NACIONALNI INŠTITUT ZA BIOLOGIJO
NATIONAL INSTITUTE OF BIOLOGY

Večna pot 121, 1000 Ljubljana

LifeWatch ERIC 2024 THEMATIC SERVICE WORKSHOP SERIES

Biodiversity Observatory Automation

Ljubljana, 11.04.2024

National Institute of Biology

Marine Biology Station Piran

April 2024

THEMATIC TOPICS – LifeWatch ERIC 2024 Thematic Service Workshop Series

Biodiversity Observatory Automation, 11.04.2024

www.lifewatch.si

VENUE:

NIB, Večna pot 121, 1000 Ljubljana

Seminar room, 1st floor

PROGRAM

9:00 – 9:10	*Greetings from Slovenian hosts* – Tanja Pipan and Andreja Ramšak (LifeWatch-SI)
9:10 – 9:30	*Presentation of Thematic Core Services (TCS)* – Alberto Basset (LifeWatch ERIC Service Center)
9:30 – 10:10	Invited talk: *Ecosystem Virtual research environment: from data FARIfication to digital twins* – Zhiming Zhao (University of Amsterdam)
10:10 – 10:25	Talk: *Challenges to Implement Darwin Core Meta Data Standard within GeoNetwork portals* – Magdalena Năpăruş-Aljančič, Žan Kafol* and Tanja Pipan (Karst Research Institute ZRC SAZU; *KAFOL.NET)
10:25 – 10:40	Talk: *Case study: Landscape features and biodiversity in agroecosystem* – Danijel Ivajnšič and Nataša Pipenbaher (University of Maribor)
10:40 – 11:20	Invited talk: *Using high-throughput species discovery with robots and Nanopore sequencing to overcome taxon biases in biodiversity science* – Rudolf Meier (Museum of Natural History, Berlin)
11:20 – 11:30	Coffee break
11:30 – 12:10	Invited talk: *Environmental DNA and DNA metabarcoding for biodiversity monitoring and assessment* – Gentile Francesco Ficetola (University of Milan, Department of Environmental Science and Policy)
12:10 – 12:25	Talk: *Use of unmanned aerial vehicles in ecological research* – Jaka Črtalič, Hubert Potočnik, Nik Ojdanič (University of Ljubljana)
12:25 – 12:40	Talk: *Camera traps and citizen science App for biodiversity monitoring* – Luka Duniš, Žiga Velkavrh and Elena Bužan (University of Primorska)
12:40 – 13:00	Debate

13:00 – 14:00	Lunch break
14:00 – 14:30	Invited talk: *LIFE NarcIS - NAtuRe Conservation Information System in Slovenia* – Rok Havliček (Slovenian Environment Agency)
14:30 – 14:45	Talk: *Next-generation multi-modal monitoring of Rana arvalis in Slovenia – preliminary results* – David Stanković, Sara Strah, Mojca Vek, Mariana Carreira Santos, Mladen Avramović and Jernej Polajnar (National Institute of Biology, University of Aveiro, University of South Bohemia)
14:45 – 15:00	Talk: *Acoustic and vibrational biodiversity monitoring* – Jernej Polajnar and Rok Šturm (National Institute of Biology)
15:00 – 15:20	Coffee break
15:20 – 16:00	Invited talk: *Presentation of the LifeWatch Belgium observatory services* – Klaas Deneudt (VLIZ)
16:00 – 16:15	Talk: *Novel approaches to surveying habitat types and organisms on the seabed* – Lovrenc Lipej, Borut Mavrič (National Institute of Biology, Marine Biology Station Piran) - CANCELED
16:15 – 16:55	Invited talk*: Estimating structural diversity of forests using national remote sensing data* – Anže Martin Pintar and Mitja Skudnik (Slovenian Forestry Institute)
16:55 – 17:15	Coffee break
17:15 – 17:45	Workshop, moderated debate – Cene Fišer (University of Ljubljana)
17:45 – 18:00	Conclusions and Wrap-up

Chair of the organizing committee:

Andreja Ramšak

Organizing Committee:

Andreja Ramšak, Magdalena Năpăruş-Aljančič, Tanja Pipan, Nataša Pipenbaher, Urša Vilhar, Cene Fišer

Technical design:

Katja Uršič

LifeWatch Thematic Service Workshop

Biodiversity Observatory Automation

11 April 2024

Ljubljana, Slovenia

https://www.lifewatch.eu/thematic-services-workshops/biodiversity-observatory-automation/

Short Description of the aim of the Workshop Thematic Topics Biodiversity Observatory Automation

Andreja Ramšak (National Institute of Biology)

Abstract: A warm welcome to all of you who are attending today's workshop from Thematic Topics Series Biodiversity Observatory Automation at NIB.

