants adaptation. The high temperatures and extreme drought stress that are the main characteristics of heat waves, affect plant physiology and metabolism, and in turn affect plant growth and reproduction with two main consequences: adaptation or extinction (4). Although in the last years ecological studies recognize the importance of these extremes as drivers of plant growth and mortality, as well as drivers of ecological and evolutionary processes, our knowledge is still fragmentary. In some cases, extreme climatic events exert a strong selective pressure on plant species that may lead to extinction of more vulnerable species (5).

(1) Mondoni A., Pedrini S., Bernareggi G., Rossi G., Abeli T., Probert R., Ghitti M., Bonomi C., Orsenigo S., (2015, accepted): Climate warming could increase the recruitment success in glacier foreland plants. *Annals of Botany*.

(2) Abeli T., Orsenigo S., Guzzon F., Faè M., Balestrazzi A., Carlsson-Granér U., Müller J.V., Mondoni A., (2015, in press): Geographical pattern in the response of the arctic-alpine Silene suecica (Caryophyllaceae) to the interaction between water availability and photoperiod. *Ecological research*.

(3) Mondoni A., Orsenigo S., Donà M., Balestrazzi A., Probert R., Hay F.R., Petraglia A., Abeli T., (2014): Environmentally induced transgenerational changes in seed longevity: maternal and genetic influence. *Annals of Botany*, 113: 1257-1263.

(4) Abeli T., Mondoni A., Rossi G., Orsenigo S., (2014): Effects of summer heat waves on Europe's wild flora and vegetation. *Agrochimica*, 58: 128-132.

(5) Orsenigo S., Mondoni A., Rossi G., Abeli T., (2014): Some like it hot and some like it cold, but not too much: plant responses to climate extremes. *Plant Ecology*, 215(7): 677-688.

D1.7.2.6: Ecology of red squirrel in conifer forests

In the year 2000 researchers from the Universities of Turin and Insubria started a research on the ecology of the red squirrel (*Sciurus vulgaris*) in alpine coniferous forests: the ASPER (Alpine Squirrel Population Ecology Research) Project. The aim of ASPER is to build a long-term data set on the population dynamics and food resources of red squirrels living in montane and subalpine conifer forests. These time-series data are used to explore habitat selection and local adaptation by red squirrels to the different conifer forest-types. Acquiring this knowledge is essential to better understand the role that this arboreal rodent has in forest ecosystems in relation to climatic conditions and tree seed-crop production. It is also essential to define red squirrel conservation strategies in the Alps in response to the possible expansion of the American grey squirrel that is outcompeting the native congener in the areas of introduction.

The ASPER Project is run by researchers of the Turin University in the Gran Paradiso National Park (Western Alps) and by researchers from the University of Insubria in some sites in Valtellina (Central Alps). In Gran Paradiso, red squirrels are monitored in two second-growth, subalpine conifer forests that differ in tree species composition, diversity and size of trees. The site in Val di Cogne is a mixed forest of Norway spruce, *Picea abies* (45%) and Larch, *Larix decidua* (54%) with few dead trees (1%). The site in Val di Rhemes is dominated by Norway spruce (85%) with some mixed patches with Larch (11%); trees are larger than at Cogne, and dead trees are common (4%), occurring throughout the study site.

In 2014 the project continued in the framework of the NextData Project. Field work continued in 2014 and it is planned for 2015. Current data analyses are directed to estimate the influence of climatic conditions on conifer seed-crop fluctuations and the link between climate, seeds and squirrels.

Main results

Population density. Fluctuations in squirrel densities were positively correlated with food availability, measured as the size of conifer seed-crops produced each year. In spring and summer, population increases were mainly caused by higher immigration rates and correlated with the previous year's seed-crop. In contrast, squirrel densities and rates of population increase in autumn – i.e. new animals entering the population from August to October – were strongly correlated with the same year's autumn seed-crop. Moreover, in autumn both number of locally-born juveniles and immigration rates increased with the upcoming seed-crops. The best model was obtained correlating squirrel densities in May and July with seed-crop production of the previous year, and autumn density with seed-crop production of the same year (Fig. 1).

