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RESTORING BIODIVERSITY ALONG THE ITALIAN GREEN BELT:

forgotten bunkers, abandoned meadows and disappearing ponds

Activity 1.7 - Manual of interventions

Best practices and know-how manual for habitat and species restoration:

A. PRE-ALPINE GRASSLAND RESTORATION

B. WETLAND (PONDS) RESTORATION

C. BUNKERS REPURPOSING FOR BATS

by

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A. GRASSLAND RESTORATION

This section provides the insights and experience gained from our BESTbelt project, detailing challenges encountered and recommendations based on our work to guide the planning, implementation, and monitoring phases of future grassland restoration projects. The primary goals are to preserve and enhance grassland biodiversity, support traditional agropastoral activities, and sustainably manage local resources. Below are the progressive intervention phases we advise following:

1. IDENTIFICATION AND ASSESSMENT OF THE INTERVENTION AREA

- **Description:** Select and define the target area for restoration. Assess existing vegetation conditions and the presence of key plant and animal species, with particular attention to species of high conservation concern.
- **Precautions:** Avoid disturbing sensitive habitats. Consult ecologists and botanists for a detailed analysis of the species present.
- **Methods and Timing:** Determine if the land is privately or communally owned. For private land, engage with owners early to discuss project feasibility and post-funding maintenance, potentially involving local shepherds. Conduct initial assessments before peak growing seasons to capture accurate data on biodiversity.

2. DEFINING OBJECTIVES AND PRELIMINARY PLANNING

- **Description:** Establish clear, specific restoration objectives, such as reducing shrub cover or enhancing plant biodiversity.
- **Precautions:** Engage local stakeholders, including farmers and community associations, to ensure alignment with traditional practices and foster long-term project sustainability beyond the funding period.
- **Methods and Timing:** Schedule interventions based on seasonal factors and resource availability, keeping in mind long-term goals.

3. PRELIMINARY ENVIRONMENTAL MONITORING

- **Description:** Conduct baseline surveys to document grassland conditions, focusing on shrub and tree cover and plant species composition. Use drone imagery and permanent vegetation quadrants for precise before-and-after comparisons.
- **Precautions:** Use non-invasive methods to minimize habitat disturbance, ensuring baseline conditions are well-documented for future reference.
- **Methods and Timing:** Begin monitoring at the start of the growing season for optimal data collection.

4. VERIFICATION OF OWNERSHIP AND REGULATORY CONSTRAINTS

- **Description:** Verify property ownership and compliance with local regulations, as grassland restoration often involves small, scattered land parcels with varied ownership. Early engagement with property owners is essential to avoid legal issues or resistance.
- **Precautions:** Confirm land access rights and secure permissions from each property owner, especially for areas with multiple land parcels. Collaboration can also support long-term site management.
- **Methods and Timing:** Initiate verification and contact with landowners well in advance, ideally during the planning phase. For communal or ambiguously owned land, consult local authorities to establish acceptable management practices.

Fig.1 Preliminary operations on meadows, selection of the vegetation to be cut, monitoring sessions.

5. REDUCING SHRUB AND TREE COVER

- **Description:** Remove invasive shrubs and trees that hinder grassland biodiversity and support the return of native herbaceous species.
- **Precautions:** Use sustainable methods, such as manual removal or light machinery, to minimize soil disturbance. Retain some large trees to provide livestock shelter during summer.
- **Methods and Timing:** Conduct interventions during non-breeding seasons (late autumn to early winter) when vegetation is dormant. Take care with winter operations, as icy conditions can complicate forestry work.

6. ADDRESSING PREDATOR MANAGEMENT: WOLVES AND LIVESTOCK PROTECTION

- **Description:** Predators in restoration areas present challenges for livestock grazing, which is essential for grassland maintenance. Implement predator management strategies, including livestock-friendly fencing, guard dogs, and secure water access points.
- **Precautions:** Install fencing and consider using guard dogs to deter wolves and other predators without disturbing the ecosystem.
- **Additional Water Sources:** Constructing small ponds or watering troughs can provide secure water sources within protected areas, reducing the need for livestock to roam to open water sources.
- **Methods and Timing:** Set up predator management structures and water sources at the start of the grazing season to avoid interruptions.

