From simple vegetation surveys to management of biodiversity data
Problems in setting up a database for alpine flora

This study discusses the establishment of the FlorEM database for alpine flora which intends to become a reference on plant diversity. The difficulties in setting up the database, its advantages and limitations are all presented here.

Databases containing long data series are reference tools for biodiversity monitoring taking into account the various anthropogenic and environmental pressures. Vegetation databases are very important given the primary role of plants in ecosystem functioning, the sensitivity of plants to global change and their role as indicators for the diversity of other taxonomic groups (Nic Lughadha et al., 2005). Their integration and use in local and national environmental policies nonetheless remains a major issue (Henry et al., 2008). To that end, databases must be easy to access, fast and simple to use for scientists, environmental managers and also for decision-makers. It was with all the above in mind that the FlorEM (Flore des Ecosystèmes Montagnards - Flora of mountain ecosystems) database was designed.

The FlorEM database

The Alps are in the front lines in terms of climate and land-use change. Profound changes have already been observed in the distribution and composition of alpine flora (Dirnböck et al., 2003). They are thus a favourable territory for the creation of a vegetation database, particularly for the emerging questions on the long-term impact of droughts and extensification.

The team of agricultural ecologists in the Cemagref Mountain ecosystems research unit in Grenoble have studied the grassland vegetation from the montane to the alpine zone for almost 40 years. Initially, the surveys were carried out to characterise the flora for pastoral management. The large number of surveys, the large geographic area covered and their precision (measuring the abundance of plant species and not only their presence or absence) are however valuable features in view of long-term monitoring of plant diversity.

The idea of compiling and organising the surveys emerged about ten years ago. It first took the form of an inventory, then the need to design an efficient computerised system rapidly became obvious to ensure the continued usability of the database and enable regular updates with new surveys.

The first step in setting up FlorEM was the construction of a simple, floristic database containing just the vegetation relevés. However, the floristic data alone are not sufficient to answer questions on the impact of climate change or modifications in land use. Consequently, a second step linked each relevé with descriptors of the environment (altitude, geographic coordinates, edaphic characteristics, etc.), management (pastoral techniques, fertilisation, management history, etc.) and functional descriptors (productivity, fodder quality, plant functional traits, etc.). This step was essential for correct interpretation of changes in plant diversity and to link the observed modifications with changes in climate or land use.

Today, FlorEM contains almost 5 000 vegetation relevés carried out since the 1970s in the montane to alpine zone in the French Alps and Pyrenees and integrated in a database management system. The short-term objective is to put the database on-line to enable public access to the inventory of the relevés (see below) and subsequently controlled access to the vegetation surveys themselves.

The first access level to FlorEM is thus the list of the 5 000 vegetation surveys with, for each survey, a description including the date, location (precise to cadastral unit or summer pasture and, in some cases, with geo-referenced coordinates) and the protocol used (line transect, line length, quadrats, sampled area, etc.).

The second access level can be used to link the description with the vegetation data itself, namely the list of species, their abundance or frequency, and in certain

❶ Floristic surveys in mountain (Alpe-d'Huez, France).

cases, the descriptors of the environment and pastoral management. Concerning the functional descriptors, only productivity, when it was measured, is linked to the surveys. A "plant functional trait" database (leaf surface, digestibility, nitrogen and carbon content of plants) is now being created and will be linked to FlorEM.

To date, virtually all of the relevés have been carried out in the Northern Alps (27%, notably in the Vanoise, Beaufortin, Oisans and Maurienne regions), the Southern Alps (50%, in the Vercors and Briançonnais regions) and in the Pyrenees (13%). The altitudinal distribution of the surveys underscores the biogeographic specificity of this database addressing environments starting at the montane zone, but primarily the subalpine zone with 50% of the surveys carried out above 2 000 metres, 25% between 1 500 and 2 000 metres, and 25% below 1 500 metres altitude.

Difficulties and constraints of this type of database

The relevés included in FlorEM were carried out in the context of specific studies and were not intended for the database, with as a result two major disadvantages. The first is that the site descriptions are often incomplete, the second is that the survey methods were not always identical.

Data heterogeneity

For FlorEM, three main causes of data heterogeneity exist:

- different goals for the studies in which the surveys were carried out;
- different protocols and sampling methods depending on the issues addressed;
- significant variability in the precision of the survey location data.