The workshop is organized by the Slovenian LifeWatch Consorcium, and this is also a great opportunity for consortium members to gather and put on display current research, and discuss together with members of LifeWatch nodes on further actions under this this Thematic Topics Biodiversity Observatory Automation. We are honored to host eminent researchers who dedicated time for today's meeting, I warmly welcome Dr Zhiming Zhao (University of Amsterdam), Dr Rudolf Meier (Museum of Natural History Berlin) and Dr Gentile Francesco Ficetola (University of Milan). A warm welcome goes also to prof. Alberto Basset, Vanessa Morroco, Ant Turkmen representatives of LifeWatch ERIC. I would like to thank LifeWatch ERIC for financial and logistic support.

We tried to prepare interesting meeting and bring together experts to present key achievements and obstacles in monitoring and observational approaches and discuss the drawbacks and needs of different stakeholders.

Just to remind, the Biodiversity Observatory Automation workshop is one of a series of LifeWatch-ERIC workshops dedicated to reviewing and updating the requirements for effective biodiversity assessment in an era of unprecedented environmental change and biodiversity loss. While there are several limitations in biodiversity assessment, such as time-consuming field work and even more demanding post-field work data processing and data storage, we are facing advances in automation of data collection, increasing computational power and possibilities to use artificial intelligence.

In this workshop we will explore possibilities offered by variety of modern approaches to monitor and detect biodiversity (from aerial observations to eDNA), from design of data collection, data curation, and data exploration including use of AI to FARIfication of data to digital twins.

In a video presentation we will learn about the LIFE NARCIS project, and the national information system that links different databases, and will have a positive impact on decision-making processes, shorten administrative procedures in different areas and will improve cooperation between public institutions dealing with nature conservation.

Presentations also cover terrestrial, freshwater, and marine ecosystems.

The final part of our meeting today is dedicated to intensive discussion on meaning of Biodiversity Observatory Automation, its development and challenges in the near future. Discussion is open to all participants to express expectations, needs, suggestions how to organize this thematic topic in benefit of scientific community, professionals and stakeholders, to support their research, promote collaboration and exploitation of technology and knowledge.

I kindly invite you to stay with us until the end of meeting.

Invited talk

Ecosystem Virtual research environment: from data FARIfication to digital twins

Zhiming Zhao[1]

[1] University of Amsterdam, Faculty of Science, Informatics Institute, Postbus 94323, Amsterdam, Netherlands

Abstract: Data-centric approaches are increasingly important in studying environmental and ecological problems, e.g., biodiversity loss and food safety. To conduct such investigations, researchers often have to reuse research assets, for example, observational data, AI models, workflows, and infrastructure services from different parties for building computational experiments. Digital twins recently emerged as an important method for conducting the predictive study of complex environmental and earth science systems, where researchers can test different scenarios and models over a digital representation of the physical system, e.g., in BioDT for biodiversity, DTO for ocean and LTER-LIFE for ecosystems. However, the construction of digital twins is very challenging; it not only requires advanced modeling and simulation expertise from different domains, and profound computing and software engineering skills but also massive high-quality data for building the models and validating the system. In this talk, we will discuss the challenges and practices of data FAIRification and digital twin development and present our ongoing work on the virtual research environment in the context of LifeWatch Virtual Lab and Innovation Center.

Invited talk

Using high-throughput species discovery with robots and Nanopore sequencing to overcome taxon biases in biodiversity science

Rudolf Meier[1]

[1] Museum of Natural History, Leibniz Institute for Evolution and Biodiversity Science, Invalidenstraße 43, Berlin, Germany

Abstract: Biodiversity science tends to neglect hyperdiverse arthropod clades although they are species-rich and provide many ecosystem services. I first document that more than half of the flying insect diversity in many samples is concentrated in 20 family-level clades regardless of where the samples were collected. I then demonstrate how little is known about most of these clades by comparing the species richness in samples with the number of described species. This leads to the conclusion that we need new approaches to species discovery and taxonomy of “dark taxa”. At the Center for Integrative Biodiversity Discovery at the Natural History Museum Berlin, we are currently optimizing a robot ("DiversityScanner") that detects, images, and measures individual specimens before they are placed into microplates for DNA barcoding with rapid and cost-effective techniques involving Nanopore sequencers. After presorting the

specimens based on DNA barcodes, we use morphological data for selected specimens to validate/fix "barcode clusters" to become species ready to be identified or described. I will show that this approach allows for quickly converting a "dark taxon" from largely unknown to sufficiently well known for biomonitoring. I will also show how the images for common species can be used to train Convolutional neural networks (CNNs) for future specimen identification with images alone. Overall, I will argue that dark taxa can be tackled by applying high throughput methods to one local sample at a time.

