Biodiversity monitoring and enforcement across centre and periphery: Exploring the interplay between citizen science, technology, law and policy

Anna Berti Suman, Leo Mensel, Patricia Tiago, Aouefa Amoussouvi

The workshop "Biodiversity Monitoring and Enforcement" was held on 4 March 2026 on the occasion of the European Citizen Science Conference - ECSA 2026 and was co-convened by the EU-funded ENFORCE project, in particular by partners A Sud and ECSA, and by the ECSA Working Group on Monitoring Biodiversity using Citizen Science. For an outline of the session, see: Biodiversity monitoring and enforcement across centre and periphery: Exploring the interplay between citizen science, technology, law and policy.

Biodiversity monitoring is essential to understanding ecosystem health and informing conservation action. Yet traditional monitoring efforts often lack the spatial and temporal coverage needed to capture complex biodiversity dynamics. Citizen science offers a powerful complementary approach, engaging diverse publics in the co-creation of knowledge while filling critical data gaps.

The workshop explored the challenges and the opportunities coming from citizen science approaches in monitoring biodiversity. Through short presentations and interactive discussion in a World Café format, we gathered perspectives from practitioners, researchers, citizen scientists, and policy stakeholders to reflect their diverse insights on key questions posed by the convenors. Participants had the opportunity to share methodologies, tools, and case studies, identifying synergies and gaps across initiatives.

Based on prompts from the convenors, we discussed the importance of data quality, validation mechanisms, and possible protocols that can be adopted or adapted to ensure consistency and comparability across projects. We also explored strategies to foster long-term engagement of communities and volunteers around shared biodiversity issues. These inputs will contribute to co-developing a roadmap for scaling up biodiversity monitoring with citizen science in Europe and beyond, aligning efforts across disciplines and sectors, with a distinctive attention to applications in enforcement contexts.

After an introductory note from the convenors, we listened to the short pitches of:

- **Kate Evans (Gothenburg Global Biodiversity Centre**) on "Bridging Science and Society: A Blueprint for Citizen Science in European Biodiversity Hotspots".
- **Christos Georgiadis (UoC–NHMC), Michalis Probonas (University of Crete - Natural History Museum of Crete)** and team on "LIFE Themis Application: A review of its use from citizens and results from complaints / reports concerning environmental crime in Natura 2000 sites in Crete, Greece".
- **Alessandro Oggioni (CNR - IREA), Chiara Fedrigotti (MUSE - Science Museum Trento) and Laura Criscuolo (IGG - CNR)** on "User profiling in Citizen Science applications: enhancing data reliability and informativity through behavioural and contextual analysis".

Funded by the European Union
UK Research and Innovation
Project funded by
This project has received funding from the European Union's Horizon Europe programme under grant agreement 101134447- ENFORCE. Views and opinions expressed are however those of the authors) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them. Co-funded by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding Guarantee. This work has received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

- **Ulrike Sturm and Susan Karlebowski (Museum für Naturkunde Berlin)** on “User engagement in biodiversity observation apps”.
- **Finn Danielsen (NORDECO - Nordic Foundation for Development and Ecology), Gitte Kragh (Aarhus University and NORDECO) and Aja Faurschou (NORDECO)** on “Involving citizens in Denmark in monitoring the Kunming-Montreal Global Biodiversity Framework”.
- **Julia Flister (Museum für Naturkunde - Leibniz Institute for Evolution and Biodiversity Science)** on “Citizen Science and Artificial Intelligence for Biodiversity Monitoring”.
- **Isayvani Naicker (Evisights BV)** on “Building bridges between citizen science and environmental policy for monitoring biodiversity compliance and enforcement using evidence from citizen science as actionable insights for policy”, representing the ENFORCE project.
- **Annika Vogel (Anhalt University of Applied Sciences)** and team on “Branching Out: Testing the Suitability of Outdoor Navigation Apps for the Recruitment of Citizen Scientists for Nature Conservation Projects”.
- **Sophie P. Ewert (Museum für Naturkunde - Leibniz Institute for Evolution and Biodiversity Science)** and team on “Learnings about Citizen Science as a pillar of biodiversity monitoring in Germany”.