7. COLLABORATION WITH LOCAL STAKEHOLDERS FOR GRASSLAND MAINTENANCE

- **Description:** Actively engage local stakeholders, such as farmers, to help maintain grasslands through traditional grazing and mowing practices.
- **Precautions:** Ensure grazing and mowing are conducted sustainably, avoiding overgrazing and promoting rotational use.

- **Methods and Timing:** Schedule grazing and mowing to coincide with the rest periods of key plant species.

Fig. 2 Cutting operations on meadows and revival of low-impact traditional agropastoral activities.

8. POST-INTERVENTION MONITORING

- **Description:** Carry out ongoing monitoring to assess the effectiveness of restoration actions and track biodiversity responses within the grassland.
- **Precautions:** Collect detailed data on plant species and shrub cover, evaluating the success of management practices like grazing.
- **Methods and Timing:** Conduct seasonal monitoring for at least 2–3 years post-intervention, ideally revisiting permanent plots to track changes.

Fig. 3 Biodiversity surveys on meadows with the plot method

9. DOCUMENTATION AND SHARING OF RESULTS

- **Description:** Create an open dataset and an intervention manual to share knowledge and support project replication. Useful platforms include iNaturalist and PlantNet.
- **Precautions:** Ensure data accuracy and completeness before dissemination.
- **Methods and Timing:** Publish results upon project completion, updating open data platforms like iNaturalist to promote conservation and knowledge sharing.

Fig. 4 Restored meadows and biodiversity.

B. WETLAND (PONDS) RESTORATION

This section provides the insights and experience gained from our BESTbelt project, with a focus on pond restoration. We outline the challenges encountered and offer recommendations to guide the planning, implementation, and monitoring phases of future pond restoration projects. The primary goals are to preserve and enhance aquatic biodiversity, support local water needs for agropastoral activities and wildlife, and sustainably manage habitat conditions for sensitive species like amphibians. Below are the progressive intervention phases we advise following:

1. Identification and Assessment of the Intervention Area

- **Description:** Identify and assess ponds in need of restoration. Evaluate existing conditions, including water quality, vegetation, sediment accumulation, and habitat suitability for local species, particularly amphibians and reptiles.
- **Precautions:** Conduct assessments carefully, as these areas are often habitats for sensitive species. It is essential to avoid disturbing amphibian populations and aquatic vegetation.
- **Methods and Timing:** Perform assessments during the off-breeding season (late autumn/early winter) when amphibians are less active. For ponds in conservation areas or with protected species, consult with ecological experts early in the process.

2. Defining Objectives and Preliminary Planning

- **Description:** Establish clear restoration goals, such as increasing water retention, reducing sedimentation, or improving habitat conditions for specific species.
- **Precautions:** Due to amphibian sensitivity and regulatory constraints surrounding their handling, aim to avoid direct interference with amphibian habitats whenever possible. Engage stakeholders, including local wildlife authorities, to ensure that restoration aligns with local conservation goals.
- **Methods and Timing:** Plan restoration activities for seasons that will have minimal impact on amphibian breeding, prioritizing late autumn through winter.

3. Preliminary Environmental Monitoring

- **Description:** Conduct a baseline survey to document existing conditions in and around the pond, including vegetation, water quality, sediment levels, and the presence of amphibians (included abundance of eggs) and other sensitive species.
- **Precautions:** Avoid capturing or handling amphibians directly, as special permissions are typically required. Instead, use observational techniques to assess populations and habitat conditions.
- **Methods and Timing:** Schedule monitoring before any physical interventions, ideally during the low-activity season for amphibians to reduce disturbances.

4. Securing Permissions and Regulatory Compliance

- **Description:** Verify property ownership, check for protected species, and ensure compliance with environmental regulations, especially if amphibians or other sensitive species are present.
- **Precautions:** Handling or relocating amphibians generally requires specific permissions. Avoid physical handling whenever possible to minimize stress on populations and prevent legal complications.
- **Methods and Timing:** Contact local conservation authorities well in advance to secure any required permissions and confirm allowable restoration methods, especially in protected or multi-owner areas.

Fig. 5 Preliminary monitoring operations on ponds.

