

Environmental Outlook Status of Caves in Italy

Detailed version

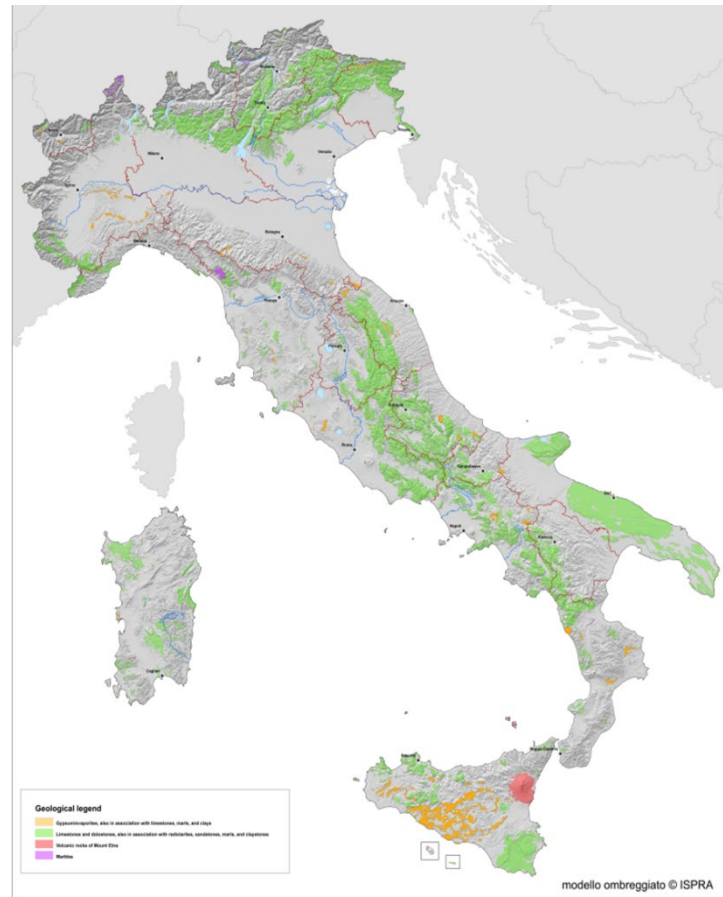
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Geological Diversity and Caves

The geological landscape of Italy is diverse and particularly complex, with karstic regions covering approximately one-sixth of its total land area (around 50,000 km²). These karst areas vary in size and composition across different regions, influencing the types and distribution of caves. The regions most affected by the karst phenomenon are Friuli Venezia Giulia, Veneto, Puglia, Tuscany, Sardinia and Sicily, as well as some areas of the central and southern Apennines.

Over a century of exploration has led to the discovery of 44,362 caves, primarily in carbonate rocks such as limestones and dolomites. Additional caves exist in lava fields, gypsums and other evaporitic formations. The regions with the most important caves in Italy include:

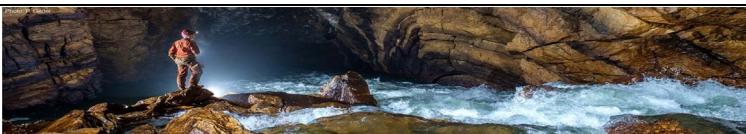
- Sardinia (Codula Ilune system, >70 km)
- Lombardy (Pian del Tivano system, >60 km)
- Tuscany (Monte Corchia complex, ~56 km)
- Friuli Venezia Giulia (Col delle Erbe system, >45 km)
- Piemonte (Piaggia Bella system, >40 km)
- Veneto (Piani Eterni complex, ~37 km)



Types of Caves

Caves in Italy can be categorized based on their access, use, and geological significance:

- Natural caves: Formed in carbonate, evaporitic, and volcanic rocks; these include deep vertical caves, extensive horizontal networks, and marine caves (~5,000 documented marine caves).
- Artificial caves: Italy has a rich history of man-made caves (~5,155), including mines, underground aqueducts, ancient rock settlements, religious sanctuaries, and military structures.



Cave Protection Status

The Italian Speleological Society (SSI) and other organizations manage databases, land registry and catalogs of caves. The National Cadaster of Artificial Cavities was established in 1989 to document man-made underground structures.

All natural caves in Italy are considered habitats of Community interest according to the European Union Habitat Directive (92/43/EEC). Specifically, they fall into two types of protected habitats:

- Habitat 8310 - Unexploited caves for tourist purposes. Includes natural caves and caverns not subject to significant man-made modifications
- Habitat 8320: Fields of lava and natural excavations
- Habitat 8330 - Submerged or semi-submerged sea caves. Covers coastal and underwater caves

These habitats are protected to preserve their biodiversity and the species that inhabit them, many of which are rare or endemic.