Discussion points

In ***Table 1 – Future of Biodiversity Monitoring,*** the participants discussed the following questions: Where should biodiversity monitoring efforts focus in the coming years? What innovations in technology, frameworks, policies, or tools are needed to advance this field? What barriers exist?

In ***Table 2 – From Local to Global,*** the participants addressed the following prompts: How can local initiatives be connected to a global agenda? What are good examples of initiatives that managed to attain this goal? What structural, technical, or governance barriers limit this scaling-up process, and how can they be overcome?

In ***Table 3 – Compliance & Enforcement,*** we shared with the participants the following questions: How can biodiversity data from citizen science initiatives support environmental law enforcement actions, integrating them with official data? How can such data be recognised as admissible evidence, for example in court cases? How to tackle the gap between citizen science observations and regulatory responses?

Funded by the European Union
UK Research and Innovation
Project funded by
Swiss Confederation
This project has received funding from the European Union’s Horizon Europe programme under grant agreement 101134447- ENFORCE. Views and opinions expressed are however those of the authors) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them. Co-funded by UK Research and Innovation (UKRI) under the UK government’s Horizon Europe funding Guarantee. This work has received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

Enforce
Empowering Citizens for Environmental Action

ecsa 2026 conference
oulu | 3-6 march

Key takeaways

Highlights from *Table 1 – Future of Biodiversity Monitoring*

The discussion emphasized that the future of biodiversity monitoring must combine technological innovation with inclusive, user-centred approaches and stronger integration of ecological and social knowledge systems. Real-world examples illustrated both successful practices and ongoing challenges.

From Species Observation to Ecosystem Dynamics: The discussion stressed that biodiversity monitoring should move beyond static species observations toward a more dynamic and systemic understanding of ecosystems. This includes tracking phenomenological eco-processes such as species interactions (e.g., pollination) and changes over time and space, as illustrated by monitoring efforts in Flanders, Belgium. Participants highlighted the importance of incorporating not only species presence but also absence data and population densities. Diversifying the type of data format beyond images, for example, in expanding the use of acoustic monitoring in forests and oceans, was also identified as a key direction. In addition, the integration of Indigenous and local knowledge systems was considered essential, with examples from Canada showing how "learning from the land" can inform local governance. More broadly, biodiversity monitoring should connect ecological data with cultural and social dimensions, including narratives, which requires stronger collaboration between natural and social sciences.

Designing Inclusive and Accessible Monitoring Tools: A major theme of the discussion was the need for accessible and inclusive technological solutions. Experiences from Madagascar and South Africa showed that in contexts with low literacy levels, tools must be extremely simple, relying on images rather than text and enabling automatic analysis of observations. Artificial intelligence is increasingly important in this context, particularly through image recognition systems that can identify a large proportion of species and thus support large-scale participation.

Adaptive Monitoring and User Feedback Systems: Adaptive and participatory monitoring approaches were also highlighted. Platforms such as iNaturalist could enable adaptive sampling by suggesting which species users should monitor. These systems could integrate more feedback loops that could help users to better understand what their data means and why it matters, while also providing alerts about local ecosystems. Other applications demonstrate how structured data collection can be improved, for example, by guiding users to photograph different parts of plants such as stems, leaves, and flowers. A mushroom monitoring app further illustrates innovation by encouraging multisensory engagement, including smell, to enrich both data and user experience. Such features improve both engagement and data quality.

