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# The monitoring global guideline framework for biodiversity monitoring

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## Summary

To preserve and protect nature, the Post-2020 Global Biodiversity Framework calls for increasing the area of the Earth under effective conservation management (CBD, 2021). Monitoring the status of species and habitats allows assessment of management outcomes and is the cornerstone to improve adaptive management strategies. The applications for biodiversity monitoring extend to outreach, education, and general scientific discovery. We provide a framework through the Monitoring Global Guideline (MoniGloG) for monitoring the state of biodiversity in conservation areas around the globe.

The MoniGloG describes four phases of a monitoring programme. In the Preparatory Phase, legal obligations of regional or international scope must be considered. The next step is to assess the availability of previous data and determine the main threats facing the park. Balanced against the site conservation goals, a mission statement containing a monitoring priority list of biological and environmental features should be generated.

The programme should then be collaboratively assessed with stakeholders and park staff during the Conceptual Phase. We propose the use of a monitoring concept worksheet to help frame the following questions: why monitor, what requires monitoring, where and when will monitoring occur, who will participate in the programme, and how many human and financial resources are available to the programme. Questions can be addressed iteratively and revisited as necessary. The outcome is to identify realistic monitoring targets considering site logistics.

Selection of methods and tools occurs in the Implementation Phase. This step requires clear research objectives, basic knowledge of the selected indicators, and a robust statistical design. After determining methods, equipment should be obtained and customised for the programme. Technical staff must receive appropriate training, particularly with unfamiliar technologies. Test runs are recommended to optimise field procedures. Data should be collected in a simple, standardised way and should include descriptive metadata. Following the test runs, data should undergo a statistical analysis to verify the suitable procedures. All elements of test runs should be recorded in a preliminary field manual.

When the field manual is finalised, the ongoing monitoring cycles can begin. We provide field logistics and data management checklists that can be adapted to any monitoring programme. Data should be backed up and archived in their simplest form in a stable digital environment. For transparency, findings should be presented in different formats to stakeholders. Results of the monitoring programme will guide decisions in the Re-evaluation Phase whether the monitoring programme should continue, be adapted, or terminated and resources dedicated to another purpose.

## Keywords

adaptive management; long-term monitoring; monitoring guideline; change detection; conservation; evidence-based decision-making

## Introduction

The state of biodiversity continues its global downward trajectory, despite intergovernmental policies intended to preserve it (Cowie et al., 2022; IPBES, 2019). The 1992 Rio Convention is perhaps the most consequential of these policies, resulting in the ratification of the Convention on Biological Diversity (CBD) in 1993. This landmark agreement was intended to protect global biodiversity and to this day guides international biodiversity policy. Since ratification, multiple strategic plans have been implemented to halt biodiversity loss and promote ecosystem services. The 2010s-era Aichi Target 11 called for at least 17 per cent of terrestrial areas and 10 per cent of coastal and marine areas to be conserved (CBD, 2010). Target 3 of the CBD's current Post-2020 Global Biodiversity Framework has set forth a goal of placing at least 30 per cent of the world's terrestrial areas under effective conservation by the year 2030 (CBD, 2022), the so-called 30 × 30 objective.

Much work will be required to reach the 30 × 30 objective, not only through designating additional areas for nature conservation, but also by improving management effectiveness of present and future sites. Management effectiveness can only be determined through targeted monitoring programmes. Yet, globally unaligned monitoring protocols used in protected areas (PAs) and other effective area-based measures (OECMs) challenge our scientific ability to determine whether management actions are truly effective. We introduce the Monitoring Global Guideline (MoniGloG) to remedy the shortcomings of these globally unaligned monitoring protocols. MoniGloG provides a framework to conceptualise biodiversity monitoring systems (BMSys) prior to and during implementation, facilitating comparisons of data and techniques in a standardised way.