5. Manual Sediment and Vegetation Removal

- **Description:** Carefully remove excess sand, soil, and overgrown vegetation that reduce water depth and contribute to sedimentation.
- **Precautions:** Use manual tools to avoid excessive soil disruption, which could impact amphibian habitat. Avoid mechanical equipment that can cause vibrations or alter the pond's structure, as it may disturb sensitive species.
- **Methods and Timing:** Conduct sediment removal during colder months when amphibians are less active and likely to be buried or dormant in nearby woodlands. Manual methods are preferable to ensure minimal impact.

6. Managing Water Quality and Algae

- **Description:** Enhance water quality by removing excessive algae and sediment that may limit light penetration and oxygen levels in the pond.
- **Precautions:** Be cautious with algae removal to avoid sudden shifts in water chemistry. Avoid chemicals or rapid changes that could harm amphibians and aquatic vegetation.
- **Methods and Timing:** Regular manual algae control is recommended, ideally scheduled during colder months. If possible, create shade around the pond to naturally limit excessive algal growth.

7. Supporting Biodiversity with Natural Features

- **Description:** Enhance pond habitat by adding natural features like small stones, logs, native aquatic plants, and wood piles that can provide shelter and breeding grounds for amphibians and other wildlife. Wood piles near the water offer ideal hibernation sites for amphibians, especially during colder months.
- **Precautions:** Avoid introducing non-native species and ensure that any added features are beneficial for local species. Maintain a balance to prevent overcrowding the pond.
- **Methods and Timing:** Introduce habitat enhancements in phases to monitor impacts on water quality and species use. Early spring, after sediment removal, is often an ideal time to introduce these elements.

8. Predator and Livestock Management

- **Description:** Protect pond habitats from livestock overuse and manage predator access to support amphibian populations.
- **Precautions:** Install livestock-friendly fencing to prevent animals from entering and disturbing the pond. If predators pose a risk, consider non-intrusive deterrents to maintain the pond as a safe habitat for amphibians.

- **Methods and Timing:** Install protective fencing and other measures before the start of the grazing season to ensure uninterrupted habitat stability.

Fig. 6 Manual restoration on ponds.

9. Post-Intervention Monitoring

- **Description:** Implement long-term monitoring to assess restoration success, focusing on water quality, sediment levels, and amphibian population response.
- **Precautions:** Avoid invasive monitoring techniques and continue to refrain from handling amphibians unless necessary and permitted. Document changes to track habitat improvements and identify any emerging issues.
- **Methods and Timing:** Conduct monitoring seasonally for at least 2–3 years post-restoration, with a particular focus on amphibian breeding seasons to observe population recovery and habitat use.

10. Documentation and Knowledge Sharing

- **Description:** Compile data from the restoration process into an open dataset and a manual to facilitate future project replication and knowledge dissemination. Share observations on platforms like iNaturalist or relevant aquatic biodiversity databases.
- **Precautions:** Ensure all data, particularly regarding sensitive species, is accurate and complies with privacy or conservation requirements before sharing.
- **Methods and Timing:** Publish results and update data on open-access platforms upon project completion, with annual reviews to keep information current and useful for conservation efforts