Consequently, the FlorEM database was filled with a vast array of different, often independent, short and mid-term survey projects. The differences between observers, notably concerning species identification (use of different floras or taxonomies), in the use of protocols or in the gathering of pastoral-management data led to intrinsic heterogeneity between surveys. For example, for the line transects, used mainly for agro-ecological characterisation, there were discrepancies in the lengths of the lines (20 to 100 metres long), in line types (lines in one or two parts), in the sampling effort per line and in the distances between two measurement points (10 to 50 cm). Similarly, for the quadrat method (spatially limited squares), better suited to ecological monitoring, different areas were used, ranging from 0.25 to 100 square metres.

It was thus necessary, prior to setting up the database, to inventory the methods employed and take that variability into account in database design. This point was crucial to avoid interpretation bias caused by the survey method for relevés carried out at the same place, but with years or decades between two samplings (see photo ❶).

Interpretation bias may also be caused by uncertainty in survey locations. In the 1970s, most survey locations were marked on aerial photos or maps, even hand drawn, whereas today, surveys are geo-referenced. In the database, there are significant differences in the precision of locations.

The above highlights a crucial problem encountered by the teams constructing these databases, i.e. the disconnect between the time scale over which changes in biodiversity must be apprehended (at least a decade) and the duration of funding programmes for research and projects, generally one to four years.

Database updating and formatting

The value of a database depends heavily on regular updating. But in the current context, the absence of specific personnel for this task means that updating may be irregular. That is why we now plan to create an ergonomic interface for on-line access by all personnel to facilitate the entry of new information. In the future, data access will be possible via the FlorEM portal in "query" mode (data extraction) for all personnel and in "entry" mode (entry of new data) for contributing users. This step should enable easier and more timely entry with closer ties between entries required for a given project and those for FlorEM.

The progress made in setting up FlorEM has received strong support from regional efforts and synergies spanning the entire Alpine range because the database is being set up in parallel with an even larger inventory by the Zone Atelier Alpes (Workshop Zone Alps), certified by CNRS and recently labelled SOERE (Systèmes d'Observation et d'Expérimentation, sur le long term, pour le Recherche en Environnement - Long-term observation and experimentation systems for environmental research). A partnership with the Botanical conservatory of the Alps in Gap-Charance has also been set up for data exchange and in view of making the database available to more users.

Data mining and data valorisation

FlorEM is intended primarily for exploration of vegetation data for research and science advice for the mid and long terms. It supplies information on modifications in plant diversity and on the capacity of alpine flora to adapt to global change.

Currently, an initial research project is concentrating on the Vercors massif ("Impact and management of climate change" programme funded by the Ecology ministry). It studies the effect of droughts on subalpine pastures. Starting in 2010, approximately 200 surveys, some of which are over 30 years old, will be resampled. This first phase in the Vercors will test the precision of the location data for the old surveys. To avoid the problems caused by the use of different protocols, there are a number of possible solutions, including using only the presence-absence data of species. Unfortunately, those solutions are rarely satisfactory. That is why experiments to compare different survey methods for estimating plant diversity are now underway on our sites or have already been studied, notably in forest environments (Archaux et al., 2007). The results should make it possible to use surveys for long-term monitoring even if they were carried out with different protocols. The goal is to expand resampling to a larger part of the Alpine territory in the years to come.

Two sites in the Isère department have a network of 12 pairs of plots, grazed and not grazed, that has existed for over 20 years on the Vercors high plateaux and 30 years in Alpe d'Huez. The vegetation has been regularly sampled over the years. The plots are an extraordinary advantage for FlorEM in understanding the interaction between climate change and modifications in pastoral management. The continuation of these experimental observation systems is of critical importance for the future of FlorEM.

FlorEM updating is done with data coming in many cases from public research programmes. Consequently, data must be made freely available. However, the database management system must ensure that the persons who collected the data are associated with its subsequent use. In response to requests from other organisations and environmental managers, data access must be organised to ensure effective interaction between the people using the requested data and those who collected it.

Conclusion

The FlorEM database may be an important tool for long-term monitoring of plant diversity in alpine environments in a context of global change. Coordinating its construction and regular updating in view of ensuring access by all those interested in the data is a worthy challenge. This type of database must at some point be capable of supplying useful data for environmental policies on the regional level. Drafting of a good-practices guide for the database is an important first step in order to facilitate regular updating and collaborative use. Unfortunately, in spite of the acknowledged need for long-term biodiversity monitoring, there is not sufficient funding to maintain such databases over the long term or to ensure updating. But with the establishment of long-term observation systems, we may hope that such funding will become possible. ■

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Mountain pasture of Montclocher (Savoie).

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