## Methods

The proposal for MoniGloG was accepted in 2020 for eventual publication by the International Union for Conservation of Nature World Commission on Protected Areas (IUCN WCPA). MoniGloG is a designated Work Package of the Austrian FFG-funded project BioMONITec, which began in 2021. Since then, development of MoniGloG has been guided by a core writing team at the UNESCO Chair on Sustainable Management of Conservation Areas, Carinthia University of Applied Sciences (CUAS), and supplemented with contributions by external collaborators and a diverse international Working Group. Existing guidelines from IUCN and other scientific organisations were consulted, and professional experiences from contributors were used as the basis for the guideline.

## Results

Setting up a new BMSys is a complex process. The higher the quality of conceptualisation that is invested prior to implementing a BMSys, the less effort is required during implementation. The value and ease of implementation of a well-considered programme will further exceed that of a poorly conceived programme. We propose a framework for establishing new BMSys consisting of four phases. The first phase is the Preparatory Phase. In this phase, the background site information is gathered to help target the BMSys appropriately. The Conceptual Phase follows, in which all logistical considerations are identified and debated internally. The third phase is the Implementation Phase. During this phase, the field work and data analysis procedures take place. The MoniGloG framework concludes with the Re-evaluation Phase. During this final phase, managers and administrators determine whether the BMSys adequately achieved its purpose, whether it should be renewed in the original form, or whether it requires a significant revision before being renewed.

The Preparatory Phase establishes the need for site-based biodiversity monitoring through producing a list of priority monitoring targets. PAs and OECMs have certain legal obligations and site goals. A background investigation of the site will help managers identify the requirements. The outcome of the Preparatory Phase is the development of a brief BMSys mission statement. The mission statement should summarise the primary conservation targets and how the BMSys will evaluate the activities, considering threats, reporting requirements, key species and habitats, and biodiversity obligations.

In the Conceptual Phase, the details of the BMSys are articulated. Logical, well-reasoned responses to the fundamental questions of the Conceptual Phase will provide managers with a realistic view of what can be accomplished given the circumstances surrounding the BMSys (Lindenmayer and Likens, 2009). These questions are:

- **Why monitor**:
  - what is the purpose of the monitoring effort;
  - what is the expected outcome;
  - is there scientific, cultural, or other value associated with monitoring?
- **What indicators should be monitored**:
  - is the object under observation a rare species or habitat;
  - is population size important;
  - is an abiotic proxy being monitored to represent the biological community?
- **Where will monitoring occur**:
  - what is the area of interest;
  - will monitoring be area-wide or plot-based;
  - what is the minimum spatial resolution of the indicator?
- **When will monitoring occur**:
  - at what point of the season should monitoring begin;
  - how often will monitoring be repeated;
  - how long will the programme go on;
  - does monitoring occur due to a special circumstance, i.e. natural disaster?
- **Who will be involved in monitoring**:
  - who are the partners and stakeholders;
  - how large is the monitoring team;
  - what skills are available in-house;
  - will third party assistance be required?
- **How many resources are available for monitoring**:
  - what is the available budget;
  - what infrastructure is on-hand;
  - do available human resources match the minimum required human resources;
  - is involvement of staff secured for many monitoring cycles;
  - are supplemental resources available?

We provide the reader with a blank monitoring concept worksheet to help shape the responses to the fundamental questions (Figure 4). Working through the worksheet allows managers and field personnel to consider factors in a step-by-step manner, minimising the complexity of each topic. Questions can be discussed in any order amongst managers, staff, and stakeholders. Questions can be revisited. The outcome is to identify a realistic and achievable scope of the BMSys based on available resources and site factors.