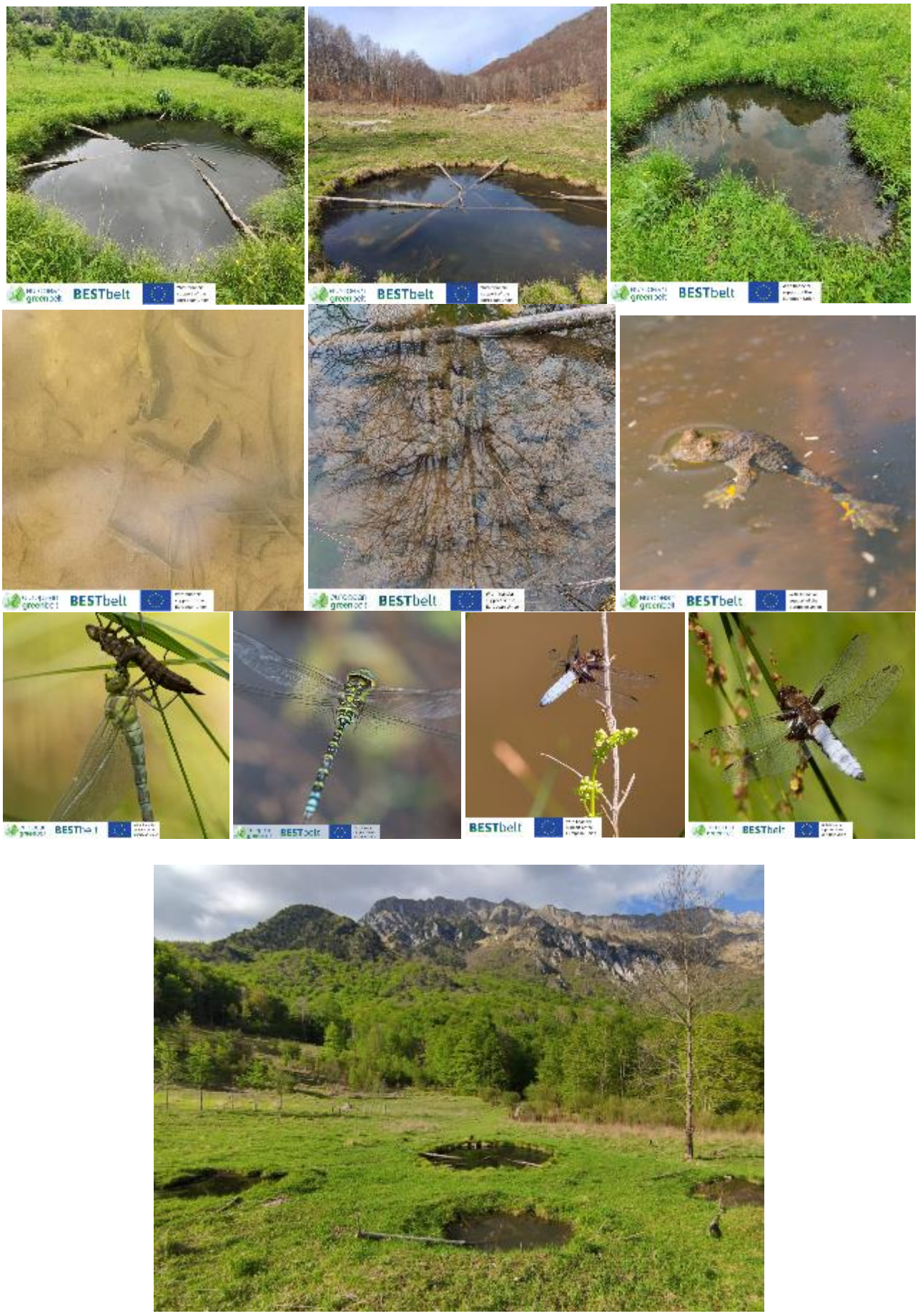

Fig. 7 Restored ponds and biodiversity.

C. BUNKERS REPURPOSING FOR BATS

This section provides insights and experience gained from our BESTbelt project, with a focus on restoring abandoned bunkers as bat habitats. We outline the challenges encountered and offer recommendations for planning, implementing, and monitoring phases of future bat bunker restoration projects. The primary goals are to enhance roosting opportunities for bats, ensure minimal disturbance to these highly protected species, and preserve the historical integrity of bunkers. Below are the progressive intervention phases we advise following:

1. Identification and Assessment of Bunker Sites

- **Description:** Identify and assess bunker sites suitable for bat habitat restoration, focusing on structures with the right depth, temperature, and humidity levels to support bat roosting and hibernation.
- **Precautions:** Bats are sensitive, highly protected species; any disturbance can disrupt roosting patterns. Automated tools, such as bioacoustic recorders, should be prioritized to monitor bats without direct interference.
- **Methods and Timing:** Conduct assessments in the non-breeding season (late autumn or early winter) when bats are less likely to be present. Engage bat ecology experts early in the process to confirm habitat suitability.

2. Defining Objectives and Preliminary Planning

- **Description:** Set clear objectives for habitat enhancement, such as improving roosting suitability while preserving bunker structures as historical sites.
- **Precautions:** Avoid structural changes to the bunkers to respect their historical value. Temporary or reversible features should be used to create roosting spots without altering the bunker's appearance or stability.
- **Methods and Timing:** Plan interventions to coincide with the bats' non-breeding and non-hibernation seasons to minimize disturbance. Coordinate with local historical preservation authorities to ensure compliance.