Invited talk

Environmental DNA and DNA metabarcoding for biodiversity monitoring and assessment

Gentile Francesco Ficetola[1]

[1] University of Milan, Department of Environmental Science and Policy, Via Celoria 10, Milan, Italy

Abstract: Through their life, organisms continuously release their DNA in the environment (environmental DNA; eDNA). In the last decades, several approaches have been used to extract eDNA from the environment, and to improve our assessment of biodiversity. eDNA can be used for biodiversity assessment through multiple approaches, including a) the amplification target species (e.g. endangered species, alien species…) using specific primers; b) the amplification of eDNA with universal primers, followed by high-throughput sequencing and taxonomic identification using reference databases (eDNA metabarcoding), and c) shotgun sequencing and other metagenomic approaches. Each approach has pros and cons, and the selection heavily depends on the study targets. Through the presentation, we will assess the strengths and limitations of the different approaches for biodiversity assessment on the basis of eDNA extracted from water, soil, sediments and air; we will evaluate the issues of taxonomic identification in absence of complete reference databases; and we will discuss potential future development. eDNA analyses have great potential to boost biodiversity analysis, but the complexity of the different steps must be carefully taken into consideration. Furthermore, its results can be more effective for conservation management if complemented with traditional data and expertise by local managers.

Invited talk

Presentation of the LifeWatch Belgium observatory services

Klaas Deneudt[1]

[1] Flanders Marine Institute, Marine Observation Centre, Jacobsenstraat 1, Oostende, Belgium

Abstract: To support the biodiversity and ecosystem research in Belgium, Flanders Marine Institute (VLIZ) and Research Institute for Nature and Forest (INBO) have put in place local marine, freshwater and terrestrial observatories. These observatories apply innovative techniques to generate long term data series that can support biodiversity studies on plankton, fish, birds and mammals. State of the art sensors are acquired and deployed in the field to gather high resolution data on occurrence and behavior of marine organisms and their environment. The assembled infrastructure includes imaging sensors for phytoplankton and zooplankton characterization and identification, acoustic telemetry devices for fish detection, GPS trackers for bird observation and tracking, camera traps and acoustic hydrophones for mammal detection, etc. Further innovation of the observatories is envisaged through advancing automation of the data collection, (ai based) processing, and data flows and through the use of autonomous platforms carrying the sensors. The construction and operation of this observatory is part of the Flemish contribution to the Lifewatch ESFRI, which is funded by the Research Fund - Flanders (FWO).

Invited talk

LIFE NarcIS - NAtuRe Conservation Information System in Slovenia

Rok Havliček[1]

[1] Slovenian Environment Agency, Vojkova 1b, Ljubljana, Slovenia

Abstract: In Slovenia, the LIFE NarcIS project has been running since 2021, establishing a modern national nature conservation information system that will provide easier, faster and more transparent access to up-to-date and credible data on biodiversity, nature conservation activities and other data relevant to nature conservation in one place. Currently, there are a number of different databases, but they are mostly disconnected and primarily intended for use within the organisations that maintain them. As a result, the standardisation, sharing and use of data are weakened, which weakens conservation efforts. Data is largely inaccessible to the public in a modern, digital way. A consortium of eight partners is developing an information system that will enable more efficient implementation of nature conservation legislation, strategic planning for nature conservation and better monitoring of the actions taken. The system will have a positive impact on decision-making processes, shorten administrative procedures in different areas and will improve cooperation between public institutions working

in the field of nature conservation. It will also help to make data more accessible to end-users. It will provide tools for more effective management of species, their habitats and protected areas, as well as tools for data review and input. LIFE NarcIS will provide the backbone for future upgrades – digitalisation of processes and introduction of e-commerce.