Both natural and artificial caves in Italy can fall also under specific laws concerning extractive activities, mineral waters, archaeology, fine arts, and regional environmental regulations. Protection is primarily granted through **Parks, Reserves, and regional laws**, ensuring some level of conservation.

Legal Framework for Cave Protection

All natural caves in Italy are considered habitats of Community interest according to the European Union Habitat Directive (92/43/EEC). Specifically, they fall into two types of protected habitats:

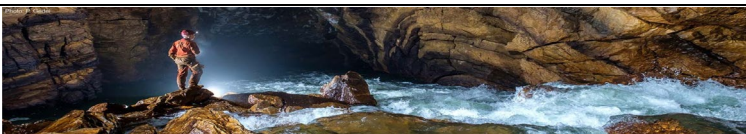
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These habitats are protected to preserve their biodiversity and the species that inhabit them, many of which are rare or endemic.

Both natural and artificial caves in Italy are not automatically protected but fall under specific laws concerning extractive activities, mineral waters, archaeology, fine arts, and regional environmental regulations. Protection is primarily granted through Parks, Reserves, and regional laws, ensuring some level of conservation.

Mining and Archaeological Cave Protections

Underground mines are regulated by D.P.R. no. 128 of 09/04/1959 (Police Regulations of Mines and Quarries), which was later updated through Legislative Decree no. 624/96. This legislation governs mining activities, ensuring safety and environmental considerations.



For caves of historical, archaeological, or geological significance, protection falls under the Code of Cultural Heritage and Landscape (Legislative Decree 22.01.2004 no. 42). This code provides legal safeguards to preserve culturally and geologically important caves.

Regional and Environmental Protections

Almost all Italian regions have implemented specific regulations aimed at protecting speleological heritage and geological diversity. These regulations complement national laws, ensuring a broader framework of conservation.

The Framework Law on the Environment (Legislative Decree 152/2006) does not explicitly mention caves and karst systems but indirectly applies to them through regulations concerning groundwater and land protection.

European Habitat Directive Protections

The Habitats Directive (92/43/CEE) provides protection for caves and karst habitat. Non-touristic caves are classified as habitats of community interest, listed in Annex I of the directive under:

- Habitat 8310: Caves not exploited for tourism, considered significant natural habitats
- Habitat 8320: Fields of lava and natural excavations
- Habitat 8330: Submerged or semi-submerged sea caves

Under this Directive, caves within the Natura 2000 network receive an additional layer of conservation. While this offers broad protections, the Italian government is responsible for ensuring compliance and effective cave management at a national level.

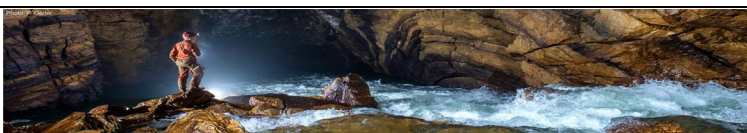
Property Rights and Access to Subsoil

Cave access and ownership in Italy follow the same legal principles as surface land ownership. This means:

- The cave entrance and the underlying cavity belong to the landowner. According to article 840 of the Civil Code, the ownership of the land extends to the subsoil and to the space above it, but only as far as the owner can exercise an interest and a utility. However, there are different exceptions and limitations: mineral resources, oil fields, natural gas, mineral and thermal waters are the property of the State (Mining Law of 1927), and underground archaeological sites are also state-owned. If the subsoil has environmental or geological value (e.g. protected caves), there may be restrictions imposed by the state or regions. Consequently, caves are generally considered a state property, while access to the cavities remains to the landowner• The landowner has the right to restrict or permit access, including through fencing or other protective measures.
- If no explicit access restrictions are in place, speleologists and the public may explore caves freely.

Water and Caves Protection

Groundwater associated with caves has long-standing legal protections. Royal Decree no. 1775/1933 remains a key law ensuring the safeguard of underground water resources, maintaining constitutional



validity. This was further reinforced by Legislative Decree 152/2006, which establishes specific water quality objectives to comply with Directive 2000/60/EC.

However, Decree 152/06 has a significant gap: while it focuses on underground aquifers, it does not provide explicit protection for groundwater within caves. Instead, surface waters receive more direct regulation, leaving some legal uncertainties regarding groundwater preservation in karst systems.

Role of Parks and Reserves in Cave Protection

Given the fragmented nature of cave-specific legislation, the establishment of Parks and Natural Reserves has become one of the strongest methods of cave conservation in Italy. Many caves fall within protected areas, where strict environmental controls help mitigate human impact and preserve delicate subterranean ecosystems.