3. Preliminary Environmental Monitoring

- **Description:** Conduct a baseline survey to document the current state of each bunker, focusing on existing microclimatic conditions, such as temperature, humidity, and airflow, which are crucial for bats.
- **Precautions:** Use non-invasive methods like automated humidity and temperature loggers to establish environmental baselines. Avoid entering areas where bats are present to minimize stress and maintain stable conditions.
- **Methods and Timing:** Install monitoring devices early to record baseline conditions for future comparison. Ideally, gather data for several months to understand seasonal microclimatic variations within the bunker.

4. Securing Permissions and Regulatory Compliance

- **Description:** Verify property ownership and consult with wildlife authorities to ensure compliance with regulations, as bats are highly protected species and may require specific permissions for monitoring or habitat modification.

- **Precautions:** Any handling or close monitoring of bats requires special permits and should be minimized. Confirm compliance with both conservation and historical preservation requirements.
- **Methods and Timing:** Contact local conservation and historical authorities well in advance to secure necessary permissions and clarify allowable restoration techniques.

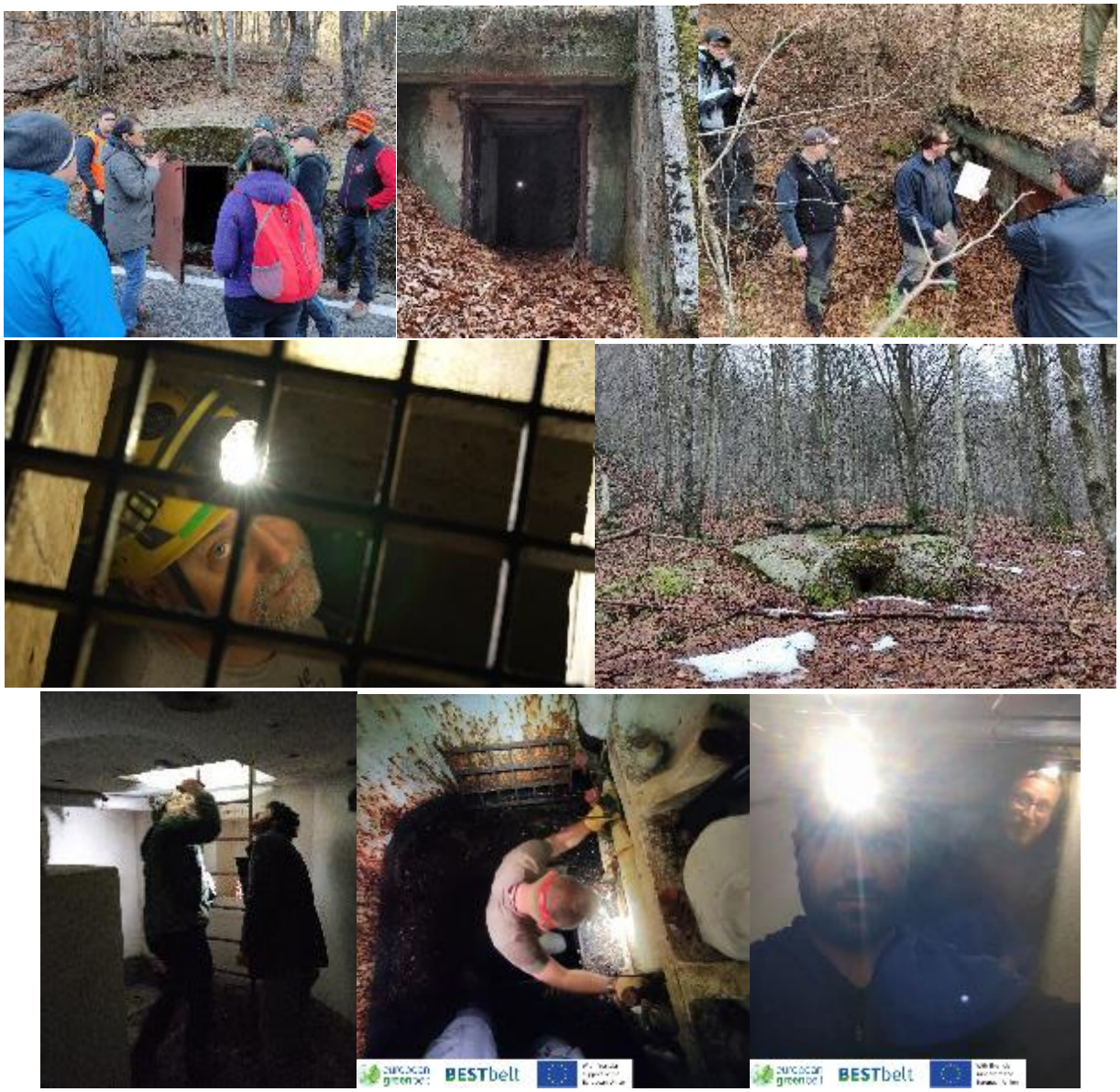

Fig. 8 Preliminary operations, selection and exploration of suitable bunkers.