Invited talk

Estimating structural diversity of forests using national remote sensing data

Anže Martin Pintar[1] and Mitja Skudnik[2]

[1] Slovenian Forestry Institute, Department for Forest an Landscape Planning and Monitoring, Večna pot 2, Ljubljana, Slovenia

[2] Slovenian Forestry Institute, Department of Forestry and Renewable Forest Resources, Večna pot 2, Ljubljana, Slovenia

Abstract: Natural processes, environmental impacts and forest management form the structure and functioning of the forest, which are interlinked. The structure of forest stands includes vertical (e.g. number of layers) and horizontal elements (e.g. spatial position of trees, gaps) as well as species diversity. For example, the structure of forest stands can be represented by the number of trees, species composition, height and diameter at breast height of trees. Data on forest stands can be obtained through field descriptions of stands, field measurements and the evaluation of stand characteristics as well as using remote sensing data. The assessment of the vertical and horizontal structure of forest stands is crucial for supporting forest management activities, e.g. for planning forestry measures or assessing the suitability of habitats for rare and endangered species. One of the main advantages of using remote sensing data for forest structure assessment is the ability to obtain accurate data for larger areas quickly and cost-effectively.

We will present a brief overview of the possibilities of detecting the forest structure using different remote sensing technologies. We will explain an example of using data from the Laser Scanning of data (LSS) to assess the diversity of forest structure. We will also present an example of using LSS data and data from the Cyclic Aerial Survey of Slovenia (CAS) to detect and describe the characteristics of forest gaps in structurally diverse forests.

Short presentation

Challenges to Implement Darwin Core Meta Data Standard within GeoNetwork portals

Magdalena Năpăruş-Aljančič[1], Žan Kafol[1,2] and Tanja Pipan[1]

[1] Karst Research Institute, Titov trg 2, Postojna, Slovenia

[2] KAFOL.NET

Abstract: LifeWatch Slovenia (LifeWatch-SI) is a consortium of 10 partners from nationally and internationally recognized scientific institutions, universities, a regional park, a national museum and a non-governmental organization, all active in the field of biodiversity and ecosystem research, with the Karst Research Institute ZRC SAZU serving as the national coordinator and headquarters of LifeWatch-SI.

The national project RI-SI-LifeWatch (2019 -2021), granted by the Slovenian Ministry of Education, Science and Sport and the European Regional Development Fund, was aiming for the national node to establish a network for monitoring and collecting data on biodiversity and the environment, obtained and processed through the acquisition of high-performance research equipment. As part of this project, an IZRK metadata portal (https://metadata.izrk.zrc-sazu.si) was established at the Karst Research Institute Data Centre using the open-source GeoNetwork platform to provide administration tools and a user interface for cataloguing interdisciplinary environmental data and access to data products. The new metadata portal adheres to the FAIR data principles and data lifecycle, collecting and mapping various datasets, databases, research sites and equipment, virtual labs, processes and codes. The portal is open to all LifeWatch-SI partners to publish their metadata with optional links to download the data. Although the portal provides end users with standardized metadata and datasets for multidisciplinary research areas (e.g. bio-geo-chemical data, time series, geospatial data) as well as a repository for secure data storage, we still face the challenge of implementing the Darwin Core taxonomic standard in the latest GeoNetwork version, which is so urgently needed in a RI dedicated to biodiversity such as LifeWatch.

Short presentation

Landscape features and biodiversity in agroecosystem

Danijel Ivajnšič[1] and Nataša Pipenbaher[1]

[1] University of Maribor, Faculty of Natural Sciences and Mathematics, Koroška cesta 160, Maribor, Slovenia

Abstract: Years of agricultural intensification across Europe's plains, valleys and hills had left behind a more or less generalized land use pattern dominated by profitable land cover types. Small landscape features with no direct (financial) benefit to the farmer, have been, in many cases, removed and converted to arable land. This study investigates the possibilities to

integrate small woody landscape features (SWLF) into the new (2023-2027) CAP measures, which are in conjunction with the EU Green Deal ambitions and support biodiversity preservation in agroecosystems. A spatial SWLF preservation/restoration potential algorithm, based on the most recent European (SWF2018) and improved national level (SWLF2015) status databases, was developed and then applied to identify priority SWLF management regions and areas in Slovenia. In the ecological evaluation of Slovenian regions, especially from biodiversity perspective, for the time being, owing to the spatio-temporal and methodological unsystematic nature of the available data, we are practically dependent on foreign databases. However, the currently available spatial data enable the preparation of biodiversity, landscape matrix, geomorphological and socio-economic indicators, which, together with the assessed state of landscape features, are an objective criterion for quantifying the Slovenian area in terms of the need to preserve or re-establish SWLF in various scales (macro- and mezo-regions, 1 km^2 and 300 m grid). In addition, a self-standing (LPIS independent) information, monitoring and decision support system has been designed for a target priority area (Goričko) in different spatial scales (from regional, 1 km, 300 m, AH to parcel level) to bypass existing gaps in SWLF-targeted CAP measure implementation strategies in Slovenia. Such results are urgently needed across all European countries to easier, faster and better realize CAP national strategic plans.

