

Adapting to climate change within the underground habitats of the Cavities of Mas d'Azil, Mériçon, Tourtouse and Unjat

VULNERABILITY ASSESSMENT AND ADAPTATION PLAN SUMMARY

VULNERABILITY ASSESSMENT

The Pyrenees are a recent mountainous massif that began its formation in the Cenozoic era and harbor an exceptional biodiversity. This can be explained by the confrontation of many different climates inducing a great variety of habitats in an agricultural and forestry context rather extensive and where human pressures seem relatively low. And this exceptional biodiversity can be found both on the surface and in the underground environments.

The variety of karstic environments in the department of Ariège illustrates the great diversity of the geotopes present. They offer a vast quantity of different cavernicultural contexts of which important volumes are favourable to the populous colonies of bats which find their shelter there and an epigeous context favourable to their preys, the invertebrates. Bats bring a significant quantity of organic matter underground via their guano. They thus favour a rich invertebrate fauna with an incredibly high rate of endemism due to the history of the Pyrenees. These invertebrates, often present in the soil, are thus maintained by an abundance of food provided by these mammals.

Human beings also frequent the caves for cultural purposes related to history through archaeological remains, but also for the practice of sports and the study of underground environments as a whole through speleology. The conservation of the remains can, in certain cases, be diminished by corrosion induced by their breathing and their excrements. On the other hand, the frequentation of underground cavities, whether for scientific, sporting or tourist purposes, can be negative for the quietude, reproduction or hibernation of bats. The work of the managers is to adapt these practices so that they remain compatible with the whole heritage of the cavities.

At the same time, **the karst environment and all that it shelters, namely the heritage and human activities, are exposed to climate change.** Caves, however little studied, reveal better than elsewhere the galloping progress of climate change. Because of the small variations in climatic conditions within the cave, climate drift can be observed much more clearly than outdoors, as well as the influence of climate change on temperature and other conjectural factors such as humidity or CO₂ concentrations.

The evolution of these climatic parameters will not be without impact on the heritage contained in the caves. Without knowing precisely the trajectory of these parameters on the sites studied, we can make some hypotheses on the basis of work done on these sites or elsewhere. Cave-dwelling species choose caves for the conditions they offer in terms of tranquillity or microclimate, which is already changing rapidly. **We can therefore expect an evolution of the occupation of caves, positive or negative, by these species.** These microclimatic conditions are also crucial for the **conservation of archaeological and cave heritage** in particular. Drying out or an increase in temperature can modify the processes in place that have protected these remains for thousands of years.

The study and conservation of karst is also strongly linked to the ability of us humans to move through it. It is possible that **the conditions of access will change for the needs of conservation in tourist sites** if the levels of CO₂ come to exceed concentrations incompatible with their conservation objectives.

The main conclusion of this diagnosis is that it highlights the vulnerability of the underground environments of the Ariège but also the opportunity that is offered to us to know them better in a context of climate change. **The level of ignorance regarding conservation issues is such that underground environments now deserve a share of attention and studies that are equal to the current upheaval.**

ADAPTATION PLAN

Caves and karstic environments in general are also undergoing the effects of climate change. In Ariège, the average annual temperature is rising faster than in the rest of the world: **the Mas d'Azil station has recorded an increase of 1.4 to 1.7°C since 1952**. Even if precipitation is stable, **episodes of prolonged drought and heat waves are expected to be more recurrent**.

This may have effects on the environments by modifying the karstification processes, but also on the species (choice of habitat, life history traits) or on the conservation of archaeological remains for example.

The complexity of underground environments, due to their three-dimensional structure, the effects of water infiltration and the small variation of important climatic parameters makes their study difficult. Few studies and even less long-term monitoring are carried out, which makes it difficult to identify the role of anthropic pressures on these environments. **Agriculture, forestry management, and the use of underground environments are all factors of influence that are also likely to evolve in response to climate change and must be anticipated** so that they can be integrated into the management of sites protected for underground issues.

It is because of this complexity that adaptation through active management of the identified influencing factors seems too early in relation to the identified gaps, namely the understanding of the natural processes and the functionality of the underground environments. This prerequisite is now essential for reasoned management in the future.

Some actions already initiated are essential for adaptation to climate change and must be continued and re-prioritized. **Long-term monitoring, awareness-raising actions and the reduction of anthropic pressures on heritage objects are essential points to promote adaptation.**

However, new actions need to be initiated, such as modeling the ecological niches of heritage species or prospective work for the creation of protected areas so

that they already include the evolution of the climate and the distribution areas of species.

Such management and research issues are coupled with a need for improved governance and access to funding. **This encourages the creation of the National Underground Nature Reserve of Ariège (RNNSA) which could become a true research platform on underground environments and climate change.** Given the challenges we face in terms of acquiring knowledge, the RNNSA would allow us to bring together managers, elected officials, university researchers and socio-professional users of these sites who may be concerned.

Climate change is therefore not a fatality since it also offers opportunities to highlight underground environments and reveal their uniqueness, their fragility and their importance in human culture and history. Many gaps in knowledge remain to be filled in order to understand and manage karst environments in relation to climate change, but they are now, in part, known and many partners have already invested or shown their interest in working on these sites.

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[Adaptation plan](#)