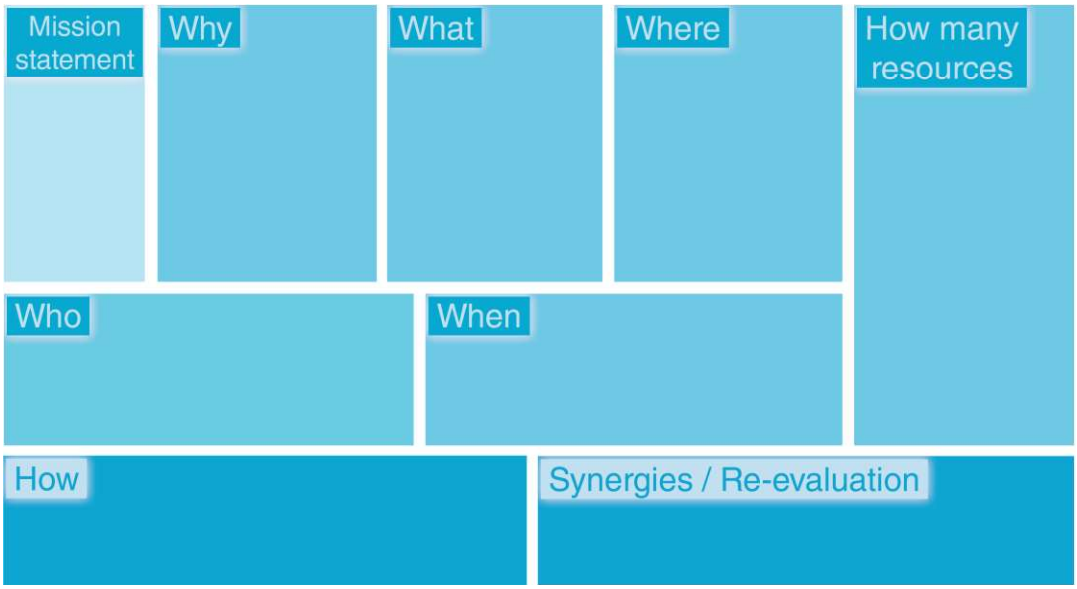


*Figure 4 Overview of the Monitoring Concept Worksheet (MCW). The basis of the BMSys is determined through the mission statement developed during the Preparatory Phase (light blue coloration). The six questions "why", "what", "where", "when", "who", and "how many resources" (intermediate blue coloration) of the Conceptual Phase will identify "how" monitoring will be conducted in the Implementation Phase, as well as potential synergies with other management programmes (dark blue coloration).*

During the Implementation Phase, the field procedures of the BMSys are put into practise. A decision on sampling design – supported by adequate statistical procedures – is a required first step and will be based on knowledge of the indicator that will be monitored. Once the field design is determined, materials are acquired. Many new monitoring devices are available today, and an overview of traditional and novel techniques is provided in MoniGloG. All components of field implementation should be documented in a preliminary field manual. This should include collecting metadata (Huettmann, 2009), how field data will be analysed and to whom the data will be presented. A series of test runs should then be conducted to ensure that the methodologies are suitable for the site and the selected indicators. Any deficiencies identified during the test runs can be corrected without affecting the quality of the actual data series. The preliminary field manual should be revised to reflect the best work flow from the test runs, resulting in a finalised field guide. Closely following the field guide should help maintain continuity of the BMSys despite personnel changes. In sum, the Implementation Phase outlines on the monitoring concept worksheet "How" the BMSys will be implemented.

The final Re-evaluation Phase of the BMSys is a critical element of management effectiveness. By the nature of scientific programmes, most projects are time-bound. Whilst most projects successfully reach their scheduled conclusion, projects occasionally fade away in an elusive manner. To determine effectiveness of a management programme, this must be avoided. This phase reserves resources to review the outcomes of the programme at its scheduled conclusion, identifying successes and deficiencies. The analysis will provide a basis for administrators and decision-makers to approve a continuation of the programme as-is, to recommend significant modifications, or to allocate limited resources in a different way. In the face of ever-evolving biodiversity obligations, and given the pace of today's technological breakthroughs, re-evaluation will provide room to incorporate the most recent developments into future programmes.

We conclude MoniGloG with a brief review of methods and technologies that are available to implement BMSys. High-throughput genetic techniques and advanced sensors are enabling a new era of 'big data' collection driven by artificial intelligence and machine learning (Dalton et al., 2021). Modern devices include acoustic sensors, camera traps, drone- and satellite-based sensors, and miniaturised telemetric devices. However, uneven availability of these tools, and in some cases non-standardised methodological approaches, may limit their value. As traditional monitoring techniques will continue to be an important component in BMSys, their implementation is discussed in comparison to high-tech methods.

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