Our data support the hypothesis that red squirrel populations in conifer forests increase the population size in synchrony with resources, thereby eliminating population lags normally present when resources occur in pulses. Summer survival rates were higher than during winter, maybe as a result of regular episodes of extreme weather conditions (low temperatures, heavy rainfall or snowfall) during the winter period across all sites.

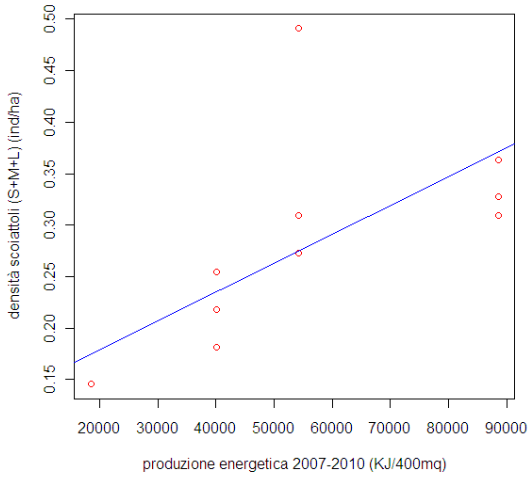

Fig. 1 Correlation between conifer seed-crop production (energy content) of the year n and the density of squirrels (ind./ha) calculated in September of year n and May and July of year n + 1.

Body condition and fitness: food availability is likely to influence body condition and, in turn, fitness. The intensity of this response may vary between populations of the same species on a small spatial and temporal scale. Squirrel body size did not differ between sexes but differed between areas. Seasonal variation in squirrel body mass was small with no evidence for fattening in autumn. Females were slightly heavier than males, but this difference was largely explained by mass gain of females during reproduction. Differences in size and mass between populations were partially explained by habitat-related differences in body size and variability of seed crops, suggesting differential selection for smaller squirrels in spruce-larch forests against selection for bigger and heavier animals in mixed broadleaf and conifer forests and in Scots pine forests with a more stable seed production. The probability of reproduction by females increased with body mass, but varied strongly between habitats and years, with more females reproducing in years with rich seed-crops. In both sexes, body mass positively affected probability of settlement and length of residency.

Spatial pattern: Red squirrels responded to food shortage due to spruce-seed failure by strongly increasing home ranges in the following year, and moving to patches with other food resources. They abandoned the spacing pattern of reduced core-area overlap in males and nearly exclusive core-areas in females, found in less variable habitats. After richer seed-crops, it took squirrels about one year to reduce the size of their home ranges and core-areas and return to a spacing pattern of stable home ranges and intra-sexual territoriality of adult females. These results show that the spacing behaviour in red squirrels is a plastic, conditional strategy with individuals adapting the size and/or location of their home ranges in relation to local distribution and abundance of food resources.

Squirrels and fungi: In summer–autumn, nearly all red squirrels in Gran Paradiso fed on hypogeous fungi and the large number of spores found in fecal pellets suggests that they act as spore dispersal agents of hypogeous mycorrhizal fungi. Mycorrhizal fungi are important for the growth and maintenance of forest ecosystems, and forest-dwelling mammals can maintain a high level of inoculation in tree-roots within the forest. Red squirrels have large home ranges and are known to disperse over more than 5 km. Considering their mobility and the large number of spores found in faeces, red squirrels may play an important role as long distance spore dispersal agents. Hence, disseminating spores of mycorrhizal fungi, the red squirrel could play a role in the maintenance of conifer forests in the Alps (Fig. 2).