Short presentation

Use of unmanned aerial vehicles in ecological research

Hubert Potočnik[1], Nik Ojdanič[1] and Jaka Črtalič[1]

[1] University of Ljubljana, Biotechnical Faculty, Chair of Ecology and Environment Conservation, Jamnikarjeva 101, Ljubljana, Slovenia

Abstract: Unmanned aerial vehicles (UAVs) are valuable tools for remote sensing. Their main advantage over satellite imagery is their higher spatial resolution and the timeliness of the data. Two of the most commonly used attachments for monitoring flora and fauna are the multispectral camera and the thermal imaging camera, which are mounted on the UAV in addition to the visual spectrum camera. The use of multispectral cameras allows the calculation of vegetation indices, which provide information on the physiological characteristics of plant stands. The vegetation indices can thus be used to detect the biomass of plant stands, their productivity, the chlorophyll and water content in leaves, the leaf area index and the overall vigour of the stands. The use of photogrammetric techniques additionally allows the creation of digital twins from which morphological characteristics can be observed. The unique spectral signatures make it possible to map different vegetation types simultaneously.

Thermal imaging cameras are most commonly used for monitoring the status and distribution of medium- and large-sized species. These effectively separate warm-blooded animals from their surroundings, allowing us to detect specimens, determine abundance and gain insight into the spatial characteristics and other ecological factors of individual species.

Use of UAV and remote sensing techniques thus represent a new tool and an alternative to field measurements, which are often energy and time consuming, especially in areas such as impassable wetlands, areas with dense vegetation or other areas that are difficult to access by humans. However, field measurements are still needed to obtain some of the reference values for the properties we want to detect, but on a much smaller scale.

Short presentation

Camera traps and citizen science App for biodiversity monitoring

Luka Duniš[1], Žiga Velkavrh[2] and Elena Bužan[1]

[1] University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies, Department of Biodiversity, Glagoljaška 8, Koper, Slovenia

[2] University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies, Department of Mathematics, Glagoljaška 8, Koper, Slovenia

Abstract: Wildlife monitoring plays a crucial role in modern conservation and sustainable population management practices. The remarkable advancements in digital camera technologies (e.g., IR motion sensors, ML with AI) have enabled us to use modern methods, such as camera traps, to achieve the objectives of wildlife monitoring that can vary from assessing species' presence/absence to estimating their density in a particular area. Camera traps are animal-friendly, cause little or no disturbance to the animals, and create permanent and verifiable records of the presence and interactions of various species. By implementing international standards for data collection and analysis, following established camera-trapping protocols, and using novel analysis tools, such as the Agouti tool, we can improve the reliability and comparability of results between periods and regions. Agouti, for example, includes photogrammetry methods to estimate camera trap detection zone size and animal speed of movement using a computer vision process. Using Agouti, we were able to estimate the density of wild boar, European roe deer and red deer in some areas of Slovenia.

From July 2022, we also started to adopt citizen science as a tool for monitoring wildlife in Slovenia. In collaboration with the Hunting Association of Slovenia, University of Primorska, University of Ljubljana and Faculty of Environmental Protection of Velenje, we have developed an application called SRNA to collect additional metadata on game and non-game species presence, reproductive potential and health status. By combining data collected by different modern monitoring methods, we strive to improve the management of species in Slovenia.

Short presentation

Next-generation multi-modal monitoring of *Rana arvalis* in Sloveia – preliminary results

David Stanković[1], Sara Strah[1], Mojca Vek[1], Mariana Carreira Santos[2], Mladen Avramović[3] and Jernej Polajnar[1]

[1] National Institute of Biology, Department of Organisms and Ecosystem Research, Večna pot 121, Ljubljana, Slovenia

[2] University of Aveiro, Department of Biology, Campus de Santiago, 3810-193 Aveiro, Portugal

[3] University of South Bohemia in České Budějovice, Faculty of Fisheries and Protection of Waters, South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses, Zátiší 728/II, 389 25 Vodňany, Czech Republic