Funded by the European Union
UK Research and Innovation
Project funded by
Swiss Confederation
Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

This project has received funding from the European Union's Horizon Europe programme under grant agreement 101134447- ENFORCE. Views and opinions expressed are however those of the authors) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them. Co-funded by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding Guarantee. This work has received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

Citizen Science Models and Frugal Innovation: Citizen science models provide further examples of innovation. In Finland, a two-step system combines volunteer observations with scientific validation, ensuring both scale and reliability. In Sweden, high public engagement is complemented by strong governmental trust in citizen-generated data, creating a robust monitoring framework. Birdwatching communities worldwide were also mentioned as long-standing and effective contributors to biodiversity monitoring having developed a set of best practices. At the same time, innovation is not limited to high-tech solutions. Frugal approaches, such as using tea bags to store insects or monitor soil quality, demonstrate how low-cost, low-tech methods can be effective and scalable.

Data Quality, Integration, and Knowledge Gaps: Despite these advances, several challenges remain. Data quality is a key concern, particularly due to the limited number of trained taxonomists available to validate observations. Integrating different data systems is another major barrier, especially when attempting to merge established databases with newer tools and technologies. Developing interoperable and systemic data infrastructures is essential to better integrate diverse data sources. There is also a risk that users may rely heavily on automated tools such as artificial intelligence without developing a deeper understanding of species and ecosystems, which highlights the need for stronger educational and engagement strategies.

Toward Integrated, Inclusive, and Scalable Monitoring Systems: The discussion concluded that advancing biodiversity monitoring requires a balanced and integrated approach. This includes developing inclusive and user-friendly tools that can be used across diverse contexts, strengthening feedback mechanisms to improve both engagement and data quality, and scaling citizen science models that combine broad participation with scientific validation. It also involves integrating Indigenous and local knowledge systems and fostering interdisciplinary collaboration, particularly with social sciences, as seen in examples in Canada and in the opening keynote lecture of the ECSA 2026 conference by Camilla Brattland and Bente Sundsvold on the study of arctic coastal ecosystem integrating natural scientific data and Sámi knowledge.

Balancing High-Tech Innovation with Social Engagement: At the same time, there is a need to expand the use of advanced technologies such as artificial intelligence, while ensuring that users remain connected to and informed about the ecosystems they observe. Finally, promoting successful examples as proof of principles from countries such as Finland and Sweden can help build trust and demonstrate the effectiveness of these approaches. Overall, biodiversity monitoring must evolve as both a technological and a social endeavour, grounded in inclusivity, collaboration, and real-world applicability.

Funded by the European Union
UK Research and Innovation
Project funded by
Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra
Swiss Confederation
Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

This project has received funding from the European Union's Horizon Europe programme under grant agreement 101134447- ENFORCE. Views and opinions expressed are however those of the authors) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them. Co-funded by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding Guarantee. This work has received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

Highlights from *Table 2 – From Local to Global*

In **deciding whether to scale up**, it is important to follow ecological pathways, e.g., along water courses/migratory species; build initiatives from the bottom up and maintain a common core, while allowing flexibility in implementation. Overall, the transition from local to global should happen as a consequence of strong local initiatives, not imposed from outside. There may be a need for intermediary organisations that help connect initiatives internationally. There are trade-offs between local and global: initiatives need to balance the choice of staying highly focused on a specific place and/or topic and the need to be connected to international networks such as ECSA. The incentives that would stimulate local groups to join international networks should be under scrutiny.

Need for capacity building and support: There is a specific need for capacity building for local groups (e.g., on mapping, species monitoring and even storytelling); and to provide guidance for groups on how to organise their initiatives, linking them to global infrastructures such as GBIF, and improving the communication about initiatives (e.g., BioBlitzes, BioMonWeek). Overall, this support should recognise the diversity of local contexts and embrace local languages when appropriate.

Among the best practices shared: Worth mentioning is the Alliance for Biodiversity Knowledge, as well as projects that started locally and then spread to neighbouring countries or Europe (e.g., the Nature Observation Marathon from Estonia to other countries).

Funding schemes: Were discussed, including cascade funding as an important mechanism (e.g., Irish Local Funding Strategy from national funder); and the need for transnational funding to follow, e.g., migratory species; and the need for funding that helps scale initiatives from local to global. Overall, funding should also embrace the diversity of initiatives.