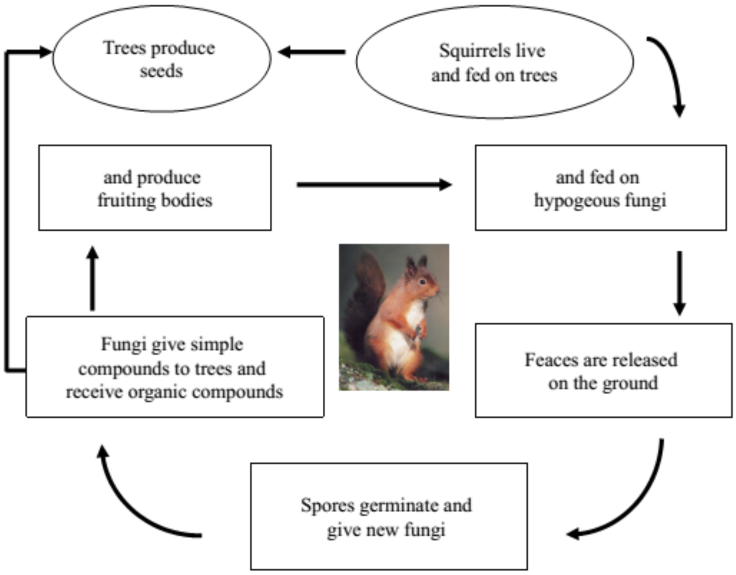

Fig. 2. Red squirrels feed on hypogeous fungi and disperse their spores through the feces; these spores will germinate originating mycorrhizal fungi that are important for the growth of the trees that will produce seeds eaten by squirrels.

Monitoring constitutes a key element in the management and conservation of species. We tested if indices derived from the proportion of hair-tubes visited by red squirrels correlate with population estimates obtained by live trapping. Hair-tube indices correctly predicted squirrel densities in the Western and Central Alps. A combined data set pooling the sites of these two regions based on the first three years successfully predicted the two successive years. In addition, a combined model derived from areas monitored for five years (Fig. 3) had predicted density values from an English data set. We therefore believe that the predictive model developed in this study could be of general value and be used to monitor squirrel populations in European low density conifer habitats.

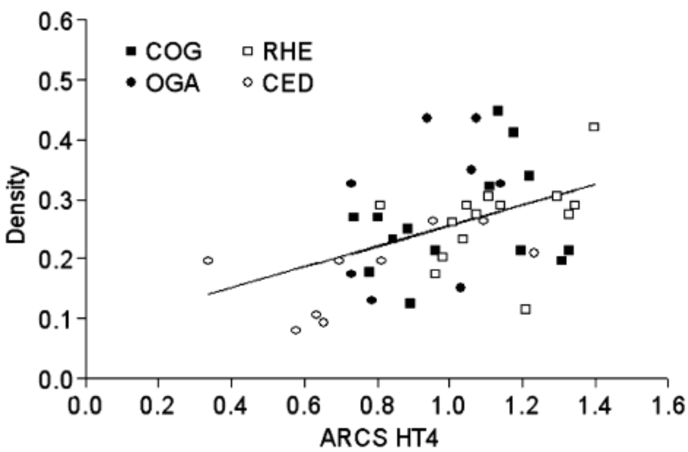

Fig. 3. Linear regression of the density (squirrels/ha) recorded in four Alpine forests on the proportion of hair-tubes visited by squirrels (ARCS HT4)

Main publications:

BERTOLINO S., WAUTERS L., DE BRUYN L., CANESTRI-TROTTI G., (2003): Prevalence of coccidia parasites (Protozoa) in red squirrels (*Sciurus vulgaris*): effects of host phenotype and environmental factors. *Oecologia*, 137, 286-295.

BERTOLINO S., VIZZINI A., WAUTERS L., TOSI G., (2004): Consumption of hypogeous and epigeous fungi by the red squirrel (*Sciurus vulgaris*) in subalpine conifer forests. *Forest Ecology & Management*, 202, 227-233.

WAUTERS L.A., BERTOLINO S., ADAMO M., VAN DONGEN S., TOSI G., (2005): Food shortage disrupts social organization: the case of red squirrel in conifer forests. *Evolutionary Ecology*, 19, 375-404.

WAUTERS L.A., VERMEULEN M., VAN DONGEN S., BERTOLINO S., MOLINARI A., TOSI G., MATTHYSEN E., (2007): Effects of spatio-temporal variation in food supply on body size and body mass and its consequences for fitness. *Ecography*, 30, 51-65.

WAUTERS L.A., VERMEULEN M., VAN DONGEN S., BERTOLINO S., MOLINARI A., TOSI G., MATTHYSEN E., (2007): Effects of spatio-temporal variation in food supply on body size and body mass and its consequences for fitness. *Ecography*, 30, 51-65.

BERTOLINO S., WAUTERS L., PIZZUL A., MOLINARI A., LURZ P., TOSI G. (2009): A general approach of using hair-tubes to monitor the European red squirrel: a method applicable at regional and national scales. *Mammalian Biology*, 74, 210-219.