5. Typical Restoration Activities: Partial Closure or Opening of Bunkers

- **Description:** Adjust the bunker's entry points to enhance security and airflow. For fully open bunkers, consider partial closures to prevent predator access while allowing bats to enter freely. For completely sealed bunkers, partially open entry points to improve airflow and create suitable roosting conditions.

- **Precautions:** Implement closures or openings using non-invasive and reversible materials (e.g., mesh or lightweight barriers) that do not alter the historical structure permanently. Ensure modifications do not obstruct natural airflow, as stable humidity and temperature are critical for bats.
- **Methods and Timing:** Conduct these modifications outside of roosting or hibernation seasons to avoid disturbing resident bats. Use temporary, removable materials that can be adjusted as needed.

6. Enhancing Microclimatic Conditions

- **Description:** Where necessary, install temporary structures like wooden partitions or hanging bat boxes to adjust airflow, humidity, and temperature within the bunker to optimize bat roosting conditions.
- **Precautions:** Use non-permanent materials that can be removed without damaging the bunker. Ensure structures are deep enough to maintain stable humidity and temperature but do not obstruct the bunker's original layout.
- **Methods and Timing:** Install enhancements after confirming environmental modifications align with both bat needs and historical preservation goals. Wooden or fabric materials are generally ideal for temporary, reversible solutions.

7. Reducing Disturbance with Automated Monitoring

- **Description:** Use automated audio recording devices, such as bioacoustic monitors, to track bat presence and activity with minimal human disturbance. This approach is critical for ongoing monitoring in sensitive habitats.
- **Precautions:** Automated audio monitoring significantly reduces the need for direct human presence within the bunkers, minimizing the risk of disturbing roosting bats. Ensure that recording devices are non-invasive and battery-operated.
- **Methods and Timing:** Set up audio recorders during the non-roosting season and program them to operate intermittently to collect sufficient data without disturbing bats. Use data analysis software to assess bat activity remotely.

8. Enhancing Bunker Habitat with Non-Invasive Features

- **Description:** To encourage roosting, install temporary features like wooden shelves or bat boxes that provide bats with additional perching areas and hibernation spots.
- **Precautions:** Ensure all features are non-permanent and do not require structural changes to the bunker. Avoid excessive additions that could impact the historical ambiance or layout.
- **Methods and Timing:** Install habitat enhancements in stages to monitor their effectiveness. Consider early spring as an ideal time for setup, allowing bats to gradually acclimate before peak roosting seasons.

9. Maintaining Suitable Conditions for Bat Habitats

- **Description:** Monitor and maintain humidity and temperature to ensure the bunker remains a viable bat habitat. Deep bunkers with consistent microclimates are ideal for year-round bat occupancy.
- **Precautions:** Avoid frequent entry to maintain stable internal conditions. Use automated humidity and temperature loggers to continuously monitor bunker conditions without disturbing the bats.

- **Methods and Timing:** Collect seasonal data to ensure microclimate stability across different times of the year, particularly during summer and winter.

Fig. 9 Restoration activities on bunkers, monitoring equipment and bat-friendly structures installation.

10. Post-Intervention Monitoring

- **Description:** Implement long-term monitoring to assess restoration success and track bat population trends within the bunker.
- **Precautions:** Avoid invasive monitoring methods and refrain from entering the bunker except when necessary. Use automated systems to track changes and gather data on bat occupancy over time.
- **Methods and Timing:** Conduct monitoring throughout the year, with a focus on the bats' active and hibernation seasons. Data from automated recorders and loggers should be reviewed seasonally to assess habitat suitability and occupancy trends.