Underground Geological Heritage Status

The geological heritage is significant, with a national inventory documenting cave of karstic, volcanic, and anthropogenic origins. Important sites include:

- Monte Corchia (Tuscany): A long and deep karst system (~57 km long, 1,187 m deep)
- Abisso Paolo Roversi (Tuscany): Italy's deepest known cave (-1,350 m)
- Mount Etna (Sicily): Hosts extensive lava tubes and volcanic caves
- Bolognese Gypsum Regional Park (Emilia Romagna): Hosts some of the most important gypsum caves in Italy

Protection Actions and Contributions

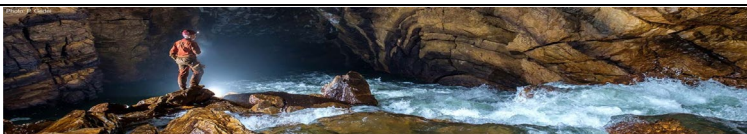
Ongoing monitoring research deals with a limited number of caves; monitoring is the first step towards protection actions. At present, a limited number of caves were involved in continuous monitoring programs of hydrological parameters and fauna, and the reports of the studies included protection actions and recommendations for cave conservations. Among them:

- Additions to the Cave Cadastre with realization of faunal database and monitoring of cave fauna of SCI IT3340006 “Karst of Trieste and Gorizia” - 2008/2009. Friuli Venezia Giulia Autonomous Region, Central Directorate for Agricultural, Natural, Forest and Mountain Resources, Service for the Protection of Natural Environments and Fauna.
- Biological groundwater monitoring of Monte Albo (Sardinia) - 2012/2013. Province of Nuoro, Agriculture Environment Sector and Provincial Police.
- Biological monitoring of Monte Abo aquifer and Locoli cave (2024-2025). MaB UNESCO Reserve “Tepilora, Rio Posada, Montalbo” and Regional Natural Park of Tepilora, Sardinia (ongoing project mainly based on eDNA sampling).
- Two caves will be included in the Biodiversa+ Project Sub-BioMon (Developing and testing approaches to monitor subterranean biodiversity in karst), of which Italy is a partner country (<https://www.sub-biomon.net/>)

Cleaning caves actions

“Puliamo il Buio” – An Initiative for Subsoil Protection

The Italian Speleological Society (SSI), in collaboration with Legambiente, has relaunched the “Puliamo il Buio” (Clean the Darkness) initiative to tackle pollution in caves and underground environments.



Since 2005, this project has aimed to:

- Clean natural and artificial caves.
- Document pollution levels and assess risks.
- Propose concrete solutions to mitigate contamination.

Illegal waste dumping in caves poses a severe threat to karst environments, endangering underground fauna and contaminating crucial water resources. “Puliamo il Buio” actively combats this issue through cleaning operations and awareness campaigns.

This initiative has seen the participation of numerous speleologists who, equipped with the necessary tools, have worked to remove waste and document cave conditions.

The project extends beyond Italy, linking with the European “Clean Up the Dark” program, which unites speleological communities from Croatia, Germany, Slovenia, and other nations in preserving karst environments.

Collaboration with Legambiente’s “Puliamo il Mondo” program has expanded the initiative’s reach, engaging more volunteers and increasing public awareness about underground pollution.

Participants can contribute by:

- Reporting at-risk areas.
- Organizing cleaning activities with their speleological groups.
- Spreading awareness about underground environment protection.

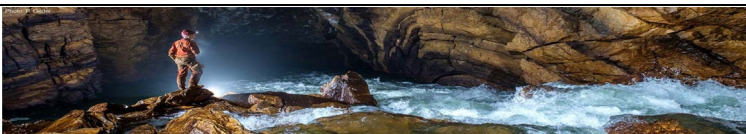
For more information or to join the initiative, contact info@puliamoilbuio.it or visit [Puliamo il Buio website](https://www.puliamoilbuio.it).

Cave Animal of the Year – Raising Awareness for Subterranean Biodiversity

The **Cave Animal of the Year** campaign in Italy, launched by the **Italian Speleological Society (SSI ETS)** in 2018, aims to promote awareness of subterranean fauna. Inspired by the German Speleological Society’s initiative, each year a cave species is highlighted to emphasize its ecological importance and the need for habitat protection.

Key species featured in recent years include:

- **2019** – The common cave fly (*Limonia nubeculosa*).
- **2020** – The cave diplopod (*Plectogona sanfilippo*).
- **2021** – The cave beetle (*Italodytes stammeri*).
- **2022** – The bat (*Miniopterus schreibersii*).
- **2023** – The cave scuds (*Niphargus* spp.).
- **2024** – The cave salamanders (*Speleomantes* spp.), threatened by chytridiomycosis.