Abstract: The western edge of the range of *Rana arvalis* is fragmented, with several isolated populations scattered from northeastern France to central Slovenia. In Slovenia, the isolated population in the southern periphery of Ljubljana possibly harbors the most important breeding areas in Slovenia. This population, restricted to a complex of shallow water wetlands and floodplain forests, is under strong anthropogenic pressure due to urbanization, intensive agriculture and human recreational activities. Population numbers in its largest breeding area appear to have declined over the last decade. However, as there is no regular biomonitoring for this species, these estimates are not reliable. In addition, conventional biomonitoring for this species is difficult and time-consuming and must be carried out in a very limited period when clutches have already been laid but are still fresh enough to allow reliable identification. To improve knowledge of the occurrence and spatial distribution of this species, enable more accurate identification of population trends and provide better guidance to wildlife managers, we are establishing a basis for a next-generation multimodal biomonitoring program for *R. arvalis*. As part of ongoing activities, we are evaluating the performance of automated acoustic monitoring, eDNA detection and visual observation using aerial drones to collect data on the relative abundance and phenology of this species. Preliminary analysis of automated acoustic and eDNA monitoring of *R. arvalis* shows great promise.

Short presentation

Acoustic and vibrational biodiversity monitoring

Jernej Polajnar[1] and Rok Šturm[1]

[1] National Institute of Biology, Department of Organisms and Ecosystems Research, Večna pot 121, Ljubljana, Slovenia

Abstract: Passive acoustic monitoring (PAM) is being increasingly adopted for studying a wide array of ecological questions, both basic and applied. Technical development of data acquisition, storage and processing capacities have in recent years improved reliability,

accessibility and versatility of this approach, and the method is starting to be implemented in national biodiversity monitoring schemes in developed countries. Keeping limitations – the chief of which is being restricted to sound-producing organisms – in mind, several exciting developments are in progress, targeting terrestrial and freshwater ecosystems to complement classical (e.g. manual surveys) or other advanced monitoring approaches (e.g. eDNA). In an earlier stage of development is an analogous approach which focuses on neglected insect communities comprising species that produce substrate-borne vibrations. We have begun developing the analysis of vibrations emanating within terrestrial environments – the vibroscape – for reliable assessment of ecosystems. This pioneering approach is already showing that information in the vibroscape can be used to distinguish among insect communities. Technological development in the last years shows promise that an automated and autonomous recording system in this area will soon be feasible as well.

Round table: Where we are now with biodiversity observatory automation?

Moderator: Cene Fišer

Attendees: Klaas Deneudt, Gentile Francesco Ficetola, Rudolf Meier, audience

Round table aimed to wrap up the lectures of the workshop, identify the progress and opportunities, as well as open challenges. The key issues can be summarized into five main messages.

The “biodiversity observatory automation” is vaguely defined term, covering diverse techniques of data-collection and associated data-analysis. The term encompasses many contemporary activities, such as citizen science, remote sensing or machine learning that all contribute to “big data science”. The most widely used data collection comprise several molecular approaches (barcoding, metabarcoding, eDNA), visual information (photos and videos recorded by stationary photo-traps or cameras attached to drones), and mechanic vibration (sound, substrate born vibration). An important role in the entire process plays machine learning, that can process large amounts of information and link it with species identities.

The need for use of diverse methods stems from the multi-facies nature of the living world, each facies elucidating different aspects of species’ biology. The applicability of individual techniques depends on the biology of the taxon and the type of habitat that taxon lives in (terrestrial, aquatic). The effectiveness of how these methods identify species, depends on completeness of the libraries, which link organismal signals (sequences, images, voices, vibrations) and their species identity. The completeness of libraries varies.

Large amounts of organismal signals from the environment cannot be identified through the existing libraries. These incomplete libraries raise a question whether or not Linnean taxonomy is applicable within the biodiversity automated observation. An argument in favor of the Linnean taxonomy emphasizes that discarding the existing names would lead to loss of the past knowledge, including IUCN status. An argument against the Linnean taxonomy reasons that

novel methods might fairly quickly build up a new system that would replace the lost names and more effectively monitor present status of the organisms.

Novel approaches may suffer from two major weaknesses. Firstly, incomplete libraries do not allow broad data integration. Unless conducted within the same laboratory the interchangeable use of different methods is presently limited. Moreover, repeatability of some methods is low. For example, sequences acquired from different eDNA sampling campaigns can be compared in a common framework only if acquired by the same research team, whereas sequences from different research teams should not be aligned in a joint analysis.

Biodiversity automated observation will depend of adequate data storage, such that it will allow efficient species identification and data retrieval. This calls for a broad consensus of minimal standards applied to biodiversity databasing.