11. Documentation and Knowledge Sharing

- **Description:** Compile data and findings from the restoration process into a comprehensive, open-access dataset and manual for future reference. Share insights with conservation organizations and historical preservation communities.
- **Precautions:** Ensure that data on protected species is securely handled and complies with conservation guidelines. Coordinate with historical organizations to document the use of the bunker for both ecological and educational purposes.
- **Methods and Timing:** Publish results on conservation platforms and historical preservation networks to promote best practices and facilitate future restorations of similar sites.

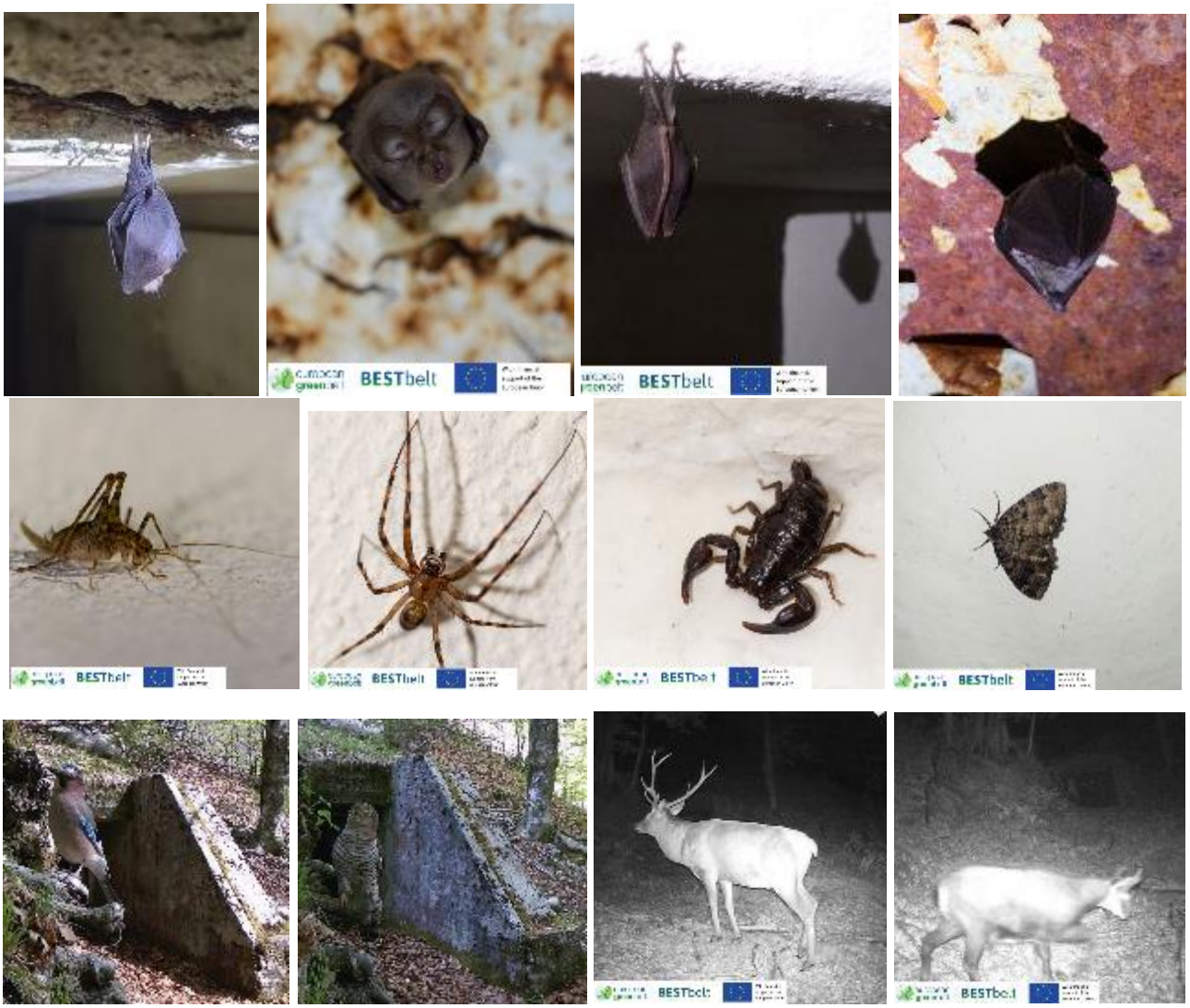

Fig. 10 Biodiversity in bunkers and surrounding areas.