- **2025** – The cave moth (*Triphosa dubitata*), highlighting the need for further research into subterranean ecosystems.

The campaign involves public outreach through brochures, school programs, tourist cave exhibitions, and scientific workshops. By promoting the conservation of cave fauna, this initiative plays a crucial role in raising awareness about the fragility and significance of Italy's subterranean biodiversity.

Biodiversity Conservation Status

Italy's caves host rich subterranean biodiversity, with 3,674 species identified, including:

- Troglotic fauna: ~785 obligate cave-dwelling species
- Key taxa: Coleoptera (382), Pseudoscorpiones (92), Araneae (72), Diplopoda (65), Isopoda (55)
- Endemic species: Particularly in Sardinia and in the Pre-Alps (that are also biodiversity hotspots).

All bats and cave salamanders (genus *Speleomantes*) are protected by the Habitats Directive and their implementation in Italian regulations (Presidential Decree 357/97 and integrations). Further species listed in the annexes 2 and 4 of the Directive are the olm (*Proteus anguinus*) and the cave beetle *Leptodirus hochenwartii* present in the caves of the Classical Karst Region, northeastern Italy (provinces of Trieste and Gorizia), mostly included in the Special Area of Conservation IT3340006 'Carso Triestino e Goriziano'.

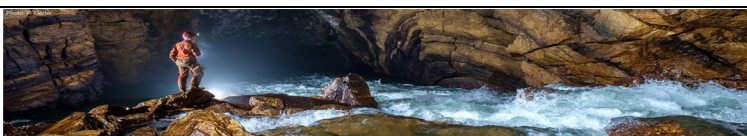
The conservation status of the Habitats Directive species, following the 4th Directive Report (2013-2018), is Favourable (FV) for *P. anguinus* and *L. hochenwartii*, while the situation is more complex for cave salamanders of the genus *Speleomantes* (7 species) and bats (at least 5 species can be considered troglophiles, i.e., 4 species of the genus *Rhinolophus* - *R. ferrumequinum*, *R. hipposideros*, *R. euryale*, and *R. mehelyi*- and *Miniopterus schreibersii*). While 4 species of *Speleomantes* are ranked FV, 3 of them (i.e., *S. genei*, *S. flavus*, and *S. sarabusensis*) are considered in an Unfavourable-Inadequate (U1) conservation status. Moreover, all bats are in U1 conservation status, while *R. euryale* is considered in a Unfavourable-Bad (U2) status, i.e., at risk of extinction. The outlook is negative for all bat species.

All cave inhabitants are strictly protected in some regions due to Regional Laws (like in Friuli Venezia Giulia, Sardinia, and Abruzzo).

Conclusion

Caves are an invaluable part of Italian geological, ecological, and cultural heritage. Future priorities include:

- **Enhancing legal protection** for caves and their ecosystems
- Extending protection measure to all system, from surface to underground environments, strictly connected.
- **Improving monitoring and conservation efforts.**
- **Balancing tourism and conservation** through responsible management.
- **Expanding research on climate change impacts** on subterranean environments.



References

- AA. VV., Cave and karst of Italy. *Speleologia*, n. 68 (2013). Special issue for the 16th International Congress of Speleology, Brno, 2013: 103 p. + 1 plates.
- Boscolo L., 2013. Catalogo topografico e sistematico della fauna raccolta in grotte d'Italia. *Speleologia*, 68: 42-44.
- Cicogna, Fabio (ed.), 2003. Grotte marine: cinquant'anni di ricerca in Italia / a cura di Fabio Cicogna, Carlo Nike Bianchi, Graziano Ferrari, Paolo Forti. Ministero dell'Ambiente e della Tutela del Territorio, 2003: 505 p.
- Parise M., Galeazzi C., Bixio R., Dixon M., 2013. Classification of artificial cavities: a first contribution by the UIS Commission. *Proceedings 16th International Congress of Speleology, Brno, 21-28 July 2013*, vol. 2, p. 230-235.
- Sello, Umberto (ed.), 2009. *Evoluzione della Speleologia in Italia* / a cura di Umberto Sello con Pino Guidi e Giuseppe Muscio. Progetto Power Point 2009. Società Speleologica Italiana, UIS.
- Stoch F. (ed.), 2001. *Grotte e fenomeno carsico* (English edition: *Caves and karstic phenomena*). Quaderni Habitat (English edition: *Italian Habitats*), Ministero dell'Ambiente e della Tutela del Territorio e Museo Friulano di Storia Naturale, 158pp.
- SSI, 2025. <http://speleo.it/catastogrotte/aree-speleologiche/>