Highlights from *Table 3 – Compliance & Enforcement*

Positive views towards the use of citizen science data for enforcement purposes: Argued that recognizing the use of such data for enforcement may establish or re-establish trust between citizens and institutions especially through the establishment of standardised and shared data collection pathways; using citizen science data is a sign of recognition of the citizens' efforts to protect the environment and would further create awareness on the issue among the citizen scientists and their networks; even when the data quality are not up to official standards, still citizen science can provide data, which could function as trigger for monitoring and investigations, filling official data gaps. Even when citizen science data is not fully recognised, it can be used to pressure governments to action.

Funded by the European Union
UK Research and Innovation
Project funded by
Swiss Confederation

This project has received funding from the European Union's Horizon Europe programme under grant agreement 101134447- ENFORCE. Views and opinions expressed are however those of the authors) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them. Co-funded by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding Guarantee. This work has received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

Recommended Steps

Legal frameworks should therefore be adapted to consider citizen science data; efforts should be made to ensure that a certain format and level of detail required by authorities is met by citizen science data (this could be done through approaches like the Data Readiness Levels (DRLs) as proposed by the ENFORCE project); established frameworks could avoid that different volunteers use different methods, establish clear and verifiable chains of custody for the collected evidence, and prevent errors in citizen science data collection. It was stressed the importance for authorities to train staff on how to work with citizen science data and how to collaborate with communities; in addition, policy needs to be implemented to make this training mandatory. Inspiring frameworks come from the concept of 'nature rights', as they require stewards of nature, which could create pathways for citizen scientists to support environmental compliance. Beyond DRLs, it was pointed out that we may also need a scale for "Authority Readiness Level" towards citizen science.

Concerns towards the use of citizen science data for enforcement purposes: Included the fear of citizen scientists not wanting to defend their observations in court; the possibility that citizens do not want to give out their details, especially to authorities (although the possibility of anonymous reporting has proved viable in some citizen science initiatives, for example in the ENFORCE project); the risk that access to land may be lost if citizen scientists are seen as checking wildlife and data that can be used against land owners; the fear of misuse of citizen science data throughout the process; the argument that "science and enforcement are separate" and should be kept separate as it is the responsibility of elected authorities to enforce, which should not be shifted to the hands of the public authorities: by collecting data for enforcement purposes, citizens may allow authorities to dodge responsibility.

Project-specific and country-specific contexts have also been discussed: In the Netherlands, for example, it is unlikely for the municipalities to use e.g., citizen science water data because the data level is different. Here, the standards for citizen science would need to be closer to agency values and even then there is no assurance of uptake. A similar situation was reported for Italy with water data too and for Slovenia with air quality data. Differently, in Sweden, there is a track record of authorities using civic data, for example from hunters to control moose population in local forests. There would be the need for a certain level of harmonization at least across European Union countries of these approaches. A case was reported from the German Environmental Agency on the issue of overreporting by concerned citizens on an invasive ant, asking the agency to verify. The case exemplifies the importance of clearly communicating with the citizens and having resources ready to be able to answer questions, in order to manage expectations from citizens. Also, in this case, there should have been an opportunity for experts to verify the data. In the UK, there is a pilot project on civic reporting of ash pollution and associated diseases, which achieved a high degree of reliability and scaled up globally. The local government saw value in the project, coordinating volunteers and verifying data.

Join our community!
join-enforce.eu

LinkedIn
ENFORCE

Youtube
ENFORCE_EU

Project Coordination:
info@join-enforce.eu

Dr. Svetlana Klessova
Project Coordinator
G.A.C. Group France

Prof. Chrysi Laspidou
Scientific Coordinator
University of Thessaly

Funded by the European Union

UK Research and Innovation

Project funded by
Swiss Confederation

This project has received funding from the European Union's Horizon Europe programme under grant agreement 101134447- ENFORCE. Views and opinions expressed are however those of the authors) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them. Co-funded by UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding Guarantee. This work has received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).